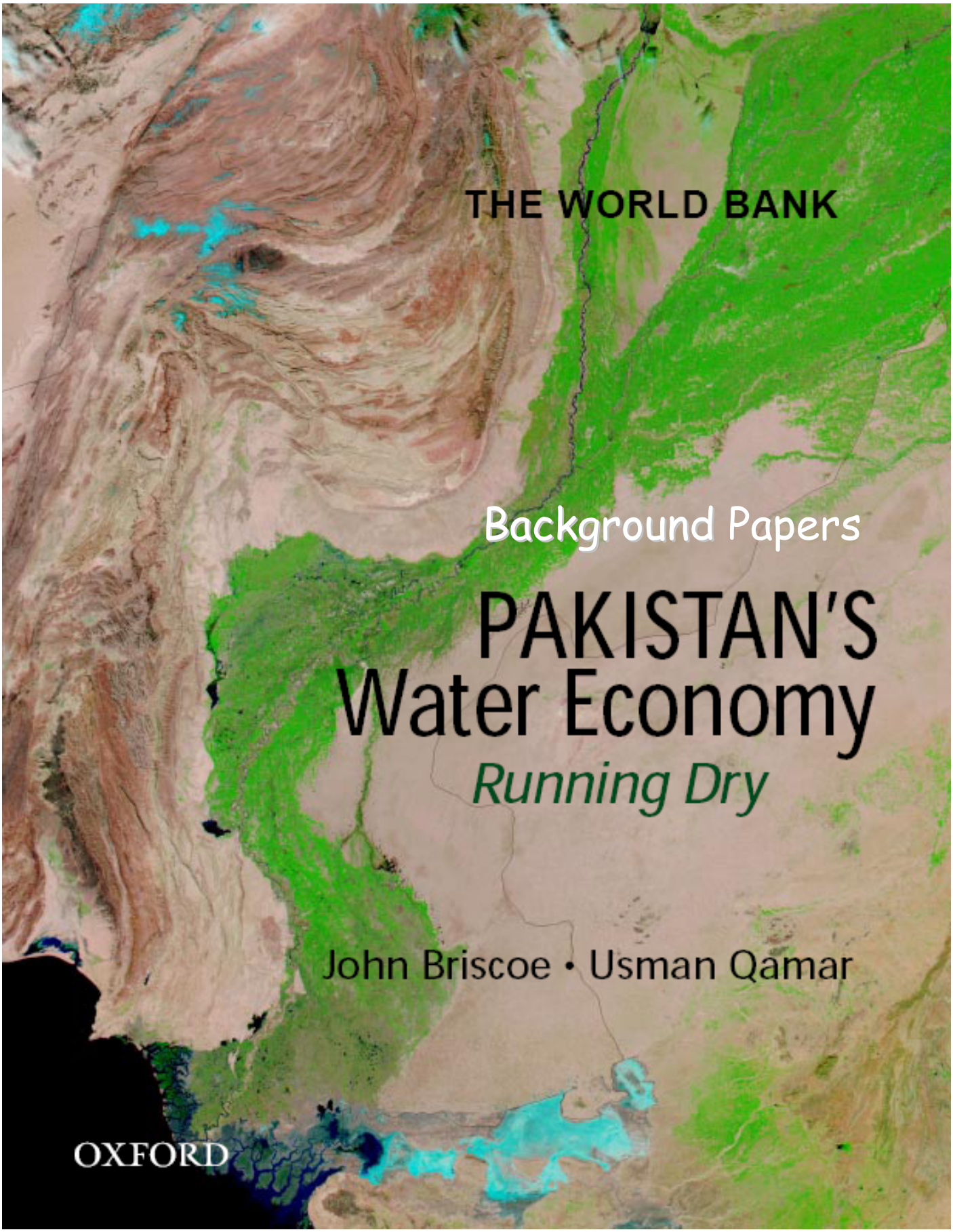

THE WORLD BANK

Background Papers

PAKISTAN'S Water Economy

Running Dry

John Briscoe • Usman Qamar

OXFORD

Table 1.1: List of background papers (available in the enclosed compact disc)

	Background Paper	Author(s)	Designation
1.	Water, growth, and poverty	Sarfraz Khan Qureshi	Former Director, Pakistan Institute of Development Studies
2.	Human and social dimensions	Karin Siegmann and Shafqat Shezad	Research Fellows, Sustainable Development Policy Institute
3.	Water and environmental sustainability	Vaqar Zakaria	Managing Director, Hagler Bailley
4.	Water and energy	Imitiaz Ali Qazilbash	Retired WAPDA official
5.	Water balances and evapotranspiration	Shahid Ahmad	Chief Scientific Officer, Water Natural Resources Division, Pakistan Agricultural Research Council
6.	Water rights and entitlements	Faizul Hasan	Chief Engineer, ACE (Pvt.) Ltd., and Project Coordinator, General Consultants for WAPDA
7.	Sustainable, accountable institutions	Sardar Muhammad Tariq and Shams-ul-Mulk	Former Member (Water), and Chairman, WAPDA, respectively
8.	Drinking water and sanitation	Khurram Shahid	Consultant
9.	The political economy of reform	Imran Ali	Professor, Lahore University of Management Sciences (LUMS)
10.	The role of large dams in the Indus System	Pervaiz Amir	Economist, Asianics Agro. Dev. International
11.	Groundwater development and management	Frank van Steenbergen and Shamshad Gohar	Metameta Research and Ground Water/ Water Quality Specialist, PCWSSP
12.	Modernization of agriculture	Pervaiz Amir	Economist, Asianics Agro. Dev. International
13.	The policies and prospective plans for development and management of water resources by the federal and provincial governments	Sardar Muhammad Tariq and Shams-ul-Mulk	Former Member (Water), and Chairman, WAPDA, respectively
14.	Flood control and management	Asif Kazi	Former Special Secretary, Ministry of Water and Power, and ex-Chairman, Federal Flood Commission
15.	Drainage and salinity management	M.N. Bhutta and Lambert Smedema	Director General International Water Logging and Salinity Research Institute (IWASRI)
16.	The evolution of Bank lending and non-lending for water in Pakistan	Usman Qamar	Senior Irrigation Engineer, The World Bank
17.	The evolution of Bank lending and non-lending for water supply and sanitation	Pervaiz Amir and Nadir Abbas	Economist, Asianics Senior Water Supply and Sanitation Specialist, The World Bank

Water, Growth and Poverty in Pakistan

By

Dr. Sarfraz Khan Qureshi

Country Water Resources Assistance Strategy
Background Paper # 1
March, 2005

Water, Growth and Poverty in Pakistan

Dr. Sarfraz Khan Qureshi[1]

1. Introduction

The UN Millennium Development Goals and the consensus at the World Summit on Sustainable Development (WSSD) have brought poverty reduction to the centre stage of the international development agenda. In countries such as Pakistan where water is an increasingly scarce resource the relationship between water growth and poverty is therefore of crucial importance.

The Millennium Development Goals (MDGs) are important in their definition of a clear international agenda for focusing efforts on poverty reduction. One of the goals—to stop the unsustainable exploitation of natural resources and to halve by 2015 the proportion of people who cannot access or afford safe drinking water—clearly relates to water and must be a focus of efforts to improve the role of water in poverty reduction. Also agreed upon at the Johannesburg WSSD was to adjust the goal on sanitation to halve the proportion of people without access to adequate sanitation—20% of the world's population—within the same time frame.

The role of water in achieving the MDGs is not confined to only these issues, however, as water management can contribute to realizing all of the MDGs and is of particular significance for MDGs related to promoting health, reducing hunger, increasing income, and improving the living conditions of the urban poor. Any strategy to maximize the role of water management in poverty reduction must consequently identify which actions can ensure that water contributes to realizing all of the MDGs.

A multidimensional view of poverty provides a basis for the development of integrated approaches that have poverty reduction as an explicit goal. This reflects the perspective that poverty reduction is not something that happens indirectly or coincidentally. It is something that

[1] Background Paper completed under contract with the World Bank for the Water CAS 2005. While nothing contained in this paper is original its contribution lies in the collection and organization of materials under the water growth and poverty relationship.

must be directly targeted, with specific and focused steps to address particular aspects. The need to target more effectively the needs of the poor is one of the central themes that also emerged strongly from the Water and Poverty Initiative that followed the WSSD. The central assumption of the initiative was that one must not assume that actions that are good for water management or economic development in general will necessarily also contribute to poverty reduction. We must be clear and explicit as to how they will contribute and, where necessary, adapt our actions to maximize their poverty impact. Poverty reduction should therefore, not just be the general but vague goal of water management; but should be the explicit and targeted purpose of these actions.

The basic assumption of the water and poverty Initiative was that water resources are extremely important to the poor. The report on the water and poverty initiative notes that the extent to which this is the case varies from place to place, but generally poor people depend upon water resources in four ways.

- Water resources are direct inputs to production. Agriculture is the most obvious and the viability of agriculture is closely linked to reliable access to water. However, there are many other areas of production including tree and garden cultivation around homesteads, livestock raising, fishing, small-scale manufacturing such as pottery, brick-making, tanning as well as services such as laundering. Water is also vital for many types of manufacturing and other larger economic activities that provide employment for the urban poor in particular. The poor often rely on these non land-based production activities to give essential diversity to their livelihoods and to overcome their lack of assets.
- Water resources are a basis for the health and welfare of the poor, and especially of vulnerable groups such as children, the elderly, and women in general. Both the quality and the quantity of water matter greatly in this, and safe and adequate quantities of water are recognized as a precondition for an acceptable standard of development, to meet the UN Millennium Declaration targets for 2015—to halve the proportion of people who suffer from hunger, cannot access or afford safe drinking water, and are without adequate sanitation. This is one of the most obvious areas where gender perspectives are of particular importance, as women are the providers of water in the home.
- Water resources are critical to the viability of the ecosystems through which the poor access the natural resources on which many aspects of their livelihoods are based. Even where water is not a direct input into production, other natural resources (such as forestry, fishing, or grazing) that are contingent on the viability of ecosystem processes depend on the flows of water through these systems. For example, naturally occurring annual floods provide low-cost protein, an important input into the livelihoods of the poor.

- Water, when there is too much or too little, may also affect the poor, as they are the most vulnerable to water-related hazards such as extreme floods, droughts, major storms, landslides, and pollution. This vulnerability can undermine any effort to break the poverty trap and can even cast the not-so poor into poverty by destroying the basis of their livelihoods through a cataclysm. Low resilience to these water-related vulnerabilities is a defining characteristic of poverty where these threats exist.

This paper therefore, looks at the issues related to the overall relationship of water to growth and poverty in Pakistan. It examines the direct relationship of water to agricultural production and growth and eventually to poverty reduction. It also examines the relationships of water with poverty reduction through the other avenues described above. The paper concludes with some guidelines for the direction of future work and potential areas of collaboration between the World Bank and the Government of Pakistan

2. Rural Poverty in Pakistan

Available estimates of the money-metric measure of rural poverty indicate that the incidence (headcount) declined steadily from 49.3 percent in 1984-85 to 36.9 percent in 1990-91 and to 33.4 percent in 1993-94. Similarly the poverty gap declined from 11.9 percent in 1984-85 to 7.8 percent in 1990-91 to 6.4 percent in 1993-94 (Table 1).

Table 1: Poverty Estimates for Pakistan

	1984-85	1987-88	1990-91	1993-94	1998-99	2001-02
Urban	38.2	30.7	28.0	17.2	24.2	22.7
Rural	49.3	40.2	36.9	33.4	35.9	38.9
Overall	46.0	37.4	34.0	28.6	32.6	32.1

Note: 1998-99 data from PIHS; all other years HIES. PIHS and HIES combined since 1998-99.

Source: World Bank (2002), p. 20. For 2001-02, Government of Pakistan, Pakistan Economic Survey (2002-03)

However, for the decade of the 1990s overall, officially reported rural poverty rates hovered around 36 percent despite reasonable reported agricultural growth. Real agricultural GDP according to the Government statistics rose by 4.6 percent per annum, yet the percentage of rural poor living below the poverty line remained essentially unchanged between 1990-91 (36.9 percent) and 1998-99 (35.9 percent), and even rose to 38.9 percent in 2001-02, a drought year[2]

[2] Survey evidence suggests that incomes and the level of poverty (headcount) vary substantially across regions of Pakistan, though problems of sample size and sample design prevent definitive conclusions. World Bank

Most available analyses are conducted at a highly aggregate level. Treating the entire country as one, specifically when it involves the analysis of agricultural performance vis-à-vis other macroeconomic indicators, is intrinsically a myopic approach. Although a majority of the studies have not considered regional variations much beyond the rural/urban differences, the few studies that have divided the regions on the basis of agro-ecological differences have found significant differences. Malik (1992) assessed the effect of economic growth on poverty and inequality across agro-climatic zones by computing the correlation of changes in poverty and inequality with changes in per capita income. The analysis was based on the full sample HIES data sets for 1984-85 and for 1987-88. Although the time period is rather short the results were significant. The study grouped the districts of Pakistan into nine agro-climatic or crop zones following Pickney (1989) [for this grouping see annex table 1].

On an aggregate, Malik (1992) found a significant decline in poverty between 1984-85 and 1987-88. He also found that the rural sector accounted for more than its share of the poor while the urban sector accounted for less in 1987-88. At the disaggregated level there was a decline in inequality among the poor; yet overall inequality increased in all the zones during the two time periods. Poverty was highest in cotton/wheat Punjab, followed by low intensity Punjab in both the years, whereas it was lowest in barani Punjab. Using the same methodology, Malik (1994) added another year to the earlier estimates. He found that the declining trends in poverty for the years between 1984-85, and 1986-87 were reversed between 1986-87 and 1990-91. The overall patterns were consistent. His estimates show that rural poverty was higher than urban poverty. The provinces of Punjab and NWFP on aggregate and the rural sector of Punjab, Sindh and NWFP based on an indicator that he developed showed a higher share of poor as compared to the share in population. The considerable variation in the expenditures across regions reflected differences in both prices and consumption patterns.

Qureshi and Arif (1999) extended the Malik (1994) study to include 1993-94 to 1998-99. They reported the highest level of rural poverty in Balochistan in 1998, followed by cotton/wheat zone of Sindh, low intensity Punjab and cotton/wheat Punjab which was contrary to what Malik

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(2002) reports rural poverty headcounts for 1998-99 that vary little between Punjab (34.7 percent) and Sindh (37.1 percent), but are higher in NWFP (46.5 percent).

(1994) had found for the earlier years. The lowest poverty levels for Barani Punjab were consistent in both studies. Qureshi and Arif (1999) extended Malik(1994) analysis to include estimates of poverty levels across regions by household status. Farm households were better off in all zones except in Barani Punjab and Balochistan. More recent work by Kemal (2003) has analyzed poverty across the agro-climatic zones for the year 2000-01. He finds that the cotton/wheat Sindh zone reported the highest incidence of rural poverty followed by cotton/wheat Punjab, low intensity Punjab and rice/other Sindh. Rural poverty exceeded 50% in all these districts. Barani Punjab showed the lowest incidence of poverty. Decomposing the data for farm and non-farm households revealed similar poverty patterns across the two categories in barani Punjab, Low Intensity Punjab, NWFP and Balochistan. However in the remaining zones there were sharp variations. Farm households were poorer in the remaining zones falling in Sindh, but better off in the remaining Punjab zones.

Table 2: Poverty head count and change in the incidence of poverty by agro climatic zones

Agro-climatic zones	Poverty headcount					Percentage change in poverty headcount during		
	1984-85 (1)	1987-88 (2)	1993-94 (3)	1998-99 (4)	2001-02 (5)	1987-88 to 1993-94	1993-94 to 1998-99	1998-99 to 2001-02
Rice/Wheat Punjab	14.3	8.2	33.1	47.7	36.9	75.2	30.6	-29.3
Mixed Punjab	22.7	15.9	21.0	31.4	45.8	24.3	33.1	31.4
Cotton/Wheat Punjab	29.3	21.9	25.4	36.5	52.9	13.8	30.4	31.0
Low Intensity Punjab	28	27.1	24.2	32.6	50.7	-12.0	25.8	35.7
Barani Punjab	5.7	3.9	13.8	27.5	24.3	71.7	49.8	-13.2
Cotton/Wheat Sindh	20.5	18.9	34.1	39.4	53.4	44.6	13.5	26.2
Rice/Other Sindh	24.3	20.6	26.9	36.8	50.6	23.4	26.9	27.3
NWFP	9.1	8.2	28.7	28.2	44.6	71.4	-1.8	36.8
Balochistan	28.5	7.9	21.9	54.4	36.6	63.9	59.7	-48.6

The above mentioned studies confirm the heterogeneity of rural poverty across zones and over time and indicate the strong need for more disaggregate analysis to understand the relationship between agricultural growth and rural poverty. .Water resource availability and use determines these cropping patterns and are in turn are related to the large diversity in the incidence of poverty through agricultural growth.

The type of irrigation can be established from the findings of National Input Output Survey of major crops which interviewed 1700 farmers distributed across all agro-ecological

zones in Pakistan, with the exception of Balochistan. Exclusive use of the public irrigation resource is reported by the largest number of farmers in the survey. This proportion is highest in rice other Sindh followed by cotton wheat Sindh which are the poorest regions in The largest proportion of farmers relying on purchased groundwater was in the cotton/wheat zone of Punjab (Bahawalnagar, Bahawalpur, Multan/Vehri, R. Y. Khan and Sahiwal districts), where more than a third of all farmers bought tubewell water (Table 3). The low intensity Punjab zone was second with 30 percent and the mixed cropping zone of Punjab which includes Faisalabad District had the third largest proportion (2.18 percent) of tubewell water buyers. Although 16 percent of farmers in the barani zone of Punjab which includes Attock, purchased groundwater and 36 percent owned tubewells, tubewell use is concentrated in Jhelum District and is very low in Attock District itself (Punjab, Bureau of Statistics 1988, 53). Less than 3 percent of use any groundwater in either of the zone in Sindh. Of 138 farmers interviewed in the National Input Output Survey in the NWFP zone, only 5 percent reported purchasing tubewell water.

Table 3: Type of irrigation and access to tubewell water by Agro-Ecological Zones

Source of Irrigation	Punjab Zones					Sindh Zones		NWFP Zones except D.I. Khan	Total
	Rice / Wheat	Mixed	Cotton /wheat	Low Intensity	Barani	Cotton / Wheat	Rice/ Other		
Un-irrigated	0.7	0.0	1.0	0.0	48.0	0.0	0.0	51.4	6.2
Public irrigation sources only	26.5	17.3	27.4	30.4	0.0	85.0	97.1	42.8	37.9
Only purchased tubewell water	9.6	0.6	4.1	6.2	16.0	2.1	0.0	3.6	5.2
Canal and purchased tubewell water	4.7	21.2	31.3	23.8	0.0	0.7	0.7	1.4	14.0
Own tubewell water only	31.4	7.7	7.8	5.7	36.0	0.7	0.0	0.7	12.3
Canal and own tubewell water	27.0	53.2	28.4	33.9	0.0	11.4	2.1	0.0	24.3
Total sample size	407	156	387	227	50	140	140	138	1645

Source: National Input Output Survey data, University of Agriculture, Faisalabad, 1991/92 (D. I. Khan District of NWFP is included in Punjab's low intensity zone.)

There does not exist any legislation to regulate the exploitation and development of ground water. Its indiscriminate exploitation is posing serious mining problems and environmental concerns due to redistribution of salts in the groundwater. Farmers are perhaps not aware of the harmful effects of groundwater pumping using brackish and unfit groundwater in irrigation and intrusion of saline water into the fresh groundwater zone or do not appreciate the implications in this context.

Malik (2005) finds that the actual growth of the agriculture sector was lower than that reported in the official statistics. This and the observed rise in the prices of major staples may explain the low correlation between agricultural growth and rural poverty reduction in the 1990s. In addition, the skewed structure of land ownership and access to other factors of production in rural Pakistan have also contributed to the disconnect between agricultural growth and poverty reduction in the 1990s. His study found that poverty was inversely related to proportion of income from crops i.e. in agro-climatic zones where a larger proportion of income was drawn from crop agriculture poverty tended to be higher. One important characteristic of the poverty of the people is their vulnerability to the variability of crop incomes especially in the cotton zones. One good crop year is usually followed by a bad year and it takes the poor two or three years to recover from one shock. The World Bank's Poverty Assessment Report argues that the volatility of growth during the 1990s was an important factor in the stagnant levels of rural poverty. It also argues that low agriculture productivity was also an important factor. The long drought and its effects on livelihoods also may have contributed substantially to this.

2.1. Poverty and Agricultural Productivity.

While many factors contributing to low agriculture productivity in Pakistan have been identified and studied[3], the major theme of the findings of the World Bank's Poverty Assessment is the role played by unequal asset ownership in undermining agriculture productivity and water availability – particularly the ownership of land. The highly skewed distribution of land ownership in rural Pakistan has a substantial negative impact on agricultural production and productivity and an indirect effect on the agriculture resource base. The World Bank's Poverty Assessment points out that among the mechanisms at work are:

1) Inefficient land purchase and leasing markets contribute to the translation of unequal land ownership per household into unequal operated area, and since larger operated areas have lower cropping intensity, land inequality leads directly to low overall productivity (though not necessarily per unit of land irrigated since as the World Bank's Poverty Assessment argues owners of large land areas have greater access to assured water supplies, and possibly groundwater in fresh groundwater areas, and may choose to cultivate or operate only a part of this

[3] *"Strategic Reforms for Agriculture Growth in Pakistan"* Edited by Rashid Faruqee, WBI Learning Resources Series, World Bank, 1999.

holding because of water scarcity or other reasons – more detailed data on the behavior of large land holders should be analyzed in the planned follow-up assessment[4];

2) Land inequality, because of the prevalence of tenancy, can also lower incentives to invest in land – one important consequence of this is the lack of investment in short and long-term measures to combat soil degradation, soil erosion and water logging and salinity that are so pervasive in Pakistan. A second consequence may be reluctance to invest in new water management practices and water saving irrigation technologies as well as new cropping systems. Both of these consequences contribute to the persistence of low agricultural productivity

Inequities in access to canal water are reinforced by land inequality since larger land owners are often able to influence irrigation officials to enable them have greater access to water allocations along a distributary or minor canal, or to obtain sanction for an illegal outlet or for illegal direct pumping from canals. The resulting uncertain and/or lower water supplies to tenants, small farmers, particularly tail-enders, contributes directly to low productivity.

2.2. Poverty and Water Availability.

2.2.1 Poverty and Rural Livelihoods

Most rural livelihoods in Pakistan depend directly or indirectly on agriculture, and agricultural productivity depends importantly on the availability of irrigation – specifically the public provision of canal water. Despite the development of groundwater as an additional source of irrigation, and its sales and purchases in local informal water markets, canal water remains the critical and most important source of water for irrigation on the Indus plain. In this regard the World Bank's Poverty Assessment found that:

- Ownership of a plot within a watercourse command area confers access to irrigation water, but does not guarantee canal water availability
- Water use appears to vary systematically with the location of the watercourse along the main channel (distributary or minor) as well as the location of the farmer's plot on the water course command area – specifically, water availability decreases

[4] Many large landowners are absentee, and engaged in various professions in the cities often giving them greater access to information and investment capital. Regardless, some large land owners may be apart of the solution as well. They are among the most advanced and productive farmers in Pakistan, using groundwater in conjunction with canal water, as well as the most modern agronomic and irrigation practices, in some cases operating mainly through tenants. Much could be learned about more effective and more productive use of water from these farmers, if the lessons learned could be disseminated, other barriers removed, and innovation scaled up.

significantly if the watercourse is located near the tail of the distributary or minor, and/or if the plot is located near the tail end of the watercourse.

This location effect is well known, but the World Bank's Poverty Assessment suggests that the interplay of at least two factors to be important in affecting water availability:

- The first is the deteriorated condition of many distributaries, minors and watercourses, and their related structures such as gates and outlets – seepage losses along these canals are often high and their hydraulic performance low with the result that the system does not function as it was designed or intended. Thus, plots in different parts of the command area but especially near the tail of these canals would receive less water than was intended.

- Second, the World Bank's Poverty Assessment found that when the data are controlled for plot location, the availability of canal water increases significantly where farmers reported informal payments for water and where there is less inequality of land ownership. the World Bank's Poverty Assessment notes that since larger landowners are likely to be able to lobby more effectively with irrigation officials and politicians, this latter finding suggests that water availability depends to some extent on the ability of cultivators to influence irrigation officials.

The Assessment found hard evidence for three key findings:

- A significant percentage of small farmers and tailenders actually get less water than their share
- Per-acre water delivered to these farmers is significantly lower than that delivered to large, upstream farmers
- There is widespread lack of transparency in water allocation.

The lack of transparency in water allocation is important, and stems largely from the long-standing lack of participation of farmers in water management decisions combined with the tendency of the departments over time to centralize management decisions such as water allocation. These two factors over time have the effect of greatly diminishing transparency and information access. Farmers generally understand the natural variability of their main source of water supply, the Indus River (an important reason why groundwater has become so important since it provides an opportunity to smooth water availability by reducing the unreliability of supply and overcome water shortages, as well as improve irrigation timing), but want to know what their share is and when it will be delivered – with this information they can make good or at least informed and lower risk decisions on how best to use both the water and their land (and

possibly respond more appropriately to incentives). Because of the characteristics of the hydrology of the Indus River and the limited storage capacity, availability of water for irrigation often varies during the season (despite efforts to improve forecasts, there are no guarantees), but this variability and uncertainty does not seem to be the primary issue with farmers -- transparency and timely information, participation in decisions about what to do when there are shortages, and delivery on whatever is agreed, are the more important issues.

The World Bank's Poverty Assessment provides new insight into the factors that influence canal water availability, and the benefits of investment to increase water availability as opposed to access to water (which depends only on the location of the farm plot), from which one can draw some tentative conclusions. First, that substantial productivity benefits, and to an extent **the economic benefits (since productivity may continue to stagnate), claims for new water resources development investments will be very difficult to achieve** unless there is substantial investment to improve the performance of the irrigation system and its governance. Second, the large and pervasive effects of **unequal land ownership may severely limit** these benefits and possibly their hope for broader impact on rural economy. Although the problems created by unequal land ownership are formidable, the challenge is to develop **a new system of governance for water management that to the maximum extent possible overcomes the negative effects of unequal land ownership on water availability (for example, the tendency for local elites to capture FOs, and problems with existing land leasing and tenancy arrangements).** Third, traditional public sector thinking in Pakistan would presume that overcoming these constraints is an important role of **the departments** (i.e., they are there not only to construct these systems but to operate them in the farmer's and the public's interest), but **cumulative experience in Pakistan and the evidence from the Poverty Assessment** suggests that this role today is in many cases less effective than it once was, and in some cases, may act perversely to reinforce **the mal-distribution of water**[5]. Overcoming these two problems is one of the several important aims of the current institutional and governance reform process.

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[5] A striking example is the existence of a large number of uncontrolled direct outlets (DOs) in the Nara Canal in Sindh. These are outlets which draw water directly from the main canals that often have no outlet control (gates for example, and where these exist they are not easily controlled by the ID). These types of outlets are illegal under the 1873 Irrigation Act, but have been permitted and a majority have been accorded official sanction over the years. The cumulative effect of the steady increase in these DOs has been to increase the command area of the Nara Canal by more than 30% making it impossible to distribute water to large areas in the tail portion of the canal command area without a major increase in diversion and a change to a rotational method of water

Research and studies currently available including the Poverty Assessment[6] suggest that **investments in additional water supply and improvements in irrigation service** that increase equity, cropping intensity or cropped area, and improve supply reliability **are essential but not enough** to have **a substantial effect on poverty** in rural Pakistan. Ali and Byerlee's[7] decomposition of crop sector productivity growth in Punjab from 1971-94 showed that on average about half of the positive contribution of technological change (cropping intensity and new crop varieties) and public investment (roads and literacy) was offset by soil and water degradation. Water resource development would contribute directly to increases in cropping intensity, and hence would appear to be a key factor in crop sector productivity in Pakistan. But without governance reforms that improved water availability to poor and marginal farmers, and a coherent and effective strategy to reverse degradation of soil and water resources, their economic benefits and poverty impacts thereof could be greatly reduced.

A recent study makes it possible to quantify the impact of better water resource management on productivity through its impact on the incomes of the poor. The recent study by Dorosh et al (2005) presents such analysis.

Based on data available from the Agricultural Census, Agricultural Price Commission, National Accounts, and MINFAL the estimates from the Social Accounting Matrix 2001-2 constructed by Dorosh et al (SAM) indicate that returns to land account for 55 percent of value added in crop production and 27 percent of total agricultural income (including livestock, fishing and forestry). Returns to operated land on medium and large farms alone account for 21 percent of total crop value added. Total returns to labor are 27 percent of value added in the crop sector, but the share of hired labor in the sector value added is only 5 percent.

Given this large share of land incomes in agricultural value added and the skewed distribution of land, medium and large land owners (those with 12.5 acres or more), who account

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distribution among the distributaries since outlet discharges become unreliable if the flow in the canal is outside the range of about 70-110% of design discharge.

6 Further follow-up to the Poverty Assessment including more detailed studies of these factors and related issues is needed and is being initiated (importantly, data on actual canal flows and water availability, and the state and performance of the relevant portions of the canal network would need to be introduced into the study). The study of the performance of factors markets (land, labor, and water) recently initiated by the Bank and GOP will also provide insight into the complex web of relationships and factors that influence the incentives and disincentives farmers face, and the broader economic and poverty impacts of water resources development and irrigated agriculture in the Indus basin.

7 *Productivity Growth and Resource Degradation in Pakistan's Punjab: A Decomposition Analysis;* Mubarik Ali and Derek Byerlee; World Bank Policy Research Working Paper No. 2480; November 2000.

for 10 percent of agricultural households, receive an estimated 32 percent of agricultural incomes.

However, agricultural incomes (including livestock) generally account for only 56 percent of total incomes for agricultural households (41 percent of total population in Pakistan). Including rural non-agricultural households (31 percent of national population), the share of agricultural incomes in total rural incomes is only 37 percent. Thus, incomes from rural non-agricultural activities, including processing and trade of agricultural products, small industry, construction and general trade and transport services account for 63 percent of total rural incomes, and essentially all of non-transfer incomes for about 40 percent of the rural population (Table 4).

Table 4: Pakistan Rural Agricultural Incomes

	PRHS	PRHS	SAM	SAM
	Agric Inc Per Capita ('000 Rs)	Agric Inc Share (percent)	Agric Inc Per Capita ('000 Rs)	Agric Inc Share (percent)
Medium and Large Farms	15.7	83.5	29.9	57.2
Small Farms	6.1	67.9	8.6	54.8
Landless Farmers	7.2	87.7	5.3	59.7
Rural Agric Workers	2.2	53.1	5.5	53.1
Rural Non-Farm Non-Poor	0.3	1.9	0.1	0.4
Rural Non-Farm Poor	0.2	6.3	0.2	4.5
Total Rural	6.1	69.7	5.6	37.2
Rural Agric Households	7.1	74.8	9.6	55.9

Source: Pakistan SAM 2001/02; Pakistan Rural Household Survey 2001/02.

The contribution of agricultural growth to increased rural incomes is not limited to farm incomes, however. Increases in agricultural production generally involve increased demand for agricultural inputs, processing and marketing services. Also, as household incomes rise, consumer demand for both urban and rural products and services increases. To the extent that the supply of goods and services is elastic, these increases in demand can spur increases in production and further increases in demand.

This analysis of growth linkages in Pakistan reported in Dorosh et al (2005) uses a variant of the fixed-price, linear input-output (IO) model, and the semi-input-output (SIO)

model.[8] The SIO model uses fixed coefficients to simulate inter-industry production and consumption linkages, assuming fixed prices in all sectors. This analysis of growth linkages is used by Dorosh et al (2005) to evaluate the impact of improved water resource availability on the tail end farmers

The authors note that the excess use of water by farmers at the head of canals, and water supply shortages in the canal itself result in lower productivity for farmers at the tail end of canals. One simulation of the model reported in this paper captures the effects on productivity and incomes of easing the water constraint by providing more water to farm plots at the tail end of canals. This gain in supply of water to tail end farmers could be achieved through better water distribution or increased availability of water achieved through measures such as canal lining good governance. In the simulation, this increase in water at the tail end is assumed to have no effect on productivity of farmers at the head end, however.

Detailed data on the share of land affected by water shortages at the tail end of canals is unavailable, but limited survey evidence (University of Faisalabad 2003 survey, Z. Hussain, 2003) suggests that approximately 27 percent of farmers are located at the tail end of canal systems. In the simulation, productivity of crop production at the tail end is increased by 30 to 90 percent, based on the productivity differentials between head and tail farms reported in Table 5.[9] Tail end land is assumed to be distributed by farm size in the same proportions as the average distribution of small farm land in each region (Sindh, Punjab, Other Pakistan),

Table 5: Crop Yields by Location along Canals (tons/hectare)

	Head	**Tail**	**Ratio Head: Tail**
Wheat	2.4	1.7	1.4
IRRI Rice	2.9	1.9	1.5
Basmati Rice	2.2	1.7	1.3
Sugar Cane	54.7	29	1.9

Source: National Agricultural Commission Report (1987), p. 289.

As shown in Table 6, large farmers enjoy the largest percentage increase in incomes as a result of this productivity gain, with incomes of large and medium farmers in Sindh rising by

[8] This presentation of the SIO model is derived from Dorosh and Haggblade (2003), "Growth Linkages, Price Effects and Income Distribution in Sub-Saharan Africa". *Journal of African Economies,* 12(2).

[9] Cotton production of tail end farmers is increased by 50 percent (the arithmetic average of the productivity differentials in Table 6).

15.0 and 9.9 percent, respectively. Incomes of large and medium farmers in Punjab rise by 10.7 and 8.4 percent, respectively. Small farm owners and pure tenants in these two provinces benefit as well, as their incomes rise by 6.1 to 6.6 percent. This distribution of benefits broadly reflects the shares of returns to irrigated land.

Table 6 Simulation Results: Percentage Change in Household Incomes

	Base Income[a]	Increased Water Productivity
Large Farmers-Sindh	19.1	15.4
Large Farmers-Punjab	64.1	10.7
Large Farmers-Oth Pak	10.8	7.6
Med Farmers-Sindh	44.6	9.9
Med Farmers-Punjab	146.0	8.4
Med Farmers-Oth Pak	35.6	9.0
Sm Farmers-Sindh	57.6	6.1
Sm Farmers-Punjab	318.9	6.6
Sm Farmers-Oth Pak	125.0	4.2
Sm Farm Renters-Sindh	43.7	6.2
Sm Farm Renters-Punjab	46.0	6.3
Sm Farm Renters-Oth Pak	15.0	4.4
Agric Workers-Sindh	20.8	3.3
Agric Workers-Punjab	68.2	3.6
Agric Workers-Oth Pak	9.5	1.5
Non-farm Non-poor	400.8	3.4
Non-farm Poor	134.4	3.3
Urban Non-poor	1744.0	1.7
Urban Poor	181.4	3.5

However, in spite of the significant (and perhaps over-optimistic) gains in output modeled here, incomes of agricultural workers in the two provinces rise by only 3.3-3.6 percent and incomes of the non-farm rural poor rise by only 3.3 percent. Thus, in spite of a 14 percent increase in the value of production of major crops and large GDP multipliers, the gains to the poorest rural household groups (agricultural workers and non-farm rural poor) are relatively small.

Table 7: Distribution of Estimated Returns to Farm Irrigated Land (Major Crops), 2001/02

	(bn Rs)	% of Total	% of Total HH Revenues
Large Farmer Sindh	1,310	1.1%	6.9%
Large Farmer Punjab	4,849	4.0%	7.6%
Large Farmer Other	845	0.7%	7.9%
Med Farmer Sindh	10,067	8.4%	22.6%
Med Farmer Punjab	25,602	21.4%	17.5%
Med Farmer OthPak	8,466	7.1%	23.8%
Small Farmer Sindh	7,103	5.9%	12.3%
Small Farmer Punjab	41,746	34.8%	13.1%
Small Farmer OthPak	9,676	8.1%	7.7%
Landless Farmer Sindh	4,099	3.4%	9.4%
Landless Farmer Punjab	4,774	4.0%	10.4%
Landless Farmer OthPak	1,365	1.1%	9.1%
All Farmers	**119,902**	**100.0%**	**12.9%**
Large Farmers	7,004	5.8%	7.5%
Medium Farmers	44,134	36.8%	19.5%
Small Farmers	58,525	48.8%	11.7%
Landless Farmers	10,238	8.5%	9.8%
All Farmers	**119,902**	**100.0%**	**12.9%**

Source: Pakistan SAM 2001/02.

Note: Small farms are defined as ≤ 12.5 acres.

The total water flows from the river Indus and its tributaries are 139 MAF annually. The total consumptive use is 46 MAF (consumptive use: 31 MAF, municipal use 5 MAF and outflow to sea 10 MAF) and the losses are 93 MAF. The losses through the surface supplies are huge. Water losses are of two types, conveyance losses (68 MAF) and loss to the sea 25 MAF after accounting for seawater intrusion. The conveyance losses include canal to watercourse head (26 MAF) losses for watercourse head to outlet (35 MAF) and application losses (12 MAF) (Government of Pakistan 2002).

The loss to the sea is colossal but mostly out flow is during the monsoon. Drought is already at the doorstep due to global warming. Parts of Sindh and Balochistan have already experienced worst drought of the past 30 years. Therefore, it seems imperative to conserve water at all cost. There are 18 feasible dam sites where water can be stored. Government should make

efforts to develop political consensus to resolve the issue of dam sites and start the construction at feasible sites.

2.2.2 Non Agricultural Uses of Water

Nonagricultural users extract 5.3 billion cubic meters from the system annually, of which 80 percent is returned to the system, albeit of degraded. .

Non-agricultural use is expected to increase from the equivalent of 4 percent of the surface water diverted for irrigated agriculture to about 10 to 15 percent within the next 25 years. Most of this water will return to the system, but its quality will be degraded. This will cause an unacceptable quality decline in the middle and lower reaches of the Indus River, threatening many of the areas that rely on the system for irrigation and domestic water supply. Available statistics based on the Pakistan. Integrated Household Surveys show only marginal improvements in access to water for drinking and sanitation. Tables 8 to 10 below confirm this pattern

Table 8: Distance to Water Source by Province and Distance -- PIHS 1998-99 & 2001-02

	INSIDE THE HOUSE	0-0.5 KM	0.5 - 1 KM	1-2 KM	2-5 KM	OVER 5 KM
1998-99						
Tap Water	86	13	1	0	0	0
Hand Pump/M.Pump	90	9	1	0	0	0
Dug Well	53	38	5	3	1	1
River/Canal/Stream/Pond	4	68	15	5	2	5
Total	77	18	2	1	0	1
2001-02						
Tap Water	87	12	0	0	0	0
Hand Pump/M.Pump	88	11	1	0	0	0
Dug Well	45	47	5	1	1	1
River/Canal/Stream/Pond	8	84	7	1	0	1
Total	79	19	1	0	0	0

Notes:
1. Households traveling the distance indicated to the water source as a percentage of all households using the specified source. "Total" gives the households traveling the distance indicated as a percentage of all households in the province.
2. Categories: "Tape water" consist of both tap water inside and outside house; "handpump/M.pump" includes handpumps both inside and outside, motor pump and tube well outside the house, "Dug Well" includes well open and well closed both inside and outside the house; River/Canal/Stream" includes canal, river, spring, stream, pond.
3. Totals for columns may not add up to 100 because of rounding.

Table 9: Main Source of Drinking Water

	1995-96 PIHS			2001-02 PIHS		
	URBAN	RURAL	OVERALL	URBAN	RURAL	OVERALL
Tap in house	56	11	25	53	8	22
Tap outside house	4	2	3	5	2	3
Handpum/M.pump	33	66	56	36	70	61
Dug Well	3	11	8	2	10	7
River/Cal/Stream	0	5	3	0	9	6
Other	3	6	5	3	1	1
Total	100	100	100	100	100	100

Notes:
1. Household obtaining water from the source indicated expressed as a percentage of the total number of households.
2. Categories: 'Tap Water" consist of both tap water inside and out side house; "Hand pump/M.Pump" includes handpumps both inside and outside, motor pump and tube well outside the house; "Dug well" includes well open and well closed both inside and out side the house; "River/Canal/Stream" includes canal, river, spring, stream, pond and "Other" includes public standpipe (Supplied by tanker), water seller and other.
3. Totals may not add to 100 because of rounding.

Table 10: Type of Toilet used by the Households

	1995-96 PIHS			2001-02 PIHS		
	URBAN	RURAL	OVERALL	URBAN	RURAL	OVERALL
Flush	75	17	34	89	26	45
Non-Flush	13	14	14	5	15	12
Communal Latrine	4	3	3	-	-	-
No Toilet	9	66	43	5	59	43
Total	100	100	100	100	100	100

Notes:
1. Households having the type of toilet indicated, expressed as a percentage of the total number of household.
2. Categories: "Flash" consists of flush connected to public sewerage, flush connected to pit and flush to open drain while "Non-Flush" contains dry raised latrine and dry pit latrine.
3. Communal latrine was not included as a separate category in the 1996-97 PIHS questionnaire nor for the 1998-99 PIHS questionnaire.
4. Totals may not add to 100 because of rounding.

3. An Analysis of Options

The foregoing clearly illustrates the variety of ways in which water effects the poverty status of the people of Pakistan. Looking at the disaggregated picture of poverty incidence across the different agro-climatic zones, it is obvious that there is a need for both the broad as well as the poverty targeted interventions affecting water are needed since water is such an increasingly scarce source in Pakistan. The interventions in terms of resource development as well as service delivery can be expected to have an impact. However, the available data seem to suggest that the broad across the board interventions are likely to have less of an impact on poverty than the more

specific and targeted one. In terms of the overall relationship between improved water availability across the board and increase in agricultural production/productivity, the available evidence tends to indicate that the benefits would accrue unequally and the poor would be affected only marginally. However, the service delivery type of broad based interventions that effect water supply utilities and improved functioning of water users associations, etc. have greater potential for positively effecting the welfare of the poor. The largest impact in terms of both the productivity and production impact of water resource development and management as well as the targeted and improved water services, for example rural water supply and sanitation projects can be expected to have much more significant impact.

Available evidence indicates that "there is little doubt that water sector investment must increase substantially and that the increase in investment in modernization and improvement in all levels of the Indus Basin Irrigation System including the new storage is great but it comes just at the time when the fiscal space is limited and the challenges and needs are great."

Available projections on the additions to water supply are bleak. These indicate that even under optimistic assumptions, that two new storage reservoirs could be built on the Indus Rive Basin Irrigation System over the next 25 years, these would add at most about 8-12% to the total water supply of the Indus Basin Irrigation System. This increment would come at the cost of decreased security or reliability of supply and increasing management challenges, and possibly irreversibly environmental impacts in the lower Indus River and its actuary. Among the alternative supply options ground water development is already nearing its practical limit and water conservation may be able to add only about 5 percent to total supply. This shifts the focus of the debate to finding effective demand management and modernization and rehabilitation and on water conservation.

Simulation exercises using the annual flows of the Indus Basin and the current total diversion as reported in the Ministry of Water and Power's Water Sector Strategy indicate that aggregate water supply reliability may decline and total system storage and diversion on the Indus River are increased. The critical assumption in these models is that all storage is released and diverted in the Rabi season. These results are in contradiction of one of the basic reasons for increasing storage capacity, i.e. to improve water supply reliability (i.e. in response to the recent drought experience).

These estimates also indicate that only a small uncertain amount of additional ground water is available and savings from water conservation over the long term may only be about 5-10 MAF. Therefore, the largest potential addition to water supply can come from the average annual flow to the sea which is about 38 MAF. This is the total amount of water that can be developed and used. Of this 35.6 MAF is available in the Kharif and another 2.4 MAF in the Rabi (dry season).

The projections on the water requirement side indicate that there is a total requirement of between 40 to 70 MAF as against the potential supply of 44 to 50 MAF. This means that under any scenario, water will have to be used much more productively and efficiently and its quantity and quality will have to be managed much more effectively in the future. On the requirement side the projections assume at least a 10MAF for environmental flow requirement and 9MAF for industrial and domestic demand. The increase in irrigation water demand is projected to be between 5 to 30 MAF. Accord deficit of 11 MAF and systems of 5-10 MAF are assumed in these requirements.

The important conclusion of this analysis was that "some important trade-offs were going to be required, expectations lowered, policies changed especially in regard to water prices and energy prices for ground water use for agriculture, and changes in the way water is managed and used".

The foregoing puts the onus of water management on the demand side; on issues of water delivery and use efficiency; governance, water pricing, rehabilitation and modernization of infrastructure and improved O&M incentives for wise and more productive use of water. These are all areas that require much greater research and analysis before appropriate intervention can be suggested.

The combination of high population growth, persistent poverty, lagging growth in the rural sector, and the looming constraints on water resources and irrigation development outlined in World Bank's Public Expenditure Review (2004) suggests that water resources development and management in the next 40 years will be and must be by design substantially different than the past 40 years. The strategy proposed by that document lists the:

- Better integrate irrigation, hydropower and agricultural development investment and policy
- Modernize both the water infrastructure and the institutional and governance arrangements for water management

- Balance near-term and long terms benefits, investments in both water infrastructure and water management, and in both supply management and demand management
- Reflect a more rigorous economic, social and environmental analysis to ensure that project priorities and plans make the best use of the limited resource and fiscal space
- Be supported by a new consensus on water management and development that avoids the costly political conflicts of the past

The World Bank's Public Expenditure Survey (2004) found that the Federal Government is committed to a governance reform program at least at the policy level. The Federal Government has a vital interest in the outcomes of the reform process although water is a Provincial subject since these outcomes are essential to achieving its long term social and economic objectives in the rural sector (assuming this continues to depend to a large extent on an increasingly productive irrigated agriculture sector) for which the Federal Government is proposing a huge increase in public expenditure for inter-provincial water resources infrastructure (new dams and canals, and eventually drainage). On the other hand, the Provinces are and will continue to be increasingly dependent on the Federal Government to underwrite an increasing share of their essential water sector investment programs (on the order of 200 to 600 billion Rs through to the year 2025). Hence, neither party can afford to remain at arms length from the reform process, implying that, in effect, it is something that only concerns the other.

The World Bank's Public Expenditure Review divides water sector investments into three categories – sustainability and productivity, management and system modernization, and system expansion. It finds that the three are to varying degrees divisible and can be scaled to fit the availability of funds (keeping in mind the principle of allocating sufficient funds to achieve timely implementation). However it finds that the addition of new storage dams to the system poses more difficult problems because of the large, lumpy character of these investments.

The Bank's Public Expenditure Review correctly identifies that the Government has two important and inter-related sets or groups of policy choices to make:

1. First, investment policy in terms of not only how much new water supply to develop, but also which of its key strategic problems it will tackle first and what the longer term sequence of investment and development should be. Should it for example solve the problem of fully and reliably implementing the Accord, close the early kharif deficit, modernize the existing irrigation system, or expand irrigation into new areas, and in this context what would be the best sequence in which to develop additional storage and how should this storage be allocated and these reservoirs be operated? At present, only the

slow pace of project preparation and the PSDP's limited resource envelope are the only thing dictating the sequence and priority of development.

2. Second, policies that affect incentives to use water more efficiently and productively, and to achieve sustainable and effective O&M. These policies include the principles and institutional arrangements on which irrigation water distribution between the canal head and the farmer's field channel will be based; water pricing and the flow of revenues, especially retention of revenues within the FO's canal network; electricity pricing in the agriculture sector – this may be the best and most efficient way to begin managing and regulating the use of groundwater since an informal groundwater market is already functioning; water rights or entitlements to empower FOs and farmers to use their water more efficiently and productively and reduce inter- and intra-provincial water conflicts.

There is a consensus amongst the analysts that water pricing and water rights policies are bound to be controversial, and the Government has been moving in the perverse direction of increasing electricity subsidies in agriculture combined with the accelerated expansion of electricity distribution to promote greater tube-well use. The World Bank's Public Expenditure Review finds that among the water policy issues, fundamental changes in water pricing policy seem most likely to move forward in the near term if the governance reform program moves ahead (however slowly). As the governance reform program progressed over the past few years, there has been often heated discussion of abiana (to recover O&M costs) assessment, collection and where the revenues go, but very little about the fundamental principles and elements of a policy on the objectives of water prices, what water prices should comprise, or how they should be established or regulated. One of the great weaknesses of the present system is the politicization of water prices that has resulted in their being frozen and disconnected from any sensible or logical basis, even the simple one of O&M costs. Abiana is largely treated as a rate without any basis except the perception of what might be accepted without too much controversy or political pain.

The principle of collection and retention of water charge revenues within the system for its operation, maintenance and improvement (with limited and declining cost sharing by Government) that has been at least an implicit part of the governance reform program is a huge step, but there is no clarity yet as to what the water pricing policy objectives are, and what water prices encompass overall, i.e., what services (and their associated cost) are to be included in determining the rate, the extent to which capital costs will be included in the rate base (or which capital costs), by whom and how will prices be periodically adjusted, or the extent to which certain costs will be shared between the farmers and the treasury and in what proportion, etc.

The key policy questions identified by the World Bank's Public Expenditure Review that require immediate and further analysis are:

- Can future incremental water supply and demand be balanced? What fundamental changes in sector policy (water rights water allocation and operations, water pricing and revenue sharing, electricity pricing in the agriculture sector, etc.) would be needed?
- Should irrigated area and irrigation water supplies be expanded? How much? Should another major shift in cropping pattern be considered in planning? What changes will be needed in irrigated agriculture and water management (infrastructure, incentives, governance, etc.) to insure higher efficiency and productivity?
- How much should water supplies be expanded? How should these new supplies be allocated and distributed? Can the related threat to sustainability from water logging and salinity be resolved cost effectively? How can privately developed groundwater be integrated with water logging and salinity control and increased canal flows?
- Is additional storage needed? How much storage should be built and in what sequence? Should operating policies be changed? Can irrigation and hydropower policies be better integrated?
- What happens as the limits of water resources are approached? What should the target level of water security and reliability? Should different levels of security be associated with different water rights? How can environmental and social impacts on the lower Indus River and estuary of increased water resources development be mitigated?
- What is the role and scope of water conservation? What new policy and legislative framework is needed for effective groundwater management? What regulatory and monitoring mechanisms should be put in place?
- What are the long-term consequences of continued storage depletion?
- Are economic returns commensurate with the cost of water?

There are no readily available answers to these questions and there is therefore an immediate need for further study of each of these areas. These questions can be grouped, as in the international literature on water and poverty , into the following six areas for improving the water security of the poor:

- **Pro-Poor Water Governance**. Strengthen pro-poor water governance through water policies, laws, action agendas, and better information management. Introduce pro-poor safeguards in integrated water resources management, improve stakeholder consultation and participation, and mainstream gender and empower women to

improve water management. Increase public awareness about and political support for the water security needs of the poor.

- **Improved Access to Quality Water Services**. Increase the access of the poor to water services: drinking water supply (with hygiene and sanitation), irrigation and drainage, and other areas. Put people at the center of viable and affordable services, mobilize funds from all sources, increase public awareness, and improve the accountability of service providers.
- **Pro-poor Economic Growth and Livelihood Improvement**. Increase investments in agriculture, rural development, and other water-using sectors that generate direct income for poor communities. Strengthen the asset base of the poor and help develop sustainable livelihood diversification opportunities.
- **Community Capacity Building and Empowerment**. Invest in capacity building in poor communities to help them improve the management of their water resources, negotiate better access to water services, and improve their livelihoods through income-generating activities. Ensure gender equity in water management.
- **Disaster Prevention and Mitigation**. Improve the resilience of the poor to water-related disasters through better forecasting and relief and recovery systems, including both structural and nonstructural investments in prevention, adaptation, and mitigation interventions.
- **Management of the Environment**. Introduce sustainable natural resource management arrangements with the participation of the poor, particularly in the upper watersheds, wetlands, and other common property resources.

Research on these areas will help define actions that can make water more accessible to poor people.

Pakistan's Water Challenges:
A Human Development Perspective

By

Karin Astrid Siegmann and Shafqat Shezad

Country Water Resources Assistance Strategy
Background Paper # 2
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Pakistan's Water Challenges:
A Human Development Perspective[1]

By Karin Astrid Siegmann[2] and Shafqat Shezad[3]

Abstract

This paper gives an overview of human and social dimensions of Pakistan's water policies to provide the basis for water-related policy interventions that contributes to the country's human development, giving special attention is being given to concerns of women and the poor. While Pakistan may not be a water-scarce country, nonetheless, water stress, poor water quality, and inequitable access to water adversely affect large portions of the population. Considerably less water is available in Balochistan and Sindh, in the tail end of the irrigation distribution system, and for the poor. Though women have a distinct role in water management both for domestic and productive purposes, they are hardly represented in user groups. This suggests that it is water management rather than water availability that is at the core of Pakistan's water crisis. The unequal distribution coupled with population pressure, urbanisation, and progressive industrialisation poses a serious challenge to water management in Pakistan in the 21st century.

Already now, insufficient access to and poor quality of water resources is a major obstacle to human development in Pakistan. This takes several forms. Water-related diseases, such as diarrhoea, hepatitis, dysentery, and malaria are among the main causes of death. Industrial water pollution directly poses health hazards and indirectly threatens sources of livelihood, e.g. for fishing communities. Insufficient water for food production through water-logging and salinity, seepage, unequal distribution in the irrigation system, and droughts leads to drops in agricultural production and thus endangers small farmers' food security.

Domestic water supply as well as irrigation management saw a shift towards more participatory and privatised approaches during the 1980s and 1990s. Assessments are mixed about the success of the participatory schemes. Overall, coverage with safe drinking water in all provinces dropped from 1995 to 1999. In irrigation, due to a focus on physical targets rather than on capacity building in water user associations (WUAs), positive effects of these schemes were largely appropriated by the economic and political elite, increasing the marginalisation of poorer farmers.

The following points are identified as crucial for water interventions that better serve human development:

- A genuinely participatory approach in water management including the voices of all stakeholders, in particular women and the poor;
- A pro-active approach to tackle landed and bureaucratic power structures;

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- Capacity building in user groups and in the government agencies rather than investment in infrastructure alone;
- Economic incentives, such as secure property rights, to improve access to water for the marginalized and more efficient use of the scarce resource;
- Health implications of water-related interventions should be assessed before embarking on them;
- Water conservation should be given priority over large storage projects. If they are constructed, environmental and social impact assessments should be conducted with true stakeholder participation.

Table of contents

1. Introduction: Water and human development in Pakistan

Pakistan, once water-abundant, is now a water-stressed[4] country. Annual per capita water availability in Pakistan has dropped to 1,384m^3 in 2002 (WRI, 2003b). Population Action International (2002) estimates Pakistan to be water-scarce by 2025. In 1991, withdrawal of the available water was mostly for agricultural purposes (97%), and only about 2% for domestic uses and industry, respectively (WRI, 2003b). While Pakistan may not be a water-scarce[5] country by hydrological definitions, nonetheless, water stress, poor water quality, and inequitable access to water adversely affects large portions of the population. This suggests that it is water management rather than water availability that is at the core of Pakistan's water crisis.

The following example illustrates the deficiencies in water management. In Hyderabad, the second largest city in the province Sindh, contaminated water took the lives of 38 persons between April and May 2004 and caused severe complications for thousands of others leading to their hospitalisation (The News, 2004). It is assumed that the water of the Manchar Lake - providing drinking water to the city - caused the human suffering. The Manchar Lake water is fed with saline surface water from the Right Bank Outfall Drainage (RBOD), an intervention to provide drainage to fields located at the right bank of the Indus. At the time of the water contamination, the releases from Manchar Lake were not properly diluted with water from Sukkur barrage. Due to poor laboratory facilities at their water treatment plant, Water and Sanitation Agency (WASA) authorities did not detect the contamination (EPA, 2004). The event points to the crucial importance of access to safe water for human well-being and development – and to its interface with political, management, and environmental factors.

1.1 Relevance of water for human development

Human development is a process of enlarging people's choices. The most critical ones are to lead a long and healthy life, to be educated, and to have access to the resources necessary for a decent standard of living. Human development has two main aspects. On the one hand, it involves the formation of human capabilities, such as improved health, knowledge, and skills. On the other hand, it refers to the use people make of their acquired capabilities for leisure, productive purposes, or for being active in cultural, social, and political affairs (Haq, 1995; UNDP, 1990).

Safe drinking water is essential for people's direct consumption, for sustaining and improving people's health. Conversely, water-related diseases are among the most common causes of illness and death. According to a former director-general of the World Health Organisation (WHO), the number of taps per 1,000 persons is a better indicator of health than the number of hospital beds (Daudpota, 2001). Therefore, the objective of halving the proportion of people without sustainable access to safe drinking water figures prominently among the United Nations' Millennium Development Goals (UN, 2000).

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[4] 'Water stress' refers to a condition where a country's annual availability of renewable freshwater resources is less than 1,667m^3 and more than 1,000m^3 per person in the population (Engelman and LeRoy, 1993).

[5] 'Water scarcity' commonly refers to countries where annual availability of renewable freshwater resources is less than 1,000 cubic meters (m^3) per person in the population (Engelman and LeRoy, 1993).

In addition to water for people, i.e. water for drinking and other domestic purposes, irrigation is second major application of water. Water for food determines the productivity of agriculture to a large degree and thus indirectly affects food security of the population.
Apart from water for people's direct consumption and water for agricultural production, there are other uses of the precious resource relevant for human development. Domestic uses in cooking, sanitation, washing, and cleaning are important prerequisites for hygiene and health. Other productive applications, such as hydropower generation and watering of livestock, indirectly generate income.
Taken together, these main uses of water indicate that the availability of water in adequate quality and supply has a major impact on human development.

1.2 Challenges and opportunities in the interface of water and human development in Pakistan

In a water scenario until 2025, the Pakistan Water Vision 2025 identifies the following challenges for water management at the beginning of the 21st century (Pakistan Water Partnership, 2000):

- Inadequacies in municipal water supply and sanitation leading to the pollution of water resources and deteriorating health standards;
- Severe shortfalls in food production;
- Depletion of forest resources, leading to increased soil erosion, silting of reservoirs and increased variability of flows. Persisting water-logging and salinity problems and salt accumulation in soils;
- Surface storage capacities will be depleted by siltation and groundwater resources at the brink of exhaustion with a sharply declining watertable in Balochistan.

Population growth is one of the triggering factors for this scenario (Table 1.1). Pakistan's population has increased from 85 to 141 million between 1980 and 2000. By 2025, the population is estimated to increase by another 63% with an increasing number of migrants to urban centres.

Table 1.1: Population, urbanisation, and industrialisation in Pakistan, 1980-2025

Year	Population (million)	Population growth rate (%)	Urbanisation (% of population)	Industrialisation (share of manufacturing in real GDP in %)	Water demand for domestic use (MAF)
1980	84.9	3.0	24.1	13.8	-
1990	110.8	2.6	34.7	17.4	4.1
2000	140.5	2.1	47.5	23.0	5.2
2025*	228.8	2.4	-	-	9.7

Sources: Population Reference Bureau (2004); Ministry of Finance & Economic Affairs (2004, 2001); Federal Bureau of Statistics (1991); Kahlown and Majeed (2002)
Note: *estimate

It is estimated that urban water demand, including industrial demand, will increase by 95% from 2001 to 2025. Already now, major cities in Pakistan face problems of

groundwater mining and lowering of the water-table (Ahmad, Bari and Muhammed, 2003). With 263% during the same period, growth in rural domestic water demand will even be higher (Memon, 2004). The growing population not only leads to increases in domestic and industrial water demands but it also adds to the pressure on the poor infrastructure to treat sewage and industrial wastewater. It is amplified by migration into cities and industrialisation.

The agricultural sector as well is under pressure to accommodate the increasing population's need for food. So far, it produces 23% of Pakistan's gross domestic product (GDP) (Ministry of Finance, 2004) and 68% of the rural population directly or indirectly depends on income from agriculture. 90% of food grains come from irrigated agriculture (Hussain, 2004). Wheat alone constitutes 47% of the poors' calorie intake in Pakistan, underlining the importance of food grain production for food security (Khan and Ahmad, 1996). It is estimated that Pakistan has to double its annual food production every 15 years, in order to maintain its status quo in meeting requirements of food. This implies an estimated increase in water requirements of about 40% until 2025 (Kahlown and Majeed, 2002). Food production is endangered due to the mentioned high extent of water-logging and salinity on agricultural land. In 1998, 9.1 million hectares (ha) agricultural land were affected by water-logging, and 4.9 million ha by severe water-logging, i.e. 33.7 and 18.2% of the agricultural land, respectively. Almost 13% of the cultivated land is saline (Ministry of Food, Agriculture&Livestock, 2004; FAO, 2004). These twin menaces have led to crop declines of about 30% in yields of major crops (Pinstrup-Andersen and Pandya-Lorch, 1994) and thus threaten Pakistan's food security.

These challenges, serious as they are, also provide incentives for change in water management, and thus opportunities. Although increasing competition for water and deteriorating quality suggests an expanding scope for conflict, it also provides an incentive for new forms of co-operation and innovation (WCD, 2000).

1.3 Scope of the paper

In order to give a policy-oriented overview about the human development dimension of Pakistan's water interventions, this paper reviews existing literature on water policies and practices in Pakistan. It has a double focus on water for people, and water for food, or agricultural uses of water. However, in practice, the distinction between water for direct consumption and other domestic uses and for productive purposes is unclear. For example, where groundwater is saline, irrigation and other surface water becomes a crucial resource for drinking, domestic purposes, *and* agriculture (Nizamani, Rauf and Khoso, 1998). Surveys conducted on the non-agricultural usage of surface water showed that nearly 90% of the Pakistani population uses surface water for domestic purposes (Waheed-uz Zaman, Jahangir and Iqbal, 1996). Special attention is given to concerns of women and the poor because of the special role of the former in water supply and management and the crucial importance of access to the resource in adequate quantity and quality to the latter. The time period considered are the two decades since 1980, depending on data availability. The human development paradigm as developed by Haq (1995) and applied by the United Nations Development Programme (UNDP) serves as a reference point for the assessment of the human and social impact of water management and interventions. Section two provides a sketch of regional, socio-economic, and gender-related inequalities in access to water. Sections three and four describe water-related policies

and environmental factors that directly or indirectly affected human development. Sections five and six analyse the impact of the triggering factors described in sections three and four on human development in Pakistan. In the last section, the paper discusses the results of the analysis developed in the previous sections and formulates recommendations about how interventions can better serve human development in Pakistan, in particular considering the needs of women and the poor.

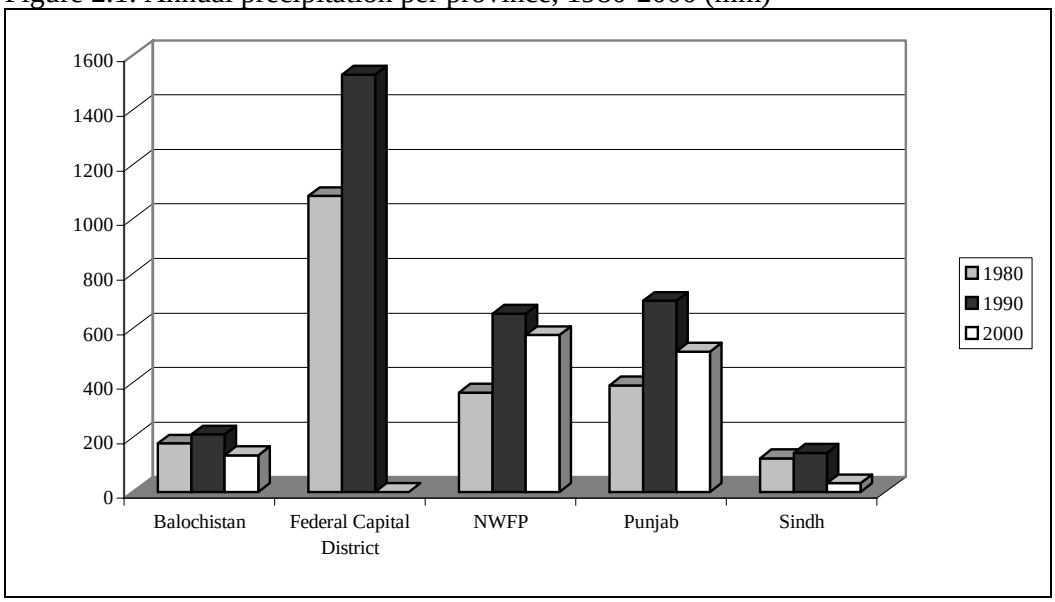
2. Overview: Pakistan's access to water – multiple inequalities

Water-stress is not only related to population pressure, urbanisation, and industrialisation in Pakistan but also results from the multiple inequalities in the country. The problem is not one of shortage only, but of uneven distribution of water across regions, socio-economic groups, and gender. This section provides a brief overview over such differences in access to water in Pakistan, thus highlighting existing and potential conflict and areas of potential intervention in managing the scarce resource.

2.1 Regional differences

Figure 2.1 substantiates the unequal regional availability[6] of water in the four provinces of Pakistan, with Balochistan and Sindh receiving considerably less precipitation than the other provinces.

Figure 2.1: Annual precipitation per province, 1980-2000 (mm)



Sources: Ministry of Food Agriculture & Livestock (Various Issues); Federal Bureau of Statistics (2000)
Note: The data points are averages calculated from main meterological stations in the respective provinces.
No data are available for the Federal Capital District for 2000.

[6] 'Water availability' is the amount of water that can be appropriated from a given point on a given stream for new out-of-stream consumptive uses (Cooper, 2003).

Precipitation is only one part of available water sources. For ground- and surface water to be available, it is crucial whether a region is located in- or outside the Indus basin. Of Pakistan's groundwater potential of 55 million acre feet (MAF), about 75% is being exploited, with 82% being used in Punjab, 8% in Sindh, 5% in NWFP, and 1% in Balochistan (Kahlown, Majeed and Tahir, 2002). This again clearly disadvantages Balochistan.

The poor water availability in Balochistan is reflected in people's (lack of) access to safe drinking water (Table 2.1). In this province and in Sindh, more than 80% of the rural population did not access safe drinking water in 1986.

Table 2.1: Source and quality of drinking water, 1986 (%of the population)

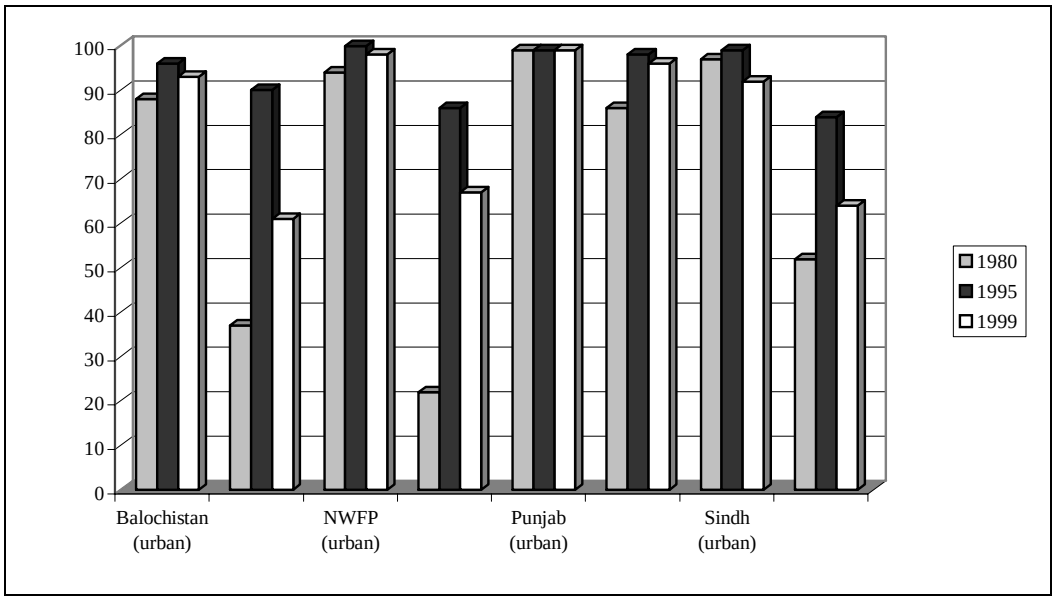
Source	Quality	Balochistan	NWFP	Punjab	Sindh	Pakistan
Piped	Potable	18	45	12	3	16
Handpumps	Potable	0	2	27	13	19
Handpumps	Contaminated	0	2	27	13	19
Other	Contaminated	82	51	34	71	46

Source: Pasha and McGarry (1989)

Little has changed in the relatively unfavourable situation of Pakistan's largest province. In Sindh and Balochistan, 62% of the area is underlain with groundwater displaying Total Dissolved Solids (TDS) of more than 3,000 which is extremely hazardous (Kahlown, 2004). A TDS value of 80-420mg/l are seen as the acceptable range for human consumption. Access to safe drinking water has been the poorest in Balochistan since 1980. However, if rural and urban areas are examined separately, rural NWFP displays an even thinner coverage until the mid-1990s (Figure 2.2)[7]. Apart from Punjab, the gap between the coverage of urban and rural areas with drinking water is considerable. A notable feature of Figure 2.2 is the drop in coverage with safe drinking water in all provinces, rural and urban, since the mid-1995s.

Figure 2.2: Safe drinking water coverage by province, 1980-1999 (% of population)

[7] Zaidi (1997) stresses the lack of comparable statistics on access to safe water in Pakistan due to inconsistent definitions and resulting methodologies. Therefore, in the following, the focus is on qualitative statements and changes in access to safe water rather than on exact percentages.



Source: IDC (2002)
Notes: The figures to the right of the urban data are rural data for the same province. Zaidi (1997) points out that the high coverage of the population with safe drinking water in Punjab seems to be an over-representation as a large number of the schemes are not operating.

Pakistan is highly dependant on irrigation for its agricultural production. There is, however, considerable regional inequality in the distribution of water for food production. Almost all of the cultivated area in Punjab, as compared to half of it in NWFP, 37% in Sindh, and 58% in Balochistan received irrigation in 2002-2003 (Ministry of Food Agriculture & Livestock, 2004). These shares have been similar in 1979-80 apart from a major increase in the share of irrigated area in Punjab until now (Ministry of Food Agriculture & Livestock, 1996). Zaidi (1999) also notes that the tubewell development crucial for irrigation during the Green Revolution was highly concentrated in Punjab.

Within provinces, one can identify considerable regional difference in the distribution between irrigation users at the head and in the tail end of the canal command. Within a watercourse command, water delivered to the head farmers is generally 32% and 11% more than to the farmers at the tail and middle reaches, respectively (Afzal, 1996). Similarly, minor or distributary canals receive different amounts of water. In view of the shortage of canal water in the country, the regions at the tail-end of the canal system are therefore at a disadvantage in adopting new crop varieties and adjusting crop patterns. Farmers in Sindh are particularly adversely affected as they are located at the tail-end of the canal distributory system and they cannot make use of the groundwater due to its salinity (Khan, 1999a). Illegal pumping from canals and excessive losses add to the inequity in the distribution (Afzal, 1996).

2.2 Socio-economic disparities

As Table 2.2 shows urban areas in Pakistan benefit the most due to better-developed public institutions for and more investment in the provision of water supply.

Table 2.2: Safe drinking water coverage in Pakistan, 1980-2000 (% of the population)

	Rural	Urban	Total
1980	70	98	80
1991	80	96	84
2000	84	96	88

Source: IDC (2002)

However, it is mainly the upper income groups that benefit from such public provision (Federal Bureau of Statistics, 2002). For example, in Karachi, the variation of daily water consumption ranges from 336 litres per day per capita in high income areas to 63 litres in slum areas (Khan, 2002). The poor communities depend to a large degree on the private sector (Rafiq, 1999). Studies show that the urban poor pay high prices for water supplies and spend a high proportion of their income on water. Flat rates for the affluent areas are as low as Rs. 35-150 per month as opposed to up to Rs. 500 per tanker charged by private vendors (Khan, 2002).
Regarding the provision of sanitation, although 95% of all urban households have toilets (Federal Bureau of Statistics, 2002), it is mainly the poorest urban households, which cannot afford them or are resident in temporary dwelling units, where neither owners nor dwellers find it worthwhile to install latrines (Qutub, 2004). In rural areas, modern sanitation is not common. 59% of all rural households have no toilets. Again, access is biased towards richer households (Federal Bureau of Statistics, 2002).

Also the availability of water for food production varies by socio-economic group. In the past, it is argued, that due to the unavailability of water for small farmers as the crucial input, the Green Revolution actually caused increases in relative poverty (Zaidi, 1999). Still, today the distribution of irrigation water discriminates against small farmers because of the unequal power of small and large landowners in the villages (Khan, 1999a). The impact of water-logging and salinisation also has a socio-economic dimension, affecting farmers with small landholdings most (Rafiq, 1999).

2.3 Gender dimensions

Women can be regarded as the world's "unofficial water managers" (Seaforth, 2004), implying that their crucial contribution to water supply and management is rarely acknowledged. This also holds true in the Pakistani context.
Many of women's domestic work routines include water-related tasks, such as cleaning the house, household sanitation, washing clothes, and last but not least fetching water, often from distant places. This is despite the socio-cultural restriction of women's movement in the context of 'purdha', i.e. the practice of female seclusion (ADB, 2000). However, they are hardly represented in management schemes for domestic water supply and sanitation. Khan (1998) reports women to be included in decision-making in only two out of 35 rural water supply schemes (RWSS) studied.

In the context of irrigation, men are seen to best represent the water-related interests and needs of the household, and congruence of interests between men and women is assumed. In much of the South Asian context, these assumptions are not valid. 66% of all female work in Pakistan is in agriculture (Federal Bureau of Statistics, 2003). Using irrigation water is not confined to men; women do use it both for productive and domestic purposes. Livestock is an important source of food and income for the farmers, and its water-intensive management is largely the responsibility of women (Noreen, 1999, quoted in Iqbal and Alam, 2000). However, evidence from water user associations (WUAs) in South Asia shows that women's participation in these

organisations is much lower than men's, in Pakistan's case it is as low as 0% (Meinzen-Dick and Zwarteveen, 1997). One of the reasons is that only a negligible number of women have a legal claim on the land and hence on water as water is allocated according to the landholdings (Noreen, 1999, quoted in Iqbal and Alam, 2000).

3. Policy matters: Water-related policies and interventions

This section outlines selected water-related policy interventions that had and continue to have a significant – positive or negative – impact on human development in Pakistan. This impact will be studied in section 6.
According to Hasan (2003), the following components of water plans in Pakistan can be distinguished. They are rural and urban water supply and sanitation, irrigation and related drainage, and finally the development of water source and storage.

3.1 Water supply and sanitation schemes

In the areas of domestic water supply in Pakistan, the past two decades were characterised by a move towards more participatory and privatised approaches to rights to water and the provision of water-related services, respectively.
Under the Social Action Programme (SAP), introduced by the government in 1993-94, a uniform policy was developed by each of the provincial and area governments that called for the involvement of user communities in rural water and sanitation services. According to it, rural water supply and sanitation schemes were being prepared in consultation with user groups who were required to take over the operation and maintenance (O&M) of these schemes after completion (Ministry of Water and Power, 2002).

In urban areas, there is so far hardly any involvement of communities or the private sector in development and management of water supply and sanitation facilities (Ministry of Water and Power, 2002). This might change in near future. The Ten Years Perspective Plan (2001-2011) mentions the privatisation of water distribution in selected large cities as an answer to low recoveries of user charges (Qutub, 2004). The commitments, Pakistan has made under its World Trade Organisation (WTO) membership add further pressure to privatise. The European Community (EC) demands unrestricted access of foreign private suppliers of water distribution services to Pakistan under the WTO's General Agreement on Trade in Services (GATS) (EC, 2000). Although the Government of Pakistan has not made any commitment of privatising the water sector in the context of the GATS, the Privatisation Commission of the Government mentions ground and surface water resources as a potential target sector for future privatisation (Privatisation Commission, 2004; Ministry of Water and Power, 2002).
The Devolution Plan, launched by the Pakistani Government in 2001, established elected local governments. Since then, the district governments headed by the district Nazims are responsible for planning, investment, and control of municipal services including water supply and sanitation (Ministry of Water and Power, 2002).

Currently, Pakistan is developing a National Water Policy. The Draft National Water Policy prioritises access to water to meet domestic water demand. It also envisions the reduction of public spending in urban and rural domestic water through effective and

enforced charges for water services. The draft policy sees a greater role for private sector involvement in the provision of urban and rural water supply (Ministry of Water and Power, 2002). On an operational level, the goals for the rural and urban water supply sectors as defined in the Ten Years Perspective Plan (2001-2011) include the provision of safe drinking water from 53 to 75% of the rural and from 83 to 96% of the urban population by the year 2011 (Ministry of Water and Power, 2002). Despite these ambitious objectives, the funds allocated to achieve these goals are modest. About 3% of the Public Sector Development Programme is allocated to the implementation of them as compared to about 20% of investment in the area of power generation (Ministry of Water and Power, 2002).

3.2 Irrigation management

Similar to the areas of water supply and sanitation, irrigation management saw a shift towards more participatory and privatised approaches during the 1980s and 1990s. In 1979, the Pakistani government introduced a Revised Action Programme (RAP) for irrigated agriculture. Rather than building more dams, the action programme concentrated on saving water and reducing drainage problems. Amongst other sub-projects, the On-Farm Water Management (OFWM) Project, was undertaken to support the RAP's objectives (Weaving, 1996). With it, private involvement in water resource development and management started. In 1982, the Water User Ordinance enabled the formation of WUAs for participation in water management at the watercourse level. In Punjab, NWFP, and Balochistan, owners, tenants, and renters were eligible to become members of WUAs. In Sindh, membership was open to those who own or possess agricultural land (Jan and Saleemi, 1996).

By 1992, it had become clear that the RAP was not resolving the overriding problems of the irrigation system. Two years later, the government and the World Bank agreed to replace the RAP strategy with a far-reaching approach, which was decentralising responsibility for irrigation O&M, and financing to a combination of farmers' groups and public utilities (Weaving, 1996). Such stakeholder participation in O&M of irrigation systems has been introduced as the institutional reform component of the National Drainage Programme (NDP). Other components included drainage sector planning and implementation. In 1995, the Government of Pakistan decided to decentralise the O&M of the irrigation and drainage system in the country and has started institutional reforms aimed at the establishment of autonomous organisations. The institutional reforms launched in 1998 entailed that Provincial Irrigation Departments were transformed into autonomous, self-accounting and self-financing Provincial Irrigation and Drainage Authorities (PIDAs) (INPIM, 2004). Under the new law, PIDAs are required to operate and maintain the irrigation and drainage system through the formation of Area Water Boards (AWBs) managing the irrigation and drainage system, which are again comprised of farmers organisations (FOs) (Rafiq, 1999). These irrigation reforms make farmers responsible for the management of O&M and the collection and allocation of water revenues.

Similar to the recommendations regarding domestic water supply, the Draft National Water Policy foresees reduced public spending on the provision of irrigation through cost sharing and irrigation management transfer. It also aims at improving agricultural efficiency and productivity per unit of water in order to meet Pakistan's growing food requirements (Ministry of Water and Power, 2002).

3.3 Water storage projects

The third area of water interventions comprises of projects for water storage. A series of large water storage projects, such as the Warsak, Mangla, and Tarbela dams, have been developed in the 1960s and 1970s. However, big water-related infrastructure projects have been initiated during the past twenty years, e.g. the Left and Right Bank Outfall Drain (LBOD and RBOD), the Greater Thal Canal. The construction of the Kalabagh Dam is under consideration since 1953 and remains a highly disputed project.

The Draft National Water Policy mentions the promotion of hydropower schemes, in particular regarding the Northern run-off-river schemes to be one of its objectives. Through the Water and Power Development Authority (WAPDA), the Pakistani Government launched the water resource and hydropower development plan "Vision 2025". According to this plan, 26m^3 billion (21 MAF) of new storage capacity is planned between 2005 and 2025 with a total budget of USD 50 billion over the next 25 years (Ministry of Water and Power, 2002).

4. Environment matters: Water-related natural disasters and water pollution

Apart from policy interventions as the ones described in the previous section, natural disasters and environmental degradation have a key impact on access to water. This section in particular highlights the role of floods, droughts, and water pollution in Pakistan. Their impact on human development in Pakistan will be analysed in section 5.

The natural environment can broadly be categorised as encompassing natural, physical, chemical, and socio-cultural aspects (Bradley, Stephens, Harpham and Cairncross, 1992). As far as water-related issues are concerned, floods and droughts may be subsumed under natural features. Chemical aspects are for example organic and inorganic water pollution. Finally, sanitation, and sewage are socio-cultural aspects of the environment. This section makes use of these categories to highlight environmental factors relevant for the interface between water and human development in Pakistan.

4.1 Natural aspects: The role of droughts and floods

The probability of floods in Pakistan is high (0.66) as compared to drought (less than 0.1) (WFP and SDPI, 2004). Floods are defined as a general and temporary condition of partial or complete inundation of normally dry land area or property from overflow of inland or tidal waters, unusual and rapid accumulation or runoff of surface waters from any source, or mudflow (FEMA, 2004). During the past 50 years, a third of all natural disasters that hit the country were floods (WFP and SDPI, 2004). Their occurrence has increased due to climate change and – more importantly - deforestation of the Himalaya as noted in section 1.2. Between 1990 and 2000 alone, Pakistan's natural forest cover has declined by 33% (WRI, 2003a). Seven of the ten worst floods during the past century took place during the past 25 years (Mirza and Ahmed, 2003). Ahmad, Bari and Muhammed (2003) observe higher peak discharges for the Chenab, the Ravi[8], and the Sutlej rivers in the period between 1961-1990 as compared to 1931-1960.

[8] In the high discharge category.

The magnitude of the area inundated is especially large in the lower Indus basin. Damage is also significant in urban areas (Ahmad, Bari and Muhammed, 2003). In 1992, for example, Punjab and Sindh experienced highly devastating floods due to the unwarranted passage of millions of cusecs of water from Mangla Dam. It affected more than 13,000 villages (Mirza and Ahmed, 2003). Another large flood hit the country in 1996 (Gadi, 2003).

Besides floods, Pakistan also has undergone severe droughts. Despite their less frequent occurrence as compared to floods, they commonly last over a longer period and affect larger geographical areas (Sheikh, 2001). Droughts have several dimensions. Agricultural drought is defined as a reduction in moisture availability below the optimum level required by a crop during different stages of its growth cycle resulting in impaired growth and reduced yields, whereas social drought relates to the direct and indirect impact of drought on human activities (Benson and Clay, 1998). Similar to floods, the incidence of drought has increased in recent years. They occur in four out of ten instead of three out of ten years. One of the reasons given for the more frequent occurrence is climate change (Roy and Ghosh, 2003).

The years 1997 to 2001 were exceptionally dry. During that period, precipitation over most of the country was less than 50% of the normal, causing severe loss to agricultural production (Kahlown and Majeed, 2002). Major crops, i.e. wheat, cotton, and rice, recorded a negative growth of almost 10%; overall agricultural growth was recorded at a negative 2.6% during 2000-2001 (Ahmad, Bari and Muhammed, 2003). Balochistan, parts of Sindh, and Cholistan in Punjab were particularly affected (Figure 4.1). Stock water ponds in were completely dried in certain areas of the Cholistan and Thar deserts, adversely affecting livestock (Ahmad, Bari and Muhammed, 2003).

Figure 4.1: Drought at the end of June 2000

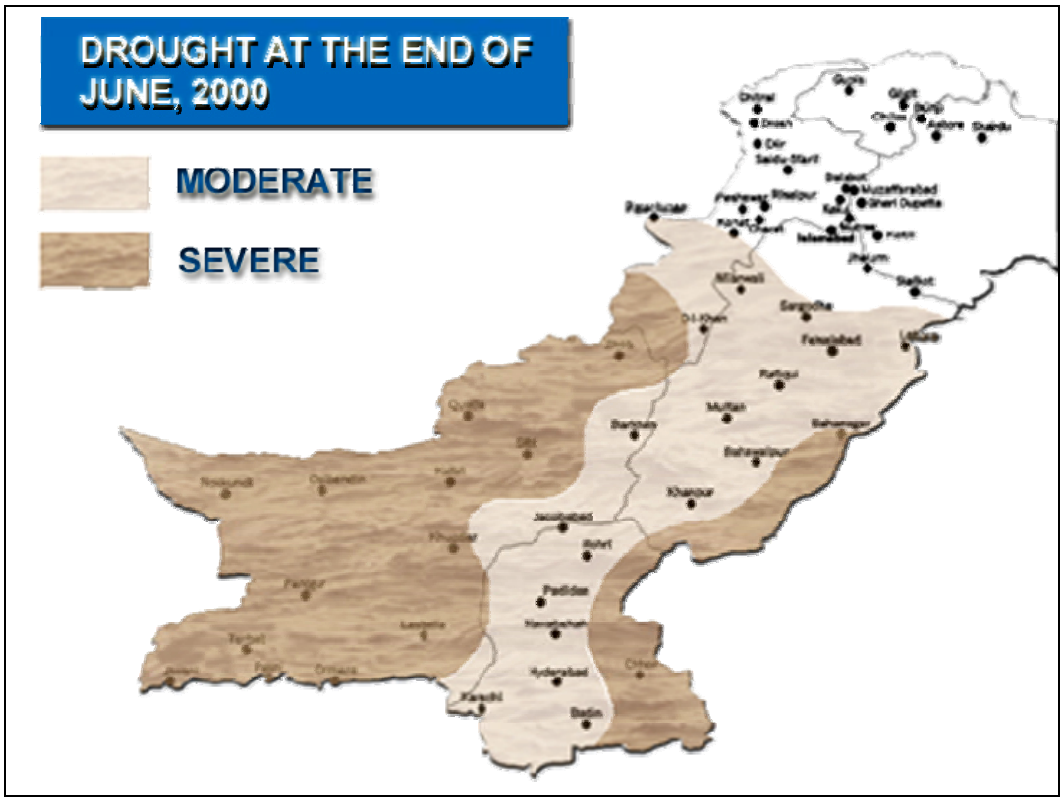


Table 4.1 mirrors the particularly severe situation for Balochistan.

Table 4.1: Drought losses of Pakistan by province (number of districts affected)

Decline in vegetation	Status	Punjab	Sindh	NWFP	Balochistan
>50%	Severely affected		1	3	17
30-50%	Highly affected	3	4	4	6
20-30%	Less affected	4	6	3	1
Up to 20%	Affected	27	6	14	2
0	Not affected				
Total		34	17	24	26

Source: WFP and SDPI (2004)

4.2 The role of environmental degradation: socio-cultural and chemical aspects
Besides natural disasters, the environment has been deteriorating in Pakistan through human intervention as well. Water pollution has three main sources: domestic sewage, industrial discharges, and agrichemical pollution.

In Pakistan, municipal sewage is a major source of water pollution. About 13 million wet tonnes of excreta are generated per year, resulting in bacterial contamination. In the urban sector alone, about 2 million wet tonnes of human excreta are annually produced of which around 50% go into water bodies to pollute them (Rafiq, 1999). Sewage treatment plants exists only in Karachi, Islamabad, Faisalabad, Peshawar, and a few military cantonments. Even these few plants have not been upgraded during the past two decades (Qutub, 2004). Lahore puts much of its untreated municipal sewage into the river Ravi, which is used for potable water supply and for irrigation further

downstream. Quetta's municipal wastewater is conveyed to a watercourse from which it is pumped to irrigate vegetables (Kahlown, 2004). According to the 1998-99 Pakistan Integrated Household Survey (PIHS), 44% of Pakistan's urban population is provided with underground drains, i.e. in most urban areas, waste-water is disposed through open drains. Some 10-30% of such sewage either remains in the streets or is discharged into water bodies. Drinking water supply lines and open sewage drains in Pakistan often are laid side by side in the streets. This results in frequent water contamination when pipes erode (WWF, no date).

Solid waste is another source of water pollution. In Pakistan, an average of 50,000 metric tonnes of solid waste is generated every day. Municipalities collect only 60% of this waste. Poor areas of the cities are generally the worst served by garbage collection services or not served at all. Adding to that, the solid waste collected in the upper and middle class areas of cities is often dumped in the slums and city peripheries, either in landfills or directly in watercourses. Compounding the problem is the fact that there is a chronic lack of health facilities to deal with the effects of water pollution. The absence of adequate nutrition, lack of education and overcrowded houses increase vulnerability to diseases (Khan, 2002).

The major industrial sources of water pollution in Pakistan are chemicals production (including fertiliser and pesticides), textiles, pharmaceuticals, tanneries, cement, electric equipment, glass and ceramics, pulp and paper board, and petroleum refinery. Industries do not control waste-water effluents through process control, waste recycling, or end of pipe treatment. Industrial wastewater containing toxic chemicals is thus disposed off untreated into nearby open land, drains, canals, or rivers from where they seep into the ground water. The industrial centres of Lahore, Faisalabad, Karachi, and Sialkot contribute major pollution loads into their water bodies. Saleemi (1993) shows that in Pakistan, around 9,000 million gallons of wastewater having 20,000 tonnes of biochemical oxygen demand (BOD)[9], loading are daily discharged into water bodies from the industrial sector. A survey conducted by the Federal Environmental Protection Agency (EPA) shows that tanneries located in Kasur and Sialkot were discharging effluents with chrome concentrations between 188-222mg/l against standards of 1mg/l prescribed in the National Environmental Quality Standards (NEQS).

Besides pollution of surface water, groundwater pollution near industrial plants is another area of concern, as industrial wastes are discharged directly into streams and drains or onto the ground. Groundwater pollution is often permanent, in that it may take hundreds or even thousands of years for pollutants such as toxic metals from tanneries or electroplating industries to be flushed out of a contaminated aquifer (Rafiq, 1999).

Box 4.1: Industrial water pollution in Pakistan

In Punjab, the Kala Shah Kaku industrial estate consists of chemical industries, tanneries, textile plants, steel re-rolling mills and others. These industries discharge effluents containing hydrochloric acid and high levels of organic matter into drains and streams discharging into the river Ravi. More than 250 industries in Faisalabad discharge high levels of solid, heavy metals, aromatic dyes, inorganic salts, and

[9] Biochemical oxygen demand (BOD) is a measure of how much oxygen is required to biologically decompose organic matter in the water. It measures the strength of wastewater discharges (Minnesota Technical Assistance Program, no date).

organic materials directly into the municipal sewers and open surface drains, ultimately also leading into the river Ravi. Discharges from the industries in the Sialkot area generally reach the Chenab river while that from Kasur, where Pakistan's major tanneries are located, is disposed of through the Pandoki drain into the Sutlej river.

More than 6,000 units or about 60% of the country's industries are located along the coastal belt of Sindh Industrial Trading Estate (SITE) and Landhi Industrial Trading Estate (LITE). Most of these industries discharge their effluents untreated into the sewers or directly into the Lyari river, the Malir river, and adjacent creeks leading to the Arabian Sea. It is estimated that about $7m^3$ of effluents are discharged into the coastal waters of Karachi per day from the industrial and municipal sources containing heavy metals and their compounds, detergents, lubricating oils, chlorine, and various organic and inorganic toxic compounds.

In the NWFP industrial cluster around Peshawar, out of 40 units, only two have waste-water treatment facilities. Others discharge their effluents into lakes and tributaries of the Indus river, mainly the Kabul river. Adverse effects of receiving such water bodies for domestic purposes, have been identified, especially those originating from leather tanning operations.

Source: Rafiq (1999)

Especially in the northern half of the country, agricultural drainage poses a real problem. Currently, most of the effluents are directly discharged into canals, rivers, or evaporation ponds, which are not environmentally safe. The contamination of water sources has increased with the excessive use of chemical fertilisers and pesticides. From 1980 to 1997, pesticide consumption has increased 67-fold. During the same period, the consumption of chemical fertilisers has risen by 136% (Khan, 2002).

Table 4.2: Water pollution control legislation in Pakistan

Legislation	Enforcing Agency	Offence
Pakistan Penal Code 1860	Provincial government	Fouling a public spring or reservoir
Factories Act 1934	Ministry of Industries	Disposing untreated industrial waste in water bodies
Punjab Local Government Ordinance 1979	Punjab Government	Polluting a water supply source for human consumption
Sindh Fisheries Ordinance 1980	Sindh Government Fisheries Department	Discharging untreated sewage and industrial waste in water.
Balochistan Water and Sanitation Ordinance 1988	Water and Sanitation Authority	Discharging unlicensed industrial waster water into sanitation or water systems
Canal and Drainage Act	Provincial Governments	Fouling of Canal Water
Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA)	Pakistan Environmental Protection Agency (EPA)	Makes EIAs mandatory

Regulation 2000

Source: Khan (2002), Rehman (1994)

Table 4.2 exemplifies that environmental legislation to sanction water pollution does exist in Pakistan. Apart from the laws listed, a more recent example of relevant environmental regulation are the abovementioned NEQS. They were enacted in 1993, and delineate allowable limits for 32 pollutants in effluents and industrial discharges along with other limits.

5. The human development impact of natural hazards and water pollution in Pakistan

This section assesses the human development impact of the environmental factors outlined in the previous section. It asks the question how human health and productive activities, especially in agriculture have been affected by floods, droughts, and water pollution.

5.1 The human development impact of natural hazards

As outlined in section 4.1, natural hazards have seriously affected the Pakistani population. Since independence, the cumulative financial loss through floods has been estimated at around Rs. 110 billion besides the loss of more than 6,500 human lives (Ahmad, Bari and Muhammed, 2003). In urban areas, the poor are more vulnerable to flooding. They tend to settle in the low lying urban areas, which are affordable but flood-prone (Khan, 2002). Displacement through floods has significant health implications, with diseases such as cholera and dysentery becoming rampant in temporary shelters and camps (Ahmad, Bari and Muhammed, 2003). In rural areas, flooding destroyed farmhouses, damaged crops, and buried topsoil under infertile sediment, thus hurting agricultural production. Thus, apart from the directly negative effect on human health and life, floods also severely affected income-generating activities and thus sources of livelihood. As a result of the floods in 1992 alone, about 5,000 people were either killed or reported missing, and the state suffered a loss of USD 2 billion. Agricultural growth was rendered negative for 1992-1993 (Ahmad, Bari and Muhammed, 2003). Only in Punjab, approximately 880,000 acres of cotton crop (20-50% of the total crop) were destroyed. The floods of 1996 killed 134 people and led to a serious estimated loss of Rs. 19.8 billion to property and livestock (Gadi, no date).

Table 5.1: Human impact of flood in Pakistan, 1980s and 1990s

Year	Property Damaged (Rs. million)	Lives Lost	Villages Affected
1978	51,489	393	9,199
1988	25,630	508	1,000
1992	69,580	1,008	13,208
1995	8,698	591	6,852
2001	450	219	50

Source: Ministry of Water and Power (2004)

Despite the construction of flood protection embankments, e.g. in the context of the Second Flood Protection Sector Project, which started in 2000, (Ministry of Water and Power, 2002), over bank flooding remains a major problem.
Semple (2003) emphasises that the process whereby a given natural hazard, such as flooding, translates into a disaster involving loss of life, and destruction of livelihoods is essentially a political one. A key aspect in the politics of flood vulnerability is the notion that there are winners and losers in flood management, but that frequently there is no process for the winners to compensate the losers. The losers in flood management are typically the weakest, poorest, and under-represented inhabitants of flood-prone areas. They are systematically lacking the means to articulate their interests in the politics of flood management and too often find that flood management for the rich means increased vulnerability for the poor.

Severe droughts result in nutritional stress, higher morbidity, and possibly, higher mortality (social drought). The economic impact of drought is largely felt via its effect on agricultural sector (agricultural drought). This is also shown by a substantial percentage decline in GDP during the recent drought, agricultural produce, employment opportunities and widespread sale of assets by the people.
More than 3.3 million people in Pakistan have been affected by the 1999-2001 drought described in section 4.1 (Ahmad, Bari and Muhammed, 2003). According to estimates, between November 1999 and July 2000, 143 humans and 2.48 million livestock died due to damage to agriculture. Thousands became environmental refugees. The loss has been more pronounced in the arid areas of Balochistan and Sindh. Mainly women and girls had to travel longer distances to fetch water for their consumption (WFP and SDPI, 2004). In addition, increased incidence of malnutrition, diarrhea, respiratory infections, measles, malaria, school drop-outs, and permanent dislocation of families have been observed (Kahlown and Majeed, 2002).
Overall, the climate condition resulted in a rise in the poverty head count index (HCI) from 30.6% in 1998-1999 to an estimated 32.1% in 2000 (Ministry of Finance, 2004).

Box 5.1: The human development impact of drought on Balochistan, 1998-2001

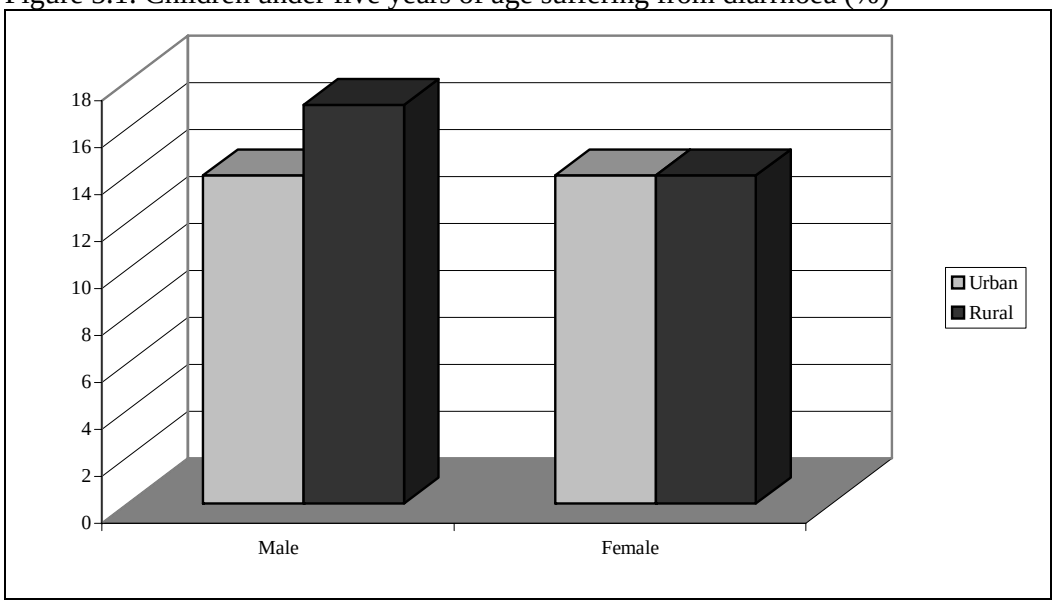
Twenty-two districts of Balochistan of a total of 26 were declared drought-affected areas in 2000. Among these, seven were declared worse affected.
As compared to the pre-drought year 1997-98, production of field and horticultural crops dropped between 19-55% and 24-37%, respectively, during the drought affected years 1998-2001. About half of all sheep and more than a third of all of goats were lost due to the drought.
The complete lack of rainfall from 1999-2000 led to increased groundwater mining through the installation of tubewells. As a result, the groundwater table has been falling by up to 3m annually in the drought-affected districts.
More than half the population in the worst affected districts of Balochistan was badly affected in terms of food availability. Milk, butter, and sometimes even water were not available for eating *rooti* (flat bread) during the drought. 5% of families in Kharan district reported to have nothing to eat.

Source: Ahmad, Bari and Muhammed (2003)

5.2 The human development impact of water pollution

The link between water pollution and human health is crucial. Water-related diseases[10] are among the most common causes of illness and death, affecting mainly the poor in developing countries.
In Pakistan, 25-30% of all hospital admissions are connected to water-borne bacterial and parasitic conditions, with 60% of infant deaths caused by water infections (Memon, 2004). The most common water-related diseases in Pakistan are diarrhoea, cholera, typhoid, hepatitis, and dysentery, kidney stones, malaria, and skin diseases (Khan, 2002). According to some estimates, more than 10,000 people die annually of renal infection due to polluted water. The diarrhoea rate in Pakistan is second highest amongst 31 Asian countries. One third of under-five deaths are owing to diarrhoea (Qutub, 2004).

Figure 5.1: Children under five years of age suffering from diarrhoea (%)



Source: Butt and Toor (2001)

In rural areas, the supply of water through hand pumps rather than through pipes results in higher incidence of diarrhoea (Figure 5.1). Apart from the regional dimension, Figure 5.1 also highlights a gender dimension in water-borne diseases, such as diarrhoea. A higher prevalence of diarrhoea is found with boys. Van der Hoek, Feenstra and Konradsen (2002) relate their similar finding to the less restricted mobility for boys as compared to girls, increasing risks of infection.

In Pakistan, the source of most water-related diseases is human excrement. As stated in section 4.2, major cities dispose off untreated sewage into the irrigation system, where waste water is reused without any consideration of river's assimilative capacity. The impact of such unsafe water supply and sanitation is mostly felt by the marginalized. Older parts of the cities are more prone to in-migration. There, sewage infrastructure is both poorly designed and corroded, which results in mixing of raw sewage and drinking water. Thus, even piped drinking water in poor urban localities

[10] Water-borne diseases causing gastro-intesinal illness (including diarrhoea) are caused by drinking contaminated water. Vector-borne diseases, such as malaria, are passed on by the insects and snails that bread in aquatic ecosystems; water-washed diseases, e.g. scabies and trachoma, originate from bacteria or parasites that take hold when there is insufficient water for basic hygiene (WWAP, 2003).

is highly contaminated. In many cases of poor urban settlements, no piped water is available. Residents have to resort to use groundwater that often contains bacterial and chemical impurities as does the surface water used for drinking and washing (Khan, 2002).

Awareness of the population about the link between water supply and sanitation arrangements and human health is lacking (Qutub, 2004). One important reason for this is that behavioural change has not been a focus of the various government and donor interventions (Arshad, 2004). Khan et al. (1996) find that even in the most sustainable water supply schemes they investigated, users lack of sense of basic hygiene. Change can however be catalysed if on the one hand, the communities feel a need for alternative practices and on the other hand role models for it are available. For example, in the BUSTI programme for the installation of soakpits in slums of Karachi, the key to the success of the project was that the community wanted some form of sanitation as the past problems with bucket latrines encouraged people to pay for better forms of sanitation. Twenty percent of the houses already had soakpits. Women played a major role as it soon became clear that the soakpits would only be used properly and maintained if women and children were taught how to use them. Therefore, females from the community were trained to give primary health education to children in their homes. The fact that the programmes health components were run by women for women lead to snowball effects in spreading health education in the community (Pasha and McGarry, 1989).

As mentioned above, in rural areas, large shares of the population depend on surface sources, such as irrigation canals, for domestic water use. Due to periodic canal closures to enable maintenance to take place, the population is forced to find ways to store water for longer periods. The quantity and quality of water provision through water tanks therefore becomes an issue (Waheed-uz-Zaman, 2000). When families have to store water for an uncertain period of time, they will impose restrictions on its use. Water for personal and household hygiene will be the first to be restricted, in order to maintain drinking water supplies. The availability of water for hygienic purposes is a key factor in the interruption of transmission of water-related diseases including diarrhoea. The large quantities of water that can be made available by irrigation systems can be an important advantage to health (Jensen, van der Hoek, Konradsen and Jehangir, 1998). This has been confirmed by Van der Hoek, Feenstra and Konradsen (2002) in research in an area in Southern Punjab where people depend on irrigation water for all their domestic needs. They assessed whether availability of water for domestic use had impacts on the nutritional status of children. The results show that children from households with a large storage capacity for water in the house had a much lower prevalence of diarrhea and stunting than children from families without this facility. Increased quantity of water for domestic use and toilet facilities turned out to be important interventions to reduce the burden of diarrhea and malnutrition. These findings highlight the importance of non-irrigation and non-agricultural uses of irrigation water and, thus, of an integrated rather than sectoral approach to water management.

Similar to the impact of municipal sewage, the water pollution induced by industrial clusters as sketched in section 4.2 has been a threat to human development in the form of human health and productivity in Pakistan. Villagers living on the banks of the Kabul river have been complaining of the prevalence of skin diseases in humans,

maladies in livestock, reduced crop yields in the areas irrigated by the polluted water, decline in fish catches, and periodic killing of fish due to toxic effluent discharges from nearby industries (Khwaja, 2003).
At the coast of Sindh, the industrial pollution combined with mangrove destruction and overfishing have resulted in a sharp decrease in shrimp production, which translates into lower earnings. This damage to fisheries and threatens fishing communities' livelihoods.
This is partly due to improper implementation and enforcement of environmental regulation, such as NEQS, due to lack of resources, equipment, skilled staff as well as training and monitoring programmes (INPIM, 2004).

The gender division of work regarding water management outlined above (section 2.3) bears special health consequences for women and girls, especially in rural areas of Pakistan. The fact that it is mainly women and girls hauling water from sources outside the home has a negative impact on the female skeletal system. Carrying heavy pots of water may lead to spinal injuries, pelvic deformities, and chronic fatigue. It may also induce premature births, spontaneous abortions or a prolapsed uterus and is of great concern during pregnancy. Travelling long distances, especially carrying heavy loads of water, utilises a large number of calories. This coupled with a poor diet can lead to anaemia and malnourishment and affects not only women's health but also that of the children she might bear (Seaforth, 2004). The scattered evidence available from Pakistan mirrors these health risks. In the Rahuki canal command area, women, especially those who were middle aged and responsible for fetching water, complained about pain in the neck and shoulders. Common diseases reported were diarrhoea, tuberculosis, hepatitis, still births, miscarriages, and thyroid, skin and eye problems. Women attributed many of these health problems to water (Nizamani, Rauf and Khoso, 1998).

In summary, water-related aspects of the environment have impacted on human development in Pakistan in the following manner:

- Through dislocation: Natural hazards forced people migrate due to floods and droughts.
- Through health deterioration: Water pollution increases the prevalence of diseases such as diarrhoea, dysentery, and malaria.
- Through economic losses: Natural hazards as well as health deterioration impliy economic losses, for example, through loss of human productivity and negative effects on crops and livestock.

Although water-related environmental factors such as natural hazards and water pollution figure prominently across the country, its impact is predominantly on the poor. This a result of the skewed distribution of amongst others sewage, sanitation and piped water facilities. Poor people are more prone to adverse health impacts because of their inadequate nutrition, unhygienic living conditions, lack of access to health facilities, and greater exposure to polluted water. This bias thus contributes to a vicious circle of poverty.

6. Poverty and inequality implications of water policies in Pakistan

Pakistan's official poverty line signifies a person as poor if he or she falls below the bracket of Rs. 750 per capita per month (Ministry of Finance, 2004).

Table 6.1: Poverty in Pakistan, 1979-1999 (%)

Year	Rural HCI	Urban HCI
1979	32.51	25.94
1984-85	25.87	21.17
1990-91	18.32	18.64
1993-94	23.91	13.58
1998-99	25.98	19.13

Source: Ahmad, Bari and Muhammed (2003)

As Table 6.1 shows, poverty as measured by the HCI has declined both in rural and urban areas of the country until the beginning of the 1990s, and then increased again. Inequality has increased throughout the 1990s, with the Gini index rising from 31.2% in 1996-1997 to 33% in 1999, but data sources are scarce (World Bank, 2004; JICA, 2003) This section analyses the implications of the policies outlined above for poverty and inequality as core aspects of their impact on human development. Existing studies hardly address this question. Therefore, the section gathers the scattered evidence available. It uses in particular the success or failure of the participatory approach in water management outlined in section 3.2 as a proxy for its impact on human development.

6.1 Impact of water supply and sanitation schemes

It is unclear whether the transfer of water supply schemes to the communities in the context of the SAP has improved access to water supply. Estimates of coverage derived from design parameters of the SAP are assumed to be a poor indicator of actual coverage as many schemes do not service the entire population of the settlements for which they were designed. Numerous surveys also found that the coverage figures mask the poor quality of the water supplied (Systems Limited, 1996). Khan et al. (1996) conducted a survey on the sustainability of water supply schemes in rural Punjab. In all cases, only 50% or less of the female group respondents were satisfied with the current level of services. Male group respondents were more satisfied with the quality of water supply and less with its quantity. However, the majority of both female and male groups were satisfied with the performance of water user groups.

Zaidi (1997) highlights that some of the schemes had been handed over to the communities despite their resistance to the idea based on the belief that a government agency rather than village water committees would be a better manager of a water supply scheme. Schemes were constructed with little social sensitivity for the needs of the rural communities. The resulting inappropriate design of the schemes was identified as a main reason why the scheme handover to communities has failed. The drop in coverage with safe drinking water in all provinces from 1995 to 1999 (Figure 2.2) at least does not indicate an improvement during the period of SAP implementation.

In their assessment of factors for (un-)sustainability of the scheme transfer, Khan et al. (1996) report that in a number of cases, manipulation of the scheme through local influentials appear to have caused the failure of the scheme. Despite the formal responsibility of the District Development Advisory Committees (DDACs) for the identification of potential water supply schemes, elected, prospective, and defeated

members of the provincial parliament often influenced the implementation of water supply schemes based on political expediency rather than on the basis of needs. In Punjab, political intervention was seen as a major reason for the failure of participatory schemes. Community-based organisations would be formed by friends of the local politicians. In NWFP, as a result of both the low tariff levels and poor collections, resources were diverted to those who can muster political support, thereby leaving some segments of the population, particularly the marginalized ones, without services. Similar findings were made during evaluations of the SAP in Balochistan (Systems Limited, 1996).

In some cases, awareness of the participatory approach was lacking. Although infrastructure had been set up, community mobilisation efforts had not been undertaken (Systems Limited, 1996). In a majority of the cases investigated by Khan et al. (1996), the communities had been informed of the imminent transfer. However, sufficient efforts were not made to make them willing and able partners in the transfer process. This is reflected in these communities' perception of scheme ownership. They - particularly the female groups who are not included in the management of the water supply schemes - perceived ownership to be in the hands of notables.
A social mobiliser orientation as often found in the water supply schemes of non-governmental organisations (NGOs), i.e. a more a genuine concern for mobilising the community, has been found to be a success factor in RWSSs (Khan, 1998). For government agencies transferring RWSSs, it did not seem to matter that formation of a community organisation or a water committee was done by working with the local notables in the community and that the general body of the community had little or no say in the decision making. Although it is much easier to approach a community via the local notables, doing so is likely to mean that the local notables will appropriate the major benefits of the scheme (Khan, 1998). Khan et al. (1996) conclude that "It is now generally accepted that to generate community involvement and ownership communities need to be involved right from the inception of the scheme. If this were done (…), social rather than engineering criteria may have been more important in site selection and scheme construction."

6.2 Effects of irrigation management schemes

During the period 1985-1999, the correlation between agricultural growth and the poverty headcount ratio was negative with the coefficient of correlation being -0.32 (Ahmad, Bari and Muhammed, 2003). This hints at the positive role for interventions that stimulate agricultural growth for poverty alleviation, especially in rural areas. In this section, the effects of some interventions in irrigation management on poverty and inequality will be assessed.

In irrigation management, Gill and Sampath (1992) find an overall increase in the inequality of irrigation distribution in irrigated crop area between 1972-1980. They attribute the stronger increase in inequality in cultivated and net sown areas as compared to farm area in the same period to the impact of land reclamation and irrigation development schemes. Large farmers benefited more from these schemes than the others for two reasons. First, the reclaimed lands were mostly the uncultivated areas in the possession of large farmers. Secondly, the proportionality principle underlying the government-owned canal irrigation distribution along with the inherent economies of scale involved in private tubewell development contributed to increasing levels of inequality. They conclude that the major source of inequality in

the irrigation distribution is essentially in terms of the inequality across farm size groups (Gill and Sampath, 1992).

Similar to the water supply and sanitation schemes, the effective participation in all stages of irrigation of the respective communities also appears to be a decisive factor for the success of the participatory irrigation schemes established under the OFWM and the NDP regarding sufficient and equitable availability of irrigation water. Despite the benefits of reduced system losses, increased food production, a shift towards higher value crops, and health benefits[11] of the OFWM in the project areas, vested interests and the prerequisites of project activities distorted the incentives to WUA participants.

More than 17,000 WUAs were formed in the context of the OFWM project. However, they remained effective only during improvement of the watercourses. Thereafter, the WUAs ceased to function in any capacity. The reasons for this were amongst others the project's emphasis on meeting short-term physical targets rather than a longer-term concern with institutional strengthening of the WUAs and their development impact (Weaving, 1996).

The projects ignored traditional local watercourse committees. As a condition for granting large subsidies for renovation, they called for the creation of new water users' associations, which would assume responsibility for maintaining the rehabilitated watercourses. Some were merely token institutions, and many were traditional committees renamed in order to qualify for the subsidies. In feudal Sindh, with its large farms, the fact that most farm families cannot join water users' associations, because they are landless labourers or sharecroppers, made even the traditional committees superfluous and the formation of new associations often no more than an empty ritual.

However, Addison (1996) finds that on watercourses improved during the OFWM, farmers earned on average a net income of Rs. 21,901, while farmers on unimproved watercourses earned 22.6% less. Net farm income increase was higher on the tail portion of the improved versus unimproved rather than in the head. This would support the view that the OFWM programme has redressed the claims of unequal distribution of water along the watercourse.

Employment for men has fallen significantly due to labour savings in irrigation management whereas women's workload in the fields has increased due to the expansion in cropped areas.

Weaving (1996) summarises that while the projects helped to alleviate poverty through their effects on farm production, they also provided large and unnecessary transfers of public resources to some of the rural elite. Watercourse improvement intended to benefit mainly small farmers. But this intention was unrealistic in much of Sindh. The self-selection of water-courses led by well-connected farmers speeded implementation but resulted in many desperately poor areas being left out.

Findings from Waheed-uz-Zaman (2000) exemplify that farmers' awareness and active participation are prerequisites to appropriate the benefits of technical improvements in irrigation management. In case of FOs in Southern Punjab, he

[11] In Punjab in particular, lining of watercourses has reduced stagnant swampy areas caused by seepage and overflow, bringing health benefits. Villagers reported to have less malaria and fewer flies. Particularly women appreciated the increased health benefits of improved watercourses (Weaving, 1996), presumably because of their role as care providers.

identifies a more equitable water distribution between head and tail-enders of the canal. It has improved by forming FO committees that correct faulty outlets and perform several joint inspections of channels together with the PIDA. In this specific case, farmers were involved in the assessment of maintenance needs to participate in the review of the legal framework for FOs on the province of Punjab. This government-FO interface helped developing the negotiation capacity of the FOs. It also increased the commitment of the higher levels of the PIDA to the participatory reforms.
In other cases where the social mobilization component was lacking in the process of forming WUAs and water user federations (WUFs), farmers were not aware of the importance of the WUAs and thus did not nominate suitable members for them. Resultantly, meetings were not held regularly at watercourse level. Information about the results of WUFs' meetings were not passed on to farmers. Similarly, in the same study area, the technical know-how passed on to presidents of WUAs in the research area through training was not found to be passed on to ordinary farmers. In some cases, farmers rejected the participatory management schemes as they assumed local influentials, mostly landlords, to dominate the WUAs (Iqbal and Alam, 2000).

The local elite may have a catalytic role in bringing forth the collective action needed for the participatory management of water schemes (Khan et al., 1996). However, in general they appear not to take on this role, presumably because of the lack of need. Studies find large landowners to be generally less cooperative in helping cleaning and maintaining the watercourses and more prone to factionalism. They also tend to more frequently violate sanctions as compared to smaller farmers. Cooperative efforts, e.g. for watercourse improvement are more likely to be supported by farmers at the tail end of watercourses, since their potential gains are greater than those at the head (Gadi, 2003), stressing the role of need as a catalyst for collective action. The local elite's resources may contribute to increased inequality in access to irrigation water and its contribution to farm productivity and thus human development. Jan and Saleemi (1996) note that the attitude of those responsible for implementation of OFWM was more favourable to large farmers. Despite the focus on poverty alleviation as explicitly spelled out in the OFWM programme, there was no focus on small farmers and tenants. Resultantly, the policy adversely affects equity as benefits were hijacked by large and influential farmers. Resources may be used to bribe officials, or influential farmers are found to plant mock orchards to lay claim on an increased share of water (UNDP, 2003; Iqbal and Alam, 2000). In addition, tariff subsidies favour the rich rather than the poor. In Pakistan, the highly subsidised rates for water are assumed to be the main cause for irrigation mismanagement. They result in the denial of the tail end communities of the system (Nizamani, Rauf and Khoso, 1998).

Gender inequality in access to water is affected by the sectoral approach to irrigation, focusing on the use of canal water for food production alone, while ignoring their multiple uses. Canal lining is promoted as a measure against seepage losses in the irrigation system. However, lined canals may hinder other uses of canal water if no countervailing measures are taken. For example, it is not possible for livestock to drink water from or bathe in the canals after lining (Weaving, 1996). Similarly, washing clothes in lined canals is not possible unless appropriate stairs are integrated in the canal (Iqbal and Alam, 2000). Both concerns are related to female tasks in production and reproduction. Given the lack of representation of women in

participatory irrigation management, gender inequality is corroborated with negative effects on human development. Again – as emphasised in section 5 – an integrated approach to water management is called for.

Box 6.1: Water stress and poverty dynamics in the Rahuki canal command

It is estimated that out of the 13 million acres comprising the greater canal area in Sindh, at least one million - mostly owned by small and poor land-owning families - do not receive sufficient irrigation supplies. The situation is particularly distressing for communities that are dependent on surface irrigation flows for drinking and other domestic uses. The Rahuki irrigation canal draws its irrigation supplies from the Hyderabad branch canal of the Sukkur barrage irrigation system. Crop yields and returns in the lower tail of the Rahuki canal are much lower than in the head area reflecting water scarcity. In recent years, water completely disappeared due to excess use of water in the head area of the canal, the last 40-45% of the canal command.

It is estimated that 17,000-18,000 persons in the Rahuki area faced water stress and that 8,000-10,000 migrated due to water or irrigation shortage over the last three decades. In the canal area, such water stress induced large flows of environmental migration, with migration occurring in the last 45% of the canal, being severe in the last 25% of the command area. The decision to migrate was particularly difficult for small landowners and the poor. Large landowners can sell land in one area and buy agricultural property in other canal areas, whereas small landowners do not have that option. The landless sharecroppers are worst affected as land could not be cultivated for many years, the sharecroppers were denied subsistence credit from the landowners, thus pushing large numbers into unemployment.

Of the villagers facing severe water stress, women were hardest hit because of the long way they had to carry water. The distance they had to carry water from varied from two to ten kilometres. Most landless people had purchased donkeys and were engaged in bush cutting on the abandoned lands and roadsides, which barely brought any profit to them. In a situation where mobility of women is restricted by gender norms, female labour migration is difficult. Those unable to leave the village for employment had to depend on traditional crafts providing them with a meagre and irregular income. Being deprived of employment possibilities, women were also engaged in making coal from burning of cut bushes.
Another survival strategy was selling land to brick kiln owners. Often soil was extracted until ground water appeared. Even with the improvement in the water flow poor farmers are likely to suffer as they lack the resources to reclaim their land. As a result, the socio-economic gap is widening due to the water scarcity faced.

Source: Nizamani, Rauf and Khoso (1998)

6.3 Water storage projects and their human development implications

More and more predictable energy supply is assumed to be an important contribution to human development. The second important argument in favour of large dams relates to food security through their beneficial impact on agricultural productivity (Khan, 1999b). The large hydropower projects initiated in Pakistan since the 1960s contributed to “clean” and more stable energy supply of in the country. Hydropower accounts for 29% of Pakistan’s power generation capacity. The main purpose of large dams in Pakistan is irrigation, with hydropower generation as a by-product.

However, large dams to create large reservoirs also cause many development concerns. Large areas are submerged by the reservoir. Increases in cropping intensity and crop yields, however beneficial, have added to the already severe problems of water-logging and salinity in the past.
Populations are displaced, often with no or inappropriate compensation for the loss of land and livelihoods. Only scant data is available about the number of dislocations involved in the various projects. In case of the Tarbela Dam, about 96,000 people were affected by resettlement (Box 6.2). The Ghazi Barotha Hydropower Project, completed in 2003, displaced 20,000 people. The total number of displaced persons due to the Chashma Right Bank Irrigation Project will amount to above 13,000 (Sungi, 2002). The dispute about the Kalabagh Dam to be built is - amongst other social and environmental factors – triggered by the estimated 83,000 people that would be affected by resettlement (Malik, 2003).
The reduction of water flows due to large dams has had a negative impact on the riverine ecosystem with repercussions on livelihoods. For example, due to average outflows of water downstream the Kotri barrage that are well below the volumes necessary to sustain the Indus delta ecosystem (Khan, 2002), seawater intrusion has been witnessed inland up to 25 kilometres[12] north of the coast with the districts of Badin and Thatta worst affected in this regard (Asianics Agro-Dev. International, 2000). The coastal mangrove forests have been destroyed, threatening the livelihoods of about 100,000 people, mostly marginalized communities. They directly use the mangroves as fuel, fodder and for grazing and generate income from seafood (Khan, 1999b). About one million acres of agricultural land has become saline and thus unfit for agriculture (Khan, 2002). Water supplies are destroyed and people are compelled to drink brackish water, exposing them to various diseases.

Large hydropower irrigation projects have also been associated with inter-provincial water conflicts. The dispute over the construction of Kalabagh Dam is an evident example. Sindh argues that as a consequence of diminished flow due to diversions for other areas than Sindh, large areas in the province would be affected, crippling Sindh's agrarian economy. NWFP's politicians oppose the Kalabagh Dam due to the submergence of thousands of acres of cultivable land, and the large-scale displacement of indigenous population. It is also assumed that the Kalabagh Dam would cause water-logging and salinity in the districts of Mardan, Charsadda, and Swabi (Gadi, 2003; Malik, 2003).

Flood control is mentioned as another objective for the construction of large storage projects. However, large dams notwithstanding there has been no reduction in the incidence and intensity of floods nor in the associated losses in lives, crops, livestock and agriculture (Khan, 1999b). As mentioned above, in 1992 and 1996, for example, Punjab and Sindh experienced highly devastating floods due to the unwarranted passage of millions of cusecs of water from Mangla Dam (Khan, 2002).

Box 6.2: The Tarbela Dam Project – contribution to and challenge for human development in Pakistan

Tarbela Dam was the world's largest earth-filled dam of the day. The main objectives of the project were to provide additional water supplies for further development of irrigated agriculture thereby increasing food production to achieve self-sufficiency,

[12] Less conservative estimates mention up to 100 km seawater intrusion (Memon, 2004).

and to generate cheap hydro power. The construction was started in 1968 and finalised in 1976. The project's overall cost of USD 1.5 billion was an overrun of the estimated costs of 81%.

Although it is not possible to separate the effect of building the Tarbela Dam from other interventions in irrigation management, irrigation diversions downstream of Tarbela in the dry season increased by 98% at Taunsa, by 168% at Guddu, and by 80% at Kotri in the post- as compared to the pre-Tarbela era. The cultivated area in the country increased by 12% from 1974-75 to 1997-98, about 8% less than what was predicted for the year 2000. The irrigated area rose by 35% during the same period, slightly higher than predicted. Cropping patterns in the Indus basin shifted towards irrigated wheat, cotton, rice, and sugarcane. However, the achievement in crop yields for the major crops in Punjab and Sindh were about 30% below the predicted levels. At the same time, water-logging and salinity have increased in the Indus basin as a result of increasing water diversion for irrigation. Increased agricultural mechanisation led to some displacement of farm labour, whereas employment in cotton- and sugarcane-related industries have increased significantly, together with forward and backward linkages in the transport sector. Another unexpected benefit was the availability of canal water for domestic purposes and livestock production in areas where groundwater is too saline. It is estimated that about 40% of the population may presently be benefiting from Indus water supplemented by Tarbela storage.
The actual average annual hydropower generation at Tarbela was 9,255GWh between 1978-1998, or 82% of the predicted. It represents over 22% of Pakistan's installed capacity for power generation. Major beneficiaries have been the enterprising industrialists who received cheap electricity thus reducing their cost of production.

The number of villages submerged as a result of water storage in the Tarbela Dam was 120 as compared to an estimate of 100. About 96,000 people were affected by resettlement. The resettlement process was amongst others criticised due to lack of participation of the affected in the planning and development process, displacement before provision of alternative land and compensation, delays in the payment of compensation, and lack of employment in new townships. A gender dimension had been totally neglected and women in particular have suffered as a result of the disruption of their social life due to migration from ancestral places.
Negative changes downstream in Punjab included the loss of forestland to agriculture and the loss of livelihood opportunities to the landless that made products from forests and wetlands along the river, representing marginalisation of poorer segments of the population that depended on the river. In Sindh, fish catches were reduced considerably as a result of reduced dry season flows. Resultantly, there has been a large-scale outmigration of population from the lower Indus delta to Karachi and other places in search of livelihood.

Source: Asianics Agro-Dev. International (2000)

Khan (2002) summarises that the absence of consultative processes involving key stakeholders of large water storage projects gives rise to poor governance in implementation.

In summary, the following effects of the selected water policies and interventions outlined in section 3 on poverty and inequality can be identified.

- A focus on physical targets rather than on capacity building in WUAs has been identified as a core problem in participatory water management schemes.
- Therefore, positive effects of these schemes were largely appropriated by the economic and political elite, increasing the marginalisation of poorer farmers and landless tenants and sharecroppers, a situation referred to as 'resource capture' (Gizewski and Homer-Dixon, 1996, quoted in Khan, 2002).
- The lack of female stakeholders' participation in WUAs is a core problem, given women's strong role in water supply and management. Ignoring their needs leads to further widening of the gender gap in resource access.

7. Water management for human development

In this last section, the paper formulates recommendations about how water-related interventions can better serve human development in Pakistan. Cross-cutting issues, such as how to ensure the representation of the interests of all stakeholders, in particular of the poor and of *both* women and men, how to prevent negative health effects of water interventions are discussed before specific suggestions are made regarding rural and urban water supply and sanitation, irrigation, and large water storage projects.

7.1 Stakeholder participation on equal footing

Three of the so-called 'Dublin Principles' set out at the 1992 International Conference on Water and the Environment in Dublin are particularly relevant for water management that takes a human development perspective. Principle 2 states that water development and management should be based on a participatory approach, involving users, planners, and policy-makers at all levels. Principle 3 emphasises that women play a central part in the provision, management, and safe-guarding of water. Finally, Principle 4 stresses the economic value of water in all its competing uses (Solanes and Gonzalez-Villarreal, 1999). The question is how to translate these principles into recommendations applicable to the Pakistani context.

Improved and safe access of water for domestic and irrigation purposes were the objectives of the moves towards the transfer of water management to water user groups throughout the 1990s, as outlined in section 3. As the previous section has shown, participatory approaches to water management both in domestic water supply as well as in irrigation management, have not yet shown the desired results. However, the discussion in section 6 hinted at some prerequisites for successful participatory water management.

The role of awareness in participatory water management has become evident. Funding and skilled personnel for raising awareness and capacity building should therefore be made available as an integral part of any effort to involve user communities in scheme management. This also holds true for flood management. Semple (2003) emphasises the need for riverine people to be organised, represented and consulted on issues of flood management. He sees a need to take district preparedness plans seriously, and to make them inclusive, rather than as a bureaucratic-led paper exercise with no real follow up.

Being staffed with engineers, government departments often do not have the capacity to undertake participatory planning for the design and development of infrastructure.

Personnel skilled in participatory planning thus needs to be a priority in recruitment efforts.
In his assessment of the OFWM, Tariq Banuri (1996) stated: "Two years ago, UNDP published a report on Pakistan's development experience in which the term *capital bias* was used to describe Pakistan's near obsession with building physical capital. This way of thinking is fast disappearing. From bitter experience we have learnt that development is about building capacity." Almost ten years later, this point still needs to be stressed when it comes to recommendations for water management in Pakistan that serves human development.

The relevance of local power structures for the success of decentralised water management has been shown. They have to be explicitly addressed in the design of schemes, for example, to prevent that the development of water markets will be in favour of large farmers, thereby widening existing socio-economic gaps. Rather than using village local notables as the entry point for communication with communities, a more effective strategy, is to ascertain who is generally trusted by the community and work with such individuals as activists and leaders (Khan, 1998). Cleaver and Elson (1995) issue a warning note about the ability of user communities to take over water scheme management completely as it isn't evident why the community should be competent to undertake most of the tasks in which governments have failed. Management tasks involving risks regarding the influence of the local elite and requiring considerable technical expertise can be left with government agencies instead of transferring them (Khan et al., 1996). Committees could then be instructed to train back-ups for these core water scheme operating and management functions.

As section 6 has shown, women's interests are hardly represented in water supply and sanitation as well as in irrigation management, due to their effective exclusion from user associations. Pakistan's Water Vision 2025 proposes the following concrete steps for gender mainstreaming in water management (Pakistan Water Partnership, 2000; emphasis added):

- *Build capacity* to increase the understanding of gender implications for water management, as part of an effort to empower women so that they can acquire the skills to enter water management at a senior level. This involves an increase in technical and scientific education offered to women.
- Identify existing female institutional forums at the village level that can be used to *enhance women's participation* in the water sector.
- *Include women* in the water-user's associations at the watercourse level as well as in farmers' organisations at the distributory and minor level.
- Encourage in-depth *gender-sensitive consultation processes* that allow both women and men to participate in decisions regarding location of water installations, technology, and price implications.

Capacity building inter-alia relates to government departments. Participatory planning implies in particular to include the interest of women as a major, but so far neglected user group. Since in most of the relevant government departments there are few women, the outreach directly from the government to women also may not be very effective.
Regarding enhanced female participation in the water sector, it is critical to identify both the public sites where it is socially acceptable for women to meet with men as well as a suitable time that does not conflict with their domestic or productive

activities. The successful example from the Environmental Rehabilitation in NWFP and Punjab (ERNP) project shows that even in the context of Pakistan where female mobility and social interaction between women and men is restricted, participation of female water users on equal footing is possible: “Women, who did not previously venture beyond the restrictive confines of their homes and neighbourhoods emerged as an influential interest group in their communities. (…) [I]t is now that for the first time, that the women are creating and controlling their own physical and financial assets and are learning new skills in the process.” (Cheema, 2004)
Section 2.3 highlighted the crucial role women play in agriculture in Pakistan. The lack of land rights for women and thus water entitlements and legal cover hamper women in their ability to have a say in irrigation management and thus to better utilize the resource. However, even if the gender division of work were such that women were not involved in agricultural work in large numbers, the interdependence of water for domestic purposes and water for food production is a recurring issue and requires integrated water resources management. In particular, the relevance of irrigation water for domestic supply and its health implications as highlighted in section 5 as well as other productive uses, such as livestock watering, exemplifies that there is a need to include women in decision-making and policy formulation regarding irrigation and drainage (Gender and Water Alliance, 2003).

The previous sections have highlighted that economic incentives discourage efficient use of water and are biased towards those who have sufficient access to the resource. The flat rates in domestic water supply for water conservation mentioned in section 2.2 are one example. In accordance with the Dublin Principle 4 mentioned above, proper pricing, secure property rights, and equitable access to economic resources can be used incentives for water conservation (Zia and Hasnain, 2000; Banuri, 1996). Cross subsidies can be extended to the poor in order to achieve universal access to the resource (Khan, 2002). For example in industrial uses, Ghous (2004) assumes 30-40% water conservation to be achievable in the paper and pulp, leather, and textile sectors by adopting water conservation techniques at the industrial unit level.

As the previous sections have shown, a major channels for the impact of water interventions on human development is their effect on health. Given the important role female household members have in domestic water management and as role models in hygiene as highlighted in section 5, water supply schemes should be accompanied by instruction on general hygiene, targeted to women (Khan et al., 1996). The incorporation of sound, health-based practices for water resource systems should thus include water quality management in source protection, treatment, and distribution of drinking water, using health impact assessments (HIA) on all development projects, including irrigation drainage and storage and power generation projects to reduce the threat of vector-borne diseases, such as malaria and yellow fever. In addition, higher level practices can also contribute, such as making the different water-use sectors responsible for the adverse health effects of their projects, having regular evaluations of the costs of ill health from water resource development and evaluating the cost effectiveness of water supply and water management interventions versus conventional health interventions (WWAP, 2003). Strengthening of the institutional capacity at the provincial Environmental Protection Agencies (EPAs) responsible for monitoring and implementing the NEQS would be an important step in this direction. This implies more technical knowledge, continuing monitoring networks, adequate economic and human resources, and adequate

environmental research. In the short run, it is suggested that EPAs may focus on few industries with comparatively higher effluent levels rather than focusing on all industries (Talpur, 2004).
Ultimately, improvements in access to safe and clean water helps reducing poverty. Productivity is increased through reduced occurrence of diseases, less expenditure on medical care, and nutrition is improved through prevention of helminthic infestations (Safe Drinking Water Group of Pakistan and The Network for Consumer Protection, 2003)

7.2 Water for people

Preconditions of water supply scheme management that enables equitable access to the resource are outlined in section 6.1 should be kept in mind. The gender division of work in water management is of crucial importance. It calls for participation of women in WUAs and for an integrated approach to domestic water supply. Addressing the potentially detrimental local landed and/or bureaucratic power structures is a decisive factor. Awareness and capacity of the user community are other important features that suggest that the preparatory phase of scheme transfer needs more attention. Khan (1998) states that public schemes need to function like development NGO projects in order to be successful. This requires social mobilisation training for government personnel and an altered incentive structure and service rules so that they have the will and flexibility to deliver. Last but not least, the communities' need for a water supply scheme is another key success factor. Specifically for water supply and sanitation schemes, larger schemes offer less opportunity for direct participation by users in planning decisions and thus addressing their specific needs. Hasan (2003) emphasises that communities express a desire to have systems in place that relate to their clan or neighbourhood (*mohalla*) identity and which can be run by these groups themselves. Implementation means a move from capital intensive and mechanised projects and decentralisation and miniaturisation of engineering systems. The treadle pump used in Bangladesh is an example for a low cost appropriate technology (Daudpota, 2000). Such decentralisation may include localised systems of monitoring water quality, e.g. portable and easy in use kits for testing crucial parameters for the potability of drinking water (Development Alternatives, 2004).

Some of the success factors of the Orangi Pilot Project (OPP) (Box 7.1) reflect these features. The need of the community triggered collective action. Creating or enhancing awareness is seen as its essential prerequisite. Community participation, including women, in cooperation with municipal infrastructural support guaranteed effectiveness and efficiency. The resulting safer sanitation infrastructure is an important tool for reducing the impact of diarrhoeal diseases for poor, vulnerable communities. Institutional arrangements should therefore be established to replicate such successful community-based water supply and sanitation schemes (Khan, 2002).

Box 7.1: The Orangi Pilot Project

Orangi is the largest squatter camp in Karachi with an estimated population of over 1.2 million. Like other slums, Orangi faces severe problems of health, sanitation, education, housing, and unemployment. Government-provided facilities, such as roads, water supply network, electricity, and some schools and hospitals, proved insufficient to solve the problems of the dwellers. In order to address them, late Akhtar Hameed Khan, a renowned social scientist, launched the Orangi Pilot Project

(OPP) in 1980. It functions as a research NGO, which helps people solve their problems by providing social and technical assistance. The basic idea of the OPP is that if properly motivated and suitably organized, ordinary people possess ample capacity to get things done. It encourages community participation and practice of cooperative action to solve the major problems of the area. In this vein, OPP identifies activists among the residents at the lane level – each consists of 20 to 40 houses –, provides training and technical details, provides further guidance and supervision and helps to simplify designs so that they are affordable and can be technically implemented locally. Moreover, the project strengthens the position of women in the communities by encouraging participation in community affairs.

The project enables low-income families to construct and maintain an underground sewerage system with their own funds and under their own management as the project's 'internal development' component. Until 1980, most households used bucket latrines and soak pits for the disposal of human waste and open sewer for the disposal of wastewater, resulting in a high rate of water-borne diseases. OPP provides social and technical guidance to help the people build underground sanitation in their homes, lanes, and neighbourhoods. People have invested Rs. 86.28 million on internal development, i.e. building over 6,250 lane sewers, 417 secondary sewers and nearly 94,000 latrines in their homes. OPP's 'external development' component comprises of a trunk sewer and/or the development of a culvert in a natural drain and treatment plants or lagoons and marine outfalls. External development cannot be undertaken by the people and is the government's responsibility. After the municipality's initial hesitation to pick up the work done by the communities, the government adopted the OPP model.
Due to its stress on community participation and thus the knowledge about appropriate and low cost solutions, OPP operates cost efficient. It is estimated that, if the government had carried out this plan, it would have probably cost Rs. 600 million. Moreover, it also empowers small family enterprises with micro-credit, provides guidance for low-cost housing, provides information regarding the causes and prevention of common diseases, conducts family planning programmes, extends training to the nursing and teaching staff so as to provide better services to the people and arranges financial assistance to the schools.

Over a couple of decades, OPP has successfully solved major problems faced by the people of Orangi, where a substantial improvement can be seen in their human development. The OPP model is being replicated in other slum areas of Karachi, numerous towns in different parts of the country, and in some other developing countries as well.

Sources: Bhagwandas (2003); Rahman (2003); Akhtar Hamid Khan (no date); Urban Resource Centre (no date); Yespakistan.com (no date)

As section 5 has underlined, hauling water is a strenuous task involving a number of serious health risks for women and girls responsible for it. Due to the restrictions imposed on female mobility, men in the Pakistani context have an incentive to make water available to their women as close to home as possible (Khan et al., 1996). Examples from Bangladesh and Rajasthan show that through consultation with female users appropriate technology for their needs can be chosen. The handpumps female users requested there, for example, were close to home and less heavy to operate (Development Alternatives, 2004).

At the same time, the government should aim at replacing dysfunctional and developing more water-related infrastructure in order to improve water quality, in particular low-cost water treatment plants for the treatment of sewage and industrial waste-water, and weigh this as central to sustainable growth, development, and poverty reduction. National Drinking Water Quality standards should be developed and implemented. The National Water Quality Monitoring Programme started in 2001 with the objectives to establish a permanent water quality monitoring network across the country (Kahlown, 2004) is a first but insufficient step in this direction.

Given the inequality in access to safe and sufficient water between the rural and urban, poor and wealthy population outlined in sections 2 and 6 and the policy move towards privatisation sketched in section 3, exemplified in recent efforts to privatise water supply in Karachi and Lahore, it is important to ensure access of the poor to safe and sufficient water supply. Private suppliers' main objective can realistically assumed to be profit generation rather than universal access. Special attention should therefore be given to regulation that ensures such universal access (Gender and Water Alliance, 2003).

7.3 Water for food

Policies needed to ensure sustainable irrigation management according to Pinstrup-Andersen and Pandya-Lorch (1994) include amongst other things improved access of the poor to productive resources. In this context, Khan et al. (2001) stress the need for land reform in Pakistan in order to counter large farmer's less efficient use of irrigation water. Apart from land reform, the prevalent corruption in the relevant departments is an obstacle on the way to more equitable irrigation water distribution that supports poor farmers development. The South African policy of de-linking land ownership from access to water may effectively ensure landless tenants and women's rights to water.

Gill and Sampath (1992) warn that if no regressivity in irrigation distribution is introduced in the development and distribution of irrigation in Pakistan, then inequality in agricultural income and wealth will increase even further. They outline different types of equity improving irrigation policies. One option is lexicographic ordering, for example in the form of the provision of irrigation water to the group of smallest farmers first, then to the second smallest group and so forth. Alternatively, equal shares could be provided to households independent of the size of their landholdings with the option for the poorer households to trade their water rights.

Apart from the inequality in the distribution of irrigation supply, due to increased demand for water for agricultural needs, water demand management is necessary. This includes water conservation measures in the irrigation systems by considering improvements in crop and water efficiencies, including lining of water courses, sprinkler and drip irrigation, the stimulation of highly profitable and low water-intensive crops, and land levelling (Memon, 2004). Alternatives need to be explored, such as the water harvesting, e.g. the *sailaba* system common in Cholistan whereby people build embankments and bunds to divert the stream and floodwater, the *khushkaba* catchment systems in Balochistan, or hill torrents management through *rud kohi* (Zia and Hasnain, 2000). Such improvements will result in a significant reduction in agricultural water demand with the surplus available for more equitable distribution both in agriculture, for domestic and industrial needs.

During the past 20 years, about 20% of the total number of watercourses have been improved. The Government of Pakistan is being implementing a plan of improving the remaining watercourses during the next five years (Hussain, 2004). In the management of water for food production, one of the indicators of equity in water distribution is that tails must get their proportional share of water. National and international experiences of canal lining to reduce water losses through seepage show that equity conditions at tail can be improved as a result of the lining of canals. In the words of a farmer: “Whatever share of water we are getting is reliable. Before the lining of the minor, the upstream influentials were making cuts frequently and downstream farmers were not sure about getting their share of water”. Improved reliability can lead to improved crop yield, more income, and thus poverty reduction in the farming community (Waheed-uz-Zaman, 2000).

Better drainage and canal lining, leading to less standing water, may reduce the risks of vector-borne diseases (Pinstrup-Andersen and Pandya-Lorch, 1994). However, sections 5 and 6 have underlined the importance of availability of irrigation water for domestic uses and thus for improved health of household members. Measures to improve the efficiency of water supply for agricultural production, such as lining of canals may impact on the availability of water for domestic purposes in communities that are dependent on surface water for washing, cleaning, and drinking. An integrated approach to water management is therefore needed in irrigation schemes, so that the supply of domestic water is given priority when allocating water in time and space within the systems (Van der Hoek, Feenstra and Konradsen, 2002). The role of WUAs should be therefore be extended to integrate domestic water use and other rural development functions.

Access to water, and resource control in general is identified as a critical area of gender disparity in agriculture. Affirmative action in these areas is necessary and includes budgets for gender mainstreaming and significant advocacy as part of government’s, agencies’, and donors’ policies. Apart from the typical extension services of information on methods how to grow various crops and agro-chemical needs extension services should also be able to advice on methods to conserve and manage water to farmers (Gender and Water Alliance, 2003). Providers and beneficiaries of extension services in Pakistan are commonly men despite the crucial role of women in agricultural activities and in water management. Extension training should therefore include gender issues, be directed towards both women and men, and women should be employed in extension services.

7.4 Water storage for human development

Regarding large water storage and power generation projects, the recommendations of the World Commission on Dams (2000) should be taken into account. Again, by bringing to the table all those whose rights are involved and who bear the risks associated with different options for water and energy resources development, the conditions for a positive resolution of competing interests and conflicts are created. EIAs and social impact assessments are legally binding and/or commonly required by the funding agencies involved. However, so far, such assessments were rarely undertaken and the commitment to a participatory approach was a lip service rather than a practical approach.

Given the costs in terms of resettlement, loss of fertile land, inequalities in recompensation schemes, government support for small storage and power plants might be a more feasible option for the future. Alternatives with a more positive impact on human development are available and should seriously be considered. Studies show that, for example, de-silting of Tarbela Dam would yield the same irrigation benefits as building of Kalabagh Dam, but at one seventh of the costs in net present value (Khan, 1999b)[13].

The previous sub-section emphasised the need for a focus shift from attempts to store and increment water supply to water conservation and use efficiency. This might also be the more economic option. Hussain (2004) underlines that resource development strategies at the macro level are expensive and time-consuming, while conservation measures at micro level are relatively inexpensive, feasible and workable. Still, there is a wide-spread imbalance between investment in large projects and capacity building.

7.5 Outlook

Pakistan's water challenge is that of protecting human health and life from water scarcity, the resource's inequitable distribution, its pollution, and from water-related natural disasters, seriously hampering human development in the country. The preceding sections have highlighted the limited success of water management in providing safe and sufficient water to all users, despite the fact that the country is not water poor. The government has committed itself to increased access to safe water supply in the Ten Years Perspective Plan (2001-2011), with the Millenium Development Goals, and even the constitution guarantees in Article 38 that the state shall provide basic necessities of life, irrespective of their sex, or socio-economic background (Islamic Republic of Pakistan, no date).

It is questionable whether the challenges can be met and the government's own targets can be achieved with less government engagement in water management as foreseen in the Ten Years Perspective Plan.

As the previous sections have shown, the following points, however, are crucial in order to achieve that Pakistan's water interventions better serve human development:

- A genuinely participatory approach has to include the voices, concerns and knowledge of all stakeholders, in particular women and the poor in water management;
- Landed and bureaucratic power structures have to be tackled pro-actively;
- Capacity building has to be prioritised over building of infrastructure alone. It needs to take place in user groups, and in the government agencies;
- Economic incentives, such as secure property rights, can help to improve access to water for the marginalized and more efficient use of the scarce resource;
- The health implications of water management should be assessed before embarking on specific water-related interventions;
- Due to the potential for harmful consequences for human development, water conservation should be given priority over large storage projects. If they are constructed, EIAs and social assessments should be conducted with true stakeholder participation.

[13] WAPDA however, considers this an unprecedented option with adverse affect the downstream hydropower projects of Ghazi-Barotha and Chashma (Asianics Agro-Dev. International, 2000).

Abbreviations

ADB	Asian Development Bank
AWB	Area Water Board
BOD	biochemical oxygen demand
CRBIP	Chashma Right Bank Irrigation Project
DDAC	District Development Advisory Committee
EC	European Community
EIA	environmental impact assessment
EPA	Environmental Protection Agency
ERNP	Environmental Rehabilitation in NWFP and Punjab
FAO	Food and Agriculture Organization of the United Nations
FEMA	Federal Emergency Management Agency
FO	farmers organisation
GATS	General Agreement on Trade in Services
GDP	gross domestic product
ha	hectare(s)
HCI	head count index
HIA	health impact assessment
IEE	Initial Environmental Examination
INPIM	International Network on Participatory Irrigation Management
JICA	Japan International Cooperation Agency
LBOD	Left Bank Outfall Drain
LGRDD	Local Government and Rural Development Department
LITE	Landhi Industrial Trading Estate
m3	cubic meter(s)
MAF	million acre feet
NCS	National Conservation Strategy
NDP	National Drainage Programme
NEQS	National Environmental Quality Standards
NGO	non-governmental organisation
OFWM	On-Farm Water Management
O&M	operation and maintenance
OPP	Orangi Pilot Project
PHED	Public Health Engineering Departments
PIDA	Provincial Irrigation and Drainage Authority
PIEDAR	Pakistan Institute for Environment Development Action Research
PIHS	Pakistan Integrated Household Survey
RAP	Revised Action Programme
RBOD	Right Bank Outfall Drain
RWSS	rural water supply schemes
SAP	Social Action Programme
SDPI	Sustainable Development Policy Institute
SITE	Sindh Industrial Trading Estate
TDS	Total Dissolved Solids
UN	United Nations
UNDP	United Nations Development Programme
UNCHS	United Nations Center of Human Settlements

USD	United States Dollar
WAPDA	Water and Power Development Authority
WASA	Water and Sanitation Authority
WUA	water user association
WCD	World Commission on Dams
WFP	World Food Programme
WHO	World Health Organisation
WRI	World Resources Institute
WTO	World Trade Organisation
WUF	water user federation
WWAP	World Water Assessment Programme
WWF	World Wildlife Found

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Water and Environmental Sustainability

By

Vaqar Zakaria

Country Water Resources Assistance Strategy
Background Paper # 3
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Abbreviations and Acronyms

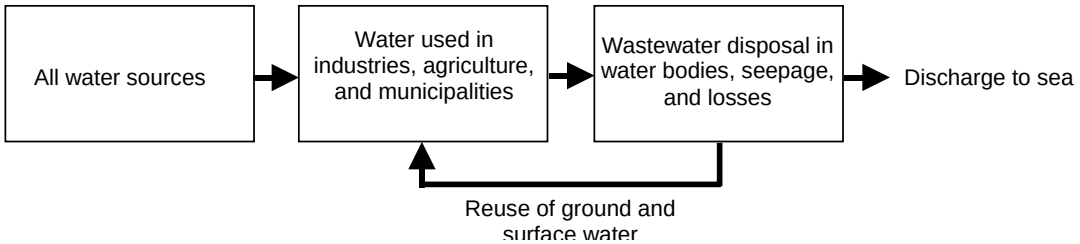
ABCD	Activity Based Capacity Development
ADB	Asian Development Bank
AEMS	Ambient Environmental Monitoring System
bcm	Billion Cubic Meter
BOD	Biological Oxygen Demand
CBD	Convention on Biological Diversity
CBOs	Community-Based Organizations
CETP	Common Effluent Treatment Plant
CITES	International Trade of Endangered Species of Flora and Fauna
CIWC	Central Indus Wetlands Complex
CMS	Convention on Migratory Species
COD	Chemical Oxygen Demand
CPP	Cleaner Production Program
CSEA	Country Strategic Environment Assessment
DMP	Drainage Master Plan
EA	Environment Assessment
EAS	Environmental Assessment System
EIA	Environmental Impact Assessment
EPAs	Environmental Protection Agencies
EPB	Export Promotion Bureau
EPD	Environmental Protection Department
ETPI	Environmental Technology Program for Industry
FPCCI	Federation of Pakistan Chambers of Commerce and Industry
HAZMAT	Handling and Disposal of Hazardous Substances and Waste
IBIS	Indus Basin Irrigation System
IBP	Indus Basin Project
ICTP	Introduction of Cleaner Technologies in Tannery Clusters of Punjab
IEE	Initial Environmental Examination
IUCN	World Conservation Union
IWT	Indus Waters Treaty
JICA	Japan International Cooperation Agency
KIE	Korangi Industrial Estate
LBOD	Left Bank Outfall Drain
M&E	Monitoring and Evaluation
MAF	Million Acre Feet

MCWC	Makran Coastal Wetlands Complex
mg/l	Milligram per liter
m^3/yr	Cubic Meter per Year
MoE	Ministry of Environment
MTR	Mid Term Review
NAWC	North-west Alpine Wetland Complex
NCCW	National Council for Conservation of Wildlife
NCPCs	National Cleaner Production Centers
NCS	National Conservation Strategy
NEAP	National Environment Action Plan
NEIMS	National Environmental Information Management System
NEQS	National Environmental Quality Standards
NGOs	Non Government Organizations
NORAD	Norwegian Agency for Development Cooperation
NWFP	North West Frontier Province
NWMC	National Wetland Management Committee
OWMP	On-Farm Water Management Program
PAs	Protected Areas
PEP	Pakistan Environment Program
PEPA 1997	Pakistan Environmental Protection Act 1997
PEPC	Pakistan Environmental Protection Council
PTA	Pakistan Tanners Association
PWP	Pakistan Wetland Project
REIP	Rawalpindi Environmental Improvement Project
SCARP	Salinity Control and Water Reclamation Project
SMART	Self Monitoring and Reporting Tool
SRWC	Salt Range Wetlands Complex
UNCED	UN Conference on Environment and Development
UNIDO	United Nations Industrial Development Organization
WAP	Wetlands Action Plan
WAPDA	Water and Power Development Authority
WMC	Wetland Management Committee
WSS	Water Supply and Sanitation
WWF	World Wide Fund for Nature

1. State of the Water Bodies

Utilization of water in Pakistan, as illustrated in **Exhibit 1.1**, is characterized by a high level of efficiency with intensive re-use and minimal outflows. Such a pattern of water utilization is typical of river basins worldwide, where the demand for water from the economic sectors is high and the outflows into the sea are generally perceived as wastage and of low economic value. An outcome of such a pattern of water utilization, particularly in the absence of environmental management, is accumulation of salts and pollutants through the system with specific locations coming under environmental stress due to deterioration in soil and water quality. Another characteristic of such systems is relative abundance of water in the upper reaches of the river basins and canal systems where the water tables tend to be high and cost of groundwater extraction is low, as compared to the lower reaches and deltas that are water deficient, have to accommodate drainage and urban effluents, and are subject to periodic flooding.

Exhibit 1.1: The Water Sector



This paper reviews the state of the water sector environment in Pakistan, and discusses the issues and options in environmental management of the water sector. The paper covers both the 'brown' issues related to wastewater outflow from the municipalities and industries and use of pesticides and fertilizers in the agriculture sector, and the 'green' issues related to the impacts of water quality, flows and availability on the water bodies and wetland ecosystems.

1.1 Freshwater Supply and Use

Pakistan's freshwater supply is primarily based on a single source, the Indus River Basin. There are other smaller rain-fed basins in southern Balochistan; however, the perennial supply of these basins is insignificant compared to the Indus Basin supply. The Indus Basin system receives about 100 MAF of freshwater annually from glacier melt,

snowmelt and rainfall (see **Exhibit 1.2**).[1] The surface water supply from the Indus River system is augmented by about 50 MAF of groundwater. The figures are based on long-term averages derived from typical data.

The water management of the Indus Basin is governed by the demands of the agricultural farmlands. Almost the entire river flow is diverted through a network of dams, barrages, and canals for irrigation. Agriculture uses about 95% of the total available water resources, with the urban demand (household, industrial and commercial) accounting for the balance. An estimated 40% of the river water supplied to the agricultural sector seeps through the canal system, distributaries, minors, and watercourses[2]. The field application losses of canal and groundwater are estimated to exceed 30%. Seepage from canals and irrigation is thus a major source of groundwater recharge and storage, from where it is extracted mainly for agricultural use. Domestic consumption is estimated at 70% of the total non-agricultural water consumption. Except for few major cities, most of the non-agricultural sectors are supplied by groundwater sources. Wastewater from the municipalities and industries drains mainly into the surface water bodies and is reutilized downstream.

The freshwater inflow in the Indus Basin does not have a regular pattern; the flow varies seasonally as well as on a year-to-year basis. There has been a pronounced decline in flows since 1999 due to a reduction in rain and snowfall in the basin's catchment area. During this period the freshwater supply has remained about 30% below average. A consequence of the decline in river flow is the near cutoff of freshwater supply to the Indus delta, where regular flows are required to avoid sea intrusion. In the 53-month period between November 1999 and March 2004, no flow was recorded downstream of Kotri Barrage during 35 months; monthly flow exceeded the 1 billion cubic meter (bcm)[3] (0.8 MAF), the mark indicated in the 1991 water sharing accord between the four provinces, for only three months.[4]

1.2 Wastewater Production and Treatment

The estimated wastewater production by various sectors is shown in **Exhibit 1.2**. As shown in **Exhibit 1.3**, ten large urban centers of the country produce more than 60% of the total urban wastewater (household, industrial and commercial). Domestic waste containing household effluent and human waste is either discharged directly to a sewer system, to natural drains or water body, is released to a nearby field, or is discharged to an internal septic tank. It is estimated that only some 8% of urban wastewater is treated in municipal treatment plants, where treatment is at best partial owing to poor

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[1] The Indus Basin is fed by two sets of rivers, the western rivers—the Jhelum, Chenab and Indus, and the eastern rivers—the Ravi and Sutlej. All these rivers rise in territories that are under the administrative control of India. The western rivers constitute the main source of surface water for Pakistan, as the waters of the eastern river were allocated to India under the Indus Water Treaty signed between India and Pakistan in 1960.

[2] Pakistan Public Expenditure Review: Accelerated Development of Water Resources and Irrigated Agriculture. First Draft. Islamabad: The World Bank, 2003.

[3] 140 million acre feet (MAF) in the traditional units.

[4] Statistical Data Collection of the Coastal Belt, Volume 1. Forest and Wildlife Department, Government of Sindh and Sindh Development Studies Centre, University of Sindh. June 2004.

performance levels, and compliance with the NEQS for municipal effluents is not achieved. Examples are the TPII and TPIII near SITE in Karachi operated by the Karachi Water and Sewerage Board (KWSB) and the treatment plant operated by the Capital Development Authority (CDA). The treated wastewater generally flows into open drains, and there are no provisions for reuse of the treated wastewater for agriculture or other municipal uses.

Exhibit 1.2: Annual Water Availability and Use and Wastewater Production in Pakistan[5]

	Raw Water			*Wastewater*	
	(MAF)	*(bcm)*	*Percentage*	*(bcm)*	*Percentage*
Available					
Indus Basin	100.0	123.31	71.4		
Groundwater	50.0	61.65	35.7		
Less outflow to sea	-10.0	-12.33	-7.1		
Total available	**140.0**	**172.7**	**100.0**		
Use					
Industry	0.6	0.69	0.4	0.39	3.1
Commercial/institutional	0.4	0.52	0.3	0.29	2.4
Urban residential	2.3	2.90	1.6	1.62	13.1
Rural residential	4.4	5.44	3.1	3.05	24.7
Agriculture	132.3	163.13	94.5	6.99	56.6
Total use	**140.0**	**172.69**	**100.0**	**12.33**	**100.0**

Source: Hagler Bailly Pakistan

[5] Source: Pakistan's Wetlands Action Plan, 2000, prepared by NNCW and WWF,

Exhibit 1.3: Wastewater Produced Annually by Towns and Cities

City	*Urban Population (1998 Census)*	*Total (Million m^3/yr)*	*% of Total*	*% Treated*	*Receiving Water Body*
Lahore	5,143,495	287	12.5	0.01	Ravi River, irrigation canals, vegetable farms
Faisalabad	2,008,861	129	5.6	25.6	Ravi River, Chenab River, agriculture
Gujranwala	1,132,509	71	3.1		SCARP drains, vegetable farms
Rawalpindi	1,409,768	40	1.8		River Soan, vegetable farms
Sheikhupura	870,110	15	0.7		SCARP Drains
Multan	1,197,384	66	2.9		Chenab River, irrigation canals, vegetable farms
Sialkot	713,552	19	0.8		Ravi River, irrigation canals, vegetable farms
Karachi	9,339,023	604	26.3	15.9	Arabian Sea
Hyderabad	1,166,894	51	2.2	34.0	Indus River, irrigation canals, SCARP Drains
Peshawar	982,816	52	2.3	36.2	Kabul River
Other	19,475,588	967	41.8	0.7	
Total Urban	**43,440,000**	**2,301**	**100.0**	**7.7**	

Source: *Master Plan for Urban Wastewater (Municipal and Industrial) Treatment Facilities in Pakistan*. Final Report. Lahore: Engineering, Planning and Management Consultants, 2002

The industrial subsectors of paper and board, sugar, textile, cement, polyester yarn, and fertilizer produce more than 80% of the total industrial effluents. However, in terms of the pollutant loads, the subsectors of serious concern are the paper and board, sugar, leather tanneries and polyester as they produce about 95% of the industrial pollutant load.[6] Selected pollutant load of industrial effluent is given in **Exhibit 1.4**.

The Kasur Water Treatment Plant is the only common effluent treatment plant for industrial wastewater that is currently functioning in the country. The plant was designed to treat a maximum of 13,000 m^3 of tannery effluent per day, and only partially meets the NEQS for industrial effluents. The common effluent treatment plant (CETP) being established in the Korangi Industrial Estate (KIE) in Karachi, will treat the industrial wastewater from the tannery zone as well as adjacent residential areas. Its reported

[6] Measured in terms of the biological oxygen demand and chemical oxygen demand.

design capacity is approximately 43,000 m^3/day.[7] In-house effluent treatment plants have been set up by some multinational companies in the fertilizer, paper, pesticides and pharmaceutical industries, and by some major exporting units in the textile industry to comply with environmental requirements of the importers and importing countries. However, the performance of the treatment capacity in terms of compliance with the discharge standards varies widely, and the combined environmental impact of these plants is insignificant in comparison with that of the total industrial effluent discharged in the country.

Exhibit.1.4: Wastewater Characteristics in Selected Industries in Pakistan

Sectors	*BOD (mg/l)*	*COD (mg/l)*	*Cr (mg/l)*	*Fe (mg/l)*	*Cu (mg/l)*	*Zn (mg/l)*	*Sulfides (mg/l)*	*Sulfates (mg/l)*	*Chlorides (mg/l)*
NEQS (Surface Water)	80	150	1.0	2.0	1.0	5.0	1.0	600	1,000
Textiles	300 -800	350 -1,200	0.3				15		
Paper and board	1,500 -2,300	7,500 -9,000		55	2.1	14			
Sugar	2,000	4,380							
Leather tanneries	1,200 -1,350	3,500 -4,000	10 -30				70 -80	800 -1,000	300 -3,200
Polyester	1,000	2,500							
Residential	285 -1,580	688 -2,640							

Sources: Field measurements by Hagler Bailly Pakistan, 2003
Background on Water, Air, and Marine Pollution in Pakistan. Islamabad: The World Bank, 1995

1.3 Water Quality

There is very little separation of municipal from industrial effluent in Pakistan, and both flow directly into open drains, which then flow into nearby natural water bodies. In the absence of the latter, the effluent collects in stagnant pools, within residential areas or near industrial plants. There is no regular monitoring program to assess the water quality of the surface and groundwater bodies. Sporadic surveys have been undertaken under various projects. In **Exhibit 1.5**, the water quality data is summarized for various surface waters of the country. There is no ambient or surface water quality standard in Pakistan. A comparison of the quality of surface water with the effluent discharge standard clearly demonstrates the extent of pollution in the water bodies due to the discharge of industrial and municipal effluent.

[7] Private communication with project consultants

Exhibit 1.5: BOD and COD Values of Natural Water Streams

Sampling Location	*No of Samples*	*BOD (mg/l*	*COD (mg/l)*
NEQS (into Inland Waters)		**80**	**150**
Streams draining into Leh Nala (Islamabad)	13	6.8-139.3	18.4-357.5
Natural Water Streams Joining the Soan River (Islamabad)	7	0-42.6	7-68.7
Tributaries Originating from the Eastern Side of the Ravi River (Lahore)	8	110-449	111.8-862
Tributaries Originating from the Western Side of the Ravi River (Lahore)	5	16-159	77.6-2,383
Ravi River (2000)	7	7.1-63	16.9-165.6
Indus River and Adjacent Water Bodies (2002)	14	21.7-84	38-170
Lyari River (Karachi)	12	219	650
Malir River (Karachi)	10	432	1,250

Sources: *Investigation of Air and Water Quality (Lahore, Rawalpindi, Islamabad)*: Japanese International Corporation Agency (JICA), 2000
Investigation on Industrial Water Quality. Islamabad: Japan International Cooperation Agency (JICA)/Pakistan Environment Protection Agency, Government of Pakistan, 2001
Pilot Water Quality Monitoring Program in Sindh. Draft Final Report. Karachi: Sindh Environment Protection Agency, Government of Sindh, 2002

The discharge of effluent into freshwater bodies and on land has also affected groundwater. Pakistan Council Research in Water Resources (PCRWR) launched a national program in 2001 for monitoring the quality of water in the country. In the first phase of the program, 287 drinking water samples from 21 cities of the country were analyzed. Arsenic was found above the WHO limit of 10 ppb in some samples collected from 8 cities. All samples collected from 4 cities and almost 50% of the samples collected from 17 cities had bacteriological contamination. Although limited scientific evidence is available, measurements in industrial areas of Karachi have revealed presence of lead chromium and cyanide in groundwater samples.[8] The same metals were also found in the Malir and Lyari rivers flowing through Karachi and discharging into sea. Samples collected from Karachi harbor have also revealed presence of trace metals in them in concentrations far exceeding any other major harbor.[9]

About 5.6 million tonnes of fertilizer and 70 thousand tonnes of pesticides (GoP, 2003) are consumed in the country every year. Pesticide use is increasing annually at a rate of about 6%. Pesticides, mostly insecticides, sprayed on the crops mix with the irrigation

[8] Investigation of Industrial Water Quality: Japan International Cooperation Agency (JICA)/Pakistan Environment Protection Agency, Government of Pakistan, 2001

[9] Background on Water, Air, and Marine Pollution in Pakistan. Islamabad: The World Bank, 1995.

water, which leaches through the soil and enters groundwater aquifers. The quantity or quality of agricultural runoff has not been measured or tested at the national level. In 107 samples of groundwater collected from various locations in the country between 1988 and 2000, 31 samples were found to have contamination of pesticides beyond FAO/WHO safety limits.[10] A pilot project was undertaken in 1990-91 in Samundari, Faisalabad District over an area of 1,000 km^2, to look into the extent of groundwater contamination by agrochemicals. In an analysis of 10 groundwater samples drawn from a depth of 10-15 m, seven were contaminated with one or more pesticides (PCRWR, 1991). The study concluded that the contamination had reached only the shallow aquifers, however, there were evidences that it was gradually reaching the deeper aquifers as well. As there has been a four-fold increase in the use of pesticide use in the country since 1990, the contamination levels are likely to have increased significantly.

1.4 Wetlands and Coastal Ecosystems

Pakistan's Wetland Resources

Pakistan possesses a great variety of wetlands from Indus delta to the high Himalayas. Area of inland waters in Pakistan has been estimated at 7,800,000 ha (Naik, 1986)[11], distributed in rivers and canals, water reservoirs, natural lakes, ponds, dhands, fish farms and delta marshes. Pakistan ratified the Convention on Wetlands of International Importance (the Ramsar Convention[12]) in 1976, and initially designated nine sites for inclusion in the list of Ramsar sites. The Pakistan's Wetlands Action Plan (WAP), recently prepared by WWF-Pakistan and NCCW gives an overview of 53 important wetlands of Pakistan and describes their location, area, threats and management status. **Exhibit 1.6** shows location of important wetlands in the country. Adopting classification system of the Ramsar convention, IUCN's Directory of Asian Wetlands and the WAP place Pakistan's wetlands into eighteen categories, description and examples of which are provided in **Exhibit 1.7**. Majority of the important wetlands identified in Pakistan are man-made reservoirs (31%), brackish lakes (35%), and fresh water lakes or dhands (17%). The other types include mangroves, lagoons and river stretches.

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[10] Policy and Strategy for Rational Use of Pesticides in Pakistan. Building Consensus for Action. Islamabad: United Nations System in Pakistan Publication, 2001.

[11] Naik, I.U. 1986. Inland fisheries and aquaculture in Pakistan: review of the progress and new activities. Paper presented at FAO/IPSC workshop on strategies for the management of Fisheries and Aquaculture in Mangrove ecosystems, Bangkok, Thailand, 23-25 June 1986.

[12] Wetlands are described as "areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporal, with water that is static or flowing, fresh, brackish or slat, including areas of marine water, the depth of which at low tide does not exceed six meters" (Ramsar Convention, 1971).

Exhibit 1.6: Pakistan's Wetland Resources

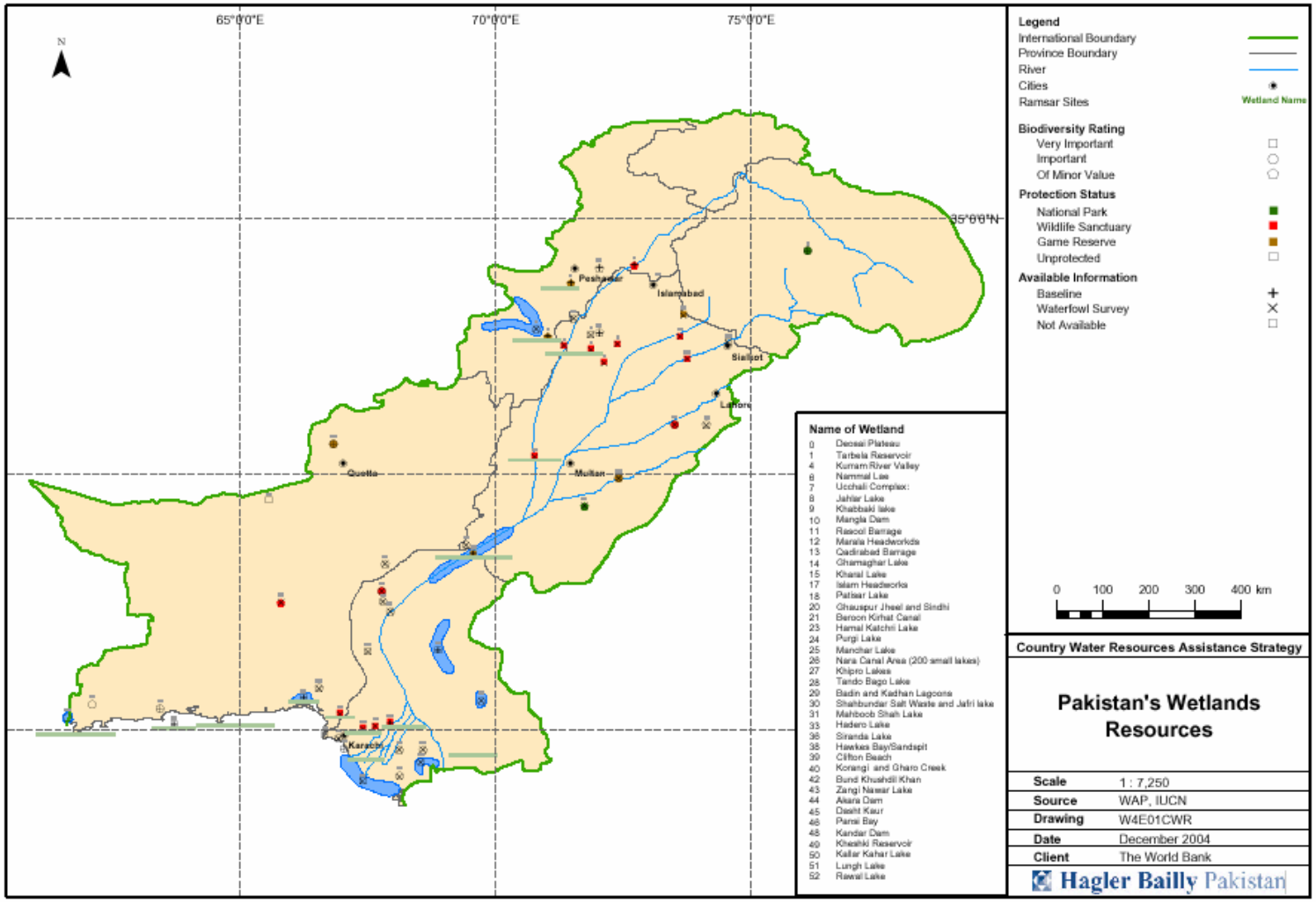

Exhibit 1.7: Wetland Types and their Representative Sites in Pakistan[13]

	Type	*Example*
1.	Shallow sea buoys (under six metres of low tide)	Miani Hor (Balochistan)
2.	Estuaries, deltas	Korangi and Gharo Creeks, Indus Delta (Sindh)
3.	Small offshore islands, islets	Astola Island, (Balochistan), Churna Island (Sindh)
4.	Rocky sea coasts, sea cliffs	Cape Monze, Paradise Point (Sindh) Gwadar coast and Jiwani coast (Balochistan)
5.	Sea beaches (sand, pebbles)	Jiwani coast, Gwader (Balochistan) Hawkes Bay/Sandspit beaches and Clifton beach, (Sindh)
6.	Intertidal, mudflats, sand flats	Pasni Bay (Balochistan), the Outer Indus Delta, Tidal link off Indus Delta (Sindh)
7.	Mangrove swamps, mangrove forest	Miani Hor, Kalmat Khor, Gawatar Bay (Balochistan), the Indus Delta, Korangi and Gharo Creeks, and adjacent creeksHawkes Bay/Sandspit (Sindh)
8.	Coastal Brackish and saline lagoons and marshes	Sonmiani, Jiwani lagoons (Balochistan) Num, Kadhan (Sindh)
9.	Rivers, streams-slow-flowing (lower perennial)	Kurram River Valley (NWFP), Dasht Kaur, Shadi khor (Balochistan) River Indus (Sindh)
10.	Rivers, streams-fast-flowing (upper perennial)	Deosai Plains (Northern Areas), River Swat, (NWFP)
11.	Riverine marshes	Taunsa Barrage (Punjab), Sujawal, River Indus (Sindh) DI Khan, (N.W.F.P.)
12.	Freshwater lake and associated marshes (lacustrine)	Keenjhar (Kalri), Rap Lake, Haleji Lake (Sindh)
13.	Freshwater ponds (palustrine)	Beroon Kirthar, Nara Canal with associated marshes, swamps, Marshes, Sadhori Lake, Khipro Lake (Sindh)
14.	Salt lake, saline marshes (inland drainage system)	Hadero Lake (Sindh), Zangi Nawar Lake, Siraandha Lake (Balochistan), Ucchali complex (Punjab), Soonhari Akan wari (Sindh)
15.	Water storage reservoirs, dams	Bund Khushdil Khan, Akra Kaur Dam (Balochistan), Haleji Lake (Sindh), Hub Dam (Sindh/Balochistan), Tarbella Dam, Baran Dam and Tanda Dam (NWFP)
16.	Salt pans (artificial)	Korangi Creek, Sandspit (Sindh), Kalmat Khor (Balochistan)
17.	Shrimp ponds, fish ponds	Coastal areas of Sindh and Balochistan, fish ponds in the Punjab
18.	Seepage lagoons and lakes	Coastal areas of Sindh and Balochistan, fish lakes of Nara Canal

[13] Source: Pakistan's Wetlands Action Plan, 2000, prepared by NCCW and WWF

The WAP places special emphasis on coastal and estuarine wetlands. These are considered as the sites of rich biodiversity and the most fragile ecosystems in context of ongoing deterioration. These wetlands serve as spawning, rearing and nursing grounds for shrimps, lobsters and fish, and provide breeding, migration and wintering grounds for thousands of migratory waterfowls and other birds. About 200 species of fishes have been reported from the delta area. The coastal zone of Sindh is considered to be a highly productive area in terms of photosynthetic processes and biodiversity. It is reported that the productivity is about ten times the average values of the world ocean and about four times the average value of the Indian Ocean. Shrimps account for about 60% exports in terms export value. The shrimp catch of Sindh during 1999 was about 24,900 of which more than half is exported.

The mangroves have traditionally been used as a source of wood for construction. However, today the residents of the coastal villages mainly use them as a source of fodder for livestock and as a source of fuel, except for very poor who cannot afford any other timber. Professional graziers from interior of the Sindh province bring large number of camels to the coastal lands for grazing and browsing mainly during the flood season.

The wetlands of Pakistan provide a diverse range of freshwater and brackish habitats that support a wide variety of biodiversity including globally significant species and genomes. A review of the vertebrate species dependent or associated with wetlands reveals a diverse picture. Eighteen threatened species of mammals including two endemics (Punjab urial and Indus dolphin), 20 threatened species of birds, 12 reptiles either threatened or data deficient, at least two endemic amphibians, 198 indigenous freshwater fishes including fifteen endemics, and 788 marine fish species are known to be associated with wetlands. Examples of key values and functions of wetlands in Pakistan include:

- Flood control; Kinjhar and Haleji lakes have been lodging Indus floods, while Manchar lake accommodates water from Indus and also from torrential hill streams.
- Ground water replenishment; most of the Indus basin has arid climate where ground water recharge from precipitation is limited. Wetlands in such areas are valuable source of ground water recharge, for example Hub reservoir in Balochistan.
- Shoreline stabilization and storm protection; lakes along the coastal line like Pateji and Cholri have been reducing sea water intrusion upstream until recently, and accommodate water during floods and storms to reduce damage in coastal areas.
- Reservoirs of biodiversity; Haleji lake holds 60,000 to 10,000 ducks and coots in mid-winter[14].
- Ecosystem services; a large fisherman community is dependant on Manchar lake for subsistence.
- Recreation and tourism and cultural importance; Haleji lake in Sindh, Taunsa barrage in Punjab and Sheosar lake in the Northern Areas attract visitors.
- Support local economy and cottage industries; baskets made from typha are an important economic activity in all central and lower Indus basin.

[14] IUCN's Directory of Asian Wetlands

Threats to Wetlands

The wetlands have generally been considered as waste lands in past, and have been used for drainage of water, reclaimed for agriculture, or treated as dumping grounds for all kind of refuse. The resources like fish, mangroves, birds, etc have been harvested indiscriminately without any attempt to regulate their exploitation. Around 36% of the wetlands are facing a high level of threat, 30% are facing threats at medium level, while the threats for the remaining 34% are not known. Major threats to the wetlands in Pakistan are summarized below:

- Floods in post Tarbella period cover less than 25% of the flood plains (WCD Case Study, 2000)[15]. Lower flooding along with construction of *bunds* has significantly reduced riparian forests. A species shift from A*acacia* to exotic *Prosopis* is common in riverine areas. This has threatened many mammal species including the hog deer.
- Estimates undertaken using satellite imagery since 1970s show a steady decline in mangrove coverage in the Indus Delta. A 1977 estimate reported coverage of 263,000 ha; a 1990 study estimated 160,000 ha of mangrove forests; and the latest estimate undertaken by SUPARCO in 2003 reported that 106,090 ha of mudflats are under the mangrove forests along the coast of Sindh. The decline in forest cover is attributed to reduction in freshwater outflow in the delta and the consequent decrease in alluvial flow and nutrients.
- Some of the drainage systems have reduced recharge of the wetlands and changed their habitats by discharging saline effluents into the wetlands. Many coastal lakes like Pateji were fresh water lakes prior to the LBOD project. A large concentration of many wintering species like Greater Flamingos have been recorded on these lakes that do not exist now.
- Land reclamation for various purposes particularly for agriculture has eliminated many wetlands. HBP (2000)[16] studied evolution of wetlands in Thatta and Badin districts by comparing 13 years old SoP sheets with recent field surveys. Several lakes had either reduced considerably in size or had completely dried up. Rice cultivation was the most common land use in these areas.
- Discharge of sewage, effluents, irrigation and industrial waste is putting a serious stress on aquatic ecosystems. Almost all sugar mills in Sindh are discharging their effluents in drains. Haleji and Lal Suhanra lakes are facing the threat of eutorophication (WAP, 2000)[17]. In a survey of 25 wetlands in Thatta and Badin districts around 80% were receiving pesticides and fertilizers (HBP, 2000). Jhaj, Babri and Sareji dhands have lost most of their historic biodiversity (HBP, 2000).

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[15] WCD Case Study. 2000. Tarbela Dam and Related Aspects of the Indus River Basin. Prepared by Asianics Agro-Dev. International (Pvt) Ltd.

[16] Hagler Bailly Pakistan (HBP). 2000. IEE of Seismic Survey in Mehran Block. Prepared for BP Pakistan Exploratoin and Production, Inc., Karachi.

[17] Pakistan's Wetlands Action Plan (WAP). 2000. Prepared by WWF-Pakistan and National Council for the Conservation of Wildlife (NCCW).

- Over exploitation of biological resources like food, feed and fuel has degraded large wetlands. Kinjhar and Manchar lakes are important examples.
- Sea-water intrusion and storms in coastal areas has destroyed ecosystem of a large number of lakes. Kalkani, Khadi and Jhim dhands are important costal wetlands that have become saline in recent years.
- Unregulated harvesting of wildlife species particularly hunting and trapping of waterfowls is causing a steep decline in populations. Chachh dhand in Thatta district supports a good population of waterfowls. However, population of wintering birds is declining rapidly due to excessive hunting. All dhands along the Nara canal are facing similar threats.
- Introduction of exotic species in lakes for example fish species is a serious threat for the population of indigenous species. Carp introduced in the Kallar Kahar lake are proliferating at the expense of indigenous species.
- Unmanaged tourism is also a significant threat to the wetlands. Major hazards associated with tourism are damage to vegetation, killing or capturing wildlife, and littering. Haleji lake, Mangla reservoir and Sheosar lake in the Northern Areas are examples.
- Climate change is also a potential threat though the nature and magnitude of impacts is not well understood.

2. Management of Pollution from Industrial, Municipal, and Agricultural Sources

2.1 Overview of the National Policy and Institutional Setup and Limitations

A description of the national policy and institutional framework for environmental management and its evolution is included in **Appendix A**. The environmental institutions in Pakistan have some important environmental achievements to their credit. Their strengths include a substantially consultative approach involving a broad representation of stakeholders in policy and strategy assessment and development of regulations and program initiatives as demonstrated by preparation of the National Conservation Strategy (NCS) in 1993, the passage of the Pakistan Environmental Protection Act in 1997, and the initiation of the National Environmental Action Plan (NEAP) in 2002.

While a comprehensive national policy and institutional framework for environmental management is in place, there are significant weaknesses in the current administrative and implementation capacity that are typical of developing country settings. Principal among these are a ubiquitous shortage of trained manpower and insufficient budgetary allocations, a lack of clear definition of roles, workplans and targets, and ineffective coordination and communications between federal, provincial and local administrative entities. The result is that, while an appropriate and necessary administrative capacity exists on paper, its effectiveness is seriously curtailed in practice due to these shortcomings. For example, the NEQS for industry and municipal discharges were originally formulated in 1993, but even voluntary compliance and reporting have yet to be instituted because of a lack of practical monitoring ability in the EPAs; the environmental assessment system (EAS) is mandatory but seldom followed in the public sector; and environmental laboratories have been established in all provinces but function with skeletal staff and budgets inadequate even for their routine equipment and chemical needs. Similarly, environmental tribunals have been created but their capacity to deal with reported cases is extremely restricted, as minimal personnel have been deputed in only two provinces to collectively oversee the entire country.

2.2 Past Initiatives, Current Developments, and Lessons Learnt

Recognizing the limitations of command and control mechanisms that rely mainly on regulatory provisions and extensive administrative capacity in the enforcement agencies, there have been a number of initiatives to address environmental management through incentive based and participatory approaches. The experience gained and the lessons learnt through the implementation of such initiatives are summarized below.

2.2.1 Industrial Polution Control and Wastewater Treatment

Examples of initiatives that have been attempted in the industry sector include a pollution charge system supported by a self-monitoring and reporting package, cleaner production projects to build capacities in the industry, and common effluent treatments plant for selected industry clusters to benefit from economies of scale in wastewater treatment. The following is a brief description of the design and outcomes of these initiatives.

Pollution Charge System

A pollution charge system for the industry was designed in 1997 under the Technology Transfer for Sustainable Industrial Development (TTSID) project implemented by the Sustainable Policy Development Institute (SDPI). The intent behind the proposal was to convert the compliance problem into an economic incentive, where the industries were to be subjected initially to a lower charge, which would gradually increase to a level where the industries would either close down or find it economic to install treatment facilities. The proposal drew on the provisions of the 1997 Act under which the government can levy a fee on the industries for the pollutants that they discharge into the environment. Unfortunately, the pollution charge system could not be implemented, since despite extensive negotiations, industries and the government were unable to agree on how the funds generated through the system would be eventually utilized. Industries were of the opinion that the pollution charges they paid should be used to help them meet the NEQS, through environmental capacity building measures within the industrial sector. Industries also did not want the funds to go into the state treasury, but wanted them to be easily accessible. The government proposed an environmental fund, into which it would deposit matching contributions.

Self Monitoring and Reporting

Parallel to the pollution charge system, a self-monitoring and reporting program was also proposed under the TTSID project to encourage the industries to collect data on their environmental performance. A system labeled as Self Monitoring and Reporting Tool (SMART) was developed to support the pollution charge program. The data collected under the SMART system could be used not only for ensuring industrial NEQS compliance by the EPAs, but also directly contribute to establishing national environmental pollution databases and baselines. The self-assessment could enable large scale coverage of industry on a standardized basis without commensurate external physical monitoring requirements (e.g., by the EPAs), provide a gradual transition towards industrial environmental monitoring, thereby gaining industry confidence and voluntary acceptance, and provide EPAs with experience in data compilation, processing, and analysis, so as to earmark areas, procedures and facilities required for more stringent on-site physical enforcement of environmental regulations later. The SMART system was subjected to pilot tests with some fifty industries participating on a pilot basis. Countrywide implementation of SMART has however been delayed mainly due to lack of financial resources and administrative capacities in the EPAs.

Cleaner Production in Industry

Given the scarcity and value of clean freshwater, and the cost of treating and properly disposing off contaminated wastewater, it is logical to investigate methods for reducing such pollution in the first place by adopting strategies that minimize and conserve freshwater usage, lower the amounts of contamination, and recycle wastewaters after some treatment to reduce the need for fresh supplies. Cleaner production programs have been implemented in the recent past and are presently underway in different industrial clusters around Pakistan are briefly described below.

National Cleaner Production Center Program for Pakistan: UNIDO is presently in the process of setting up national cleaner production centers (NCPCs) for different industries, including for oil refineries at Rawalpindi, textiles and leather industries at Karachi and Sialkot, and multisectoral at Peshawar.

Cleaner Technology Program for Korangi Tanneries: The Pakistan Tanners Association (PTA, Southern Zone) is implementing the Cleaner Technology Program for Korangi Tanneries with financial support from the Royal Netherlands Embassy.

Cleaner Production Program: The Cleaner Production Program (CPP) was a three-year program funded by the Royal Netherlands Embassy that formally came to an end in November 2003. The CPP has targeted the implementation of cleaner production technologies in the major industrial sectors of Pakistan.

Environmental Technology Program for Industry: The Environmental Technology Program for Industry (ETPI) was a joint project of the Federation of Pakistan Chambers of Commerce and Industry (FPCCI) and the Government of the Netherlands.

Introduction of Cleaner Technologies in Tannery Clusters of Punjab: The Introduction of Cleaner Technologies in Tannery Clusters of Punjab (ICTP) project was launched by the Pakistan Tanners Association (Northern Zone) with assistance from the Government of Netherlands in December 1997. Phase I of the project was completed by the year 2000, and Phase II will continue until 2005.

Cleaner Production Centre, Sialkot: The Cleaner Production Centre at Sialkot was established with the assistance of the Export Promotion Bureau (EPB) and the Norwegian Agency for Development Cooperation (NORAD). The overall objective of the project is to control the indiscriminate discharge of potentially harmful solid waste and heavily polluted wastewater.

Common Effluent Treatment Plants (CETPs)

The CETPs in industry clusters offer an economic alternative to the industries in comparison to setting up treatment facilities at the individual industrial units. In addition to lower investment and operating costs, the CETPs allow the industries to allocate scarce land and management resources to production, and shift the burden of compliance and reporting to the CETP operator. The Kasur Tannery Project was the first CETP established in the country with assistance from the UNDP and the Punjab government, and was designed to process the wastewater produced by small and medium sized leather tanning units located in the city. The first phase of the project was commissioned in 2001, and was designed to remove chromium from the wastewater and achieve about

50% reduction in the BOD content. The second CETP has been established in the Korangi Industrial Area in Karachi with support from the Export Development Fund of the Ministry of Commerce and the Netherlands government. This CETP will process wastewater from a tannery cluster located within the industrial area, and is expected to be commissioned shortly after a delay of about two years. The delays are mainly attributable to difficulties in collection of financial contributions from the participating industries.

The ADB initiated the Industrial Efficiency and Environmental Management Project in 2003 with the Ministry of Environment as the executing agency. The IEEM project aims to establish six common effluent treatment plants (CETPs) and two hazardous waste handling facilities (HWHFs) in the country. The two HWHFs will be strategically located with respect to the CETPs, and will process the hazardous sludge produced by the proposed CETPs. The project targets clusters of export-oriented industries such as textile and leather that are under pressure to comply with the local and international environmental standards as required by the importers in the US, Europe, and Japan. Options for additional treatment to produce industrial grade water for recycling are envisioned in the later phases of this project. The implementation package includes financing by local banks supported by an ADB guarantee facility, ownership of the CETP by the industry, and operation and maintenance under contract to a private sector operator. Implementation of this project has also been delayed as the industries have been slow in mobilizing and recognizing the requirements for environmental compliance imposed by the importers, and the requisite support from the government in terms of project coordination, land for the CETPs, and financing arrangements has been slow in coming.

2.2.2 Municipal Wastewater Treatment

A recently completed study calculates the costs of providing proper WSS cover to 90% of Pakistan's population as US$ 4.8 billion, with associated annual recurring costs of US$ 828 million. These are considerably less than the annual health care costs of treating WSS-related diseases (US$ 1.8 to 4.8 billion), the current additional costs of obtaining clean water (probably of a similar order of magnitude), the annual loss in fishery output (about US$ 1 billion), and other unquantified economic impacts of polluted waters, including ecological damage. It is estimated that of these losses, about US$ 2 billion a year would emanate from urban water pollution, while the annual cost of providing a proper WSS infrastructure to the whole of urban Pakistan would only be approximately US$ 0.8 billion. The economic and financial benefits of wastewater treatment and WSS investments are therefore obvious, especially given the current poor status of these in the country.

The approach in the municipal wastewater treatment has relied mainly on public sector for financing and operation of the treatment facilities. As discussed in the Section 1, the municipal wastewater treatment facilities such as TPII and TPIII in Karachi and the treatment plant operated by CDA in Islamabad have not been able to achieve the performance standards set under the NEQS. While the treatment facilities in Karachi were established with support from multilateral financing agencies, the agencies mandated to operate these facilities have not been able to allocate adequate resources for

management and maintenance of these facilities. Complete absence of regulatory or public pressure notwithstanding, the poor standard of water supply and sanitation services, inadequate tariffs and charges for the services provided, and limited capacity to collect revenues from the households and customers served can be considered as the main reasons for the failure. In absence of internal revenue generation, the municipalities and local governments are dependent on financial support from the city and the provincial governments that are already stretched for resources.

2.2.3 Recycling of Treated Wastewater

The incentive for recycling of treated wastewater from the municipal as well as industrial treatment plants varies through the country. Groundwater or surface water can be acquired at a lower cost in Punjab and NWFP where supply is generally abundant, and the only option available is disposal of the treated effluent into the open drains. The option of disposing treated wastewater into canals can also be exercised, but will require stricter monitoring particularly when the canals are closed or in low flow conditions. While this option would yield economic benefit, no additional revenues will be available to the operator of the treatment facility. On the other hand, freshwater supply is limited in Karachi and urban centers of Balochistan such as Quetta, and the price of water is correspondingly higher. To supplement the limited quantities of water available from the city water supply, the industries in Karachi are paying in excess of Rs. 20 per cubic meter for water delivered by private tankers. Recently, a private sector company has submitted a proposal to the SITE Ltd, the authority responsible for operation of the industrial estate, for supply of industrial grade recycled water produced by treatment of municipal wastewater in the existing TPII. The company has proposed to upgrade the existing treatment plant and to install additional purification facility to further process the treated municipal wastewater. The tariff for supply of water to SITE Ltd is presently under discussion. If successful, this venture could set a useful precedent where in addition to environment, both the municipality and the industry would stand to benefit from a self financed and self sustaining private sector operation.

2.2.4 Conclusions and Lessons Learnt

While some projects for CETPs have been initiated in the industry sector and some industries have installed in-house treatment capacity and adopted cleaner production techniques to a limited extent, the environmental performance of the industry sector has largely remained inadequate. It is obvious that in absence of pressures to comply, the industry has adopted a wait-and-see attitude to delay the environmental investments. The only exception are the exporting industries mainly in the textile and leather sectors which are faced with increasing competition from the competitors in the neighboring countries such as China and India, that have moved towards environmental compliance and have opted for the CETP approach where opportunities exist. Programs for treatment of wastewater in the industrial sector will therefore have to focus on the exporting industries in the near term to create models and set trends that the remaining industries can follow. With the passage of time, export related compliance pressures are expected to trickle down to the second and third tier companies that are supplying to the export industries, and the focus can be shifted to this category as well.

While expansion of the municipal wastewater treatment capacity is constrained by availability of public funds, major constraint appears to be the capacity of the concerned agencies to operate and maintain the treatment facilities. Options that can be considered in the near term are combined treatment of municipal and industrial effluents where addition of municipal wastewater facilitates the treatment of industrial effluents such as in case of the Korangi tanneries CETP project. Where markets for treated water exist such as in Karachi, opportunities to finance wastewater treatment through sale of treated municipal wastewater to the industries or possibly to the agriculture or horticulture can also be considered. Where markets for treated wastewater do not exist, enhancement of water charges to reflect true cost of delivering water and improvements in revenue recovery systems to provide resources for financing and operation of municipal wastewater treatment facilities.

2.3 Options for Management of Water Pollution

The analysis of existing environmental challenges, and national capability to respond to these, especially with respect to water pollution, points clearly to several key areas in which concerted further efforts must be made in order to affect real change in the quality of the country's water resources. These include:

- Mobilizing investments for collection and treatment of wastewater, waste reduction, and implementing high priority projects to demonstrate efficient resource use, cleaner production, waste reduction, and water recycling methods and their benefits
- Enhancing supportive policy regime by developing incentive packages and public and private sector participatory frameworks for promotion of investments
- Achievement and quality indicators, baseline data for pollution trend analysis and health impacts with focus on low income groups, and expanding the ambit and scope of water quality standards to include major receiving body benchmarks to
- Developing a commensurate administrative, management and monitoring capacity within designated implementation and enforcement agencies, particularly the municipal agencies and the EPAs, to effectively and meaningfully regulate, evaluate, and remedy pollution impacts in the country with active participation of the stakeholders and impacted groups.

2.3.1 Promotion of Investments for Environmental Management

Based on the review of the past experience and the initiatives being implemented, the options and strategy to promote investments in environmental management is summarized below:

Industry Sector

- Establishment of CETPs targeting export oriented industry clusters supported by incentive packages such as those proposed under the ADB IEEM project
- Establishment of CETPs in other industry clusters supported by incentive and regulatory packages to enhance participation of the individual industries

- Technical assistance to the private sector for planning investments in treatment of effluents, cleaner production, recycling, and waste minimization through projects such as those supported by the Dutch government.

Municipal and Urban

- Development of frameworks for private and public sector partnerships to promote private sector investments and ensure sustainability of the municipal wastewater treatment projects
- Increasing annual allocations for municipal water supply and sanitation systems in public sector development plans.

2.3.2 Other Policy Incentives and Instruments

In addition to enforcement of source and ambient water quality standards, regulatory, economic and market-based instruments that have been used to improve environmental management and protection in other countries include environmental permitting, pollution charge system, tradable pollution permits, and water pricing and effluent discharge fees. Experience with application of pollution charge system in Pakistan has already been discussed earlier this report. Key features and limitations in adopting these instruments in Pakistan are discussed below.

Environmental Permitting

Environmental permits are used to administer control over the activities of individuals/industries for the protection of the environment. Assessing industrial processes for individual industries and issuing industrial unit-specific permits would require enormous administrative capacity in the EPAs. Introducing an environmental permitting system for Pakistani industries therefore does not appear feasible, since the EPAs and other agencies, such as authorities dealing with municipal wastewater, do not presently have the capacity that would be required to implement such a system. Also, monitoring discharges from industries, and ensuring that they meet permit conditions, would be a challenging task for government agencies that at present are not even able to monitor compliance with the few EIAs that are submitted each year.

Tradable Pollution Permits

A tradable pollution permit system is an alternative to pollution charges. Tradable pollution permits allow industries to trade the right to emit specific pollutants. Unlike pollution charges, tradable pollution permits have not yet been seriously considered for implementation in Pakistan. If pollution trading were implemented in Pakistan, some of the major drawbacks that could be expected would be:

- Due to weak governance, the allocation of pollution permits might not reflect actual pollutant discharge levels in industries, but could be influenced by monetary reasons or political pressure.
- An extremely elaborate monitoring mechanism would be required to ensure that industries were not discharging more pollutants than their permits allowed.

Groundwater Water Pricing and Abstraction Management

There is presently no charge for drawing water out of surface water bodies or from groundwater aquifers in Pakistan. There is also no limit on the volume of water drawn. Similarly, there is no fee for discharging effluent, either into open water bodies, or into sewerage systems. This lack of regulation can lead to the excessive use and wastage of freshwater resources, especially in the northern parts of the country where industries mostly use groundwater for their industrial processes. Pricing groundwater in Pakistan would be a monumental task, and would require the installation of meters on wells and a very elaborate monitoring system. Under the present institutional setup, and even if institutions are significantly strengthened, groundwater metering and pricing would be almost impossible to implement.

2.3.3 Indicators, Baselines, Monitoring and Analysis

An effective M&E system would need to identify hot spots and stress points in the entire water delivery and drainage system, as well as scrutinize contributors to their pollution. Indicator sites and systems, including performance indicators for environmental management measures (such as NEQS and EA compliance), would need to be established to assess both the physical and administrative impact of relevant regulations. Specific monitoring indicators and reference benchmarks relevant to water pollution that can be considered are summarized in **Exhibit 2.1**.

Exhibit 2.1: Indicators for Monitoring of Water Quality

Impact Area	*Requirements*
Industrial Effluent Discharges and Hazardous Wastes	☙ Identification of monitoring sites and discharge points that fail to achieve the environmental quality standards ☙ Total pollution loads discharged for each NEQS parameter by geographical region through SMART reports on a periodic basis to identify possible 'hot spots' in the country
Industrial Effluent Discharges and Hazardous Wastes	☙ Identification of monitoring sites and discharge points that fail to achieve the environmental quality standards ☙ Total pollution loads discharged for each NEQS parameter by geographical region through SMART reports on a periodic basis to identify possible 'hot spots' in the country
Municipal Sewage Discharges	☙ Sewage production (actual and estimated based on population data) by region ☙ Capacity and volume of sewage treated in common effluent treatment plants and municipal treatment plants
Pollution Incidents	☙ Documentation of oil spills, chemicals, and accidental release of raw sewage or untreated industrial effluents ☙ Impacts on population, ecosystems, fish and other wildlife, and degradation of the wider natural environment

Continues…

…Continued

Impact Area	*Requirements*
Groundwater Quality and Levels	♋ Regular testing at the indicator sites ♋ Comparison with reference benchmarks, which can be set at background levels measured at relatively pristine locations.
Inland Surface Waters	♋ Biological quality, an indicator of overall 'health' of rivers and lakes ♋ Chemical quality, an indicator of organic pollution in general ♋ Nutrient status, based on phosphate and nitrate in rivers and lakes ♋ Aesthetic quality of selected rivers and lakes
Coastal Waters	♋ Monitoring of hazardous substances discharged to the sea, particularly mercury, cadmium, dioxins, and lead

Development of baselines and indicators to support the M&E systems will require institutional efforts for collection and analysis of environmental data. In addition to implementation of the SMART program that has already been tested, other existing initiatives that can be strengthened and developed are discussed below.

National Environmental Information Management System (NEIMS): The NEIMS proposal prepared by the MoE has recently completed concept clearance. The proposal calls for preparing a comprehensive report on environmental information resources available in Pakistan and the finalization of datasets, indicators and indices for monitoring the state of environment. While SMART specifically addresses industrial pollution discharge monitoring, the data collected under the program would need to be integrated with wider environmental monitoring of water pollution in order to assess priorities and needs of national environmental management.

Ambient Environmental Monitoring System (AEMS): The establishment of an environmental monitoring system to monitor ambient air and water quality around Pakistan has been proposed and approved by the Cabinet, with funding committed by JICA. The water quality monitoring component of the project will consist of a number of permanent and mobile water quality monitoring stations, which will analyze and record water quality constantly at key indicator sites.

Monitoring of Institutional Performance: Development of an internal preformance-monitoring program amongst the EPAs will permit assessment of the institutional outputs. Examples of activities and outputs that can be monitored include total number of EIAs and IEEs received and reviewed during the year by each EPA, and number of SMART industry registrations achieved and data reports received by each EPA.

2.3.4 Building Supportive Administrative and Enforcement Capacity

While incentive based approaches and programs capitalizing on export related external pressures on the industry sector recommended earlier in this report will contribute in the near term, a several-fold increase in the technical, managerial, coordination, and monitoring capacity is required across the board at the Ministry of Environment and in the EPAs, to support the environmental management in the country in the long run. Capacity building initiatives that are presently being implemented or considered for

implementation are described below, followed by recommendations on additional initiatives that will be required for effective management of water pollution.

Capacity Building of EPAs

The following capacity building initiatives have already been earmarked for the federal and provincial EPAs. However, these projects are still in their planning phases and very little progress on actual implementation has taken place so far.

Activity Based Capacity Development Project: A comprehensive capacity building project for the federal and provincial EPAs—'EPA's Activity Based Capacity Development (ABCD) Project'—has recently been proposed.[19] The main objective of this project is to provide support to the environmental protection agencies to improve their environmental regulatory compliance and enforcement mechanisms. The purpose of the project is to help EPAs develop facilities and skills by undertaking various activities grouped together in shape of nine different programs.

Pakistan Green Seal Program: The objective of this program is to accord recognition to the industries that comply with the environmental regulations to facilitate the industries in marketing of their products in the local as well as international markets.

Capacity Building in Other Public Sector and Private Sector Institutions

Training Programs for Staff of Local and District Government: As the WSS investments and functions are being delegated to the local level under the new system of local government, capacity building programs for the officials and staff of the local government institutions in management of water quality have become an immediate requirement.

Training Program for Financing Institutions: Some of the cleaner production measures may require significant investment. In most cases, large industries should be able to finance their own cleaner production measures; however, this may not be possible for smaller industries, which may require funding from financial institutions. Capacity building within financing institutions that would fund such initiatives would therefore be required, enabling them to assess the technical, environmental and economic viability of proposed cleaner production projects.

2.4 Opportunities for Engagement by the World Bank

A matrix for reforms shown in **Exhibit 2.2** summarizes the priority measures and actions in the water sector to manage water quality and its impact on populations. The reform matrix lays out the outline of a roadmap for transitioning to a more meaningful and effective policy, legislative and capacity environment by focusing on the proper execution of existing planned actions and resolution of immediate concerns with a view to building a sustainable and increasingly sophisticated national environmental management regime in the future, similar to that existing in more developed countries. In

[19] Concept submitted in July 2004

terms of assessing the gaps where the World Bank could contribute, the existing initiatives and activities can be categorized as:

- Capacity building and infrastructure development projects that are currently being implemented by the government
- Investment and technical support/capacity building projects being implemented by other donors and financing institutions
- Contributions to environmental management capacities and policies already being made by the World Bank through the programs and projects supported by the Bank

Measures and actions for environmental management in each of the above categories are outlined below:

Government Supported Capacity Building and Infrastructure Development Projects: The government could continue with implementation of currently planned capacity building programs especially NEAP, expand allocations for staffing and physical resources in the key environmental institutions, and expand public expenditure in sewerage and municipal treatment facilities. Other measures that could be adopted by the government through legislative, regulatory or administrative means include regular review and reporting of progress in national environmental initiatives at highest levels including PEPC, and mandating environmental assessment and compliance in all public and private projects. While these programs and projects provide the essential foundation for promotion of cleaner production, industrial and municipal wastewater treatment, and recycling of treated water, their impact will essentially be in the long term.

Support Being Provided by other Donors and Financing Agencies: The Asian Development Bank has initiated the Rawalpindi Environmental Improvement Project (REIP) project that covers capacity additions in sewage collection and treatment, and is supporting a project to promote investments in CETPs for the major export oriented industrial estates in the country. The Dutch government has supported cleaner production projects in the industry, and is currently supporting additional projects in this area as well. These programs and projects fulfill immediate requirements in the industry sector, and there impact will be realized in the near as well as in the medium term. In the municipal wastewater treatment, the projects continue to run a high risk in terms of financial sustainability and professional capacities to manage the operations.

Support Currently Being Provided by the World Bank: The World Bank has contributed to improving the state of environmental due diligence in the country through introduction of best practices in project and sectoral environmental assessment, and environmental management and monitoring of projects. Current involvement of the World Bank covers on farm water management projects where IPM has been added as an essential project component. A country strategic environment assessment (CSEA) is also under preparation with the support of the World Bank to address gaps in policies and implementation strategies.

Opportunities/Priority Areas Where Gaps Exist and the World Bank Could Contribute

In view of the projects already being implemented by the government, areas of interest of other donors, and contributions already being made by the World Bank, areas in which the Bank could provide support and technical assistance to the government and the private sector are summarized below:

Promotion of Investments in Municipal and Industrial Wastewater Treatment

Frameworks for Public and Private Sector Partnerships for Treatment of Municipal Wastewater: Policy frameworks are required to attract private sector investments for establishment and/or operation of treatment capacities, and possibly wastewater collection systems. Specific details that will have to be covered will include pricing of water supply and sanitation services, regulatory and administrative arrangements for cost recovery, and tariffs and incentives for the private sector to invest in and operate the treatment facilities.

Design of Investment Projects: Options that can be considered are public sector financing followed by cost recovery and operation by private sector, or on build-own-operate (BOO) basis entirely by private sector such as the proposed upgrade of TPII in Karachi to produce industry grade water.

The World Bank and IFC, depending on the type of the project, could provide implementation and financing support.

Enhancements in Existing and Planned Projects in Water and Other Sectors to Expand WSS Cover

The World Bank is already supporting WSS investments in the urban and rural areas through projects being implemented by PPAF and various other community infrastructure projects being implemented in the provinces. Similarly, management of wastewater inflow into the drainage and canal systems, and management of pesticide use through the IPM are included as components in various irrigation and on farm water management projects being supported by the World Bank. Specific options to expand the coverage of the WSS and IPM components in the existing and expected projects could be considered.

Technical Assistance for Policy Development and Capacity Building

The World Bank is supporting the MoE in preparation of a Country Strategic Environment Assessment (CSEA). Priority areas that could be addressed in the CSEA process to support the management of pollution from urban and industrial wastewaters ar listed below:

Enhancing Administrative and Management Capacity

- Training the staff of MoE and EPAs in environmental policy formulation and M&E functions.
- Strengthening of the national EA system, including mandatory EIAs, stakeholder review and consultation, regulatory approval, and subsequent monitoring and

stringent compliance, including in the public sector through institutionalized rules (e.g., in the PC-1 process and as part of project financing terms).

Indicators, Baselines, Monitoring and Analysis

- Expansion of the M&E system to cover new standards (surface water quality), benchmarks and indicators, with clear medium- and long-term milestones
- Institution of expanded regime of indicators, benchmarks, and data collection for establishing baselines.

Policy Reforms

- Review and remediation of existing policy anomalies
- Institutionalizing of environmental impact analysis of all provincial and federal cabinet level policy directives
- Subjecting all policy making to meet sustainable development objectives
- Refining and building upon policies and strategies in NEAP core areas
- Assessment of preventable health and fisheries impacts
- Devising sector-wise environmental policy actions
- Institutionalizing sustainable development priories and practices in national development

Exhibit 2.2: Requirements for Environmental Management and Priorities for Action

Action Area	*Requirements*	*Priority Measures and Actions*	
		Short Term (< 2 years)	*Medium and Long Term (3-10 years)*
Investment Promotion	Introduce policies for enhancing public and private investments in sewerage and treatment facilities and other environmental infrastructure	Implement planned common effluent and hazardous waste treatment facilities	Expand CETP implementation across industry and facilitate in-house treatment, where feasible
	Define government ownership of policy objectives through increased funding, expeditious actions, and strict public sector compliance	Increase resource allocation to current policy and program initiatives	Expand public expenditure in sewerage and municipal treatment facilities Establish budgetary floor to allocations for WSS and national environmental spending Establish self-sustaining financing mechanisms for key environmental activities. Mandate WSS infrastructure requirements in all new residential, commercial and industrial development
Indicators, Baselines, Monitoring and Analysis	Institute formal M&E instruments for regular performance and impact assessment of environmental policies along with mechanisms for accountability and corrective action	Implement existing discharge and ambient monitoring plans including SMART	Expand M&E system to cover new standards, benchmarks and indicators, with clear medium- and long-term milestones
	Expand definition, categorization, standards, and usage guidelines for water resources to include both source and ambient quality	Implement existing standards and develop key ambient benchmarks	Institute expanded regime of indicators, benchmarks, and data collection for establishing baselines Include quality trend assessment against standards for national environmental management

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Action Area	*Requirements*	*Priority Measures and Actions*	
		Short Term (< 2 years)	*Medium and Long Term (3-10 years)*
Administrative and Management Capacity	Enhance administrative, technical, management and human resource capacity of environmental agencies and government departments	Implement currently planned capacity building programs at MoE and EPAs, especially NEAP supported ABCD project	Improve capacity building through expanded allocations for staffing and physical resources Train the staff of MoE, EPAs and government departments in specialized environmental management functions Delegate and train local governments and municipalities in environmental management Train agriculture departments in IPM
	Enhance management capacity in the private sector industries	Implement currently planned cleaner production programs	Expand the cleaner production programs to cover large and medium industrial units
Policy Reforms	Remove contradictions and negative impacts of overall policy context and development activities	Initiate review and remediation of existing policy anomalies	Institute environmental impact analysis of all provincial and federal cabinet level policy directives Subject all policy making to meet sustainable development objectives
	Strengthen implementation of EA system by inclusion in project approval and financing conditions, and enhance compliance monitoring	Improve current EIA review and approval process	Mandate environmental assessment and compliance in all projects, public and private
	Establish clear linkages to sustainable development, poverty reduction, and quality improvement targets	Refine and build upon policies and strategies in NEAP core areas Assess preventable health and fisheries impacts	Devise sector-wise environmental policy actions Institute measurable water supply and quality targets for human and ecological needs Undertake basin-wide water resource management Institutionalize sustainable development priorities and practices in national development Implement environmental crediting in national accounts and planning

3. Management of Wetlands and Coastal Ecosystems

3.1 Overview of the National Policy and Institutional Setup and Constraints

A description of the national policy, legislative and institutional framework for management of wetlands and its evolution is included in **Appendix A**. Pakistan is party to the International Convention on Wetlands (Ramsar), and the National Conservation Strategy (NCS) and Biodiversity Action Plan (BAP) have been developed for environmental protection and biodiversity conservation. Protection of watersheds and water bodies are among the major programs of the NCS for priority implementation. The National Environmental Action Plan launched in 2001 includes ecosystem management as one of the four core areas. The wetland protection and management is treated as component of ecosystems management. These important national policy commitments notwithstanding, major policy, institutional and legislative constraints in protection and management of wetlands in Pakistan are summarized below:

Inadequate Legislative Cover: Among the 53 important wetlands identified in the WAP, 25 % have been notified as wildlife sanctuaries by the provincial departments, 11% as game reserves, while three sites fall in national parks. Around 60% of the remaining wetlands are not protected. Many wetlands of international and national importance including 40% of the Ramsar sites do not have legal basis for protection. In addition, the wetlands of the Indus basin particularly in the delta region are dynamic in nature; they are naturally in equilibrium of extinction and establishment. They squeeze or vanish from an area from water diversion or drought and appear in new low-lying areas. This phenomenon requires revision of protected area notifications periodically on the basis of regular status surveys. The current approach and practices on classification and notification of protected areas allows very limited flexibility for adaptive management strategies.

Lack of Recognition of Traditional Community Rights and Participation: The Wetlands Action Plan recommends community involvement in wetlands management. While the communities have traditional rights of access to wetland resources and depend on them for their livelihood support, the existing legislation does not recognize their traditional rights, thus denying the communities a role in management of the wetlands.

Lack of Baseline Information: Information on the ecological conditions of the wetlands and their socioeconomic value is limited. For most of these sites only the waterfowl census data is available, and baseline environmental conditions have been documented for only 28% of the sites. Around 87% sites do not have any management plans, four sites have unapproved plans, while three sites have approved plans that are waiting for implementation. Research and monitoring remains a lower priority for the implementing agencies.

Limited Integration of Wetland Concerns in National Policies: There is no national strategy or legislation exclusively for wetlands. National policies pay little attention on impacts on wetlands, of which water, agriculture and land policies are key examples. Awareness regarding conservation value of wetlands and its resources is lacking at the policy as well as exploitation level.

Limited Administrative and Management Capacity: The Wildlife Departments do not have adequate resources to implement the restrictions in the protected areas, and lack trained staff for the wetlands management. Coordination and networking among the provincial departments mandated with management of wildlife, irrigation, and agriculture and fisheries is weak, and the Wetland Action Committee organized at the federal level is not performing its role actively. Poor coordination among departments is often counter-productive to the conservation efforts, and introduction of exotics and agrochemicals are typical examples. In some provinces, separate wildlife departments do not exist, and the mandate of wildlife protection rests with the forest departments that are not organized for management of wetlands.

3.2 Wetlands in the Context of Water Sector Development

The wetlands structure of Indus basin has been greatly modified by the water sector developments in past 50 years. Irrigation and drainage development projects are the two fundamental interventions that have imparted a wide range of impacts, both positive and negative. Major irrigation and drainage related developments and their consequences for the wetlands are described below.

Indus Basin Irrigation System (IBIS)

The Indus River basin stretches from Himalayas to Makran coast, covering an area of 207,200 km^2. The IBIS is the world largest contiguous irrigation system developed over the past 140 years (WCD Case Study, 2000). In order to implement the provisions of Indus Waters Treaty (IWT), the World Bank initiated Indus Basin Project (IBP) to ensure that the irrigated areas in the country continue to receive water supplies after India diverted the eastern rivers. The Indus River and its tributaries were subjected to the world's largest engineering works. Three major and several minor dams, and extensive network of barrages, headworks and canals have been built for irrigation and hydroelectric purposes. The IBIS has created significant wetlands and supported wetlands system in many ways, and on the other hand impacted globally significant wetlands like the delta area and Indus River itself. Huge reservoirs like Tarbella, Chashma and Taunsa have become significant wetlands. These are supporting a large variety of resident and migratory birds, and have attained global importance. Numerous small wetlands developed from the water seepage from canals and agricultural lands all over the basin have also become important biodiversity spots.

The Indus delta is the seventh largest delta in the world (Wells and Coleman, 1984), characterized by high river discharge, moderate tide and high wave energy conditions. It experiences the highest wave energy of any river in the world, the erosional action of which was being balanced by the high discharge of Indus river before upstream damming of the river. The IBIS has resulted severe reduction in flux of both water and silt to the downstream flooding plains. The years of zero flow downstream Kotri is a useful

indicator to illustrate extent of change in flow regimes. It was zero in the pre-Kotri period, increased to 80% after construction of Kotri barrage (1962-67), further reduced to 100% during post-Mangla period (1967-75), and recorded at 96% after Tarbella (1975-98) (WCD Case Study, 2000). This severe reduction in water and sediment to the delta has impacted mangroves, and loss is estimated at 100,000 acre per year (Snedaker, 1984)[20]. Hypersaline, and nutrient poor delta now support only sparse and stunned growth, the total mangrove biomass reduction has been calculated at 99 percent (Snedaker, 1984). The remaining are being lost more rapidly due to overexploitation. Decline in offshore fish catch, increase in pollution due to reduced flushing action, sea water intrusion and increased risks of inundation in the climate change scenario are the other associated impacts.

The ecological impacts are apparent in the whole basin, ranging from terrestrial ecosystems to the aquatic life. The upstream migration of Mahsheer (*Tor putitora*) has been prevented during summer, and occasional peak releases from dams can wash out the substrate and fish immediately below the dam. The catches of migratory fishes like palla and baramundi have been significantly reduced, for example catch of Palla has been reduced from about 1,000 tonnes during the 1980s to 200 tonnes per year in 1990s (WCD Case Study, 2000). Populations of hog deer and smooth coated otter are threatened due to loss of habitat. The population of blind Indus dolphin has been segmented and declined, but still surviving in fragmented habitats.

Drainage Projects

Natural subsurface downward drainage of ground water is limited mainly due to flat nature of Indus basin. Permanent seepage from a huge network of irrigation system and surplus water from the irrigated fields created waterlogged conditions over a period of time. Considering magnitude of the problem, the Federal government took responsibility to eradicate water logging and salinity. Since 1960s, WAPDA has implemented an ambitious program of Salinity Control and Water Reclamation Projects (SCARPS), and by mid of June 2003 61 projects have been completed. The On-Farm Water Management Program (OWMP) was initiated in 1977 to reduce the water loss at watercourse level. This includes earthen-cum-lining of the courses thus reducing seepage. Unlike the IBIS the drainage network is not connected, much of the drainage is either used in IBIS or disposed into rivers and canals. The Left Bank Outfall Drain (LBOD) was a major development towards this end, it aimed at improving the drainage, irrigation and the rehabilitation of saline and water logged soils by disposing effluents to the sea.

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[20] Snedaker, S.C. 1984. Mangrooves: A summary of knowledge with emphasis on Pakistan. In: Haq, B.U. and J.D. Milliman (eds.). Marine Geology and Ocenography of Arabian Sea and Coastal Pakistan. Van Nostrand Reinhold Co., New Yark.

Environmental impacts and damage to the natural resources was not a consideration during design and implementation of the earlier drainage projects. Recently completed drainage sector environmental assessment studies, for example Drainage Sector Environmental Assessment[21] and EMP of NDP[22], reveal significant adverse impacts.

- Drainage has squeezed or dried many wetlands, and local communities for agriculture have reclaimed the land.
- Disposal of effluents to the natural lakes like Manchar, Cholri, Pateji, Sanrho has changed their ecological conditions and original assemblage of biodiversity. The populations of fresh water birds and fish species are greatly reduced.
- Effluents from urban and rural areas including municipal, agricultural and industrial waste, traveled through the drainage structure, have adversely impacted the aquatic ecosystems.
- Stress on mangroves and delta's biodiversity initially caused by the low Indus discharge has been further intensified through saline effluents.

Recently a Drainage Master Plan (DMP)[23] has been developed inclusive of an Initial Environmental Examination (IEE) that attempts to address the environmental implications and impacts on downstream users resources. The Panel of Experts appointed by the World Bank to review the DMP made wide-ranging recommendations for improvement of environmental and social sustainability of the plan. Recommendations of the panel that have significant implications for preservation and management of wetlands include a sub-basin approach to management of water resources based on participatory decision making and supported by a comprehensive M&E system, with the primary objective of balancing the utilization and drainage of water to satisfy the competing economic and environmental demands on the water supply and drainage systems. The implementation of this approach in Kotri basin recommended as a pilot project will be of great significance in demonstrating its effectiveness, and will set the stage for replication throughout the country.

3.2.2 Recent Initiatives in Wetland Development and Management

The 'Coastal and Marine Resources Management and Poverty Reduction in South Asia' Project

The project 'Coastal and Marine Resources Management and Poverty Reduction in South Asia' (ADB RETA NO. 5974) was funded from a grant from the Asian Development Bank and in-kind contribution from IUCN–The World Conservation Union. The Technical Assistance (TA) was provided primarily to strengthen cooperation in the integrated management of coastal and marine eco-systems in South Asia. Recognizing that the coastal and marine resources in South Asia are being rapidly degraded due to various economic and management issues and the resources are crucial to sustaining

[21] Prepared by national Engineering Services Pakistan (Pvt.) Ltd. and Mott MacDonald International Limited, 1993

[22] Prepared by Pakistan Drainage Consultants, 2000

[23] Prepared by WAPDA, 2004

coastal economies, the project aimed at promoting cooperation in the development of appropriate strategies and approaches such as the *'Integrated Coastal Zone Management'* (ICZM) approach that could benefit all the countries.

The project provided an overview of the institutional, human, physical, hydrological, and ecological status of the coast of Pakistan, aimed at developing strategies for effective management of coastal resources. The TA identified, and tested in pilot programs, approaches to promote the protection of ecologically sensitive coastal and marine resources while at the same time seeking to alleviate poverty through regional cooperation. The project was based on a holistic approach to the coastal ecosystems—mangroves, fishery, and estuary—and their linkages.

Using a set of social, economic and ecological criteria, five High Priority Areas (HPAs) were identified in Pakistan.[24] These included Bundal/Khipranwala/Muchaka Island Complex, Juna Bunder/Jhaki Bunder, Korangi/Rehri Creek, Keti Bunder, and Shah Bunder Block 1. The components of the ICZM strategy were tested under a pilot program for one selected HPA, the Korangi Creek-Rehri area near Karachi. Under the pilot program, crab culture and mangrove forestry were successfully undertaken in the HPA. The strategy places particular emphasis on collaborative institutional arrangements and participation of coastal communities, the details of how and to what extent these were achieved in the pilot program are not available in the project report.

The recommendations of the strategy are the following:

1. **Research:** In order to make informed management decisions, research needs to be carried out on socio-economic and ecological aspects of the delta in order to understand the structure and dynamics of mangrove ecosystem and its relationship with other coastal systems. In particular research is required in the following areas:

    Fisheries (present productivity and potential, patterns of catch, fishing methods and effort, transportation and processing losses, marketing methods)

    Fisher-folk (The impact of middlemen and the immigrant populations)

    Delta ecosystem dynamics (energy, hydrological and nutrient cycles, environmental factors controlling mangrove diversity, stability, and productivity)

    A biodiversity profile of the coastal areas including habitat and ecosystem maps and basic ecology particularly nature of microbiological processes and their significance

    Development and feasibility of forestation techniques, shrimp aquaculture, mangrove honey production, and potential economic uses of mangroves

    Recording and codification of traditional empirical knowledge on mangroves and its examination in light of modern scientific knowledge

[24] HPAs are defined as ecologically sensitive geographical areas requiring priority investment and development support.

2. **Management Plan:** A mangrove utilization and management plan needs to be prepared that should include zoning for sustained yield production, preservation, and conversion to other land uses such as aquaculture, petroleum exploration, port and harbor development or human settlements.
3. **Legislative and Administrative Support:** Formulation of appropriate rules and regulations to support the national mangrove utilization and management plan.
4. **Pilot Studies:** Further pilot studies need to be undertaken on the use of novel techniques in extended benefit-cost analysis as applied to various developmental uses of mangrove areas and in support of ecological-economic valuation of various tradeoffs associated with the different mangrove uses.

Projects Implemented by WWF for Recovery and Development of Mangroves

WWF Pakistan, with support from European Union, WWF UK, and GEF Small Grants Programme for Promoting Tropical Forestry is implementing projects to demonstrate sustainable development of mangrove forests. The first phase of the projects was initiated in 1997, and the demonstration sites include Keti Bunder on the Indus Delta, Rehri and Sandspit near Karachi, and Sonmiani, Kalmat Khor and Jiwani on the Balchistan coast.

Project activities have included plantations aimed at recovery and arresting degradation, community mobilization and organization, promoting awareness on wetland values among the communities, and preparation of sustainable development plans. Supporting activities have included promotion of fuel-efficient woodstoves to reduce demand for fuel wood, and supply of natural gas as replacement fuel at Sandspit. The models of community participation that have successfully been tested have relied on establishing linkages with increased production of shrimps, of which Sonmiani is cited as an example. Following the initial recovery phase, improved availability and sustainable supply of fuel wood and fodder are expected to emerge as benefits in the long term as the condition of the mangroves is stabilized. The success of the demonstrations in the Indus Delta has been relatively limited owing to reduction in freshwater flows, higher grazing pressures, and higher population densities.

Assessment of Economic Costs and Benefits of Release of Water Into Indus Delta

IUCN is currently conducting a study aimed at developing guidelines for artificial flood releases from reservoirs to maintain downstream wetland ecosystems and dependent livelihoods. The study is part of a larger study being conducted by the Institute of Hydrology with support from DFID focusing on river basins in selected countries in different regions. The study area includes area directly or indirectly influenced by flows of freshwater released downstream form Kotri barrage.

The study has identified the range of environmental effects and appropriate techniques for valuation of the impacts, and covered an evaluation of net economic benefits of wetlands ecosystem resources including agriculture, livestock, forests, and fisheries. Initial findings indicate that net economic benefits of wetland ecosystem resources on which survival of the majority of the communities of the area depends need to be enhanced and sustained. The study recommends a detailed cost benefit analysis and

evaluation of loss of wetland economic resources in the downstream Indus Delta. Since the estimated economic values are positive, the study suggests that adequate discharge of water below the Kotri barrage is warranted to harness the economic potential of the area. Pointing towards the risk associated with insufficient data availability, the study recommends a comprehensive survey of the area and collection of primary data and information on prevailing resource situation and utilization.

Pakistan Wetland Project

Ministry of Environment has recently launched the Pakistan Wetland Project (PWP) for the protection and management of wetlands on national level. The project will be implemented by WWF Pakistan, and aims to mainstream wetland conservation in Pakistan through compiling essential data, development of a National Wetlands Conservation Strategy, capacity building, and raising public awareness. The project will also develop sustainable wetland conservation measures at the following four demonstration sites selected to represent conditions in four broad wetland ecological regions:

- Makran Coastal Wetlands Complex (MCWC)
- Central Indus Wetlands Complex (CIWC)
- Salt Range Wetlands Complex (SRWC)
- North-west Alpine Wetland Complex (NAWC)

3.3 Options for Management

Review of the existing conditions of wetlands and analysis of policy and institutional response to the impact of project interventions indicate several key areas that need immediate attention. The proposed options, their scope and requirements are described in this section.

Reforming the Policy Regime

The existing institutional setups, management practices and policy regimes give limited or no attention to the economic, social, and ecological considerations in management of wetlands. Specific areas that need attention are outlined below.

Integrating Economic and Social Considerations in Strategies for Management of Wetlands

The recent research conducted by the IUCN and the projects implemented by the WWF indicate that the wetlands provide substantial net economic benefits and are a source of livelihood support to the communities living in their vicinity. The research and studies also indicate that wetland ecosystems have suffered from irreversible damage following alterations in hydrological regimes and the communities depending on them have been marginalized to the extent that resettlement and rehabilitation may be warranted. Assessments of environmental and social impacts at project design stage and strategies for allocation of water to the wetlands will have to be upgraded to account for these considerations. Special financial provisions may be required to offset any losses of

income for specific social groups resulting from the application of regulatory provisions such as restrictions placed on economic activities in protected wetlands. There is therefore a need to develop guidelines for assessment and management of wetlands that take into account the economic and social costs of human interventions in wetland systems.

Integrating Ecological Approach in Management of the Hydrological Basins

International experience has shown that sustainable management of wetlands and long-term protection is possible only through their consideration at the level of the hydrological basin and not within the narrow limits of purely wetland or adjacent territory. The DMP has divided Indus basin into 20 basins. Ecological factors need to be integrated in management of these basins with participation of water sector agencies and wetland management bodies. It would be useful to define zones within each basin with respect to wetlands distribution and importance. Water requirements for wetlands in each zone should be identified and ensured while planning development projects in hydrological basins. Legislative reforms at provincial and federal level are required to establish and empower sub-basin and basin level institutions for management wetlands. Mandatory periodic performance review and reporting at sub-basin and national level by designated institutions should be incorporated in the national wetlands strategy.

Promoting Community Participation

Wetlands and their peripheral zones support economic activities of the primary sector: farming, fishing, hunting and aquaculture. For broad-based and effective participation in wetlands resource management, the local communities and CBOs must be empowered to make decisions to regulate and use wetlands resources. Such initiatives will therefore require amendments in the existing legislation to allow sharing of benefits with the communities. These can include:

- Sustainable fish harvesting and aquaculture
- Revenue from hunting of game birds
- Provision of environmentally friendly visitor services for tourism and recreation

Social system and leadership structures need to be understood while involving the communities, and their participation has to be legitimized through appropriate regulatory amendments. The communities need to be encouraged to establish CBOs that can facilitate the process of their participation in wetlands management. The CBOs will require training to enhance their capabilities for participation. The Pakistan Wetland Project is expected to demonstrate community participation in wetland management at four selected sites in the country.

Integrating Requirements of International Wetland Conventions in the National Policy and Regulatory Process

Being signatory to several international conventions relating to wetlands, Pakistan has an obligation to integrate wetlands management in national policies, that requires development of a National Wetlands Conservation Strategy. The sustainable use of wetlands needs to be included as crosscutting theme in national policies particularly for

water and agriculture sectors. The rules and regulations required for the wetlands management also need to be incorporated in federal and provincial legislations. A federal legislation to implement CBD, Ramsar Convention and CITES is being formulated by the NCCW in collaboration with IUCN, this would be an effective step towards wetlands management provided that the provincial departments support this initiative. All wetlands of national and global significance, as identified in the WAP, should be provided legal protection to regulate human use and exploitation by other means. All Ramsar sites should be declared as wildlife sanctuaries to give maximum protection available under the law.

Establishing Indicator Systems

Wetlands response to the policies and programs need to be continuously monitored to evaluate performance of the interventions and health of ecosystems. Periodically recording standardized observations, conducting surveys of key elements, taking photographs from fixed points, and conducting interviews with resource users are basic monitoring methods. Preparing inventory of the all wetlands is the basic step, followed by surveys to collect baseline information on environmental, social and ecological conditions. Wetlands ecosystems are dynamic in nature, periodic surveys of important wetland are therefore necessary to update and track the picture of the evolution of wetlands through time. A simple system of indicators to track key parameters of performance and sustainability on an annual basis can be a very powerful tool for the monitoring and evaluation of the progress. Periodic reporting of the following indicators for condition and health of wetland ecosystems will be useful:

Indicators to evaluate ecological trends:

- Population of resident, breeding and visitor water fowls
- Population of wetlands dependant mammals and other vertebrates
- Quality and quantity of water in wetlands
- Number of violations recorded

Indicators to evaluate economic and social sustainability:

- Impact on communities dependant on wetlands or involved in wetlands management
- Revenue collected in terms of hunting, fishing, and tourism
- Working status of community based organizations and their participation in wetland management.

Conducting Research on Wetlands Resources and Values

Recommendations for research on socio-economic and ecological aspects of the Indus Delta as suggested by IUCN in the project ‘Coastal and Marine Resources Management and Poverty Reduction in South Asia’ are listed in Section 3.2.2 of this report. The research requirements for other upstream wetlands would be similar in nature. Conducting the research, however, will require substantial resources and investments in capacity building in the local institutions.

Raising Awareness

Awareness of wetlands values and function is a dire need for enhancing performance of the wetland management. All stakeholders including water and agricultural sectors, local communities and general public should be targeted in awareness campaigns. The WAPDA, provincial irrigation departments, and other relevant departments working in the water sector need to establish and strengthen environmental units within their organizations to ensure that these considerations are incorporated in their policies and the EIA requirements are duly observed during implementation of the projects.

Following options can be considered:

- Public awareness activities and materials on wetlands values and functions should be published
- Wetlands awareness campaigns, workshops, seminars, symposia need to be organized
- Training material on appropriate use of wetland resources should be developed for communities
- Guidelines on operation and utilization of the wetlands should be developed for the government and the private sector

Mobilizing Financial Resources

Adequate financial resources need to be allocated for protection and management of wetland resources. Federal and provincial resources should be mobilized to approve funds wetlands conservation initiatives; external financial and technical support should also be sought. It would be useful to establish a National Wetlands Trust that will solicit and manage funds from public and private sources. The Trust could be managed by the NWMC in collaboration with NGOs, universities and government departments. Major investment venues are:

- Wetlands development and conservations projects
- Training of staff and community organizations
- Awareness campaigns
- Development of sub-basin and basin level institutions for management of water use and drainage
- Special allocations for wetland areas where low-income groups can be potentially impacted.

Enhancing Administrative Capacities

The regulatory departments presently do not have sufficient staff and resources to guard and manage the wetlands under their jurisdiction. The staff also does not possess professional skills for management of wetlands, and need to be trained in scientific surveying and evaluation techniques. There is strong dissatisfaction among staff of the wildlife departments regarding the field accessories and amenities they are provided with. The lack of incentives to work in remote areas for a long time weakens the interests of the staff and erodes work quality. Collaboration with international organizations like

Ramsar Bureau and Wetlands International and incorporation of their agenda at the national and local level will improve professionalism in the management agencies.

The existing Wetland Management Committee needs to take more active role and act as the lead agency at federal level for management of Pakistan's wetlands. The WMC should promote working relationship among the wildlife departments and with other institutions in the water and agriculture sectors such as WAPDA, and the provincial irrigation and agriculture departments. The WMC should identify the stakeholders for the wetlands management networking, and develop modalities and structures for the exchange of information.

A number of projects for development of water resources have been completed either without EIAs, or with limited attention to compliance with the internationally accepted standards and guidelines for assessment and mitigation of impacts on sensitive wetlands. Consultation with the wildlife departments and the communities dependent on the wetlands is generally very limited. A recent example is construction of a river diversion tunnel in Deosai National Park that will be initiated shortly by WAPDA, where 90% of the river flow will be diverted draining out the downstream wetland. No public consultation or detailed studies on ecological impacts have been conducted as a part of the project design process. The EPAs need to ensure that their assessments teams have requisite expertise to evaluate the EIAs, and the concerns of the primary stakeholders are properly addressed.

3.4 Priorities and Sequences for Change

Based on the experience in wetland management in the country, the options discussed in previous section to improve wetlands management in Pakistan are grouped into two categories i.e., short term and medium term, and long term, and listed in order of priority.

Short and Medium Term Actions

1. Development and application of frameworks, methodologies and techniques for evaluation of net economic and social benefits of wetlands and assessment of impact of project and management interventions on the wetland values
2. Preparation of guidelines for management of high priority wetlands taking economic, social, and ecological factors into account
3. Wetlands surveys to make inventories and document their status in order to provide baseline for monitoring
4. Provisions in federal and provincial laws to recognize traditional rights of the communities and to involve them in management and profit sharing
5. Establishment and empowerment of sub-basin and basin level institutions for management of wetlands to support consultation and networking among stakeholders and to initiate collaborative actions for rehabilitation of wetlands
6. Raising awareness for local communities and public departments on value of the wetlands
7. Legal protection for all wetlands of national importance particularly Ramsar sites

8. Formulation of National Wetlands Conservation Strategy to provide a long term framework for revision of WMP, and active role of the Wetlands Management Committee to manage wetlands at the national level
9. Appropriate staffing, training, and management systems in the implementing and regulatory organizations, supported by appropriate budget allocations

Long-term Actions

1. Inclusion of wetlands conservation as crosscutting theme in national policies particularly for water, agriculture and land sector
2. Integration of international conventions like Ramsar, CBD, CWS, CITES into national policies
3. Zoning of basins and sub-basins with respect to wetland values
4. Establishment and strengthening of environmental units in irrigation and agriculture departments
5. Special allocation of fund for areas where low income groups are impacted by project interventions
6. Federal service to manage wetlands of national and international importance

Recommendations for World Bank Engagement

The analysis of challenges being faced in the management of wetland resources in Pakistan, national framework to cope with these issues, and effectiveness of existing arrangements identifies many key areas where external support can accelerate the process.

Stengthening of Policy Process

The following areas can be considered for engagement on a priority basis:

Integrating Economic and Social Considerations in Strategies for Management of Wetlands: Specific activities that could be supported, as identified in Section 3.3 of this paper, could include development and testing of frameworks for estimation of economic costs and benefits of wetland interventions, and development of guidelines for release of water to the wetlands to preserve the wetland values.

Integrating Ecological Approach in Management of the Hydrological Basins: In continuation of the support being provided by the World Bank for development of the Drainage master Plan, follow-up assistance for setting up and operationalizing of sub-basin and basin level institutions for management of water resources and wetlands could be considered. As already suggested for the pilot phase, Kotri sub basin would be an important are for engagement in view of the complexity and magnitude of impacts on wetland values already experienced.

Integration of Wetland Concerns and Enhancements in Water Sector Projects

The World Bank is currently financing projects that are directly or indirectly connected to important wetlands, where opportunities exist for enhancing wetland values through the

projects or by supporting other initiatives for improvement of wetland values. A recent example is the rehabilitation of Taunsa barrage, where baseline surveys are scheduled for the upstream wetland area that includes a wildlife sanctuary. The baseline information generated will help in evaluation of future project impacts, and will be utilized by the Pakistan Wetland Project being implemented by WWF Pakistan with support from GEF. An improved fish ladder design and has also been included in the scope of the project. Similar approach and models for additional investments to enhance wetland values and to improve their management can be continued through the EIA process in other water sector projects to be financed by the World Bank.

Other Options for Supporting Wetland Management

Additional areas that can be considered for support by the World Bank are listed below:

- Implementation of Integrated Coastal Zone Management (ICZM) strategies developed under the ADB project on 'Coastal and Marine Resources Management and Poverty Reduction in South Asia' to the high priority areas (HPAs) defined in the project
- Extending coverage of the Pakistan Wetland Project to additional areas
- Formulation of National Wetlands Management Strategy, and ensuring its enforcement in the water sector
- Technical and financial support for research on wetlands and establishment of national wetlands database
- Establishing environmental units in the irrigation and agriculture departments to enhance environmental due diligence and monitoring capacity

Appendix A: National Policy and Institutional Framework for Environmental Management

Exhibit A.1 provides an overview of the institutional set up for environmental management in Pakistan. The Pakistan Environmental Protection Council (PEPC), headed by the chief executive of the country, is apex body responsible for environmental policy direction and management overview. The Ministry of Environment (MoE) is the primary administrative organ responsible for policy formulation and execution, and oversees a number of specialized line agencies responsible for various implementation and enforcement functions, including the federal and provincial environmental protection agencies (EPAs) and the forest and wildlife departments, and various other departments. Under the relatively recent reorganization of the local government structure, district environmental offices have been created to cater to local concerns, provide feedback and help focus and prioritize action on the ground.

A serious, concerted policy dialog on the environment based on a national strategic approach was begun in the 1990s in Pakistan, prior to which various environmental issues had been dealt with under various piecemeal initiatives, by disparate bodies. The comprehensive National Conservation Strategy (NCS) was formulated and approved by the federal cabinet on March 1,1992, just in time for the UN Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil. In 2001, the PEPC in its ninth meeting approved a National Environment Action Plan (NEAP). This policy instrument aimed to improve the environmental conditions in the country through a programmatic, result-oriented approach. These two major policy initiatives, the NCS and NEAP, currently define the overall environmental policy context in Pakistan. In addition, the Ministry of Environment is currently engaged in preparation of a National Environmental Policy that is expected to be released shortly.

The Pakistan National Conservation Strategy (NCS) is a broad-based policy statement aimed at achieving environmentally sustainable economic and social development in Pakistan. It sets out basic guidelines for an integrated effort aimed at protecting the environment and natural resources of the country. The NCS has 14 program areas for priority implementation, out of which four directly or indirectly relate to the water sector. The program areas that directly relate to the water sector address resource conservation, such as conserving biodiversity, marine and coastal resource management, and fisheries, as well as pollution mitigation in the industrial and municipal sectors.

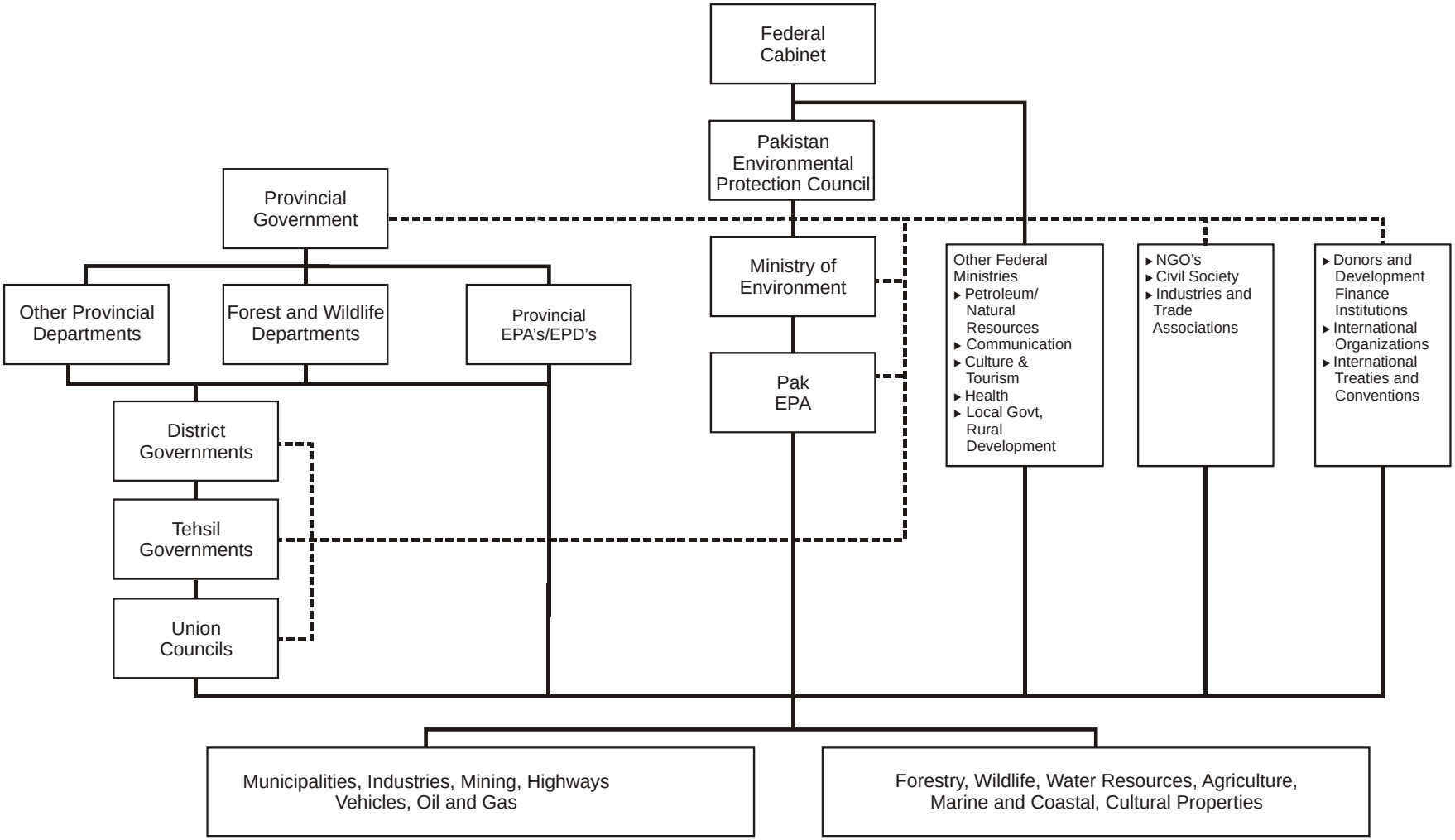
The GoP formally launched the National Environmental Action Plan (NEAP) in February 2002. The primary objective of the NEAP is to initiate actions and programs for achieving a state of the environment that safeguards public health, promotes sustainable livelihoods and enhances the quality of life of the people of Pakistan based on a goal-oriented programmatic approach. NEAP reprioritizes policies already mentioned in the NCS; hence it is not a radical departure from the NCS context. Two out of the four core

areas of NEAP, the clean water program and the eco-system management program, relate to the water sector.

A comprehensive Mid Term Review (MTR) of the National Conservation Strategy was undertaken in 2000 to assess the achievements, impacts and prospects of the NCS since its implementation was begun in 1992. According to the conclusions of the MTR, the primary achievements of the NCS had been raising awareness and institution building. The NCS process has also strengthened civil society institutions and their influence in the environmental debate. However, as a policy instrument, according to the MTR, neither is the NCS operating as a national sustainable development strategy nor does it have the implementation capacity to achieve its goals.

The NEAP has attempted to address some of these deficiencies by prioritizing action areas and specifying targets, resources, and responsibilities more clearly in key program areas. While some capacity was added at the federal level with the assistance of the UNDP, the NEAP has yet to complete the activities that were to be the precursors for the development of a detailed action plan. Currently it remains in the planning stage. According to its initial assessment, the NEAP has become a project clearinghouse for the provinces, but has so far failed to give a strategic direction to the national environmental institutions, and has not yet succeeded in mobilizing additional financial resources for environmental programs in the country. The shortcomings in the national policy process notwithstanding, these initial and important policy initiatives have enabled the development of new legislative and regulatory instruments for ensuring environmentally friendly development. The notable achievements in this respect include the adoption of the overarching Environmental Protection Act (1997), Environmental Guidelines (1997) for conducting environmental assessments, Environmental Regulations (2000) defining the environmental assessment process, the National Environmental Quality Standards, NEQS (1993) for pollutant limits in municipal and industrial effluent and emissions, and several other laws relating to the protection of marine and aquatic resources. This important legislation has enabled the creation of several key enforcement agencies at the national, provincial and local levels, including the Environmental Protection Agencies, Environmental Tribunals, and District Environmental Officers.

Exhibit A.1: Environmental Institutions in Pakistan



A.1 Legislative and Regulatory Framework for Management of Industrial and Municipal Effluents

The Pakistan Environmental Protection Act (PEPA 1997) extends to air, water, soil, marine and noise pollution, as well as the handling of hazardous waste, and provides for:

- The establishment of National Environment Quality Standards (NEQS)
- Comprehensive environmental impact assessment (EIA) regulations
- Establishment of environmental tribunals, and
- Financing measures, including imposition of pollution charges.

The Act considerably enhances the powers of the federal and provincial Environmental Protection Agencies (EPAs) and delegates the authority to monitor and enforce key provisions of the Act. Under the Act, the discharge or emission of any pollutant or noise, which is in excess of the National Environmental Quality Standards (NEQS), is prohibited, and penalties are prescribed. The NEQS specify maximum allowable concentration of pollutants (32 parameters) in municipal and liquid industrial effluents discharged to inland waters, sewage treatment facilities, and the sea (three separate sets of numbers). Pakistan's Environmental Assessment (EA) system is also one of the stipulations of the1997 PEPA. Other existing laws that also relate to pollution prevention of water bodies include Canal and Drainage Act (1873) and the Punjab Minor Canals Act (1905), which prohibit the corrupting or fouling of canal water, Sindh Fisheries Ordinance (1980), which prohibits the discharge of untreated sewage and industrial waste in water, and The Greater Lahore Water Supply Sewerage and Drainage Ordinance (1967).

The Pakistan Environmental Protection Agency is charged with implementation of the PEPA 1997 throughout the country, and specifically in the federal area of Islamabad. The provincial EPAs are charged with implementation of PEPA 1997 within their respective provinces, and are responsible solely to their respective departments in the provincial governments. In the case of the Punjab, the EPA has been wholly integrated into the provincial Environmental Protection Department (EPD). The districts will eventually be empowered with PEPA 1997 implementation, and even the smaller local units of government—the tehsils and the union councils—will take on these responsibilities under the devolution plans of the federal government. At the district level, an Environmental Officer is to be appointed to maintain environmental standards and further delegate tasks within the district and its municipalities. At the moment, however, this is not yet the case. Still, the EPAs/EPDs in the Punjab and Sindh have physically assigned their staff to a number of districts where they act as district officers of the EPA/EPD.

The EPAs have gradually built up their internal environmental qualifications and technical experience and facilities, although still remain significantly short in terms of resources and staffing levels. They have also been successful in establishing laboratory facilities in all their provincial and federal offices; have established and operated the environmental assessment system requiring projects to obtain prior EPA clearance; and have undertaken several awareness raising and educational drives. In the near future, the

EPA's are poised to launch the Self Monitoring and Reporting Tool (SMART) for monitoring NEQS compliance in industry, and to undertake representative ambient water and air quality measurements at major city locations on a regular basis.

A.2 Institutional, Legislative and Regulatory Framework for Management of Wetlands

Pakistan is party to four international conventions relevant to the wetlands conservation; International Convention on Wetlands (Ramsar), Bonn Convention on Migratory Species (CMS), Convention on Biological Diversity (CBD), and Convention on International Trade of Endangered Species of Flora and Fauna (CITES). National Conservation Strategy (NCS) and Biodiversity Action Plan (BAP) have been developed for environmental protection and biodiversity conservation. Protection of watersheds and water bodies are among the major programs of the NCS for priority implementation. The National Environmental Action Plan launched in 2001 includes ecosystem management as one of the four core areas. The wetland protection and management is treated as component of ecosystems management.

Wetland and waterfowl conservation is a provincial subject in Pakistan, each province has its own legislation which is implemented by the respective wildlife or forest departments. Wetlands are covered in the following legislation categories:

- Islamabad Wildlife (Protection, Preservation, Conservation and Management) Act, 1979
- The Punjab Wildlife (Protection, Preservation, Conservation and Management) Act, 1974, revised in 1991
- The Sindh Wildlife Protection Act, 1972 revised in 1996.
- The Balochistan Wildlife (Protection, Preservation, Conservation and Management) Act, 1974
- Azad Jammu and Kashmir Wildlife Act, 1975
- Northern Area Wildlife Preservation Act, 1975

These acts provide basis for creation of protected areas in three fundamental categories; National Parks, Wildlife Sanctuaries and Game Reserves. All provinces have made considerable process in the establishment of protected areas (PAs) that are providing legal cover for the protection and conservation of a number of wetlands in the country. Examples are Sheosar lake and other alpine lakes in Deosai National Park, Rawal lake in Margalla Hills National Park, and the Patisar lake in Lal Suhanra National Park. Some wetlands are PAs in their own capacity like Haleji lake and Hub Dam Wildlife Sanctuaries. Currently around 30 PAs are providing legal basis for the protection of wetland resources.

The National Council for Conservation of Wildlife (NCCW) in the Federal Ministry of Environment, Local Government and Rural Development, is the focal point at national level for the Pakistan's international obligations and agreements regarding biodiversity conservation. The NCCW was established in 1974, and is responsible to coordinate with

the provincial governments regarding the wildlife issues. Working under the same ministry, Zoological Survey Department (ZSD) is responsible for conducting surveys and research on wildlife, wetlands and waterfowls. The Indus Flyway Committee was established in 1978, which acted in consultative capacity for the research and management of waterfowls. This committee it is not functional at present.

The protection and enforcement of regulations for conservation of wetlands is handled by the following provincial wildlife and forest departments:

1. Punjab Wildlife Department, Lahore
2. Sindh Wildlife Department, Karachi
3. Balochistan Forestry and Wildlife Department, Quetta
4. NWFP Wildlife Department, Peshawar
5. Northern Areas Forest Department, Gilgit
6. Department of Fisheries and Wildlife, AJ&K, Muzaffarabad

These departments are custodians of wildlife in their respective provinces, and responsible for managing wetlands including Ramsar Sites. In order to provide focal point for networking between provincial departments for effective wetlands management, NCCW established a National Wetland Management Committee (NWMC) in 1996. The NWMC has representation from all provincial departments, and also from NCCW and NGOs. The Water and Power Development Authority (WAPDA) is also considered as an important stakeholder, as it owns and manages many important wetlands like Mangla and Tarbella reservoirs. The other institutes that have relevance to the wetlands management are Pakistan Agricultural Research Council, Pakistan Science Foundation, Universities and NGOs like WWF and IUCN.

Water and Energy

By

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Country Water Resources Assistance Strategy
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WATER AND ENERGY

Imtiaz Ali Qazilbash

1.1 Overview of Pakistan's Hydropower Potential

The Indus basin is the fifth largest in the world. The mighty river Indus is fed by snowmelt from the Pakistan's northern mountain ranges, the Karakorams, the Himalayas, and the Hindukush snow ranges which are larger than any other part of the world except the North and South poles. It drops about 6000 ft in about 300 miles from Skardu to Tarbela creating a colossal amount of stored energy, secure from outside interference, perpetual, environmentally clean and the cheapest.

Pakistan has a hydroelectric potential of about 50,000 MW, when the whole of Chitral as well as Skardu gorges are comprehensively assessed. The river Indus with its tributaries and distributaries is the main source. Its main gorge, between the Skardu and Tarbela, has a potential of almost 30,000 MW according to A.V. Karpov**. (1)** These include Basha (4500 MW), Dassu (3700 MW), Bunji (5200 MW), Thahkot (1043 MW), Patan (1172 MW), Rahikot (670 MW), Yulbo (710 MW), Yugo (1000 MW), Tungas (625), and Skardu or Katzara possibly 4000 to 15000 MW. Another almost 20,000 MW potential as available on various sires on the rivers: Swat, Jhelum, Neelam, Punch, Kunhar, etc.

Despite this huge potential, after the completion of Tarbela in 1977, no comparably large hydroelectric project was undertaken. The loss that this has caused to the natural economy is incalculable.

1.2 Current Utilization of Hydropower

Hydroelectric power stations currently in operation have a total installed capacity of almost 6500 MW. Mangla was commissioned in 1967 with additions up to 1994. Tarbela in 1977, with additions up to 1993. Apart from these, the only recently completed ones include Chashma 184 MW, 2001 and Ghazi Barotha 1450 MW, 2004.These power stations with their installed capacities are given in Table 1.

Table 1: Hydropower Stations in Operation

Hydropower Station	Capacity MW
Warsak	240
Mangla	1000
Tarbela	3478
Chashma	184
Ghazi Barotha	1450
Malakand	20
Dargai	20
Rasul	22
Nandipur	14
Chichokimalian	13
Shadiwal	13
Various Small hydroelectric stations	17
Total	**6471**

2.1 Evolution of Hydropower Leading to Creation of the Water and Power Development Authority

In 1947 there were districts in East and West Pakistan where there was hardly any electricity. In 1959, in West Pakistan, the total generation capacity was 119 MW (excluding KESC) with 52 MW hydro and 69 MW thermal. In the North West Frontier Province there was the hydroelectric power station at Malakand established in 1938 with 9.6 MW augmented to 20 MW in 1952 and 20 MW Dargai hydroelectric power station completed in 1952. Both are on an irrigation canal of the river Swat. There was also Kurramgarhi 4MW, 1958. In Punjab there was the 22 MW Rasul hydroelectric power station also on an irrigation canal and a small 1 MW one at Renala. The other main cities and towns had small local thermal power stations. The villages were mostly without electricity. The largest city at that time, Lahore has a small thermal power station at

Shahdara. Lahore's power supply was supplemented by import from India from Joginder Nagar hydropower station.

This state of affairs needed change. To develop the country, it had to produce sufficient electrical power capacity as well as the means to transmit and distribute it. West Pakistan had one of the world's largest irrigation systems. There was considerable knowledge of its rivers and the hydroelectric potential. For a long time it was known that by building a dam on the narrow gorge of the river Kabul at Warsak a hydroelectric power station could be built. Work on the construction of the Warsak hydroelectric power project was started in the 1950's and it was commissioned in 1960 to produce160 MW. It was extended to 240 MW in 1980.

Not only was Warsak the country's first medium sized hydroelectric power station, this project produced teams of engineers and technicians, professionally of high calibre. These engineer and technicians were then responsible for creating teams to work on and competently operate the later, much larger power stations of Mangla and Tarbela.

Realizing that Pakistan had tremendous hydroelectric potential on the river Indus, its tributaries as well as the other rivers, a most important national endeavor was undertaken. In 1958 was enacted the West Pakistan Water and Power Development Authority, WAPDA, Act for the unified and coordinated development of water resources of West Pakistan.

The work on WAPDA's projects started, before WAPDA came into existence, in the Power Development Section of the Pakistan Industrial Development Corporation, P.I.D.C, in Karachi. These projects included:

- 240 MW natural gas power station at Piranghaib, Multan.
- Transmission system forming the grid to interconnect Warsak and Multan power stations with Lahore, Lyallpur (Faisalabad) and the other load centres through 132 kV grid substations and transmission lines Warsak – Peshawar– Wah – Rawalpindi – Kharian; Warsak – Daudkhel – Sargodha – Lyallpur (Faisalabad) – Lahore; and Multan – Lahore.
- Telecommunications and Control System for the upcoming power grid.

2.2 Success and Failure of WAPDA

Although WAPDA Act was enacted in 1958, it became operational in Lahore on 1 January 1959, when Mr. Ghulam Faruque brought with him a rather small group of engineers of the Power Development Section of the PIDC, to form the nucleus of WAPDA, with himself as its Chairman.

Since WAPDA was established for water–power development, one of its primary tasks was to identify sites for water power development and to determine their potential. For this purpose the Planning and Investigations department was set up under a most competent and visionary engineer, Mr. Monawar Ali Shah. Starting in 1959, surveys and investigations were started at dozens of sites, including mostly large and medium ones. Prefeasibilities of a large number of hydroelectric projects were undertaken.

With the signing of Indus Basin Treaty in September 1960, WAPDA embarked on what at that time was the world's largest water sector development project. WAPDA's record in the first eighteen years of its existence up to 1977 was spectacular. It successfully built and commissioned Mangla dam and hydroelectric power station with initial live storage of 5.3 MAF and power production of 1000 MW, as well as Tarbela dam and hydroelectric power station, with live storage of 9.7 MAF and installed capacity of 3728 MW. Tarbela storage releases started in 1975 and power generation started in April 1977. WAPDA also built very large canals, as well as 5 barrages. It completed large Waterlogging and Salinity Control projects as well as several Surface Water schemes. It successfully completed the small hydroelectric power stations on canals in the Punjab, at Chichokimalian, Shadiwal and Nandipur.

WAPDA put up thermal power stations at Multan, Faisalabad, Hyderabad, Kotri, Guddu, Quetta etc. Another successful endeavour was constructing a nationwide grid system with 132 kV, 220 kV and 500 kV transmission lines and grid substations stretching from Warsak in the north to Karachi in the south; and from Sialkot in the East to Quetta in the West. For the operation of Power Grid an elaborate state of - the - art Telecommunications and Control system was planned, designed, engineered, installed and operated with its Load Dispatch Centre at Kot Lakhpat outside Lahore. This system provided for the first time in Pakistan multi-station direct distance dialing telephony as

early as 1961-62, telemetering, teleprotection and it also provided automatic load-frequency control.

Furthermore the electrification of Railways was started. The 200 mile Lahore – Khanewal section was commissioned in the early 1960's.

Village electrification was rather slow in the coming. Up to the late 1960's, the average number of villages electrified per year in West Pakistan was hardly 100-200. With much effort on the need of accelerating the rate of village electrification, it was increased to about 1000 per annum by the end of 1970's, and increased to around 5000 every year in the late 1980's and 1990's. (Still about 40% of villages remain without electricity).

The part of WAPDA's charter on which there was no progress has been Inland Navigation.

The period between 1950 and 1976 was the golden era of WAPDA. It had embarked upon and completed one of the biggest development programmes in the world. It had a galaxy of world class engineers, highly qualified professionals, competent and of high integrity. Starting with 119 MW in 1959 Pakistan had an installed power capacity of 1741 MW by end 1969, which at that time was more that the installed power capacity of South Korea, 1636 MW. By 1976 the installed power capacity had reached 2,775 MW.

WAPDA's great achievements starting in 1959 (actually 1958) up to 1976 can ascribed to number of factors.

- Firstly the great Chairman Mr. Ghulam Faruque who had vision and who truly understood the goal of a development organization and the necessary methodology to achieve them. He had the genius to gather the most competent and highly qualified professionals for every project and every position and give them authority with responsibility.
- WAPDA remained in that period an autonomous organization, with no interference or hindrances placed by other government entities.
- Most modern management methods were utilized some even ahead of their time, like non hierarchical structures. Discussions on projects were without restraints.

WAPDA during that period may not have been perfect, and it may be a little behind the Swedish State Power Board, on which it may have been modeled or the Tennessee Valley Authority, but not much. Visiting and studying organizations similar to WAPDA, like the two mentioned above, as well as Niagara-Mohawk New York; Consolidated Edison New York; Ontario Hydro Canada; Bonneville Power Administration, Washington and the Tennessee Valley Authority, comprehensive Reports were produced discussing their management systems, organization and procedures of these organizations.

WAPDA's deterioration started after 1976. Up to that time all of WAPDA's Chairmen and Members of the Authority were top-rate persons including the civil service or professional WAPDA engineers. From 1976 to 1991 WAPDA was continuously headed by those who were neither from WAPDA nor with the professionalism, competence or integrity required to successfully run the country's largest development organization. There was too much authoritarianism. The culture of open discussion was suppressed under a military officer – subordinate system.

If economic development was to be achieved, large amounts of electric power would be needed. For that purpose the pace of hydroelectric development should have been accelerated. Since this was not done, there were power shortages leading to the electricity crisis in the late 1970's, 1980's and 1990's. To start with it could be argued that some thermal power was needed, but the stress should have been on hydroelectric power. Instead thermal power stations were built one after the other. The reason given each time was that since power was needed urgently, a thermal power station could be added in 2-3 years whereas large hydroelectric power stations would take longer. The other excuse was that all three provinces were against Kalabagh. But no reason was given why the other three large and many medium projects could not be built during this long period of over 25 years. The real reason unfortunately was that kickbacks for thermal projects are possible very much earlier.

Despite this shortages still persisted in the early 1990's leading to the 1994 Power Policy. Terms negotiated with the IPP's were far too generous. They resulted in too heavy a drain on WAPDA as well as leading to unaffordable electricity tariffs.

After Tarbela's completion, for a quarter century, not only was no hydroelectric power station built even the work of completing the Feasibility studies and preparing bankable documents of the many known large and medium hydroelectric projects was not undertaken. WAPDA, the organization whose primary purpose is water-power development became a thermal power development organization. The hydel: thermal ratio which should have been 70:30 became 30:70.

In the period from 1976 to 1991 ----- in 15 years, this commendable water power development organization became inefficient and corrupt.

Tremendous damage has been caused to all sectors of the economy. Because more and more thermal power was added, billions of dollars of oil had to be imported every year. Yet power shortages persisted from the late 1970's for over 20 years. Because Railways were not electrified with hydroelectricity, more oil had to be imported. (Oil import has already about $3.15 billion this year) This badly affects the balance of payments. Due to the fact that more and more thermal power was added with much higher cost than hydroelectricity (during that period the cost of electricity per kWh from Mangla remained at Rs 0.03 and Tarbela Rs 0.11), electricity became unaffordable for industry, agriculture and all other consumers. This resulted in demand growth slowing down.

For a developing country this has been most unwelcome situation, since electric power should have been the engine of growth. Instead the lack of affordable electricity has been a brake on the economy. About 40% of the population still remains without electricity. The high cost thermal IPP'S burden is another result of ignoring hydroelectric development.

3.1 Case for Hydroelectric Power Development in Pakistan -- Cost Comparisons and Environmental Considerations

It is generally believed that the cost of installing hydropower is very much higher than thermal power. But Pakistan's experience is otherwise.

The largest thermal and hydel power stations recently built include the 1292 MW HUBCO thermal power station with a cost of $1.8 billion i.e. $1393/kW installed and the

1425 MW Ghazi Barotha hydel power station built at a cost of about $1.5 billion i.e. $1053/kW installed. Even at an assumed Load Factor of 60%, per kWhr cost of HUBCO is much higher at Rs4.48 compared to the hydel's Rs2.2. **(12)** HUBCO's cost climbs further at lower Load Factors.

WAPDA's experience shows that during the same periods hydros have had a much lower cost per kW installed as well as per kWh, as shown in Table 2. **(3)**

Table 2: Capital Cost of Thermal and Hydel Power

Power Station	Commissioning Years	Cost/kW Installed Rs
Multan Thermal	1960 - 63	977
Warsak Hydel	*1960 - 81*	*1179*
Faisalabad Thermal	1967	1815
Faisalabad Gas Turbines	1975	1877
Guddu Thermal Units 1and 2	1974	3205
Kotri Gas Turbine Units 3 and 4	1978	3572
Guddu Thermal Unit 3	1981	9052
Guddu Thermal Unit 4	1986	9714
Kot Addu Thermal Units1 to 4	1987	10378
Kot Addu CC Thermal Units 9 and 10	1991	14830
Mangla Hydel 1 to 8	*1967-69,1973,74,1981*	*1578*
Tarbela Units 1 to 4	*1977*	*737*
Tarbela Units 5 to 8	*1982*	*4103*
Tarbela Units 9 and 10	*1985*	*3423*
Tarbela Unit 14	*1991*	*14830*
Chasma Nuclear Unit 2	After 2005	168583

The cost of hydel generation per kWhr is undoubtedly much lower. The cost of generation of Tarbela up to 2000 remained below Rs 0.17 and went up to Rs 0.54 in fiscal year ending June 2003. Mangla remained at Rs 0.03 till 1990 and remained Rs

0.12 till June 2003. Compare this with WAPDA's thermal power stations with costs generally ranging between Rs 2.46 to Rs 2. 97 in June 2003.

The cost of thermal IPP's that came after the 1994 Power Policy are also extremely high compared to hydel power stations, and even compared to WAPDA's thermal power stations, both in the cost per installed kW as well as the cost per kW hr. Their ranges from Rs 3.5 to Rs 4.5 to Rs 5.3, which at $ 1 = Rs 59 range between 6 cents to 9 cents. This is at an assumed load factor of 60 %. With lower load factors, which are often the case, these costs are even higher.

Pakistan has total coal reserves estimated at 185 billion tonnes, located mostly in Sind at Thar and Lakhra, with a generation potential expected at about 100,000 MW. Balochistan is stated to have a potential of 150 MW; Punjab 130 MW and NWFP 10 MW. The largest reserve of 175 billion tonnes of lignite coal located in the Thar desert is yet to be investigated. **(11)**

At present only 150 MW FBC plant is being operated at Lakhra, commissioned in 1966. Its cost was about Rs36667 per kW installed and at 60 % load factor at Rs 2.7113 per kWhr.

Not only is hydel the cheapest form of energy, it is expected to remain so for many years. Countries with hydro potential have first exhausted them before going for other forms of energy. Alternate energy sources such as wind, solar, hydrogen and fusion have still a long way to go to be competitive economically. Hydroelectricity is also the cleanest environmentally.

The world's fossil fuels are fast depleting. Most of the favourable resources have already been explored and the cost of new explorations is becoming too high. Oil prices continue their upward trend and have already exceeded $ 52 per barrel. Pakistan's Ministry of Petroleum has stated that natural gas will only be available for power generation up to 2010.

The environmental cost of coal and furnace oil and power stations will be prohibitively expensive.

Most importantly strategic dependence on fuel oil can not be afforded by any country. The dominance for oil resources will get more acute.

Hydroelectric potential is undoubtedly Pakistan's greatest energy resource, and this has to play the dominant role in Energy planning.

3.2 Efforts for Hydroelectric Power Development in Pakistan since 1975

The high level National Seminar on the Role of the Hydroelectric Resource in the Development of Pakistan was held at Lahore in 1975. It was chaired by the Minister of Water and Power. The participants were the federal Secretaries of the Ministry of Water and Power, Science and Technology, Chairman and Members of the Water and Power Development Authority and two hundred leading power and water engineers. This author's keynote paper was accepted recommending to the government:

- Starting work on two major hydroelectric projects to take the installed capacity to 12,000 MW by 1982
- Conducting urgently a Ranking Study on the major sites of the River Indus

With the change of government in 1977, hydroelectric development suffered a major setback. The Ranking Study was delayed up to 1981 and completed in 1984 by Montreal Engineering Company. Until 2000, Pakistan's vast hydroelectric resources were completed abandoned, even by the very organization that was created for water – power development, WAPDA. This author needs to be excused for mentioning a few of his sustained strivings leading finally to WAPDA coming up with Vision 2025:

- Keynote paper at the Group 83 National Seminar on the Energy Crisis in Lahore in 1983, identifying the excellent sites on the Indus and other rivers, as well as advocating the necessity of starting work on them urgently..
- At the 1986 Seminar on National Consensus, arranged by The Muslim and participated by prominent political leaders and economists, the necessity of a quantum jump with hydroelectric power was convincingly put across and given wide coverage in press. This theme has been stressed in 30 articles published in the Dawn, Muslim, News, Frontier Post, Nation, between 1974 and 2003.
- The list of 42 identified hydroelectric projects was presented at the Seminar on the Eighth Plan arranged by the Planning Commission of

Pakistan on January 1991**. (2)** All these projects form part of the WAPDA's Vision 2025 programme produced in 2000.

Efforts made in the North West Frontier Province met with tangible success. In early 1980's the NWFP government was got convinced of the benefits of hydroelectric development. The Small Hydel Development Organization was created, which was later changed to SHYDO, Sarhad Hydel Development Organization. This organization has done considerable work in collaboration with GTZ, in identifying a large number of medium and small sized hydroelectric sites. A total potential of about 5000 MW has been identified.

Azad Jammu and Kashmir government also started work of identification of hydroelectric sites. **(4)** They were helpful by GTZ of Germany, MECO of Canada and HEPO of WAPDA. A total power potential of over 4000 MW at .43 sites has so far been identified. 5 projects above 50 MW totaling 1018 MW are on the fast tract. A large area of Neelam valley remains to be surveyed for identification of new sites. System studies have recently been started for the Master Plan to make AJK self sufficient in energy through hydroelectric power generation as well as the required transmission network.

3.3 Vision 2025 – WAPDA's Programme for Water Resources and Hydropower Development

It took all those years from June 1975 to August 2000 to finally get massive water power development back into the focus so essential for Pakistan's development. Launching by WAPDA of the Water Resources and Hydropower Development Programme, Vision 2025, **(5)** is of momentous import and will have far reaching beneficial effects. WAPDA has once again been brought back to its original and primary task of water resources and hydroelectric development. Although WAPDA's record before 1976 is replete with tremendous development, the programme that it has embarked upon is greater than anything it has undertaken before. It would add 27,000 MW of power as well as 65 MAF of additional water storage at an estimated cost of $ 45 billion.

Under the Part I of this programme, approved by the Federal Cabinet in August 2000, WAPDA has started work on the firming up of the Feasibility Study of the first

ranked project of Basha Dam, prepared by Montreal Engineering in 1984, and in which later studies showed had certain deficiencies. A major portion of this work was to be completed in February 2003 and to be fully completed by November 2003. It has been delayed and completed in November 2004. If no further impediments are put in its way, it's Engineering and Tender documents should be available by mid 2007.

In Part II and III on January 17, 2001 the Chief Executive of Pakistan approved WAPDA's proposals for:

- Undertaking detailed designing up to tendering stage of Mangla raising.
- Undertaking detailed designing up to tendering stage of hydropower projects (to meet the expected power shortage of 500 MW by 2005 – 06 of Jinnah 96 MW, Malakand III 81 MW, Upper Jhelum Canal 97 MW; Golen Gol 106 MW; Allai Khawr 121 MW; Duber Khawr 130 MW; Pehur High Level 12 MW.
- Authorizing WAPDA to undertake feasibility studies on small hydropower projects on canals and barrages. There are 591 such identified sites with a total power potential of 550 MW. These studies were to be completed within one year.

4. How Hydropower Fits into the Current and Projected Future Structure of Energy Sector in Pakistan

4.1 Current Structure

Out of a total installed power capacity of 19414 MW in 2004, there are only 3 large hydropower stations and 2 medium sized ones. There are also several small ones. The total hydropower installed capacity is 6492 MW. The hydel: thermal mix had deteriorated to about 30:70. With the recent induction of Ghazi Barotha hydropower station, there is a small improvement to 33:67.

The total installed capacity **(3)** is shown in Table 3 below. WAPDA's and KESC's thermal power stations are old, some over 40 years old. There is also the essential element of auxiliary consumption in thermal plants. Therefore their effective capacity is less than their name-plate rating or installed capacity.

Table 3: Installed Power Generation Capacity 2004

Installed Power Generation MW	
Hydro	6,492
Oil and Gas	12,302
Nuclear	462
Coal	150
TOTAL	**19,414**

4.2 Projected Future Demand

There are several estimates of projected future demand of energy. It is to be noted that generally the basic data is from WAPDA, which generally has based its projections on suppressed demand. It is also a fact that for many years the economy has been faring badly and the power shortages followed by unaffordable tariffs have been contributing factors.

The National Power Plan **(6)** prepared with Canadian assistance starting in 1991 projected 64,000 MW for 2018 for WAPDA and KESC. This National Power Plan's Comparative Generation Forecasts is shown in Figure 1. The Reference Forecast is based on Energy based forecast; GDP growth of 6.52 through the period; Load Factor 67.9% reducing to 56%. The NPP Forecast is based on GDP growth of 6.5% through the period and Load Factor 65% through the period. The NPP forecast with Demand Side Management (DSH) scenarios is the third one.

The Pakistan Water Sector Strategy **(7)** prepared by the Ministry of Water and Power's office of the Chief Engineering Advisor in giving the Demand Projections has considered three scenarios for estimating the future power demand:

I. The estimated natural / unrestricted growth of 11%. The aggressive revival of the sick industries announced by the Government also supports 11% demand growth. However, it is very optimistic because of slow revival of the industry during the last several years. The peak demand is expected to increase to 33,640 MW in 2010 – 2011 and 145,031 MW in 2024 – 25.

II. The actual demand increase i.e. a projected constrained restricted demand growth rate of 8.8%. The peak demand is expected to increase to 27,541 MW in 2010 –

2011 and 89,700 MW in 2024 – 25.

III. Based on a conservative increase in demand of around 6.1%. The peak demand is expected to increase to 21,423 MW in 2010–2011 and 49.078 MW in 2024–25.

Although the expected demand growth during the next ten years (September 2001 to 2010 – 2011) is 9,573 MW even at the extremely conservative demand growth of 6.1%, additions to the generation capacity should be much larger due to:

- Accommodation of retiring (old) plants and to cater for ever increasing system losses. (Losses increased from 24% in 1994 to 30% in 2000).
- Seasonal variations in hydropower capacity.
- Provision of adequate spinning and maintenance reserves

It should be emphasized; states the Water Sector Strategy, that even with the addition of 10,000 MW to the system on the next 10 years, the total generation capacity would be insufficient to cover any unusual shortfalls in hydropower capacity, such as the conditions which prevailed in the country during the recent drought. At the most conservative growth rate of 6.1%, the shortages of power supply will start accruing from the year 2004 – 2005 even after the commissioning of all the planned units in the public and private sector. With the Government projecting 8% growth, the second scenario of estimated future power demands as given in Table 4 would appear to be the preferred course.

Table 4: Projected Growth of Power Sector

Year	**Potential Peak Demand MW 11% Growth**	**Restricted Peak Demand MW 8.8%Growth**	**Potential Peak Demand MW 6.1% Growth**
September 2001	11,850 actual	11,850 actual	11,850 actual
2010/11	33,646	27,541	21,423
2024/25	145,031	89,700	49,078

The present water shortage has already created the conditions mentioned. It is also a fact that hardly 40% of the populations have access to electricity. To elevate the living conditions, as evident from many studies, access to electricity must be provided to the remaining population. Also efforts are needed in directions to lessen the burden of high oil prices. The electrification of Railways would be a big step. This could be followed by electric buses in the cities.

As proved by the tremendous expansion of the Telecommunication sector, because of greatly increased availability, easier availability of electricity would logically increase demand.

Furthermore availability of economical and reliable electricity should be seen as the engine of growth. Therefore very serious consideration needs to be given to the higher projections recommended by the Pakistan Water Sector Strategy. It would have to be ensured that to the maximum extent all future demands are met by hydropower.

5. Siltation and Hydropower

A large part of the watershed of the Indus River and its tributaries lies in Indian held Kashmir and Pakistan has little control over that part. The watershed of the Kabul River lies in Afghanistan. It is estimated that the Indus and its tributaries carry about 0.35 maf (0.435 BCM) of sediment annually of which 60% remains in the system where it deposits in the reservoirs, canals and irrigation fields**.(8)** To remove the deposited silt in the canals, annual silt clearance is undertaken. An extensive watershed management programme involving forestation, construction of sediment traps and speed – breakers etc has been undertaken in the catchments of Mangla and Tarbela dams to reduce silt deposition. This programme has been quite effective in reducing silt flow into the reservoirs. But over sedimentation of the main reservoirs is still a concern and measures for replacement of lost storage will have to be taken, particularly when by the year 2010 the on - line storages would lose a total gross capacity of about 5.9 MAF.

According to the Pakistan Water Sector Strategy on estimated over 24.5 million hectares of the upper Indus Basin watershed lies in the Northern Areas, Azad Jammu and

Kashmir, NWFP and northern Punjab. The rate of soil erosion in the watershed areas is accelerating mainly due to overgrazing, deforestation, poor land use practices, cultivation of marginal lands enforced by the rapid population growth, and lack of alternative sources of fuel wood as well as economic opportunities in the mountain communities. There is an estimated 1.2 million hectares of eroded land and a further estimate indicates that 76% of land is affected to varying degrees, by wind and water erosion.

In the NWFP the annual soil loss due to water erosion is estimated at 2.5 tonnes/ha on unprotected land while on steeper slopes of the Tarbela catchments area the erosion has been estimated at 40 tonnes/ha. The live storage capacity of Tarbela and Mangla reservoirs is estimated to have reduced by 20% by 2000 and is likely to reduce by 33% by 2020 due to resulting reservoir sedimentation.

Most of the sediments brought down by the Indus are trapped on the Tarbela reservoirs about 200 million short tonnes. The live and gross storage has diminished from the original 11.6 MAF and 9.7 MAF, by 16% and 22% to 8.1 MAF and 9.1 MAF respectively by 1997. The loss of live storage results in the gradual reduction in the regulated yield of the reservoir, leading to reduction of storage and hydropower. Sedimentation has also formed a delta at the upstream end. Erosive action of silt-laden water on the dams outlet works and turbine, increases maintenance cost, eventually rendering them inoperative.

5.2 Remedies for Siltation

The Watershed Management Project implemented by the NWFP Forestry Department in two consecutive phases since early 1970's have been quite effective in the reduction of soil erosion and rate of sedimentation of Tarbela reservoir. This effort needs to be continued and made even more effective for Tarbela as well as the other reservoirs. It is also essential that the rapid deforestation estimated at 7000 – 9000 ha annually be strictly checked. About 88% of deforestation is due to tree cutting for fuel. An average figure in the mountain areas cut four trees annually (worth about Rs. 400,000). Very serious consideration has to be given to providing alternative and cheap energy for cooking and heating etc. Thousands of sites exist for micro and mini hydel power stations

and they should be established on an urgent basis. While working on micro and mini hydel sites in the NWFP it was found that 20kW to 50kW to 100kW hydel power stations could be set up between Rs. 500,000 to Rs.1, 000,000. The resulting benefits would far outweigh these costs.

For Tarbela the sediment problem was recognized at the outset. Its life was forecast to be 55 years. The life of the project was originally intended to be prolonged by a combination of scouring through tunnels 3 and 4. Dam engineering at that time did not provide sediment modeling techniques that are presently available and which would enable the rational design of reservoir flushing.

Various experts and consultants have been studying the sedimentation problem of Tarbela. An inspection panel constituted in 1991 had recommended that:

"A comprehensive master plan for the management at the Tarbela dam project should be initiated on the basis of studies of Sediment research and system planning for the Indus basin, so as to decide the minimum pool levels for the life of the project, need for sluicing outlets and particularly their intake levels. The plan should include watershed and sediment management, alternative arrangement for power sources if the power units have to shut down during sluicing, downstream regulation of sluiced water and studies to minimize the damage of waterways and turbines by sediment". **(8)** They further stated that there is hardly any time for study and implementation of proposals which may require modifications of tunnels, or for providing new tunnel / orifice spillway and new intakes for tunnels 3 and 4 as necessary. The delta can reach the intakes in 6 years time (2009) and therefore, the urgency of the situation should be made clear to all concerned.

With this impending disastrous situation, one clear solution that should no longer be postponed is the urgent construction of an upstream dam, necessarily Basha. Only that can increase the life of Tarbela by 30 to 40 years, as is widely known in WAPDA.

6. Large, Medium and Small Hydropower Sites in the Indus System

About nine hundred and fifty hydroelectric sites have so far identified on the Indus system. Out of these, two projects Basha and Bunji are above 4000 MW and two Dassu and Kalabagh, are above 3000 MW. Five projects are in 1000 MW range: Patan,

Thahkot, Yugo, Phandar and Neelum-Jhelum. Twelve projects are between 400 MW to 750 MW. Twelve projects are between 190 MW to 340 MW. Sixteen project are between 96 MW to 171 MW; ten between 60 MW to 84 MW. Between 40 MW to 55 MW there are 10 projects; between 20 MW and 38.96 MW, nineteen. Besides these, there are also other small identified project sites including 102 between 9.92 MW and 19.5 MW, 133 between 5 MW and 9.92 MW; 182 between 1 MW and 5 MW and about 406 between 1 MW. Table 5 shows 21 large and medium projects.

Table 5: Large and Medium Hydropower Projects

S #	Projects Name	Power Generation MW	Water Storage MAF	State of Investigations Feasibilities, Engineering	Estimate of Projects Costs
1	Basha	4500	7.3	Feasibility completed	$ 6.4 billion
2	Dassu	5200	-	Feasibility being undertaken	
3	Bunji	4720	-	Feasibility being undertaken	
4	Kalabagh	3600	6.1	Feasibility and engineering completed	$ 6-7 billion
5	Patan	1172		Pre-feasibility	
6	Thahkot	1043		Pre-feasibility	
7	Yugo	1000	4.82	Pre-feasibility	
8	Yulbo	710		Pre-feasibility	
9	Rahikot	670		Pre-feasibility	
10	Tungas	625		Pre-feasibility	
11	Phandar	1162		Pre-feasibility	
12	Neelam-Jhelum	969		Feasibility completed	$ 1.408 billion
13	Chor Nala C-1	649		Feasibility completed PC II approval	
14	Munda	750		Feasibility completion expected May 2005	$ 1 billion
15	Kargah	567		Identification/Reconnaissance	
16	Spat Gah Middle	546		Identification/Reconnaissance	
17	Spat Gah Lower	513		Identification/Reconnaissance	
18	Mashuj	464		Identification/Reconnaissance	
19	Karrang	458		Identification/Reconnaissance	
20	Doyian	425		Feasibility	$ 436 million
21	Kalam D	410		Identification/Reconnaissance	

7. Hydro as Residual to Irrigation

Although in the case of Mangla and Tarbela, the main purpose of these two reservoirs was storage for irrigation and hydroelectric power generation was an associated benefit, this need not apply to other projects. In some irrigation and hydro power generation may be equal/dual benefits, and in some, irrigation may be residual to hydropower generation. At Warsak both the benefits are more or less equal. At Ghazi Barotha the only benefit is hydropower.

In the nine ranked projects on the Indus gorge: Basha, Dassu, Bunji, Patan, Thahkot, Rahikot, Yugo, Yulbo, Tungas, seven projects are primarily for hydropower generation and only two Basha and Yugo have storage reservoirs which will help irrigation.

Similarly a much larger number of projects listed earlier have hydropower generation as their main function.

8. Programme for Hydropower Projects

A major contributor to the deterioration of the economy over the last two decades was the most reprehensible neglect of hydropower development. Instead of acting as the engine of growth power shortages and its unaffordable cost led to economic stagnation. Over 3000 industry units were shut down. Agriculture also suffered. Electricity tariffs have become so high that they have dampened demand. Massive additions of hydropower can make electricity affordable again, and the Power Sector the booster of the economy. With hydropower as the driver, it will have multipurpose benefits. As mentioned in the Water Sector Strategy study **(7)**, for over a quarter century, there has been very little investment in the Water sector. Much of the infrastructure is deteriorating for insufficient funding. Rapidly growing population with its requirements of water, food and energy has to be contended with. Per capita availability of electricity is hardly 129 watts in 2004. This is very low compared even with developing countries.

Restarting investment in the water and hydropower sector is the one sure may of improving the living standards. Although stating the above, the Study fails to grasp one important issue: The inadequate growth rates in the Power sector have kept the installed power capacity extremely low. Oil dependence has produced very deleterious effects on

the economy. There is a huge pent–up suppressed demand for affordable electricity for industry, for agriculture, for transportation, for services and the general public. Its export to India can become the greatest Confidence Building Measure.

. The Medium Term Investment Plan of the Water Sector Strategy is of very limited use in this study. It only includes a few hydropower projects being undertaken likely to be started shortly under WAPDA's Vision 2025 Programme. .

Besides the above five projects the MTIP also lists nine hydropower projects in the Private sector shown in Table 6.

Table 6: Hydropower Projects in MTIP – Private Sector

S #	Project	Generation Capacity MW	Cost	Status
1	Jinnah Hydro	96	Rs. 10.691 billion	Feasibility report updated April 2000
2	Malakand III	75	Rs. 7.620 billion	Under implemented by NWFP government
3	Duber Khawr	130		Feasibility Study completed
4	Allai Khawr	121	Rs. 10.32 billion	Feasibility Study completed and reviewed
5	Pehur High Level	10	US$ 8 million	Feasibility Study and Inception Report completed
6	Golen Gol	106 MW with year round 28 MW peek power	Rs. 6.251 billion	Feasibility Study completed
7	Khan Khawr	72	Rs. 8.1 billion	Feasibility Study completed
8	Neelum – Jhelum	969	Rs. 38.272 billion	PC-1 prepared 2001
9	Abbassian	Initial 360 or B125	Rs. 17.082 billion	Feasibility Studies available

WAPDA's Vision 2025 includes a large number of projects for the next 25 years from 2001. NWFP and AJK also have other projects identified.

Although gestation periods of hydroelectric power projects are long, but there is great deal of misinformation about how long they really need to be. Comparisons are made with the years taken for the Feasibility studies and design and engineering of Mangla and Tarbela. What is ignored is there was at that time no GPS for survey, no computers, any computerized design and engineering, nor the advanced technologies and construction methods now available. There should be no need for feasibility studies or

engineering to take 4 years or more, neither is there any justification for extending the period of construction of hydroelectric projects in the Indus gorge between Tarbela and Skardu to 10 to 12 years. Much shorter periods will now suffice.

Furthermore China has been able to complete the construction of hydroelectric power projects of 200 MW in 30 to 40 months, costing no more than US$ 595,000 to $ 833,000 per MW installed. With will and commitment, Basha and Dassu can be constructed in 6 or 7 years as WAPDA's own documents show.

First and foremost hydroelectric development has to be accelerated and given the highest priority. Most of the 950 hydroelectric projects would have to be taken up. Thousands of micro and mini hydels should also be installed in the remote areas for many beneficial reasons, not least being saving forests to prevent rapid siltation of the reservoirs.

Vision 2025 assumes Pakistan's hydroelectric potential at 41000 MW. (Actual potential will be around 50,000 MW). It gives the projects with feasibility studies completed for 7215 MW, feasibility studies in hand for 5977 MW; and projects for which feasibility studies are to be carried out for: 21,222 MW.

. The National Power Plan's Power Demand Forecast for 2014 is an installed capacity of over 40000 MW and for 2018 it is about 54000 MW to 64000 MW. For this an addition of about 35000 MW to 45000 MW is required in the next 14 years. Vision 2025 hydropower projects total only 27000 MW up to 2025. Obviously more hydropower capacity would have to be added.

In Vision 2025, WAPDA expects, at a 6% growth rate, power shortages from 2006. Shortages had already started. 500 MW shortage was expected for December 2004 and January 2005 and more in the coming months, but the recent heavy rains have increased hydel generation to a surplus of 2000 MW.

WAPDA's proposed 8 priority hydropower projects of 715 MW, estimated to cost US$ 769 million up to 2005-06 are given in Table 8.

To meet the power shortage of 5000 MW by 2010, it proposes installation of 6497 MW by the 9 hydropower and 1 thermal: projects given n Table 7.

Table 7: Proposed Vision 2025 Projects up to 2010.

S #	Project	Capacity MW
1	Raised Mangla	180
2	Thal Reservoir	52
3	Doyian (NA)	425
4	Neelum Jhelum	969
5	Kohala (Jhelum)	740
6	Matiltan (Ushu)	84
7	Gulpur (Punch)	116
8	Abbasian (Jhelum)	245
9	Rajdhani (Punch)	86
10	Combined Cycle on Gas/Coal	3600
	TOTAL	6497

Up to 2015 WAPDA has anticipated generation capacity addition of 12350 MW and proposed 16 projects adding 15887 MW. But these projects have since been further investigated leading to enhancement in their installed capacities. Basha's installed capacity has gone up from 3360 MW to 4500 MW: Dassu's form 2712 MW to 3700 MW: and Bunji's from 1500 MW to 5200 MW. There may also be additions in the other projects as further investigations get underway. Table 8 shows these projects.

Table 8: Proposed Vision 2025 Projects up to 2015

	Project	Capacity MW	Status
S # 1	Basha (Indus)	4500 (Initial3360 MW)	Preliminary feasibility study by Montreal Engineering, March 1984. Additional investigations required. were to be completed by 30 November 2003 but delayed till Nov 2004.
2	Dassu (Indus)	3700 (Initial 2712)	Feasibility underway
3	Bunji (Indus)	5200 (Initial 1500)	Feasibility underway
4	Patan (Indus)	1172	Needs Feasibility
5	Thahkot (Indus)	1043	Needs Feasibility
6	Munda (Swat)	740	Feasibility was to be completed Oct 2005. in operation by Dec 2012
7	Chakothi (Jhelum)	139	Needs Feasibility
8	Naran (Kunhar)	219	Needs Feasibility
9	Suki Kinari (Kunhar)	652	Needs Feasibility
10	Patrind (Kunhar)	133	Needs Feasibility
11	Azad Pattan (Jhelum)	222	Needs Feasibility

12	Karot (Jhelum)	240	Needs Feasibility
13	Mahl	245	Needs Feasibility
14	Combined Cycle on Gas	1260	Needs Feasibility
15	Thar Coal	1800	Needs Feasibility
16	Lakhra Coal	450	Needs Feasibility
	TOTAL	Initial 15887	Revised 20543

Grand Total addition up to year 2015 is 715 MW + 6497 + 20543 MW = 27755 MW. With the enhancement of hydel capacity of Basha, Dassu and Bunji by 5828 MW, and more enhancement in the other projects expected, it may be possible to do away with Combined Cycle on Gas Power project of 1260 MW. (WAPDA has proposed the above projects to be undertaken by Public/Private sector or as Joint Venture).

The National Power Plan Demand Forecast for the year 2015 is about 43500 MW. With the Vision 2025 projects up to 2015, the installed power capacity would be 47,169 MW. The additional 3669 MW could reduce this amount of thermal projects.

Vision 2025 projections for 2010 would add 7,212 MW, taking the installed capacity to 26,626 MW, which would be about 1000 MW short of the Restricted Peak Demand of 27.541 MW with 8.8% growth of the Water Sector Strategy. But it would be about 5800 MW above its Potential Peak Demand of 21,423 MW with 6.1% growth.

Considering that the growth in the Power sector has been very slow and that Power installed capacity targets have continually been reduced, as well as the GOP's targeting for an 8% growth, it **would therefore be advisable to plan for the 2015 with the National Power Plan Demand Forecast of 43500 MW.** It is only logical that with such a large unutilized hydroelectric potential and so many excellent sites available, maximum concentration should be on constructing hydroelectric projects. This will also normalize the hydro: thermal mix from its present unaffordable 30:70 ratio and bring down the cost of electricity. Electricity should then be available to a much larger proportion of the population

Part III of Vision 2025 includes projects given in Table 9.

Table 9: Vision 2025 Part III Projects

1	Yugo	1000 MW
2	Suki Kinari	652 MW
3	Naran	219 MW
4	Patrind	133 MW

5	Kalam	110 MW
6	Khazana	110 MW
7	Mir Khani	150 MW
8	Jinnah Barrage	96 MW
9	Malakand III	81 MW
10	Alai Khawr	121 MW
11	Khan Khawr	72 MW
12	Duber Khawr	130 MW
13	Golen Gol	106 MW
14	Upper Jhelum Canal	97 MW
15	Pehur High Level Canal	12 MW
16	591 small hydropower projects on canals and barrages	

The first steps towards better practice has to be the imposing of a sense of urgency in completing the Feasibility studies of all the hydroelectric projects given in WAPDA's Vision 2025. Not only should the timeframes given be followed, but should be accelerated.

A large number of Vision 2025 projects remain at the same state they were in Four years after the launching of the Vision 2025 programme the sense of urgency in implementing the large and medium hydropower projects is not visible. The Feasibility as well as Engineering and Tender documents of Basha should have been completed by now, but only its Feasibility has been completed by November 2004. Detailed Studies for Kalam, Mir Khani, Khazana and Naran, and Tank Zam which were expected to be completed in 2003-4, and Yugo, Suki Kinari, Patrind in 2004-5, have not started. Work has not even been started on the 1984 Ranked projects of Patan, Thahkot, Yugo, Yulbo, Rahikot, and Tungas; or on other very good sites like Phandar etc. 2001.

This is largely due to lack of adequate finances and high calibre engineers. Maximum assistance has to be provided to enable them to produce bankable documents on the fast track, starting with the most attractive very large projects in the ranges above 3000 MW, large projects above 500 MW, medium sized projects from 200 to 500 MW.

After the corporatization of WAPDA, it will only be left with hydel earnings. The World Bank could provide assistance in this area.

The PPIB should be encouraged and assisted in getting prepared Feasibility studies for hydropower projects to attract investment. Similar assistance would be needed by SHYDO and the AJK Hydro Board.

Only non-controversial projects should be addressed, particularly when there is no shortage of large and medium projects. Much greater attention has to be paid to the environment. Only those projects should be undertaken that do not displace very large number of people. Fortunately for Pakistan all the largest projects are located in the Indus gorge between Skardu and Tarbela, areas with sparse population. The medium hydropower projects are also in the mountains with sparse populations. Still environmental ecological concerns must from part of the design of the projects.

The (belated) urgency recently being expressed in starting the 960 MW Neelum – Jhelum hydroelectric project is a good omen. There should not be any more delay in starting the construction of these as well as other excellent projects mentioned earlier.

9. Financing for Hydroelectric Projects and World Bank Engagement

The cost estimated for WAPDA's Vision 2025 programme's addition of 27000 MW installed capacity and 65 MAF of water storage is US$ 45 billion. Although WAPDA's programme is for 25 years, with vision and commitment, it may well be completed earlier by 5 years and optimistically by more. Related developments particularly including power transmission systems would also require additional funds over the next two decades. To meet the peak demand of 60,000 MW by 2018, from the 7700 MW in 1992, the National Power Plan requires investment (at 1992 price levels) of US$ 140 billion which includes $40 billion for Secondary Transmission and Distribution. Since then, about 12,000 MW have since been added, together with Transmission and Distribution, still about $ 109 billion would be required.

Finances for these projects cannot be met by public funds alone although "they have been and will remain dominant and indispensable**". (9)**

The Water Sector Strategy document simply mentions financing by the private sector or bilateral funding. Since1985 the Government of Pakistan has encouraged private sector participation in the Power sector. In 1992, for this purpose, a policy was announced. A new Power Policy was announced in 1994, which because of its over-generous terms for investors, attracted 19 power projects with a total net capacity of 3453 MW. All then projects were thermal, mostly based on furnace oil. Also the Private Power

and Infrastructure Board, PPIB, was created.

In 1998 the Power Policy was changed, treating thermal and hydel projects on an equal footing, putting more emphases on the use of local fossil fuels (coal) and hydropower and encouraging the use of locally manufactured equipment and machinery. Another objective was to obtain the lowest possible tariff through a transparent bidding process.

This 1998 Power Policy evoked very poor response due to many reasons. It was reviewed and replaced by another Power Policy in 2002, with improved features. The Policy is hydrological based, putting the risk of hydrological variations on the electricity purchaser/WAPDA.

Investment in the Power business throughout the world has always been very profitable. Pakistan has excellent hydroelectric projects ranging from multibillion projects, to projects of hundred of million dollars to projects of tens of millions of dollars. These projects can recoup investments in about 7 years to 5 years. What is really needed is firm commitment from the Government to aggressively pursue these projects and consider various forms of funding. Government at the highest level has to recognize fully the importance of water and hydropower development as a source of growth-oriented sustainable poverty alleviation, as highlighted by the 2002 World Summit on Sustainable Development. Incentives for hydel investments could include two-rate tariffs with a higher one for peak power. The local communities must be given incentives, they must get tangible benefits and local interests must be protected.

As has been stated above, the most pressing priority has to be to put on the fast track, the Feasibility studies of the Vision 2025 projects, including their upstream hydrological, economic, environmental and social assessment of options. Any form of investment, private and public, can only come if feasibility studies are available, as well as bankable documents for projects.

The World Bank should firstly give Advisory support in this endeavour. This could be followed by assistance for feasibilities of the remaining of the of the 8 Ranked projects of the Indus gorge: Dassu, Thahkot, Patan, Rahikot, Tungas, Yugo, Yulbo. Some assistance may be required for Bunji. Also should be considered

Naran, Suki Kinari and Patrind on Kunhar where investigations were started in 1960; and Kalam in Swat.

Financing of, or investments in projects of around US$ 50 to 100 billion, in Generation as well as Transmission and Distribution, over the next 15 to 20 years would require many sources. A leading role could be played by the World Bank alone or jointly with the Asian Development Bank. The World Bank itself recognizes that the "changed global recognition of the role of hydropower and the strong demand from clients require a major reengagement by the Bank in the hydropower sector".

Particularly for the large hydroelectric projects of Basha, Dassu and Bunji, the requirement would be an estimated US$ 14 to 18 billion. If national consensus is achieved, Kalabagh could be added. A consortium could come up for each of these projects. These would be public or public /private partnerships. **This would be facilitated if the World Bank and/or Asian Development Bank were to furnish part of the funds required in partnership with the Government of Pakistan**. This course should not be limited to large projects but should also encompass medium sized projects. The Islamic Development Bank could also play a similar role.

The World Bank **(9)** recognizes that in stimulating these additional sources of financing, there are complementary roles to be played by all members of the World Bank Group: MICA to provide political risk insurance; IFC to participate as an investor in priority projects and for IBRD and IDA to provide a combination of investments, guarantees and assistance in developing legal, regulatory and institutional arrangements. More improvement is needed in cooperation among World Bank Group members. The World Bank has also stated that it will follow an improved approach in high-reward high-risk activities.

There is broad consensus among developing countries that the private sector has an important and complementary role to play.

There is great scope for attracting investment from the oil rich countries of the Middle East – if they are convinced of safety of investment and good returns, since they are on the lookout for investments.

Consortia of banks, local as well foreign, should be attracted to these hydropower projects by convincing them of high rate of return.

There a large amount of private capital available in Pakistan. Among the factors are the increases of remittances from overseas Pakistan is as well as their need to invest in the country. Another is the drastic cut in the Bank rate. A clear indicator is the phenomenal increase in property prices in the real estate market – resulting in commercial plots in Islamabad having already crossed Rs. 2.25 billion ($ 37.5 million). If handled in the right way much of this capital can be more productively channeled into hydropower development.

Raising of Bonds; Mutual Funds; Private/Public Partnerships are other viable options for individual hydroelectric projects. Consideration needs be given to floating shares for companies of individual projects or a combination of projects on the Stock Exchange in Pakistan as well as abroad.

The recent recognition by the World Summit on Sustainable Development that hydropower (large and small) is a renewable source of energy and that there is "a sense of urgency to substantially increase the global share of renewable energy sources -------". The World Bank recognizes that this should foster mechanisms enabling environmentally and socially sustainable hydropower projects (small and large) to benefit from the nascent trading in carbon permits. Two examples of the first activities of the Prototype Carbon Fund transactions to purchase emission reductions form small hydropower projects also have been given. Hopefully some environmentally and socially sound hydropower projects here can also be eligible for revenues from the Clean Development Mechanism.

10. Role and Comparative Advantages of the World Bank as a Development Partner in Mobilizing Public and Private Financing for Accelerated Development of Hydropower

The World Bank is unique in being involved in a very big way in Pakistan's infrastructure development since over 40 years. Its partnership with WAPDA extends over these years. The multi-billion Indus Basin Treaty, under which projects include Mangla, Tarbela, several barrages and link canals have strong World Bank involvement. It has also been involved in projects in the National Power Grid, Salinity and Reclamation, etc. Recently it has been involved in Ghazi Barotha.

The World Bank is well known and well placed. It has systems in place. It has existing disbursement structures. A large number of the country's engineers and bureaucracy are familiar with the methods and procedures of the World Bank.

All this gives the World Bank a huge comparative advantage in getting involved in hydropower projects in Pakistan. It can play the role of a catalyst most productively for itself and the borrowers.

Although middle income countries increasingly see the World Bank as the least preferred source of funding (after domestic sources, commercial lenders, bilateral donors and other multilateral development banks) because of the monetary, transaction and delay costs. But they often still express a strong desire to have the World Bank engaged in cutting edge, high reward – high – risk water infrastructure, because they believe it has a unique comparative advantage in helping them deal appropriately with the range of economic, institutional, social and environmental challenges posed by such projects. Despite this to engage with the Bank, countries with choices are less and engaged with the Bank in these areas. Recognizing this fact the World Bank has decided to follow an improved approach for involvement in high – reward – high – risk activities**. (9)**

The World Bank has discussed extensively its role in water resources management. Of the views expressed, particularly relevant to Pakistan, include:

- Improved water development and management are essential for sustainable (economic) growth and poverty reduction.
- Borrowers find that the World Bank has a strong comparative advantage in convening power, ability to link water issues to other sectors, a multidisciplinary perspective, relations with almost all riparian countries (including Pakistan and India), a combination of knowledge and financial practical resources, and engagement at all scales -------- .
- There is a strong appreciation for the scope of the World Bank Group's instruments to assist borrowers in the areas of private sector participation.

But there are other issues of concern. These pose a formidable challenge, recognizes the World Bank, in basing advice on sound objective analysis; in being realistic; in taking advantage of opportunities that arise; and in working with borrowers to

identify a set of prioritized, realizable management and infrastructure investments that can help make steady improvements through an evolving long term approach.

In the case of Pakistan, with hydropower having been ignored for a quarter century, the World Bank approach to the suggested hydropower projects requires the **infusion of a sense of urgency -** if it is to be productively engaged as a development partner in mobilizing public and private financing for the accelerated development of hydropower. In doing this it must recognize that Pakistan has had extensive experience in hydropower development. Technological expertise exists in the country. No more should it be treated as a LDC when it comes to funding. Instead it should get consideration as a MIC, so that most of the funding is utilized by and for Pakistani sources.

For the huge amounts of equipments required: generators, turbines, switchgear, instrumentation, cables and structures, industries should be established/augmented in Pakistan. These will bring in technology as well as create employment and alleviate poverty.

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Water Balance and Evapo-transpiration

By

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Country Water Resources Assistance Strategy
Background Paper # 5
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1. Introduction

1.1. Country's Broad Eco-Systems and Land Cover

Pakistan's geographical area is 79.6 million hectares (mha). It shows a great diversity of bio-climates, vegetation types and fauna. Major habitats consist of: a) flood and arid plains, sand and piedmont deserts and a variety of forests; b) grassy tundra and cold deserts; and c) lakes, rivers, swamps, and coastal marine habitats (GOP, 1992; GOP and IUCN, 1991). The country can be divided broadly into three major regions and a plateau:

- High northern mountains; with 50 peaks of over 6,700 m at confluence of three world's highest mountain ranges – Himalayas, Karakoram, and Hindu Kush.
- Indus plain; drainage basin of River Indus and its tributaries – Western Rivers i.e. Kabul, Indus, Jhelum and Chenab, and Eastern Rivers i.e. Ravi, and Sutlej. Plain consists of fine alluvium deposits by the river system.
- Lower and more arid western highlands, with highest peak of 3374 m.
- Small area in Northwest of Indus plain comprises Pothwar Plateau and Salt Range, with elevations ranging between 450 to 600 m, having topography dissected by water/wind erosion.

Ecological diversity in Pakistan is very high (WRRI 2000a). The NOAA satellite data were used by WRRI-NARC to analyse and characterize major land covers of Pakistan (**Figure 1**).

1.2. Evapotranspiration and its Significance

Evapotranspiration (E_t) is one of the most basic components of the hydrological cycle, which includes evaporation of water from land and water surfaces and transpiration by vegetation, continues to be of foremost importance in water resources development and management. As water retained in plant tissues is minor relative to the amount used in E_t, both the terms (evapotranspiration and consumptive use) are synonymous (Jensen et al. 1990). Estimation of water requirement will permit improved planning and allocation of water resources among the municipal, industrial, environment and agriculture sectors. Information on spatial variation of crop water requirement is essential for reviewing allocation of water for different canal commands in the Indus Basin (IWMI 2001a).

Agriculture sector is the largest user of water in Pakistan, as it consumes 93% of available water resources (GWP and PWP 2000). The country's cultivable area is around 22.27 mha, of which 81% is under irrigated agriculture within and outside the Indus Basin Irrigation System (IBIS)**.** The IBIS comprises of 45 canal commands having average annual canal diversion of 127 billion m^3 (**Figure 2**). Canal water supplies are inadequate to fully satisfy irrigation water requirement of existing cropping pattern, as the *Warabandi* system was designed to ration the available supplies using fixed-rotation schedules. This approach was appropriate due to lack of drainage system and expected low irrigation efficiency. The irrigation projects were designed to divert excessive supplies during high flows Kharif season and share the shortages among the provinces during low flows Rabi season. The deficiency, to some extent is fulfilled by groundwater having variable potential across the IBIS both in terms of quality and quantity (GOP 2003a; Ahmad 2003a,b; GOP 2002a,b,c; GWP and PWP 2000)

During the last fifty-seven years (1947-04), there have been substantial increases in the irrigated area (from 9.1 to 18.04 mha) and cropping intensity (from 60 to 120%) due to expansion of the irrigation system and increased canal water supplies through construction of storage dams and groundwater exploitation – a four-fold increase. The increase in productivity during the same period was almost two-fold. The need for improved management and effective use of canal and groundwater was expressed since late 70s, when Revised Action Plan (RAP) was formulated. Consequently, On-Farm Water Management (OFWM) Programmes were initiated in the country (Ahmad 1999; WSIP 1990; WAPDA 1979).

Canal water supplies are not in line with water requirement both in terms of discharge and volume. Peak water requirement of crops cannot be met, thereby negatively affecting productivity. The situation is further exacerbated due to inequity in distribution of water due to conveyance losses. Farmers at the tail-end commands are receiving almost half of the water compared to the head reaches. Farmers now increasingly complain of inflexibility of the IBIS and demand a more flexible water allocation, distribution and utilization rules, which also allow water trading among the water users (GWP and PWP 2000; Ahmad 1980a,b).

E_t data is essential for transfer of water rights (official and unofficial) from agriculture to other sectors because such transfers are limited to historical crop water use and help in regional allocation of irrigation water (PPSGDPC 1998). Hence, the assessment of crop E_t needs is not only required for better management of the current distribution of canal supplies, but also to synchronize demand-supply gap at the command level. E_t data is now crucial for resolving issues related to water apportionment, allocations, development of new storages and addressing disputes related to regional and environmental water management.

The irrigation scheduling models can be used to predict irrigation water requirements for various canal commands. Simplified information can be printed daily in the newspapers or forecasted on radio and television. Meteorological Department can provide rainfall probability information to meet seasonal and weekly requirement including information on the extreme events – droughts and floods.

1.3. Evapotranspiration and Water Balance – Historical Perspective

Various experts in Pakistan have done considerable work on evapotranspiration. Most of the work done during early periods (1947-72) on estimation of evapotranspiration of crops is either based on estimations made in lysimeters or from calculations using empirical coefficients developed from climatological data (Hargreaves and Samani 1985; Ahmad 1982; Clyma 1973; LIP 1966; Blanney and Criddle 1957). In a lysimeter study, Hussain (1970) found that the consumptive use of wheat (indigenous) and wheat (Maxi-Pak) was 339 and 522 mm, respectively. The drought tolerance character of the indigenous wheat varieties would be a source of germ plasm for introducing traits of drought tolerance in wheat.

Work on estimation of actual E_t of crops based on soil moisture depletion was initiated during 1975, when PARC initiated a National Programme on "Consumptive use of water for major crops under optimum management conditions" in collaboration with USDA-ARS (PARC 1993; PARC 1982). The actual E_t was estimated in relation to moisture stress. Field studies were continued for over 10 years in six major agro-climatic regions of Pakistan, where four levels of management allowed deficit and two levels of fertilizer were used to schedule irrigations and for soil moisture dynamics. Jensen-Haise (1963) method and Pan Evaporation data were used to estimate reference crop evapotranspiration (Et_r). Actual E_t and crop coefficients for 10 daily periods were computed.

PARC (1982) reported results of actual evapotranspiration, moisture stress-yield functions, water productivity and crop coefficients for wheat, maize, cotton, sugarcane and soybeans under six agro-climatic regions of Pakistan. PARC (1993) further reported results of 12 additional crops. The E_t information is now available for 17 crops, which can be used for planning, design and operation of irrigation schemes in the country. The actual evapotranspiration, crop yields and water productivity of 17 crops and for selected agro-climatic zones are presented in Table 1. It can also be used for scheduling of supplemental and/or deficit irrigation and for improving water productivity.

Table 1. Actual Evapotranspiration, Crop Yield and Water Productivity of Crops under Optimum Management Conditions in Pakistan (PARC 1982 and PARC 1993)

Crops	Location	Crop Evapotranspiration (mm)	Crop Yield (kg/ha)	Water Productivity (kg/mm)
Food Grain Crops				
Wheat	Faisalabad	353	3137	8.89
	Peshawar	471	2874	6.10
	Tandojam	562	4523	8.05
	Bhalwal	401	5710	14.24
	Bhakkar	475	4437	9.34
	Mianchannu	520	3629	6.98
Kharif Maize	Faisalabad	342	2137	6.25
	Peshawar	458	2219	4.84
	Tandojam	389	4260	10.95
	Bhakkar	385	2661	6.91
	Mianchannu	319	2217	6.95
Spring Maize	Bhalwal	431	2400	5.57
	Bhakkar	610	5585	9.16
	Mianchannu	715	2263	3.17
Soybeans	Tandojam	680	2033	2.99
Barley	Bhalwal	389	4600	11.83
Chickpea	Bhakkar	277	1600	5.78
Mashbeans	Mianchannu	369	820	2.22
Cash Crops				
Cotton	Tandojam	778	2005	2.58
	Bhalwal	797	1429	1.79
	Bhakkar	632	1633	2.58
	Mianchannu	587	2675	4.56
Sugarcane	Faisalabad	1390	77314	55.62
	Bhalwal	1195	80163	67.08
	Bhakkar	1482	131000	88.39
	Mianchannu	1360	69620	51.19
Peas	Tandojam	382	8380	21.94
	Quetta	374	11000	29.40
Potato	Bhalwal	388	20990	54.10
	Quetta (summer)	854	30630	35.87
Onion	Tandojam	735	39200	53.33
Tobacco	Peshawar	583	2920	5.00
Citrus	Bhalwal	1200	6160	5.13
Other Crops				
Berseem	Bhalwal	748	114430	152.98
	Jaranwala	796	96590	121.34
	Mianchannu	836	88330	105.66
	Bhakkar	783	73120	93.38
	Peshawar	567	112170	197.83
	Tandojam	1106	100000	90.41
Guar	Mainchannu	349	2090	5.99
	Bhakkar	356	2090	5.87
Sorghum Fodder	Bhalwal	444	65870	148.36
Rapeseed	Peshawar	648	2670	4.12

The moisture stress-yield functions indicated that most of the grain crops (wheat, maize, sorghum and millets) could be irrigated at 50-75% depletion of available soil moisture (management allowed deficit)

without loosing any significant yield. Cotton crop behaved differently where further stress did not affect the yield rather it helped to maintain the yield with management allowed deficit of 75-95%. First irrigation for cotton crop under basin irrigation should be scheduled 40-45 days after planting so that roots grow deeper in search of water. Terminate irrigations at least 30 days before harvest so that dry conditions favour opening of bolls to have uniform harvest. The use of rainwater should be linked to achieve effective leaching of salts from the profile, as rainwater has higher potential to leach salts compared to poor quality water.

Irrigation scheduling models have been developed based on the field data and can be used for fixed-rotation and continuous-flow system of irrigation (ICID 1992; Ahmad and Heermann 1992; Ahmad and Heermann 1990; Ahmad 1985a,b). Recently, PARC conducted a study for the "Formulation of a Strategy for Adjusting Cropping Pattern and Crop Water Requirement with Water Availability" (PARC 2004; Ahmad 2003a,b; Ahmad 1987; Ahmad 1981a; Ahmad 1980a,b) on the directive of the Prime Minister of Pakistan to the Ministry of Food, Agriculture and Livestock.

Seasonal and annual river flows in the Indus river system are highly variable (Ahmad et al. 2003; WCD 2000; Ahmad 1993; Kijine and Van der Valde 1992; Warsi 1991; Mohtadullah 1991). The analysis of the daily and monthly flows also indicated a similar trend (Bhatti 1999). The variability in river flows affects the diversion of water to the canal system even in the post-storage period of 1968-99 (WCD 2000). This variability further complicates the assessment of water balance for the IBIS (Ahmad and Majeed 2001; Ahmad 1994; Ahmad 1993; WSIP 1990). Due to the stochastic nature of river flows, the concept of probability of river flows and canal diversions at 50% level was suggested in formulating the water balance for the IBIS (Ahmad and Majeed 2001).

Pakistan Water Vision 2025 indicated that annual river flows in the post-Tarbela period are around 175 billion m^3 at Rim Stations. Out of this 128 billion m^3 are diverted to canals in an average year and augmented by groundwater, where annual groundwater abstraction is around 50 billion m^3 (GOP 2001).

Pakistan Water Strategy indicated that the IBIS commands around 14.66 million ha. Indus River and its tributaries on an average bring about 187 billion m^3 of water annually. This includes 177 billion m^3 from the three Western Rivers and 10 billion m^3 from the Eastern Rivers. Most of the inflow, about 128 billion m^3, is diverted for irrigation, with 47 billion m^3 flowing to the sea and about 12 billion m^3 consumed by river system losses (GOP 2002a).

The long-term sustainable average annual net inflow of the Indus Basin is 175 billion m^3. Canal diversions over the same period have averaged 128 billion m^3, with an average of 35 billion m^3 flowing downstream of Kotri Barrage to the sea. The actual requirement downstream of Kotri remains the subject of intense debate. However, this illustrates that Pakistan is now essentially at the limit of its surface water resources. The drought of the past four years has led to water shortages and illustrated just how close water use is to the limits of the resource (GOP 2002a).

Estimates of groundwater availability have been made in several studies, and vary from 56.3 to 65.8 billion m^3, with an average of 63 billion m^3. Abstraction of groundwater for irrigation and for urban and rural drinking water supplies is estimated as about 51.4 billion m^3. While these figures may suggest some potential for further exploitation, they are based on very little actual monitoring of the resources or the abstraction and should be treated with caution. Other evidence, such as increasing salinity of groundwater due to redistribution of salts in the aquifer and declining water levels, suggests that there is little, if any, further potential for groundwater exploitation. The Strategy has assumed that only 12 billion m^3 of additional groundwater will be successfully exploited (GOP 2002a). The upper layer of groundwater is fresh and using skimming well techniques, additional groundwater development, as envisaged in the strategy, can be accomplished safely.

In the context of increasing water demands, the limited water and finances for water sector investments, the use of water and of money must be carefully considered (GOP 2002a). While there are water shortages there is also extensive overuse of water at the head reaches and deficit irrigation is practiced at the tail-end reaches primarily due to inefficiency in conveyance and application of water, as evidenced by the problem of waterlogging and salinity. The in-equity in water availability is due to the inefficient irrigation management. There are extensive and costly plans to alleviate the drainage problem, which is primarily caused by the inefficient irrigation management and overuse of water for irrigation. Water allowances, especially for irrigation, need to be assessed and rationalised within the larger context of the water sector.

1.4. Water Shortage and Droughts

Provincial Irrigation and Drainage Authorities (IDAs) were established during 1997-98 under the provincial Departments of Irrigation and Power (IPDs). The IDAs are responsible for diversion and distribution of water and to share information with all the stakeholders and work on emergent basis during the drought periods. They also exercise the practices and schedules for managing the shortages in the canal supplies. The interventions adapted during drought periods are:

- Water releases from Mangla and Tarbela reservoirs were strategized to meet the demand during the critical periods of crop growth. The provincial IDAs prepare and submit indents to IRSA for releases from the reservoirs based on critical water demand during extreme shortages (Haq 2002);
- Canal water diversions were managed by having rotation of 14 days instead of 7 days by according higher priority for the brackish groundwater zone. Punjab province has even closed the canal water supplies to the fresh groundwater areas in extreme shortage periods, as these farmers can meet their demand from groundwater (Haq 2002);
- Crash Desilting Programme for canals were implemented to reduce losses by rehabilitation of canal sections to have reasonable hydraulic regime with active participation of water users and pooling their tractors and machinery. The government provided fuel for farmers' tractors and working lunch. The Army Engineering Corps did the monitoring.
- E_t studies were conducted by IWMI and PARC using the remotely sensed data, where drought had positive impacts in reducing waterlogging and increased productivity. Such studies have shown that over-irrigation is a common practice in Southern Punjab and Sindh province. Based on these studies the government has launched an extension campaign for farmers to irrigation under deficit scenarios.
- Working Group constituted for formulation of the next Five-Year Plan (2005-10) for Agriculture further constituted a Sub-Committee on "Cropping Pattern and Water Use Efficiency", which suggested a strategy of how to adjust cropping pattern with water availability. The major intervention is to reduce the cropped area of high-delta crops and increase the water productivity (PARC 2004).
- Skimming well technology has been widely adopted to skim the thin layer of fresh groundwater without disturbing the brackish groundwater. The private sector hand pump drilling companies turned into Skimming Wells companies – a breakthrough due to the drought adaptation strategies. The IWMI, PARC and WAPDA jointly conducted a research project, where skimming well technology was developed and small discharges of freshwater were applied using precision irrigation – drip and sprinkler irrigation (IWMI 2004; IWMI 1999).

1.5. Why E_t Perspective for Water Balance

Water balance is traditionally developed using canal water supplies, conveyance and application losses and the net water availability for crop consumptive requirement. The water balance developed using the water volume data does not indicate the limitations associated with demand-supply gap in net requirement and availability of water – a supply-based approach.

The E_t perspective is based on a demand-oriented approach, where water requirement of crops is assessed for the given cropping pattern for canal commands. E_t perspective is also related to water productivity where yield is directly a function of transpiration, whereas evaporation is a non-beneficial use. However, evaporation cannot be separated from evapotranspiration for practical purposes; therefore evapotranspiration will be used for developing the water balance. Minimizing non-beneficial uses of E_t would not only help to save water but also improve water productivity, where optimizing irrigations enhances crop yields.

1.6. Purpose of the Background Paper

Background paper presents water balance for Pakistan, from the perspective of beneficial and non-beneficial evapotranspiration. The paper examines options for restoring balance in under- and over-exploited systems, for re-allocation of E_t amongst uses and within canal commands, and for increasing productivity per unit of E_t. The paper also indicates how an "E_t perspective" changes perceptions about the challenges of water development and management. The paper further discusses the management instruments and other incentives relevant for optimising productivity per unit of consumed water at the basin level.

2. Ecosystems Characterization and Classification

2.1. PARC Physiographic Regions

Country is divided into 10 broad agro-ecological regions (**Figure 3**) considering physiography as basis for characterisation (**Appendix I-A).** Ecology and resources in these regions vary considerably. Main limitation for agriculture is water shortage because of arid climate (PARC 1980). Sedimentation in rivers and channels, erosion of soil, waterlogging and salinity, desertification and over-grazing are examples of leaky agricultural systems in the IBIS. This requires an ecological approach for water and agricultural development rather than a hardware approach presently being followed (Ahmad 1993).

Total cultivable area of Pakistan is 22.27 mha, of which around 18 mha are under irrigation using surface and groundwater. Rest 4.27 mha are under rainfed (*Barani)* and indigenous water harvesting systems. Out of this, 1.27 mha are under torrent and riverflood spate-irrigation systems in an average year (PARC 1995; Khan 1987). This leaves around 3.0 mha, which solely depend on rainwater and/or runoff. These systems provide livelihood for a large number of ecologically and economically marginal people in Pakistan.

2.2. IBM-R Agro-climatic Zones – A Mis-perception

WAPDA conducted a study for agricultural planning using the Indus Basin Model Revised (IBM-R). In this study the irrigated areas of IBIS were subdivided into nine cropping regions taking into consideration the canal command boundaries, geographic location, climate and cropping pattern (**Figure 4)**. WAPDA named it agro-climatic zones, which is a mis-perception, because these zones are primarily based on cropping patterns prevailing in the IBIS (**Appendix I-B)**.

PARC (2004) conducted a study where detailed map of PARC's cropping pattern (**Figure 5**) was super-imposed on IBM-R Cropping Zones (**Figure 4**) and variability within each zone was identified, which is considerable as some of the zones can be classified into three distinct sub-zones (**Figure 6**). Thus, there are significant variations within the IBM-R cropping zones.

2.3. PARC Agro-climatic Zones

PARC characterized the agro-climate based on seasonal indices of aridity and crop growth. The ratio of 50% probability of rainfall and actual evapotranspiration was used to characterize the aridity index. A total of 18 aridity zones were identified based on both the *Kharif* and the *Rabi* seasons (**Figure 7**). The crop growth index was estimated using the ratio of actual and required growing degree-days to mature the crop. A total of 9 zones were delineated (Roohi et al. 2002; Ahmad et al. 1999a).

Superimposing the aridity and crop growth zones, representing both the Kharif and the Rabi seasons, delineated the agro-climatic zones. A total of 52 agro-climatic zones were classified. Each zone reflects seasonal aridity and crop growth classes.

PARC agro-climatic zones are in line with E_t perspective of water balance, therefore, can provide useful information for planning, management, and conservation of water resources. Variability in agro-climate affects irrigation schedules in Punjab of Pakistan (Ahmad and Heermann 1992; Ahmad 1981a; Ahmad 1980a). Agro-climate is quite complex, involving spatial and temporal variability, thus a comprehensive and integrated approach is required considering the total activities, starting from farm planning, plantation, irrigation, harvesting, post-harvest storage and marketing.

3. Evapotranspiration

3.1. Beneficial and Non-beneficial E_t

The beneficial E_t is the amount of water transpired by the crop because yield is directly a function of transpiration. The increase in transpiration would ultimately lead towards increased water productivity. The evaporation from soil and plant surfaces is a non-beneficial E_t. For practical purposes, it is not possible to avoid or eliminate evaporation, but it can be reduced or minimized. The elements of the non-beneficial E_t in the context of the Indus Basin are:

3.1.1. Non-Beneficial E_t from Cropped Area

- Rauni (Pre-sowing) irrigation is essential for seedbed preparation, as soil is normally dry after the crop harvest and irrigation is required to have soil workability and optimum soil moisture for germination of seeds. Water required for Rauni irrigation is around 10-25 mm, but a minimum depth of 75 mm is required to cover the field under surface irrigation conditions prevailing in the country i.e. unlevelled fields, inappropriate surface irrigation hydraulic in terms of width and length of the field. The crop stubbles in the harvested field also slow down the advance of waterfront and thus increasing the advance time. The excessive irrigation also delays the seedbed preparation as heavy irrigation increases the time required for soil workability.
- At crop planting the rooting depth is zero and it grows from germination to full effective cover and it is almost constant from full effective cover till maturity. The crop water requirement is extremely low during the crop establishment phase. The field is normally tilled at the time of first irrigation and therefore, soil infiltration is higher than non-tilled field. Thus amount of water required for the first irrigation under surface irrigation system and unlevelled fields is higher and at least 75 mm is required to irrigate and cover the entire field. Thus there is a minimum depth of water required to cover the field (D_{min}). Therefore, first 2-3 irrigations depending on the crop are normally heavier than required. This results in excessive wetness of soil and growth of weeds or excessive vegetative growth of crop, which is not desirable for higher water productivity.
- Management strategies are essential to schedule irrigation for non-flexible systems having shortage of water. The moisture stress is applied at first irrigation since planting of cotton under basin irrigation, to allow crop roots to grow deeper in search of water, which is essential for having higher water productivity. Last irrigation of cotton crop has to be terminated 30 days

before the crop harvest irrespective of the soil moisture to have complete opening of bolls and to reduce time needed to complete picking of cotton. Therefore, management strategies should be used as an integral part of the irrigation scheduling criteria along with E_t.

- Crops like cotton, maize, soybeans, sunflower, sorghum and pulses are sensitive to excessive wetness, as yields of these crops are reduced due to over irrigation, thus affecting the water productivity adversely.
- Irrigations are hardly scheduled and normally applied based on the availability of canal water supplies, which is based on fixed-rotation schedules and farmers try to use all the available water on a particular turn. However, farmers to some extent follow crop water needs or demand while using the groundwater, as they have to pay high energy cost for pumping.
- Scheduling of irrigation is aimed to use rainfall effectively. Presently, rainfall is not effectively used as in certain cases rainfall occurs just after having complete irrigation. In such cases rainfall contribute mainly for leaching of salts and nutrients along with excessive wetting

3.1.2. Non-Beneficial E_t from Non-Cropped Area

The elements of the non-beneficial E_t from non-cropped areas are:

- Weeds, shrubs and plants grown along the waterways, weeds in fallow fields, and vegetation in wastelands evapotranspire at the rate which is dictated by the availability of water. The native vegetation can survive for longer duration even under water short situation. As the weed infestation is very high in the Indus Basin, it is expected that almost 20-30 % of water is consumed by weeds and thus regarded as non-beneficial E_t.
- Watercourses are the main source of providing weed seeds to the fields. Weeds grown along the watercourse shed seeds and ultimately reached the field through water. Infestation of weeds in cropped fields not only reduces crop yield but also consume water. All weeds should be regularly eradicated as part of the watercourse maintenance activity.
- Evaporation from fallow fields and waterlogged areas is also a non-beneficial E_t and contributes in accumulation of salts in the surface soil.

3.2. Spatial Variability of Reference Crop Evapotranspiration for Canal Commands

Spatial variability of reference crop evapotranspiration (E_{tr}) across the canal commands was estimated by IWMI (2001a) using GIS techniques. Computer software Surfer and GIS softwares (Arcinfo and Arcview) were used for the spatial analysis and visual representation of E_{tr} in the canal commands of the IBIS. The methodology used in this study involved the following process:

- Contours of equal E_{tr} were drawn by interpolation between stations by using Kriging method in SURFER on monthly basis. The Kriging is a superior technique because it allows the calculation of the error associated with the estimates, namely the variance of the error distribution and tries to minimize this variance. It considers all surrounded values of the variable around the interpolated points by applying the weighed coefficients.
- The canal command map was then superimposed over contour maps to obtain the monthly E_{tr} for each canal command.

The estimated monthly E_{tr} for canal commands of the IBIS are presented in **Appendix II-A.** Seasonal variation of E_{tr} (**Figure 8a, b)** indicates that upper and northeastern part of the basin has lower reference evapotranspiration (1200-1300 mm), whereas, the lower part of the basin, Southern Punjab and Sindh have much higher E_{tr} values (1700-2100 mm). E_{tr} is the maximum in the month of June. In Sindh, Guddu Barrage Canals have the highest E_{tr} in the IBIS. The monthly E_{tr} is generally maximum in June except Kotri Barrage canals (Indus delta) where maximum values occur in May due to sea effects (IWMI 2001a).

The spatial variability of E_{tr} generally increases from North to South during both Kharif and Rabi seasons over the entire IBIS (**Figures 9 and 10**).

3.3. Actual Crop Evapotranspiration for Canal Commands

The 10-daily actual E_t of six Kharif season and four Rabi season crops were computed by multiplying the average crop coefficient with average E_{tr}. The Rauni irrigation depth for land preparation was separately calculated for cotton and wheat and added to the crop water demand. **Table 2** shows the average values for Rauni irrigation (IWMI 2001a). This is a mis-conception because Rauni irrigation can't be considered as part of actual E_t. However, it is a part of the irrigation water requirement. Also important to note is that major part of Rauni irrigation is a non-beneficial E_t.

Table 2. Rauni (Pre-Planting) Irrigation for Wheat and Cotton (IWMI 2001)

Province	Irrigation Depth (mm)	
	Wheat	Cotton
Punjab	125	125
Sindh	75	200

The estimated average depth of Rauni (pre-planting) irrigation by IWMI (2001) seems on the higher side. Minimum depth of 50 mm is required for Rauni irrigation to cover the levelled field. However, for unlevelled fields with crop stubbles, 50 mm is insufficient to cover the whole field. Therefore a range of 50-75 is suggested for the Rauni irrigation. This is in line with the irrigation scheduling models developed for the IBIS (Ahmad and Heermann 1992; Ahmad 1987; Ahmad 1982; Reuss 1980; Ahmad 1980a,b).

The actual E_t computed for different canal commands of the IBIS indicated that for Rabi crops it varied in a smaller range compared to Kharif crops (**Appendix II-B, II-C**). The actual E_t for wheat, which is the major winter crop across the IBIS, varied from 271 to 515 mm at the canal command level, a variation of about 60%. The actual E_t of cotton varies from 627 to 1161 mm and sugarcane varies from 1278 to 1887 mm from the north to south of the IBIS, representing 80 and 70 percent, respectively (IWMI 2001a).

The average actual E_t of different crops for the upper and lower basin is shown in **Figure 11 (**IWMI 2001a**)**. The Rabi actual E_t is less than half of the Kharif. The crop wise variation is 20 to 30 % in Rabi (wheat and vegetables) and 50 to 100 % in Kharif (cotton, rice and sugarcane). The estimation of average actual E_t by IWMI for most of the crops is in the same range as recommended by OFWM (**Figure 12)**. However, the maximum requirement computed by IWMI is comparatively higher for cotton and sugarcane (IWMI 2001a; GOP 1997).

In conclusion, there is a need to distinguish actual E_t (net crop water requirement) from that of the irrigation water requirement. Therefore, information provided by IWMI will be used only for comparative analysis, as it includes the Rauni irrigation.

3.4. Actual Crop Evapotranspiration – National and Provincial Context

Actual E_t data of PARC were used to estimate net water requirement of irrigated crops in Pakistan. The net water requirements for the cropping year of 2002-03 were 78.4, 20.1, 6.2 and 5.0 billion m^3 for the Punjab, Sindh, NWFP and Balochistan provinces, respectively (**Table 3 and Appendix II-D**). The unit net water requirements estimated were 563, 688, 508 and 610 mm for Punjab, Sindh, NWFP and Balochistan provinces, respectively. The average actual E_t for the Southern Punjab and upper Sindh are higher than other parts of the IBIS, where highest unit depth of 688 mm was estimated for the Sindh province, which is 22% higher than the Punjab province. The other important factor should also be kept in mind that the crop growing season length is short in the southern part of the IBIS compared to northern parts. For example, the growing season length of wheat in lower Sindh is around 120 days compared to 160-180

days in the northern part of the IBIS. Thus lower Sindh has comparative advantages of having low water requirement of crops considering the growing season length, whereas it is higher based on atmospheric demand.

Table 3. Cropped area and net water requirement of irrigated area during 2002-03 in Pakistan.

Crop	Cropped Area (million ha)				Net Water Requirement (billion m^3)				
	Punjab	**Sindh**	**NWFP**	**Balochistan**	**Punjab**	**Sindh**	**NWFP**	**Balochistan**	**Pakistan**
Rabi Crops	6.263	1.065	0.443	0.398	24.69	4.77	1.85	1.40	32.71
Kharif Crops	4.724	1.103	0.491	0.224	32.87	9.16	2.26	2.14	46.42
Mix Crops	1.916	0.381	0.151	0.069	8.89	1.88	0.73	0.33	11.83
Perennial Crops	1.03	0.37	0.14	0.13	11.9	4.3	1.3	1.2	18.7
Total	13.93	2.92	1.22	0.82	78.4	20.1	6.2	5.0	109.7
G. Total Area				18.89					
mm/Ha					563	688	508	610	581

The net water requirement at the national level for the irrigated cropped area of 18.89 million ha during 2002-03 comes to 109.7 billion m^3.

4. Water Balance

4.1. Conceptual Framework

The objective of irrigation is to maintain soil water level and salt concentration in the soil solution at levels at which plant growth and crop yields are not limited by water, where adequate water supplies are available, or manage the soil water reservoir to maximize the net economic return to the farm manager, or in food and water shortage areas, to examine the production of the marketable products per unit volume of water. Various sources of water and fluxes of affecting the soil water balance are shown in **Figure 13**. The quantities affecting the soil water over the given period can be represented by the following major components:

$$\Delta W_s = W_i + R_e - W_{et} - W_d$$
$$W_i = W_{sw} + W_{gw}$$

where

ΔW_s - change in soil water contents;
W_i - volume of irrigation water;
R_e - volume of effective rainfall (rainfall entering the soil or retained on the foliage or soil surface);
W_{et} - total volume of water vaporized in evaporation from soil and plant surfaces and transpiration;
W_d - total volume of water drained from the effective root zone and not recovered by capillary rise from the sub-soil;
W_{sw} - total volume of surface water available for irrigation; and
W_{gw} - total volume of groundwater available for irrigation.

In the IBIS, especially in the Punjab and Sindh provinces, some deep percolation is essential since this is the only practical way of maintaining a favourable salt balance in the root zone. The quantity of water in the plants is not shown since the maximum amount contained in the foliage at any time usually is less than

2% of W_{et} for a growing season. The conceptual framework for the Basin level water use based on inflow-outflow method is presented in **Figure 14**.

4.2. Water Balance of the Irrigated Agriculture – National Context

The water balance of the irrigated agriculture of Pakistan was estimated using the following equation and data for the year 2002-03:

$$\Delta W_s = W_i + R_e - W_{et} - W_d$$

Canal Diversions	– 127 billion m^3
Groundwater Abstraction	– 51 billion m^3
Total Actual Evapotranspiration for Irrigated Agriculture	– 109.7 billion m^3
Rainfall Contribution	– 16.5 billion m^3

$$W_i = W_{sw} + W_{gw}$$
$$W_i = 127 + 51$$
$$W_i = 178 \text{ billion } m^3$$

$$\Delta W_s = W_i + R_e - W_{et} - W_d$$
$$\Delta W_s = 178 + 16.5 - 109.7 - W_d$$
$$\Delta W_s + W_d = 178 + 16.5 - 109.7$$
$$\Delta W_s + W_d = 84.8 \text{ billion } m^3$$

The water balance indicated that actual crop E_t for existing cropping pattern and cropped area is around 109.7 billion m^3, representing 56% of the total water available (surface, groundwater and effective rainfall). Thus 44% of water is lost due to inefficiency of the irrigation system, field application losses, deep percolation, non-beneficial E_t and escapage below Kotri Barrage This shows that there is scope of improving efficiency of the irrigation system and to reduce non-beneficial E_t. The reasons for loss of 84.8 billion m^3, representing 44% of the available water are:

- Canal conveyance losses – operational delivery losses of earthen canals network, which are enhanced due to insufficient or deferred maintenance;
- Watercourse conveyance losses – operational delivery losses of earthen watercourses, which are enhanced due to insufficient or deferred maintenance. The OFWM Programme provides funding for only 30% lining of the watercourse, thus even for the so-called improved watercourses real saving in conveyance losses is in the order of lined section only. The life of such savings is also questionable under the type of lining being used for watercourses.
- Field application losses – application losses due to unlevelled fields, in appropriate surface irrigation hydraulics, un-scheduled irrigations, fixed-rotation of water allocation schedules and quantity/quality of groundwater available.
- Non-beneficial E_t due to non-scheduled irrigations and heavy rainfall, weed infestations, fallow and waterlogged fields, etc.
- Inefficient use of rainwater due to lack of information about its occurrence and distribution.

The water balance for irrigated agriculture of Pakistan is illustrated in **Figure 15**. The E_t perspective of water balance indicates that water availability to the basin is not short if inefficiency and low productivity issues are addressed. The additional water supplies will not help to improve the efficiency and productivity in the canal commands having adequate to excess canal water supplies.

4.3. Water Balance at the Canal Command Level

Information about water balance at the canal command level is not available; therefore an indirect methodology was established to compare the water balance of different canal commands. Firstly, the work done by IWMI (2001a) was used to develop relative index of E_t per unit of Cropped Area of each canal command using the lowest E_t of the canal command of 989 mm as a unit E_t. Secondly, lowest Authorized Canal Water Allowance of 200 lps/1000 ha was used as a unit water allowance to compute the relative index.

There is a large variation in the relative index of both the E_t per unit of Cropped Area and the Authorized Canal Water Allowance. The variation in E_t per unit of Cropped Area is due to the variation in the atmospheric demand, cropping pattern, cropping intensity and cropped area under each canal command. The variation in Authorized Canal Water Allowance is due to the design parameters, the type of the canal (perennial or non-perennial), climatic variations and the socio-political context.

The relative indices of Authorized Canal Water Allowance were used to conduct the comparative analysis of relative E_t per unit Cropped Area and water availability. There was a large variation in Authorized Canal Water Allowance, therefore, the canal commands were categorized in three categories, and presented as under:

- The first category represents the Water Short Canal Commands with Lowest Authorized Canal Water Allowance of < 400 lps/1000 ha with relative index between 1-2.
- The second category represents the Water Adequate Canal Commands with Intermediate Authorized Canal Water Allowance of 400-600 lps/1000 ha with relative index between 2-3.
- The third category represents the Water Excess Canal Commands with Higher Authorized Canal Water Allowance of > 600 lps/1000 ha with relative index of > 3.

The three categories have significant variability in terms of Authorized Canal Water Supply per unit of command area, as it varied between 200-1860 lps/1000 ha. These wide variations demanded that canal categories be formed to address the issue of Authorized Canal Water Allowance in line with evapotranspiration and potential cropping intensity (**Table 4**).

Table 4. Relative Evapotranspiration/Cropped Area and Relative Authorized Canal Water Allowance in the Canal Commands of the IBIS (After IWMI 2001a).

Canal ID	Canal Name	CCA (ha)	Authorized Full Supply Discharge (m^3/sec)	Authorized Canal Water Allowance (lps/1000 ha)	Potential ET/Crop Area (mm)			Relative Et Per unit Cropped Area	Relative Authorized Canal Water Allowance
					Kharif	Rabi	Annual		
Water Short Canal Commands with Lowest Canal Water Allowance (< 400 lps/1000 ha)									
1	Upper Chenab	451012	90	200	605	384	989	**1.05**	**1.00**
3	Lower Jehlum	614488	150	244	740	412	1152	**1.22**	**1.22**
4	Upper Jehlum	220094	54	245	604	432	1036	**1.10**	**1.23**
2	Thal	773843	213	275	778	389	1167	**1.23**	**1.38**
7	Central Bari Doab	265700	73	275	623	398	1020	**1.08**	**1.38**
5	LCC East (Gugera)	647502	347	281	718	399	1117	**1.18**	**1.41**
6	LCC West (Jhang)	588614			693	405	1098	**1.16**	
11	Sadiqia	424850	139	327	954	465	1419	**1.50**	**1.64**
8	Lower Bari Doab	675667	248	367	735	444	1180	**1.25**	**1.84**
Water Adequate Canal Commands with Intermediate Canal Allowance (400-600 lps/1000 ha)									
10	Abbasia	96139	40	416	946	449	1394	**1.48**	**2.08**
9	Rohri	1045145	462	442	1065	581	1646	**1.74**	**2.21**
17	Lower Dipalpur	247718	113	456	765	547	1313	**1.39**	**2.28**

19	**Lined Channel**	220137	101	459	1116	491	1607	**1.70**	**2.30**
15	**Upper Dipalpur**	141711	65	459	737	465	1202	**1.27**	**2.30**
16	**Nara**	882491	411	466	1085	612	1697	**1.80**	**2.33**
14	**Khairpur East**	182528	96	526	998	584	1582	**1.67**	**2.63**
18	**Panjnand**	551926	297	538	993	494	1487	**1.57**	**2.69**
20	**Rangpur**	139769	77	551	809	435	1245	**1.32**	**2.76**
21	**Fordwah**	173111	98	566	902	468	1371	**1.45**	**2.83**
13	**Khairpur West**	130299	74	568	1126	590	1716	**1.82**	**2.84**
Water Excess Canal Commands with Higher Canal Allowance (> 600 lps/1000 ha)									
12	**Dadu**	236605	156	659	1278	519	1797	**1.90**	**3.30**
22	**Muzaffergarh**	331764	235	708	843	434	1278	**1.35**	**3.54**
23	**Ghotki**	368335	305	828	1132	574	1706	**1.81**	**4.14**
18	**North West**	309093	266	861	1317	492	1809	**1.91**	**4.31**
25	**Marala Ravi**	63615	57	896	585	360	945	**1.0**	**4.48**
26	**Kalri**	258592	257	994	1030	553	1582	**1.67**	**4.97**
27	**Qaim**	17121	17	993	912	501	1413	**1.50**	**4.97**
24	**Dera Ghazi Khan**	368546	411	1115	854	472	1327	**1.40**	**5.80**
28	**Fuleli**	360604	421	1167	1059	651	1710	**1.81**	**5.84**
29	**Pinyari**	322112	386	1198	1114	473	1587	**1.68**	**5.99**
30	**Begari**	340641	544	1597	1330	474	1804	**1.91**	**7.99**
31	**Rice**	209695	390	1860	1307	488	1795	**1.90**	**9.30**

The analysis of all the three categories of the canal commands indicated that the water adequate category has modest variability in Et (1202-1716 mm) and authorized canal water allowance (416-568 lps/1000 ha). The highest variability in E_t (945-1809 mm) and in authorized canal water allowance (659-1860 lps/1000 ha) was in water excess category. Therefore, there are chances that water productivity is lowest in water excess category thus providing an opportunity for improving productivity, as the cost-effectivity of interventions will be highest.

The doubling factor of E_t within each category of canal command indicated that water allocation is not based on evapotranspiration, potential cropping pattern or potential cropping intensity. all the canal commands having short, adequate and excess water allocations still do not provide water to meet the peak crop water requirement. Water in certain periods is in excess and short at peak demand especially for the short and adequate water allowances.

5. Framework for E_t and Water Balance

The framework for E_t and water balance should be based on the following four elements:

- Increasing the productivity per unit of water consumed within the context of evapotranspiration and non-sustainability indicators – waterlogging, salinity, quality of groundwater, etc.;
- Reducing non-beneficial depletion beyond the root zone;
- Reallocating water among other uses or among other canal commands within the Water Apportionment Accord and allocations for the provinces – changes within provincial contexts;
- Tapping uncommitted outflows or wastewaters within provincial contexts.

5.1. Increasing Water Productivity

The water productivity in the canal commands of the IBIS can be enhanced using the following broad interventions:

- *Changing crop varieties* — to new crop varieties that can provide increased yields for each unit of water consumed, or the same yields with fewer units of water consumed.

- *Crop substitution* — by switching from high water-consuming crops to less water-consuming crops, or switching to crops with higher economic or physical productivity per unit of water consumed. Presently rice and sugarcane are grown in ecologies, which are not suitable to attain the higher water productivity due to higher temperature and aridity.
- *Deficit, supplemental, or precision irrigation* — with sufficient water control, higher productivity can be achieved using irrigation strategies that increase the returns per unit of water consumed. There is quite a potential to save water from Rauni irrigation and by having precision land leveling, precision irrigation, precision planting – in total named as precision farming.
- *Improved irrigation methods* – to provide better environment for crop growth and productivity i.e. shifting from basin or flood irrigation to furrow irrigation and planting on ridges or shoulders of broadbeds or sprinkler/drip irrigation systems for high value crops.
- *Improved water management* — to provide better timing of supplies to reduce stress at critical crop growth stages, leading to increased yields or, by increasing reliability of water supply so farmers invest more in other agricultural inputs, leading to higher output per unit of water.
- *Improving non-water inputs* — in association with irrigation strategies that increase the yield per unit of water consumed; agronomic practices such as land preparation, precision planting and fertilization can increase the return per unit of water.

5.2. Reducing Non-beneficial Depletion

There is considerable loss of water due to in-efficient irrigation application at the field level. Most of the non-beneficial depletion loss is due to inefficient irrigation, where farmers apply water to fill the highest spot in the field, which is due to un-levelled field and inappropriate surface irrigation hydraulics. The deep percolation loss is not only the loss of water but it is an added loss of nutrients especially the nitrates. Furthermore, the leaching of fertilizers and other agricultural chemicals ultimately would affect the quality of groundwater in the canal commands having higher Authorized Canal Water Allowances.

- *Lessening of non-beneficial depletion* by reducing:
  - evaporation from water applied to irrigated fields through specific irrigation technologies such as precision land leveling and furrow irrigation in the IBIS and drip irrigation in areas where water is at premium, or agronomic practices such as residue farming using zero—till planting, mulching of fruit plants, or changing crop planting dates to match periods of less evaporative demand;
  - evaporation from fallow land, by decreasing area of free water surfaces, decreasing non-beneficial or less-beneficial vegetation, and controlling weeds
- *Reducing water flows to sinks* — by interventions that reduce irrecoverable deep percolation and surface runoff.
- *Minimizing salinization of return flows* — by minimizing flows through saline soils or through saline groundwater to reduce pollution caused by the movement of salts into recoverable irrigation return flows.
- *Shunting polluted water to sinks* — to avoid the need to dilute with freshwater, saline or otherwise polluted water should be shunted directly to sinks.
- *Reusing return flows* – by integrating crops, forest plants, forages, and aquaculture into land use to utilize different qualities of water in a sustainable manner.

5.3. Reallocating Water among Other Uses and Canal Commands

Water can be reallocated among other competing uses. The largest user of water in the IBIS is agriculture, as it consumes around 93% of total water available per annum. Therefore, the emphasis will be placed to improve water use for agriculture through reallocation to various canal commands having potential for enhancing productivity.

- *Reallocating water from lower-value to higher-value uses* — reallocation will generally not result in any direct water savings, but it can dramatically increase the economic productivity of water. Because downstream commitments may change, reallocation of water can have serious legal, equity, and other social considerations that must be addressed.
- *Reallocating water within existing Canal Commands* — reallocation will generally be difficult between the provinces as the water apportionment and rights are well defined. However, there is a possibility that each province looks into Authorized Canal Water Allocations of various canal commands and reallocates water allowance based on evapotranspiration, cropping pattern and cropping intensity to have sustainability on long-term basis. This will dramatically increase the economic productivity of water both under the deficit and excess canal commands.

5.4. Tapping Un-committed Outflows

The uncommitted flows can be used to increase the water availability especially for the commands, which are under water stress. The cost-effectivity of reuse of water will be higher where freshwater is at premium. This includes the areas of the IBIS where groundwater is of brackish quality.

- *Improving management of existing facilities* — to obtain more beneficial use from existing water supplies. A number of policy, design, management, and institutional interventions may allow for expansion of irrigated area, increased cropping intensity, or increased yields within the service areas. Possible interventions are reducing delivery requirement by improved application efficiency, water pricing, and improved allocation and distribution practices.
- *Reusing return flows* — through gravity and pump diversions to increase irrigated area.
- *Adding storage facilities* — so that more water is available for release during drier periods i.e. Rabi and early Kharif season. Storage takes many forms, including reservoir impoundments, groundwater aquifers, small dams, and on-farm ponds.

6. Optimizing Productivity and Sustainability of Water

6.1. Water and Cropping Intensity

There is a wide variation in the cropping intensity of the Rabi and Kharif seasons of various canal commands of the IBIS. The annual cropping intensity data were used to categorize the canal commands into three categories representing low, medium and high cropping intensity. The comparative analysis indicated that cropping intensity varied both for the Rabi and Kharif seasons irrespective of the Authorized Canal Water Allowance. Therefore, there are other factors, which also contribute for the cropping intensity, which includes non-water inputs and management of the available water and production practices.

- The first category represents Canal Commands with Lowest Cropping Intensity of < 100%.
- The second category represents Canal Commands with Medium Cropping Intensity of 100 to 150%.
- The third category represents Canal Commands with Higher Cropping Intensity of > 150%.

The Authorized Canal Water Allowance does not affect the cropping intensity in all the three categories, as it varied significantly within each category of canal commands. The variation is highest in the Lowest Cropping Intensity Category where it varied from as low as 200 to 1860 lps/1000 ha. This shows that the lowest and highest Authorized Canal Water Allowances are in this category. The variation in the second category was 244 to 1115 lps/1000 ha, whereas it varied from 357 to 993 lps/1000 ha for the third category (**Table 5**).

Table 5. Seasonal and Annual Cropping Intensity for Canal Commands in the IBIS (After IWMI 2001a).

No.	Canals	CCA (ha)	Authorized Discharge (m^3/sec)	Canal Water Allowance lps/1000ha	Cropping Intensity (%)		
					Kharif	Rabi	Total
Low Cropping Intensity Canal Commands in the IBIS (< 100 %)							
1.	**Pinyari**	322112	386	1198	13.5	14.5	**28**
2.	**Kalri**	258592	257	994	19	16	35
3.	**Fuleli**	360604	421	1167	36	14	50
4.	**North West**	309093	266	861	29	22	51
5.	**Dadu**	236605	156	659	24	33	57
6.	**Lined Channel**	220137	101	459	34	24	58
7.	**Marala Ravi Link**	63616	57	896	32	27	59
8.	**Depalpur Upper**	141711	65	459	37	24	61
9.	**Nara**	882491	411	466	31	32	63
10.	**Ghotki**	368335	305	828	55	24	79
11.	**Upper Chenab**	580147	90	200	41	44	85
12.	**Rohri**	1045145	462	442	42	44	86
13.	**Rice**	209695	390	1860	50	38	88
14.	**Dipalpur Lower**	247718	113	456	63	27	90
15.	**Begari**	340541	544	1597	50	41	91
16	**Khairpur West**	130299	74	568	40	52	92
17.	**Khaipur East**	182528	96	526	50	46	96
18.	**Abbasia**	96139	40	416	50	49	99
Medium Cropping Intensity Canal Commands in the IBIS (100-150 %)							
19.	**D.G.Khan**	368545	411	1115	52	48	100
20.	**THAL**	773843	213	275	49	53	102
21.	**Muzzafargarh**	331764	235	708	54	53	107
22.	**Central Bari Doab**	265700	73	275	51	67	118
23.	**Fordwah**	173111	98	566	66	57	123
24.	**Rangpur**	139769	77	551	63	60	123
25.	**PAT & Desert**	157785			50	74	124
26.	**Eastern Sadiqia**	424850	139	327	63	63	126
27.	**Lower Jehlum**	614488	150	244	57	72	129
28.	**Upper Jehlum**	220094	54	245	67	58	135
29.	**LCC East (Gogera)**	647502	347	281	67	77	142
	LCC West (Jhang)	588614			63	76	
30.	**Panjnad**	551926	297	538	76	68	144
31.	**Bahwal**	299776			76	72	148
High Cropping Intensity Canal Commands in the IBIS (> 150 %)							
32.	**Haveli**	411711	147	357	79	73	152
33.	**Mailsi**	277956	139	500	86	70	156
34.	**Lower Bari Doab**	675667	248	367	80	77	157
35.	**Qaimpur**	17121	17	993	89	70	159
36.	**Pakpattan**	516233	187	362	87	77	**164**

6.2. Water Productivity

In some areas of the IBIS especially in the Punjab province, secondary salinization and rapidly declining water tables are symptoms of the water crisis. In many, dried-up rivers and degraded aquatic ecosystems are the most pressing problem. In the Indus River system very little or no water reaches the sea during 8-10 months of the year.

In spite of development of water resources in the IBIS, which are intended for food production, malnutrition persists, mostly in among the poor communities of the IBIS and among major part of the communities outside the IBIS. Small farmers and the poor are particularly water-deprived and in situations of water scarcity they are the hardest hit. This is particularly true in regions dubbed "economically water scarce," meaning that while there is water available, there are no financial resources to harness it for use especially outside the IBIS.

Improving the productivity of water used in agriculture is the key to solving these problems (IWMI 2003a; IWMI 2000). Getting more crop per drop enhances food security and makes more water available for nature, industry and domestic users. It enables to reduce the need for investments in new water storage and irrigation infrastructure — investments that Pakistan can't afford from its own resources. By improving the productivity of water in areas outside the IBIS (Sailaba, Khushkaba, Barani, and riverrine) would contribute to the food security and incomes of some of the poorest-of-the-poor live in these ecologies. Samllholders of the IBIS also fall in this category.

The aridity, chemical and physical limitations of soils (low organic matter, salinity, poor aggregate stability), imbalance use of fertilizers and inappropriate tillage and planting methods resulted in poor productivity of crops per unit of land. Water use and irrigation scheduling are another major factors affecting productivity of crops. The majority of crops extract water from the first 60-100 cm depth of soils, where very little extraction of water is taking place from the soil depths beyond 100 cms. The water yield functions were developed based on the field research conducted by PARC for 17 crops. These data were used to develop generic water-yield functions for two broad types of crops – crops which are less sensitive to excessive wetness and crops which are sensitive to excessive wetness.

The water yield functions for crops which are relatively less sensitive to wetness like wheat, fodders, etc indicated that there is an economic optima where water productivity will be highest and with the increase in water use, there will be either no increase rather small reduction in yield. But this increase in yield with increased use of water will come through additional supply of nitrates, as they leached with excessive use of water. Thus additional use of water is not only loss of water but also an added loss of nutrients (**Figure 16**).

For water sensitive crops, there is distinct economic optimum, where water productivity will be highest, but with the increase in water use there is a distinct reduction in yield. Thus excessive use of water will result in loss of yield and nutrients and also excessive growth of weeds (**Figure 17**). These results clearly indicated that irrigation scheduling must by done considering the evapotranspiration needs and management strategies based on crop, climate and soil conditions.

Many people associate water savings with municipal water use — encouraging domestic users to practice water conservation and cities to plug up leaking supply systems. While these efforts have localized benefits, it is important to realize that cities actually consume very little of the country's water. Even in large urban metropolitans of Pakistan where most households have easy access to municipal water supplies, a person uses less than 100 liters of water per day (little of which is actually lost). Compare this to the 3,000 to 5,000 liters of water required to produce enough food to feed one person per day and to understand why finding ways of getting more crop per drop is vital to the country's future.

Another common misperception is that enormous amounts of water are wasted in irrigation — water 'down the drain'. In fact, much of the waste is recaptured by farmers, used by trees or ecosystems, recharges groundwater or it flows back into the river system to be used further downstream. The real problem is that in water-scarce areas farmers as a group has become if anything too efficient at converting water into crop production resulting in dried-up and polluted rivers. Getting more crop per drop — improving water productivity — will ensure food security and sustainable agricultural production. In water-stressed areas, this is often the only option.

The water productivity for crops is low in Pakistan compared to other countries. The comparison of water productivity of wheat between California, USA, Bhakra India and Punjab Pakistan indicated that water productivity in Bhakra, India is almost double from that of Punjab, Pakistan, whereas in California, USA, it is almost three-fold from that of Pakistan's Punjab (**Figure 18**). The low water productivity in Pakistan's Punjab is an indicator of potential for improvement in water productivity by three fold. Improving water productivity would also increase the profitability.

The question to be addressed is that "How much scope is there for improving water productivity in the IBIS and areas outside the IBIS?" In Pakistan, potential productivity is not realized in part due to inefficient irrigation management. Considering the productivity of water in more than 40 irrigation systems worldwide, an IWMI study demonstrated a 10-fold difference in the gross value production (GVP) per unit of water consumed by crops. Some of this difference is due to environment, or the price of grain versus high-valued crops. But even among grain producing areas, the differences are large. Improving performance of poorly managed irrigated agricultural systems should be a high-priority action.

Managing water in agriculture should not exclusively focus on improving the productivity of water diverted to irrigation, but must also include improving the productivity of the non-irrigated systems outside the IBIS (Sailaba, Khushkaba, Barani and riverrine). Systems outside the IBIS contribute to about 10 percent of wheat and around 50% of pulses and coarse grains. It is the primary means of food production in around 77% of the geographical area of Pakistan. Consequently, any increase in areas outside the IBIS for cereal and oilseed production would have more effect on poverty reduction and mal-nutrition than a similar increase in irrigated cereal production, as poorest-of-the poor live in these ecologies — people who currently struggle to farm marginal rainfed lands and are at the mercy of droughts.

6.3. Improving Water Productivity – Potential Options

What are the potential options available for improving water productivity? There are a variety of interconnected potential options that can improve water productivity. No single option holds the answer. There is a need to develop integrated strategies tailored to the needs of specific canal commands and river basins (IWMI 2003a). The potential options for improving water productivity in canal commands of the IBIS are presented in the following sections.

6.3.1. Crop Improvement

Crop improvement over the last century has indirectly increased the productivity of water by increasing yields with or without increasing crop water demand. In Pakistan, traditionally the focus has primarily been on getting more yield per unit of land. It is only recently that attention has turned to producing crops that can yield more with less water, withstand water-scarce and drought conditions, and thrive on low-quality (saline/alkaline) water. International crop scientists have already identified traits and genes for drought- and salt-tolerance in a number of crops. For some crops, conventional and molecular breeding techniques are expected to yield results within near future. The Future Harvest Centers of the CGIAR have already released drought-tolerant varieties of several crops for evaluation by collaborating institutes and farmers. Crops include: rice (IRRI, WARDA), maize (CIMMYT), wheat (CIMMYT, ICARDA), barley (ICARDA), cowpea (IITA), groundnut (ICRISAT), lentil (ICARDA), and sweet potato (CIP). In Pakistan, there is a growing awareness that heat, drought and salt tolerance traits will be the research focus in the future crop improvement programmes of the NARS. The real challenge is how to link the crop improvement scientists with the water management experts. The recent study on adjusting crops and cropping pattern with water availability given due focus on this issue of including drought, heat and salt tolerance as objective of the crop improvement programmes in the future (PARC 2004; Ahmad 2003a,b).

6.3.2. Reducing Land and Water Degradation

Land and water degradation constrain efforts to improve water productivity. Soil erosion in the mountains of Northern Areas and NWFP and the Pothwar plateau of Punjab, for example, reduces not only soil's depth but also its capacity to hold water and the amount of nutrients it contains. The secondary salinization due to the use of marginal to brackish quality groundwater has not only affected the water productivity but also affected soil health adversely. There is a common misperception that degradation of the agro-ecosystems is a slow process that can be always reversed with adequate inputs such as fertilizer and amendments. It is also assumed that application of gypsum will take care sodification problem but its harmful effects on groundwater are always neglected. But ecosystems are resilient only up to a certain threshold, and can collapse when pushed too far. In many cases, farmers need incentives to make long-term investments in soil and water management practices — particularly when results from such investments do not have a direct or significant impact on their incomes. Social and institutional factors, such as land tenure, also affect farmers' willingness to invest.

6.3.3. Water Husbandry for Areas outside the IBIS

Supplemental irrigation combined with on-farm water-harvesting practices, such as contoured farming, bunding and micro-catchment farming, reduces vulnerability to drought and helps farmers to get the most out of the scarce resources. Mitigating the effects of short-term drought is a key step in achieving higher yields and water productivity in areas outside the IBIS. Farmers are unwilling to risk investments in productivity-enhancing inputs, such as fertilizers and higher-yielding crop varieties, when their water supply is uncertain. In Barani, Sailaba and Khushkaba systems, farmers run the risk of total crop failure due to drought once every five years and severely reduced yields once every two years.

Studies by PARC suggest that with significant investments in water harvesting, conservation tillage and supplemental irrigation during short dry spells, yields of staple food crops could be more than doubled in many areas outside the IBIS. Deficit irrigation — a strategy that maximizes the productivity of water by allowing crops to sustain some degree of water deficit and yield reduction — holds promise for severely water-short areas, such as Sailaba, Barani, Khuskaba and riverrine. NARC studies in Barani areas have shown that applying a light irrigation of 10 mm as Rauni Irrigatin using Raingun sprinklers helps farmers to plant wheat at optimum time and increase the yield from 50-100%. Farmers wait and delay planting of wheat due to occurrence of rainfall, where delay of one-day results in loss of wheat yield by 10 kg/day (Ahmad et al. 1999b; Ahmad 1981b). For deficit irrigation to function as a realistic strategy there is a need to better understand the relationship between yield and water deficit and need to identify the types of support and incentives that farmers need to adopt the practice.

Studies conducted by PARC and IWMI indicated that deficit and supplemental irrigation could increase the water productivity compared to complete irrigation under farmers' practices and rainfed farming systems (**Figure 19**). The deficit and supplemental irrigation had increased the water productivity two-to-three folds compared to rainfed systems. The water productivity of deficit and farmers practices was almost same. The highest water productivity was achieved when scheduled supplemental irrigations were applied under the concept of full supplemental irrigation (IWMI 2003a; Ahmad et al. 1999b).

6.3.4. Cost-effective Innovative Technologies

Various forms of high efficiency precision irrigation — mainly sprinkler, drip irrigation systems, dead-level basins and furrow irrigation with planting on ridges or broadbeds — can increase yields over good but ordinary irrigation systems by 20 to 70 percent, depending on the crop and other conditions, and they do so with much less water diverted to the crop. In Pakistan, furrow irrigation with bed planting is becoming increasingly popular with farmers of the IBIS, as it saves 25% of water and 30% increase in yield of maize, cotton and wheat crops (WRRI 2000b). The research is now concentrated on maize-wheat

and rice-wheat cropping systems, as the technology is now successfully disseminated to cotton-wheat area by the OFWM Punjab. In areas where shallow groundwater is plentiful, thousands of poor farmers have used low-cost dugwells to supply water for crops for their own food security and for additional income. But still there is a need to understand the potential, or the mechanisms, for large-scale adoption of these technologies. The detailed of some of the selected technologies are provided in **Boxes 1 to 4**.

Box-1 Precision Laser Leveling and Dead Level Basin Irrigation

The basin irrigation is predominantly practiced in the Indus basin under unleveled field conditions, having elevation differences to the level that farmers have to apply 2-3 fold more water to cover the high spots and the entire field. Therefore, precision leveling is essential for having precision basin irrigation. Laser levels are now being used in the country for precision leveling. But the tillage and planting machines are not appropriate to maintain the precision leveling of the fields. Therefore, the life of the precisely leveled fields is around 2-3 years and thus laser level has to be used after every 3rd year. Farmers are now aware of the benefit of the laser leveling in saving of irrigation water and better crop yields. Level basin irrigation system is still the only option for the rice-wheat system. Around 175 laser leveling units are available in the public sector primarily with the OFWM. However, during the last 2-3 years, the laser leveling units are now being operated under the private sector arrangements. Laser leveling is going to be the future technology in Pakistan. But there is a need that the government may formulate and implement the policy for encouraging the private sector to introduce the technology in the country. This would require policy intervention and the incentives for the private sector to establish rental services to farmers for laser leveling. This would include the provision of services for engineering surveys, mapping and cut-fill plans. The cost of precision land leveling is around Rs. 3000 per acre.

Box-2: Furrow-Bed Precision Irrigation

Presently, the farmers are using basin irrigation on unleveled fields, which are having variations to the order that farmers try to cover the high spots in the field. This requires heavy irrigation to cover the entire field. The main cause is that surface irrigation hydraulics is not appropriate because the field length and width are not in line with the stream size and the soil infiltration rates. The precision land leveling has been introduced in the country, where laser leveling techniques are being used to provide precision leveling services to the farmers. Even the dead level basins require sufficient water to cover the fields. The shortage of surface water imposed due to the persistent drought further motivated the farmers to adopt precision irrigation using furrow-bed system. The furrow bed system is efficient compared to basin irrigation, as the wetted area reduced considerably. The two rows of cotton, maize and sunflower are planted on the shoulder of the bed, whereas 4-7 rows of wheat are planted based on the size of the bed. The research studies conducted by PARC, OFWM, WAPDA and University of Agriculture, Faisalabad indicated savings of 30% in water and 25% increase in yield of crops. This system is now being adopted in the cotton-wheat and maize-wheat cropping systems.

PARC in collaboration with ACIAR (Australian Council for International Agricultural Research) has initiated a project on "Water Use Efficiency of Permanent Raised Bed System under Saline Environments of Mardan SCARP Area". The research studies on maize-wheat have already led to the adoption of technology by farmers' organizations, where they provide the bed shaper cum planter on rental basis. The research studies are still underway for the rice-wheat system because shift from basin to bed planting under rice is still a challenge.

The planter linked with the bed shaper is having zero-till planting arrangement, which will help to plant under crop residue conditions, leading towards achieving minimum tillage under permanent bed conditions. Attachments have been developed to reshape the beds after every harvest and to remove weeds. Reshaping also provides loosening of the bed.

There is a need to provide extension services to the farmers through the District Water Management Officer in the area of precision furrow irrigation and precision planting on bed. The rental services should be provided by the private sector.

Box-3. Planning for Cropping Pattern and Irrigation Scheduling at the Farm Level

The canal water is being provided to the farmers under a system of *Warabandi* – continuous-flow and fixed rotation irrigation system. Farmers must be provided information and skills for adjusting the cropping pattern with water availability. Water availability from both surface and groundwater must be included while designing the cropping pattern. This decision has to be taken prior to every season and then in-season adjustments are needed based on emergent requirements. Farmers do practice Irrigation Priority based on number of factors including value of the crop, affect of deficit irrigation on crop productivity and his personal preferences. The devolution of agriculture at the district level ended with devolved departments of agriculture at the district level. The OFWM has also been devolved and there is District Water Management officer responsible for water management at the district level. But their activities are limited to watercourse improvement, precision land leveling, demonstration for precision planting and furrow irrigation named as Resource Conservation Strategies. In fact there is a need to initiate a programme at the district level for water productivity. The focus of resource conservation is on saving of water, whereas it has to be changed to water productivity. The district level Water Management capacity has to be upgraded and strengthened so that information regarding crop water needs is available daily through the media. Advisories may also be initiated so that irrigation scheduling services are available to the farmers in the public sector and then ultimately transferred to the private sector. The irrigation scheduling service should address the two important questions. When to irrigate? And How much to apply? How to apply is the third question which is addressed in other boxes.

Box-4. Precision Irrigation using Sprinkler and Drip Irrigation Systems

Sprinkler and drip irrigation materials and high pressure pumps are now being manufactured in Pakistan. For Sprinkler irrigation, Raingun systems and high pressure pumps are being manufactured by the M/S MECO Pvt. Ltd. Lahore, who provides the complete range of sprinkler systems hardware. The plastic piping is now being provided by a number of PE and PVC pipe manufacturing companies. The cost of the Raingun sprinkler irrigation systems including the installation cost varies from Rs. 15000 to 25000 per acre dependent on the layout and the design of the system. The systems can be installed based on portable systems, semi-solid set and completely solid set systems. Few companies provide services for the installation of sprinkler irrigation systems but their installation cost is higher and thus their activities are limited to the public-sector financed projects or large business concerns. The OFWM also provided services under the public-sector financed projects to the farmers but they were unable to address the farmer's total needs of irrigation and thus these systems were hardly operated by the farmers. There are number of reasons for the failure of these projects but the failure was due to inappropriate materials and inaccurate installations, whereas there is nothing wrong with the technology.

The M/S Griffon Pipe Industries, Lahore provides complete range of LDPE and HDPE based complete range of drip irrigation pipes, connections, emitters and other accessories. The M/S Civic Abyari Plastic Company, Karachi now provides complete range of PVC based drip irrigation pipes, connections, emitters and other accessories. This company also provides services for the installation of drip irrigation systems. The installed cost of the drip irrigation system varied from Rs. 20,000 to 30,000 based on the type of fruit plants, row to row and plant to plant spacing and the type of the emission points used. The M/S Engro Asai is now active in the development of local industry, private service companies and the dealers. They have established the Micro Irrigation Division and providing assistance to the plastic companies for initiating the drip irrigation companies in the private sector.

6.3.5. Improved Irrigation Management Practices

Perhaps the most important basic principle in irrigation is to deliver a reliable supply of water. In an uncertain environment, farmers will not invest in seeds, fertilizers, and land preparation, and consequently yields and water productivity will suffer. A second basic principle has to do with timing. At various times in a crop's growth cycle, water stress can be particularly damaging. Tubewell irrigation systems in IBIS typically produce yields that are twice as much as those from only canal irrigation systems having lower authorized canal water allowance. Groundwater is reliably available virtually on the farmer's demand while in most IBIS canal systems farmers must wait for their turn which may not match crop needs. The most promising intervention is to provide equitable water distribution to the head- and tail-end reaches.

6.3.6. Integrating Recycling and Reuse of Wastewater – A Basin Approach

Water reuse is already becoming an integral part of water management in many water-scarce areas of the IBIS. For example, it is a common practice for farmers in the Punjab province to place small pumps in drainage ditches to reuse drainage water – practice that was enhanced many-fold due to the persistent drought during 1998-2004, where farmers even dug pits to pump shallow groundwater once the drainage water receded. The agricultural institutions support this reuse strategy by recommending blending drainage water with freshwater to increase the useable supplies. Millions of farmers in the IBIS employ shallow tubewells to recycle the water that percolates through the soil layer — effectively capturing and using water before it flows out of the basin or create high water table. This practice also gives farmers more control over the amount and timing of irrigation applications — with dramatic effects on yields. Many farmers in peri-urban settings rely on sewage wastewater from urban areas to grow vegetables and fodders. Irrigating with low-quality water or sewage is often the only option; but even when farmers do have access to surface and groundwater, many prefer sewage because they are guaranteed a constant supply, and the nutrients the water contains allow them to save on fertilizer. Pollution and health risks should be considered when crafting reuse strategies. The problem is that in many cases reuse is an unregulated individual or community initiative — often ignored by water management agencies. This leads to sub-optimal situations in terms of degradation of water quality, human health, and water productivity.

6.3.7. Precision Planting and Irrigation – Field Practices

Conservation or zero tillage, precision planting, optimal fertilizer and water application, and other forms of soil-water management can raise productivity of water. Practices appropriate for small farmers have already been identified in many areas. The Punjab On-Farm Water Management with the collaboration of PARC and the Rice-Wheat Consortium has successfully demonstrated the adoption of zero-tillage in rice-wheat cropping zone and furrow-bed irrigation in cotton-wheat zone. The adoption by farmers was encouraging and now it is scaling up at a rapid rate. Here the challenge is to find the right mix of policies and incentives to encourage large-scale adoption of conservation tillage technologies.

6.3.8. Integrated Natural Resources Management – Basin Approach

In the IBIS, the waterlogging and salinity are the two non-sustainability indicators. Safe disposal of effluents from the areas having brackish groundwater is still a problem, as cost-effective solutions are not available. Farmers do practice community initiatives for irrigation but they hardly join hands for drainage. The initiatives taken by WAPDA for the community based tile drainage systems indicated that farmers do pump water for irrigation purposes but they are not interested to pump for drainage even under community based tile drainage systems. Therefore, alternative approaches are needed, as drainage in the context of inefficient irrigation is not sustainable. Efficient irrigation always supplement drainage, thus the objective should be to minimize the drainage effluents. The use of brackish groundwater will increase in future with

the aim of enhancing the farm productions and increasing the livelihoods. Thus the secondary salinization due to the increased use of marginal to brackish quality groundwater is going to be the serious concerns in the future.

Within farms — irrigation systems, and river basins, livestock, fish, and forests all have important water needs and implications. Integrating aquaculture into irrigation or examining the trade-offs between crop water use and water for fisheries or plantations is a means of providing more food and nutrition per unit of water. In addition to their role as water users, trees and livestock impact land and water interactions within a basin. Overgrazing or clearing forests for agricultural development or lumber can hasten runoff and sedimentation — detrimental to both upstream and downstream uses. Integrating these production systems within a basin management approach can reduce degradation and improve water productivity.

6.4. Water Use and Productivity – A Basin Approach

Basin approach recommended by IWMI applies to all water uses, but it is focused on irrigated agriculture, which is the largest user of water, as it consumes around 93% of the total water available per annum. The concepts were illustrated using four Case Studies representing differing sub-basins in South Asia. It has demonstrated that the water accounting methodology is robust in that it expresses how water is used in these situations (IWMI 2001b). The paper also draws some meaningful explanations on the present status of water use, and has suggested means by which productivity of water could be increased in these sub-basins. Of course much more detailed studies would be required before implementing recommendations, but the procedure presented should prove helpful in directing and formulating ideas It is clear from the Case Studies that conservation strategies are site-specific and there is no one solution that is appropriate for all situations. However, patterns can be identified that are helpful in forming strategies. From these Case Studies and other experiences, a framework is presented, which can be used for a general means of identifying water saving opportunities and increasing water productivity. Therefore, basin approach should be used for developing water management and water saving strategies and plans for various canal commands of the IBIS. Distributary canal can serve as a sub-basin. Sub-basin approach is vital as there are significant variations within the canal command.

The irrigation management in the IBIS is going to be a difficult task and improvements in short term will be difficult to achieve. The head and tail reaches of the canal command behave differently in terms of agro-climate, soil and water availability, which had direct impacts on cropping pattern, cropping intensity and water productivity. Studies have shown that the cropping intensity in head reaches of certain canal commands of the IBIS is almost double of the tail end reaches. This is primarily due to the huge conveyance losses in the canal system. There is a consensus that water availability at the tail end reaches is almost half of the head reaches. Thus maintaining volume equity in water distribution can result in improved water productivity and sustainability of the canal commands.

The *Warabandi* is a time equitable system, which needs improvement by adding the water loss function. The assumption behind the *Warabandi* concept is that there is no conveyance loss in the watercourse and time equity system will provide reasonable level of volume equity – completely a false assumption. Research work and pilot testing on *Warimetric* system by adding the water loss function in the *Warabandi* Formula was initiated in India. Similar activity atleast at the pilot scale is needed in the IBIS.

6.5. Policy, Institutions and Incentives for Enhancing Water Productivity

For any of the above strategies to work requires the right set of incentives and support for all the actors involved — a function of policies and institutions. Existing institutions for water management need incentives to be more efficient and to offer services that will support improvements in water productivity. Farmers need incentives to adopt technologies and practices to make the most of the water they use. Taking narrow sectoral approaches to water management should become a thing of the past. Especially as

competition for water becomes more intense, how water is managed in one sector often impacts its availability in others. Laws, regulations and organizations should be defined to encourage water management from a basin perspective.

Another area, which should be targeted for reform, is subsidies and pricing. In many cases, poorly designed subsidies can actually discourage farmers from getting the most crop per drop. The good example is the total annual subsidy of around Rs. 7 billion on electric tariff for around 14373 tubewells in Balochistan alone, which resulted in severe mining of groundwater and lowering of the water table. Now the farmers are pumping water from the depths of around 300 m in certain basins. Increases in water productivity are necessary to solve many of the problems of the water crisis, but they are not sufficient. It is imperative that these be accompanied by a poverty focus to help the poor reap the gains of increases in water productivity. Attention needs to be given to establishing and maintaining access to water for domestic uses and income-generation, affordable water-productivity enhancing technologies, and giving the poor a voice in water decisions. Whose responsibility is it? Increasing water productivity requires the coordinated set of actions from a range of people: policy makers, resource managers, farmers, fishermen, and water managers; researchers from agronomy, water resources, irrigation, and natural resources management; and in fact all the stakeholders who care about influencing policies about how water is used.

7. Challenges of Water Development and Management

The projections for the year 2015 and 2025 indicated that country is going to be short in wheat, edible oil and pulses considering the present level of production and the demand for 2015 and 2025. The country's current exports of agricultural commodities and cotton yarn are around Rs. 112 billions, whereas the total imports of agricultural commodities are around Rs. 99 billions including imports of tea, edible oils, pulses, fruits, vegetables, milk and milk products, wood and wood products.

The agriculture growth rate targeted by the Government of Pakistan for the next 5-years period (2005-10) is over 5% per annum (GOP 2004; GOP 2000). This would be achieved primarily through increasing the productivity, as new water resources would be hardly available during this period. The increase in cropped area would be possible only through: a) provision of additional water to increase cropping intensity in irrigated area of the Indus basin, which is hard to accomplish; or b) by replacing the high-delta crops with water efficient (low-delta) crops; or c) through saving of existing losses (conveyance and application). The recently launched President's Programme on "Watercourse Improvement" would provide additional water through saving of existing losses in the delivery of water from the Mogha (outlet) to the authorized Nacca (farm outlet). New storage reservoirs will not be available during the next Plan Period (2005-10) rather there will be reduction in available storage capacity in the Indus basin due to continuous sedimentation of the reservoirs (Tarbela and Mangla).

The increase in productivity would also require more reliable and adequate availability of water. Thus additional water requirement will be around 1% (1.28 billion m^3) of existing canal supplies per annum. In addition, the annual loss of storage reservoir capacity is estimated as 0.18 billion m^3 per annum.

The existing average canal diversions to the Indus basin irrigated command area are around 127 billion m^3 per annum. Additional canal supplies required to meet 5% growth in agriculture and to meet annual loss of live storage capacity of existing reservoirs due to sedimentation come to around 1.46 billion m^3.

For the next Plan Period (2005-10), the additional water required to achieve the growth in agricultural productions of 28% would be around 8.2 billion m^3, which is a considerable amount of water. Thus systematic efforts are needed to find new resources of water through improved management of existing water supplies in the Indus basin and areas outside the basin.

The recent prolonged drought posed serious questions in relation to the implementation of the agricultural strategy put forward by the Government of Pakistan. In addition, the reservoirs were not fully filled during the last six years raising further serious questions for the level of development and management of water resources for sustainable irrigated agriculture in the Indus basin. The former Prime Minister of Pakistan, in a directive to the Ministry of Food, Agriculture and Livestock emphasized the need for adjusting the cropping pattern with water availability in various canal commands of the Indus basin.

The Sub-Group on "Cropping Pattern" constituted by the Working Group on "Agriculture" under the auspices of the Planning Commission of Pakistan and task was assigned to look into the Crop Water Requirement within E_t perspective examines the existing cropping pattern and farm level irrigation practices including the irrigation scheduling and put forward a strategy for adjusting cropping patterns with water availability in the IBIS. The study was conducted for initiating discussion for the formulation of a practical strategy considering the ground realities, where hard decisions have to be made because business as usual is no more valid.

The IBIS today is a result of over one century of supply-based policies. Surface water is supplied to more than 14.6 mha or 120,000 watercourses through an extensive network of main canals, secondary canals and distributaries. The system of *Warabandi* and crop-based water charges is still in use, although discrepancies exist between official rules and rules in practice, for example the development of localized canal and/or tubewell water markets. The 1980s, however, have brought major changes that have stressed the inadequacy of the supply-oriented and engineering-driven development interventions for projects implemented so far. The equity, efficiency and sustainability are the other issues affecting the productivity in the Indus basin. Some of the challenges and constraints for future water development and management are:

7.1. Water Scarcity

The major challenge relates to changes in water scarcity that has taken place within the irrigation system. The *Warabandi* system initially imposed by the British administration played a role, as the demand for irrigation water was rather minimal due to low cropping intensity and production of primarily of low-water requirement crops like food grain (wheat, maize, sorghum, and millets), pulses, oilseeds, etc. During the last decade, however, the pressure on water has drastically increased, with more competition for quantity and quality of irrigation water within the irrigation sector, but also from other sectors of the economy. The issues related to the water scarcity are:

- As a result of changes in the macro-economic environment, farmers have increased their cropping intensities from the original design figures of 50-70% to an average of 120% per year for the Indus Basin (John Mellor Associates 1994). This has led to an increasing pressure on the surface water resources (cheap freshwater), translated into a significant interference of water users into the operation of the irrigation system (Rinaudo et al. 1997).
- As a result of inadequate canal water supplies, but also as a response to changes in the macro-economic environment, farmers have installed a large number of private tubewells to tap groundwater resources. However, current pumping rates have already led to mining of the aquifer in several canal commands with good quality groundwater (IWMI 2003b; NESPAK 1991). In areas with poor quality groundwater, farmers still have installed tubewells and pumping leads to problems of secondary salinization and sodification (Kijne and Kuper 1995).
- More recently, water needs by other sectors of the economy, such as industries and municipalities, are becoming more significant, although the overall quantity used by these sectors remain marginal as compared to water use by the irrigation sector, i.e. less than 7% of total water resources (World Bank 1994). Competition over water resources between sectors has been limited to specific areas close to large cities and industrial complexes. The main issues presently at stake include competition on groundwater use (quantity), and problems of effluents and pollution of irrigation water (quality).

- There has been a recent recognition of the in-stream needs of the Indus River. Minimum discharges from the Indus to the sea are required to limit intrusion of seawater into the coastal area. However, little is known about the minimum flows required and how this would compete for surface water resources with the irrigation sector.
- The competition for surface water resources has intensified between the four provinces, and mainly between the Sindh and the Punjab provinces. After long negotiations, the Indus River System Authority (IRSA) was created in 1992 to implement the Water Apportionment Accord that specifies surface water allocation to provinces. However, confrontations between the Sindh and the Punjab provinces regarding these allocations still arise periodically, mainly during periods of high water demand. The consensus on storage needs has yet to be attained among the provinces.
- The climate change research conducted for the South Asian countries including Pakistan revealed that the extremes are going to be severe – temperatures, droughts and floods – current changes in rainfall pattern in the Sindh and Balochistan provinces is a change phenomena. Thus there are chances that droughts will be more frequent and severe resulting in reduced water availability in the future (Ahmad et al. 2003).

7.2. Water Efficiency

The water efficiency is linked with conveyance losses in canals and watercourses and application losses in the field. These losses further aggravate the problem of water scarcity and result into problems of waterlogging and salinity. It also affects the volume-equity in availability of water due to time-equity *Warabandi* system. The issues related to the water efficiency are:

- As a result of deferred maintenance, lack of discipline and political/feudals interference the overall operational management of the canal irrigation system is affected to a level where accurate measurements are hardly taken and used in canal operational management.
- Cost-effective canal and watercourse lining techniques are not yet available even small-scale experiments were conducted by various agencies during last 50 years. The quality of contract works is also poor.
- The on-farm water management programmes although considered quite successful but 30% lining of watercourses would add limited towards water savings. The OFWM programmes could not adopt cost-effective lining techniques developed by various agencies, as they are still following 9" brick lining.
- Basin irrigation on unlevelled fields is inefficient. The furrow-bed irrigation recently introduced in the cotton-wheat area has a potential for efficient surface irrigation if issues of high cost of bed-shapper cum planter and weeds control are addressed. The cost of temporary beds is higher than flat plantations; therefore, it requires studies on the adaptation of permanent bed system.
- The locally produced sprinkler and drip irrigation systems are still costly and outside the reach of common farmers until they are linked with specific objectives of *Rauni* irrigation and to have specialized benefits through frost control and cooling.
- The high electricity prices have forced farmers to shift to diesel prime movers for pumping of water. The efficiency of Chinese single-cylinder diesel engines is low because of low combustion efficiency, low coolant temperature and engine speed. The centrifugal pumps are also not energy efficient compared to direct displacement pumps. Therefore, renewable energy sources can't be used because of high initial cost until weight balancing direct displacement pump is locally produced. Therefore, water and energy efficiency in tubewell irrigation is going to be a major issue in the next decade.

7.3. Water Equity

The water losses during conveyance and time-equity system imposed for quota of water resulted into inequity in volume of water availability. The deferred maintenance, political interference and lack of improved canal operational management further aggravate the problem. The issues related to equity are:

- The concept of *Warabandi* is based on quota and due to huge water conveyance losses it adds into inequity in water availability at the tail end reaches. The concept needs to be modified to include conveyance loss function in the *Warabandi* formulae to make it volume equity system for each shareholder instead of time equity system.
- The availability of information to the water users regarding canal flows and diversions at *Moghas* is a major limitation in arranging an organized community action to resolve the equity issues.

7.4. Water Productivity

The water productivity is the ultimate aim of irrigated agriculture in the IBIS. The increased water productivity should ultimately improve profitability of the irrigated agriculture, which is the ultimate objective of the farmer. Water productivity is the objective of the irrigation manager and agriculture experts. Farmers are mainly interested in profitability of irrigated farming systems. The issues related to water productivity are:

- The Study on "Adjusting Cropping Pattern with Water availability" revealed that marked increase in cropping pattern of 32, 68, 24, 43, 183 and 119 % was observed during the post-Tarbela period (1976-2003) for wheat, cotton, rice, sugarcane, fruits and vegetables, respectively. Reduction in area under oilseeds and coarse grains of 16 and 30% was observed, respectively. The production of pulses was stagnant during the post-Tarbela period. Increase in area under high water demanding crops like sugarcane, rice, fruits and vegetables was primarily due to availability of additional irrigation water from Mangla and Tarbela reservoir during the Rabi and early Kharif seasons. Other factors, which contributed were power generation, development of industry and road infrastructure.
- Country's rice and sugarcane improvement programme is mainly focused on development of varieties, which are high yielding and disease-resistant. Issue of water shortage or heat tolerance or salt tolerance was hardly considered as an objective of varietal improvement.
- Government would continue to give high priority to Basmati rice due to export earnings, which consumes more water compared to the coarse varieties.
- Access to laser levelling equipment by average farmers is difficult, as public sector maintains only few units. Private sector is not involved in provision of services related to laser levelling. Similar situation exists for provision of services for installation of sprinkler and drip irrigation systems.
- Water use and precision irrigation are the key factors for raising productivity of crops per unit of water because water is going to be scarce in future – crop per unit of water.
- The water development institutions like WAPDA are still designing and implementing new canal development projects in a way the country use to build the irrigation infrastructure in the last century. Alternative irrigation systems based on sprinkler and drip irrigation could have been considered for new canal development projects like Kacchi, Thal and Rainee canals. Thus there is a need to consider alternative approaches for developing new irrigation infrastructure in future.
- The current Authorized Canal Water Allocation of various canal commands is not in line with the E_t requirement or cropping pattern or cropping intensity. Therefore, there is a need to revise the canal water supply allocations based on E_t, cropping pattern, cropping intensity and soil requirement and the saving of water thus made can be utilized by the provinces for developing new projects or allocating water to commands where gains in water productivity are possible.
- A research study was conducted for the comparison of sugarcane and sugar beet in terms of crop water requirement and water productivity. The net crop water requirement of sugar beet (686 mm) is almost half of sugarcane (1200 mm). Furthermore, monthly net water requirement of sugar beet during the Rabi growing season never exceeds water requirement of sugarcane. Productivity of sugar beet per unit of water is almost double of sugarcane having almost same quantity of sugar as marketable product.

- The non-water factors affecting water productivity should also be considered while considering the water aspects like: a) lack of availability of quality seed; b) timely availability of other inputs; and c) poor crop production practices.

7.5. Profitability of Irrigated Agriculture

Farmers per say are not interested in water productivity rather their major goal of farming is to have profitability. Thus the real challenge for the water development and management experts is how to translate water productivity into profitability of irrigated agriculture.

- Water pricing in canal commands of the IBIS is based on area of crop grown i.e. for rice water rate is around Rs. 83-148 per acre, whereas cost of tubewell water to grow one-acre of paddy rice is around Rs. 6,000. Thus value of pumped water is many-fold higher than canal water supplies. Therefore, there is a need to conduct studies for valuation and costing of canal water in the IBIS; and
- Profitability of rice and sugarcane production on pumped water is now questionable because of high cost of pumped water and low yields of paddy rice and sugarcane. Water productivity of paddy rice and sugarcane is low mainly due to low crop yields and higher levels of water use. The cost of pumped water for rice and sugarcane exceeds the total cost of non-water inputs.

7.6. Resource Sustainability

The sustainability of irrigated agriculture demands rethinking about the existing approaches of irrigation especially the drainage as Pakistan is a vertical country and disposal of effluent to the sea is not a sustainable proposition. The issues related to sustainability are:

- The fallowing of land results into accumulation of salts in the upper soil surface and therefore crop based farming system is not sustainable. Diversification of farming system through integration with forestry and pastures, aquaculture and livestock would add sustainability to the Indus basin irrigated agriculture. Such farming systems need to be evaluated.
- Flood irrigation in a situation of water scarcity and more dependence on marginal quality groundwater will further aggravate the issue of salt build-up.
- Secondary salinization and sodification due to the use of poor quality groundwater is going to increase in future, as most of the fresh groundwater resources have already been exploited.

The other issue is linked with the level of financial resources available for the irrigation sector. Financial resources for the development of the irrigation sector are scarcer today than 20 years ago, both in absolute and relative terms. Several reasons explain this situation.

- Similarly to the general trend observed in the Sub-continent (Rosegrant and Svendsen 1993), the development costs of irrigation projects per unit area today are significantly higher in absolute terms, as low-cost high-potential areas have already been developed. As a consequence, significant improvements in agricultural benefits will be required if acceptable economic returns are to be realized.
- In the context of structural adjustment programs and under pressure from international lending agencies, there is a political will to reduce subsidies to the irrigation sector. Financial autonomy has become an important policy objective in Pakistan. The recent SCARP Transition Projects illustrate this concern. In order to eliminate the financial burden related to the high operation and maintenance costs of public tubewells, these projects aim at closing down public tubewells, selling them to farmers or group of farmers, or providing subsidies for the installation of private tubewells by individual farmers. The government of Balochistan is now also considering the issue of subsidy on electric tariff of tubewells and interested to progressively address this issue.

- The level of financial public resources available for the irrigation sector has drastically decreased in relative terms. This results from the disengagement of donors traditionally involved in the irrigation sector (the end of the US-Aid period in 1991 as a result of the Pressler amendment). The increasing importance of the total debt servicing of the country, is another element that limits the availability of financial public resources. Also, the competition from other sector of the economy has increased: higher economic rates of return are in fact expected from investments in industrial and infrastructure development as compared to investments in the irrigation sector.

With the increasing scarcity of water and financial resources, inefficiency, inequity and high-energy prices, it is clear that highly expensive supply-based approaches become less viable. This has been reinforced by the increasing recognition of the failure of past projects that did not yield the expected benefits that were visualized, and could not solve problems in the irrigation sector.

7.7. Implications for Medium Term (5-10 years)

The medium term implications on the development and management of water resources are:

- *Food Security* – Increasing demand for food is going to be a major challenge for the next decade, as the population is growing at a rapid rate. Furthermore, the socio-economic changes would also bring improvement in livelihood and nutrition of the rural communities. The additional requirement for food and fibre would largely come from improving the water productivity, as the development of new water resources and irrigation infrastructure would require more than 10 years and such developments are also capital intensive.
- *Water Security* – The water security in the medium term would largely come from the savings of existing losses. This would include the savings from conveyance and application losses and using affordable technologies for precision irrigation and managing the irrigation system in more equitable manner to minimize non-beneficial E_t.
- *Water Shortage* – In future there are chances that available water resources for the IBIS would further decrease due to sedimentation and loss of storage of Tarbela and Mangla dams and the persistent droughts due to the climate change. These shortages also demand that alternative options must be evaluated before embarking any new irrigation scheme for the IBIS.
- *Water Management* – The major objective for the water management in the next decade should be to improve water productivity – means improving productivity per drop of water. This would be achieved by reallocating water allowances of various canal commands in the IBIS considering the E_t perspective. But this would require a systematic analysis of the existing canal commands in terms of productivity and water efficiency. The approach of cost-effectivity is recommended to have immediate impacts on productivity and profitability of the existing canal commands.
- *Cost Effectivity* – The cost effectivity of the interventions related to water saving and water productivity should be considered as a criteria for selecting the interventions for any irrigation improvements in the existing canal commands. The canal commands having surplus water and lower crop yields have higher cost-effectivity for improving water productivity. Therefore, the canal commands categorized, as having surplus water allocations must be given higher priority for improving water productivity, profitability and sustainability.

7.8. Implications for Long Term (30 years)

The long-term implications for the development and management of water resources are:

- *Water Development* – Future water development in terms of constructing new storage reservoirs should be aimed to provide water to existing canal commands having higher marginal value of water. Providing additional water to canal commands having sufficient or surplus water and low crop productivity would further lead towards reduced water productivity and serious implications

for waterlogging. Thus provision of additional water to the existing commands should be aimed to enhance water productivity in the long run.

- *IWRM Approach* – Water development without considering the context of water management and integration of the elements of water management would not improve water productivity in the IBIS. Therefore, the future water developments have to be seen within the overall context of IWRM so that water development is supportive to the overall basin management considering participation of water users including women. IWRM approach would ultimately result into improving water productivity and sustainability in the IBIS.
- *Reformulating and Implementing Water Allocation and Use Regulations* – There is a need to re-formulate and implement water allocation and *Warabandi* rules and regulations to enhance water productivity and profitability of irrigated agriculture in the existing canal commands.
- *Institutional Restructuring and Strengthening* – The provincial Irrigation and Power Departments and the Irrigation and Drainage Authorities are outside the devolution plan, whereas the provincial Agriculture Departments have been devolved at the district level. For improving water productivity it is essential to reorganize water and agriculture departments at the Canal Command level. The proposed Area Water Boards and the Farmers Organizations is the ultimate structure needed for improving irrigation management at the canal command level. But for improving water productivity, agriculture department has to be integrated with the Area Water Board and with Irrigation and Drainage Authority. In fact, there is a need to have Irrigated Agriculture Authority at the province level and the Area Water Board as the Canal Command Board integrating both water and agriculture sectors. One thing has to be accepted that Irrigation and Power Department in its present shape is not interested in water productivity, as they are mainly interested in water delivery. Mechanisms have to be developed how to reorganize the public sector institutions at the canal command level – the challenge for the next few decades for Pakistan. Without addressing this issue there is hardly any chance for sustainable improvements in the irrigated agriculture. The recent experience of institutional reforms under NDP indicated that pilots were designed for failures and therefore, any institutional reforms have to be enforced as a decision by restructuring the whole system instead of a pilot approach. Pilots in Pakistan designed by the respective departments normally fail. The other option is that the OFWM is restructured as water management institution at the distributary canal level supporting the FOs.

7. Conclusions

7.1. Evapotranspiration

Conclusions related to reference and actual evapotranspiration of crops and spatial variation for computing net water requirement of crops for the canal commands of the IBIS are:

- Evapotranspiration and cropping intensity differ substantially in the canal commands of the IBIS due to variations in climate, soils, cropping patterns and availability of water. During the last fifty years, irrigation water requirement has increased tremendously because of doubling of both the irrigated area and cropping intensity (having four fold increases) and due to increased area under high delta crops (Ahmad 1999). Grouping of canal commands considering the agro-climates rather than existing cropping zones used for the IBM-R and the selection of appropriate methods for estimation of reference evapotranspiration for the arid areas is imperative and can make assessment of irrigation water requirement at the regional scale more effectively (IWMI 2001a). Fifty-two agro climates have been characterized for Pakistan by PARC based on aridity and crop growth indices, whereas WAPDAs classification primarily represent existing cropping zones, which need refinement.
- The variation of annual reference crop evapotranspiration from North to South of the IBIS ranges from 1200 mm to 2100 mm using the Penman method. The energy balance gives a range for actual crop evapotranspiration or net water requirement of 400 to 1400 mm.

- Two to four weeks shift in planting date, varying length of the cropping seasons and spatial and temporal variations in peak water requirement in different canal commands is an important flexibility available for water regulation during high stress periods.
- The spatial variation in net water requirement of various canal commands is more than two folds for the existing cropping patterns having same cropping intensities. Seasonal variation is about three folds. The demand hydrograph of eco-group of canals would help in operational planning of water resources.
- Cropping patterns and cropping intensities are two important factors influencing net water requirement of crops in the Culturable Command Area (CCA). The reported cropping intensities varied from 28% to 164% for CCAs of the canal commands of the IBIS, introducing a factor of six in the variation of current net water requirement. It indicates that significant changes in Authorized Canal Water Allowance can be made for canal commands having low cropping intensities (<100%), whereas areas having cropping intensities of >150% might have more chances of increased water needs in future.
- The importance of reliable data about crops, cropped area, cropping pattern and cropping intensity are paramount in assessing water demands for agriculture and level of expected water stress. The availability of such data at canal command instead of district is essential for estimating water demand.

7.2. Water Use – A Basin Approach

The water development and management efforts should be targeted to meet future water needs, in a cost-effective and socially desirable way, to obtain more financial returns from current water supplies. This is often difficult because of the interaction between different uses and complex flow paths of water within a basin. The framework was provided to better understand water use and productivity. The general conclusions drawn based on the Case Studies conducted in India, Pakistan and Sri Lanka are:

- The choices available for water savings in closed basins with high beneficial utilization, such as in the Chishtian sub-basin of Pakistan and in the Bhakra sub-division of India, are limited. In these sub-basins, efforts should focus on gaining higher productivity from water that is being depleted.
- A high rate of beneficial depletion does not necessarily lead to increased water productivity, as demonstrated by the analysis of the Chishtian sub-basin of the IBIS. Even though existing practices lead to apparently high efficiency there remains considerable scope for increasing water productivity. This illustrates the need to incorporate indicators of water productivity in assessing performance of canals.
- Within the open sub-basins like catchments of small dams, many more opportunities for saving water and increasing productivity of available supplies exist than in the closed and closing sub-basin of Chishtian. But, to increase productivity of available supplies, the water conserved must be directed to beneficial and productive uses.
- In all the Case Studies, water outflow data were sketchy and it was not clear how best to interpret the available data. There seemed to be a general lack of knowledge of environmental requirements both within and downstream of study sites and little knowledge on both how much water could or should be depleted within the sub-basins and how much water should be committed to downstream uses. This is probably due to having the primary focus on sector-oriented supply management rather than overall management of the water resources within the basin. This indicates a need for more action on overall water resource management, especially when basins become closed, and a need for more research on how to define rights to and commitments for water.

The Case Studies illustrated the need to take a basin perspective when considering how to improve water use. It is important to consider various uses of water within a basin, the use and depletion of water by each use, and quantity and nature of downstream water use. This approach allows placing irrigation within a

basin framework, to view irrigation as it interacts with other uses, and to identify means of improving water productivity.

8.3. Water Productivity and Profitability – System's Approach

The water productivity at the IBIS level is the only option left to enhance return per unit of water used at the canal command level. The systems' approach demands that water productivity be seen at the basin, sub-basin, canal command, watercourse and field level. The conclusions related to water productivity are:

- Secondary data needed for computing water productivity is available with public-sector data collecting agencies. However, this data is maintained by different agencies at different scales. Spatial databases and GIS software's can be used for efficient reconciliation of data.
- Cropped area and yield data are always under estimated by the public-sector agencies. Therefore, the water productivity estimated from secondary data is relatively lower than estimated from primary data, however, secondary data and information could be used reliably for comparative analysis.
- Productivity per unit of water or per unit of land is generally low and varied considerably among different canal commands. Cropped area and yield are the main determining factors of gross production of marketable products. Rabi and Kharif seasons cropped area and CCAs are the determining factors for estimating the cropping intensity.
- Productivity of land is relatively higher in the Kharif season as compared to the Rabi season. However, in case of water productivity, the results are opposite. Thus the efficient use of water is in Rabi season primarily due to shortage of water, reduced evapotranspiration and less frequent irrigations.
- The marginal productivity of canal water was higher in certain canal commands and increased supply to these canals augments the aggregate production.
- Importance of groundwater as a secondary water source is evident in canal commands of Punjab province. The influence of groundwater supplies is decisive in Rabi season. The groundwater supply is the main factor contributing in enhancing productivity of the Rabi season. In fact, all sources of water, canal, groundwater and rainfall are integrated to a great extent in the canal commands of the Punjab province. For instance, it is found that an extra amount of canal water will increase water productivity but at the same time it will reduce the exploitation of groundwater, especially in the marginal to brackish quality zones. This may reduce the productivity of incremental water but may increase the profitability.
- Two indicators i.e. productivity per unit of land and productivity per unit of water provide overview of production as a response of resource use and may be used in defining water reallocation strategy. However, any criteria developed for water reallocation requires understanding of relationship between cropping pattern and physical environment, more precisely depth to water table and also the relationship between physical environment and productivity. Furthermore, inter-linked water sources need to be studied in a conjunctive way.
- An integrated utilization of canal supply, rainfall and groundwater abstraction is taking place to some extent. A formal integrated water management is required, especially in view of excess canal supplies to some canal commands.
- Water productivity needs to be translated in financial terms using gross and net value production per unit of water use. The net value production per unit of water use would determine profitability of any cropping system in existing canal commands. Thus water profitability of the farming system is the ultimate objective to address the farmers' preferences.

9. Way Forward

9.1. Policy and Reforms – Recommendations

- Before investing in expanding irrigated area by either developing new canal commands or enhancing canal supplies of the existing commands, look at options for improving water productivity of the existing canal commands.
- Enforce basin approach for water savings and evaluate how changes in water management or water allocation in one canal command affect water users in another command.
- Enforce institutional restructuring and strengthening to reorient provincial IDAs to provincial Irrigated Agriculture Authorities and the Area Water Boards as the Canal Command Boards by integrating activities of irrigation and agriculture sectors.
- Undertake programmes and projects for integrated management of water from different sources: i.e. water from rivers and reservoirs is integrated with water from rainfall stored in the soil profile or in groundwater aquifers.
- Invest in irrigation management and improvement programmes to provide reliable irrigation to farmers in existing canal commands and irrigation schemes.
- Implement policies and provide incentives to support the adoption of affordable technologies and practices that will improve water productivity and reduce degradation of agro-ecosystems.
- Ensure that the poor segments of the rural communities benefit from investments in improving water use and productivity by ensuring access to water for income-generation, developing and promoting affordable water-productivity-enhancing technologies, and giving the poor a voice in water decisions

9.2. Water Savings – A Basin Perspective

Water savings essentially means diverting water from non-beneficial uses to more productive uses. For agriculture, the purpose is to enhance production per unit of water, and yet be able to release water for the environmental, domestic and industrial purposes. The practical targets for reducing non-beneficial depletion by taking care that these are not already being used for important environmental functions are:

- Reducing seepage and flows of freshwater to deep or brackish aquifers from which the water cannot be economically recovered and of the same quality.
- Reducing non-beneficial evaporation from fallow fields or waterlogged areas.
- Reducing over-irrigation due to unleveled fields or heavy Rauni irrigation or heavy first 2-3 irrigations to save water and reduce leaching of fertilizers and other agricultural chemicals.

Improving irrigation efficiency is the most appropriate way to reduce non-beneficial depletion and to save water. The IWMI concept of global context of efficiency indicates that seepage 'losses' from canals and fields may recharge aquifers and shallow dugwells used for domestic water supply. Failing to take a basin perspective when implementing water conservation strategies, not only runs the risk of not saving water but can also have a negative impact on water quality, drinking water supply, groundwater balance, and downstream human and ecological users (IWMI 2003a). The global context of efficiency normally works under two assumptions: a) energy cost is low and the water lost in recharging the aquifer can be pumped economically; and b) the water lost in recharging the groundwater can be retrieved with the same quality. Both the assumptions do not hold true in major part of the IBIS and areas outside the IBIS. Therefore, recharge to groundwater for domestic purposes must be planned and not left as victim of circumstances – status quo approach will not lead us anywhere.

9.3. Water Productivity

9.3.1. Research Themes

- Crop breeding for drought, heat and salt tolerance and higher water productivity under poor quality groundwater use.

- Undertake studies for evaluating interaction between water management practices at different levels — field, system and basin.
- Co-managing water for agriculture and environment sub-sectors of water use.
- Development and adoption of appropriate and cost-effective water use technologies and crop production practices for improving water productivity at field, system and basin levels.
- Formulate and evaluate policies and incentives needed to introduce affordable water-saving technologies and improved crop production practices.
- Develop approaches and methodologies for managing irrigation water for multiple uses — agriculture, domestic and other income-generating activities.
- Develop Decision Support Systems to support effective decision making for valuing the productivity of water in its various uses and examining trade-offs.

9.3.2. Development Themes

- Pilot Canal Command projects may be initiated in all the provinces to introduce reliable measurements for water and productivity at the watercourse, distributary and canal level. This would demand reorientation of the provincial IDAs and to develop and sustain a culture of irrigation management based on measurements of water and productivity. This would also require integrated projects jointly implemented by IDAs and OFWM.
- Future On-Farm Water Management Projects must have change in focus from merely improving efficiency to increasing water productivity. This would demand integrating activities of Agriculture Extension and Water Management Directorates General. The staff of the agriculture extension needs training and reorientation from land productivity to water productivity.
- The agriculture statistics data in the IBIS must be collected at the canal command level instead of district. This is a pre-requisite of introducing any development programme for water savings and increasing water productivity. Reorientation of the staff of the Agriculture Statistics Directorate is essential.

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11. Appendices

Appendix I.A. Characteristics of Agro-Ecological Regions (PARC 1980).

No.	Region	Temperature (C)	Rainfall (mm)	Crops
I.	**Indus Delta**	34-40, 19-20	125-250	Rice, sugarcane, pulses, berseem, wheat
II.	**Southern Irrigated Plain**	38-45, 8-12	125-250	Rice, wheat, cotton, sorghum, mustered, sugarcane, gram
III (a).	**Sandy Desert**	39-41, 7	125-250	Guar, millets, wheat
III (b).	**Sandy Desert**	40, 5.5	150-350	Gram, wheat, cotton, sugarcane
IV (a)	**Northern Irrigated Plain**	39.5-42, 6-6.2	200-500	Rice, wheat, cotton, sugarcane, maize, oilseeds, melons
IV (b).	**Northern Irrigated Plain**	38, 5	500	Sugarcane, maize, tobacco, wheat, berseem
V.	**Barani Lands**	38-38.5, 3-7	200-1000	Wheat, millets, rice, maize, oilseeds, pulses, fodders
VI.	**Wet Mountains**	35, 0-4	>1000	Maize, wheat, rice, deciduous fruits
VII.	**Northern Dry Mountains**	-	300-1000	Maize, wheat,fodders, fruit, apricot
VIII.	**Western Dry Mountains**	30-39, -3-7.7	125-500	Fruit, wheat, vegetables, fodders, maize
IX.	**Dry Western Plateau**	33-40.5, 3-15	50-200	Tropical fruits, wheat, summer cereals
X.	**Sulaiman Piedmont**	40-43.6, 5.8-7.6	125-250	Wheat, gram, lentils, oilseeds, millets, sorghum

Apppendix-IB. Cropping Regions of the Indus Basin (WAPDA 1979).

1. Northwest Frontier Mixed Cropping (NFMC)

Kabul River and its tributaries, the swat and kalapandi, drain the half saucer-shaped alluvial valley of Peshawar. It has semi-arid sub-tropical continental type of climate, with meager rain both in winter and summer. Salinity and sodicity is a very minor problem, occurring in the central part in small patches. This region is one of the most intensively cultivated areas of the country. Due to canal irrigation main crops are sugarcane, maize, tobacco, wheat and Berseem. In addition, considerable proportion of the area is under fruit orchard of pears and plums.

2. Punjab Mixed Cropping (PMC)

This zone contains nearly two million acres canal command area, mostly on the left bank of the Indus below the Jinnah barrage. The Paharpur and Chashma Right Bank canal command areas in the NWFP Province also included in this zone. The low cropping intensities and yields are due to rough topography, sandy soils and high seepage. The presence of fresh groundwater and localized waterlogging in most of the area favors the potential for tubewell development.

3. Punjab Rice Wheat (PRW)

This zone comprises of about 2.8 million acres, virtually all of it is underlain by fresh groundwater. This area has intensive development of tubewells. The abundance availability of water results in highest cropping intensities. The Basmati rice is the dominant cash crop. The rapid mechanization was observed due to relatively high returns to farming combined with a shortage of labour.

4. Punjab Sugarcane Wheat (PSW)

This area lies between PMW and PRW, and covers about 4.4 million acres. The major crops are wheat and sugarcane. About one third of the zone is saline, but the groundwater is extensively used in the rest of area. Water shortages do exist and are largely attributed to low watercourse efficiencies.

5. Punjab Cotton Wheat (PCW)

This is the largest agro-climatic zone in the Indus Basin Irrigation System, covering over 11 million acres on left bank of the Indus among Sindh Province, India, and the other Punjab zones. Cotton and wheat are dominant crops with some of the highest yields in Pakistan. Groundwater is extensively used regardless of that approximately one fourth of total area is severely saline and waterlogged.

6 & 8. Sindh Cotton Wheat (SCW) North and South

It covers about 6 million acres. Nearly half of the north and most of the south is saline or waterlogged. Yields of the cultivated area are favourable. Groundwater potential through tubewell development is minimal due to saline/brackish water. Surface water supplies are hampered by high losses, particularly at watercourse level.

7 & 9. Sindh Rice Wheat (SRW) North and South

About two-thirds of 4.4 million acres in the north is saline and the entire south is similarly classified. Rice is most favourable crop for that type of soil. Because of high water table cropping intensities and yields for other crops are lower, particularly in the south of the basin.

Appendix-II.A. Reference Crop Evapotranspiration of Canal Commands of the IBIS (IWMI 2001a)

Canal	Etr (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Upper Chenab	41	59	106	142	185	187	155	144	130	96	54	38	**1337**
Marala Ravi	39	58	104	141	182	184	149	140	125	92	51	36	**1303**
Upper Dipalpur	43	62	112	151	195	195	162	146	136	100	55	40	**1396**
Lower Dipalpur	45	66	119	154	197	211	177	164	145	103	57	43	**1481**
BRBD-INT	41	59	107	145	186	188	153	142	129	95	53	37	**1334**
Gugera	43	62	111	147	193	195	165	150	138	101	56	41	**1401**
Jhang	44	63	113	150	199	203	172	156	141	103	58	42	**1445**
Upper Jehlum	48	65	114	155	204	207	168	144	144	121	78	53	**1501**
Lower Jehlum	48	67	117	158	211	216	179	156	147	118	74	51	**1542**
Thal	48	67	120	157	207	222	190	173	150	108	61	46	**1549**
Lower Bari Doab	45	66	120	154	197	214	181	168	147	104	58	43	**1497**
Haveli	49	69	124	161	211	231	197	181	153	109	62	47	**1593**
Mailsi	47	69	126	157	198	227	193	182	155	107	59	46	**1565**
Pakpattan	47	69	126	157	198	227	193	182	155	107	59	46	**1565**
Fordwah	62	83	139	194	258	269	205	195	170	136	84	58	**1853**
Sadiqia	59	81	132	180	235	250	199	190	164	129	79	55	**1752**
Abbasia	58	82	133	172	217	235	199	188	158	123	75	55	**1695**
Bahwal	56	78	126	165	211	230	193	185	159	122	74	52	**1652**
Qaim	58	81	120	178	232	246	198	188	158	127	75	54	**1715**
Panjnad	58	82	133	172	217	235	199	188	158	123	75	55	**1695**
D.G.Khan	47	69	126	157	198	227	193	182	155	107	59	46	**1565**
Muzaffargarh	47	69	126	157	198	227	193	182	155	107	59	46	**1565**
Rangpur	49	69	124	161	211	231	197	181	153	109	62	47	**1593**
Pat Feeder	80	98	172	226	287	305	246	214	181	144	91	68	**2112**
Desert	80	98	172	226	287	305	246	214	181	144	92	68	**2112**
Begari	77	96	167	218	282	300	238	207	182	140	92	69	**2069**
Ghotki	72	92	159	205	262	280	227	202	174	135	87	65	**1959**
North West	77	96	167	218	282	300	238	207	182	140	92	69	**2069**
Rice	74	94	163	210	278	295	230	200	182	137	93	70	**2026**
Dadu	80	99	160	206	273	289	227	195	183	144	96	77	**2031**
Khairpur West	74	94	163	210	278	295	230	200	182	137	93	70	**2026**
Khairpur East	80	99	164	213	278	294	233	202	182	144	95	74	**2058**
Rohri	83	100	160	207	271	272	215	188	183	147	97	80	**2003**
Nara	87	104	158	205	268	261	208	182	183	153	100	85	**1991**
Kalri	88	103	159	208	267	238	191	172	182	153	99	86	**1946**
Lined Channel	88	103	159	208	267	238	191	172	182	153	99	86	**1946**
Pinyari	88	103	159	208	267	238	191	172	182	153	99	86	**1946**
CRBC	50	68	118	149	198	206	186	171	143	103	60	46	**1497**
NWFP Canal	42	55	96	131	178	188	161	152	125	87	52	37	**1303**

Appendix-II.B. Potential Crop Water Requirement for Canal Commands of the IBIS (IWMI 2001a).

N0	Canal	Potential Crop Water Requirement (mm)									
		Kharif Crops						Rabi Crops			
		SCane	Rice	Cotton	Maize	Sorghum	Minor	Wheat	Oilseeds	Pulses	Minor
1.	Upper Chenab	1375	630	673	310	399	724	336	268	-	372
2.	Marala Ravi	1278	587	627	289	370	676	316	247	-	345
3.	Central Bari Doab	1442	664	709	325	418	764	351	278	-	386
4.	Upper Dipalpur	1518	696	746	341	439	803	369	293		407
5.	Lower Dipalpur	1604	704	777	366	441	859	278	309		366
6.	Gugera	1536	652	749	336	406	785	316	284		392
7.	Jhang	1565	664	802	343	413	801	321	287		398
8.	Upper Jhelum	1471	610	698	316	388	734	310	286		395
9.	Lower Jhelum	1588	668	774	344	417	810	327	296		408
10.	Thal Canal	1539	725	773	325	445	817	330	285		423
11.	Lower Bari Doab	1604	710	777	366	441	859	278	309		366
12.	Haveli Canal	1606	768	786	344	439	864	271	300		415
13.	Mailsi Canal	1631	788	800	358	456	870	287	319		438
14.	Pakpattan	1695	797	818	365	465	901	296	331		455
15.	Fordwah	1694	841	881		531	931	392	323		458
16.	Sadiqia	1714	850	889		537	940	400	332		468
17.	Abbasia	1618	824	848		518	887	387	317		448
18.	Bahawal	1616	826	850		521	888	379	313		441
19.	Qiam	1693	799	819	367	467	900	299	335		459
20	Panjnad	1701	859	888		537	931	413	337		474
21.	D.G.Khan	1707	798	850	358	490	898	383	331	-	487
22.	Muzaffargarh	1632	773	820	347	475	864	357	307	-	455
23.	Rangpur	1628	766	819	342	470	866	348	300	-	446
24.	Path/Desert	1880	1318	1157		390	1216	493	388	233	485
25.	Begari	1887	1323	1161		391	1221	499	394	236	491
26.	Ghotki	1690	1259	1038		396	1145	455	299	226	470
27.	North West	1875	1317	1156		389	1219	493	394	236	490
28.	Rice	1862	1303	1144		386	1210	495	397	238	493
29.	Dadu	1841	1281	1127		382	1198	504	408	246	504
30.	Khairpur	1752	1303	1072		404	1187	476	314	238	491
31.	Khairpur East	1738	1285	1059		403	1176	482	321	243	498
32.	Rahri	1783	1225	1022		385	1139	514	362		517
33.	Nara Canal	1741	1177	988		375	1111	515	362		518
34.	Kalri	1648	1141				1138	467	357	248	527
35.	Lined Channel	1618	1117				1114	466	355	247	526
36.	Fuleli	1619	1118				1115	467	356	247	526
37.	Piyari	1630	1125				1126	467	357	248	527

Appendix-II.C. Potential crop water demands for reported crop area of 1993-94 (IWMI 2001a)

Canal ID	Canal Name	CCA (ha)	Total Ptoential ET 93-94 (BCM)			Potential ET/Crop Area (mm)			Potential ET/Culturalbe Command Area (mm)		
			Khaif	Rabi	Annual	Kharif	Rabi	Annual	Kharif	Rabi	Annual
1	Upper Chenab	451012	1.45	0.99	2.44	605	384	989	250	171	420
2	Marala Ravi	63615	0.12	0.06	0.18	585	360	945	187	97	285
3	Central Bari Doab	265700	0.85	0.71	1.56	623	398	1020	320	266	586
4	Upper Dipalpur	141711	0.39	0.16	0.55	737	465	1202	273	112	385
5	Lower Dipalpur	247718	1.19	0.37	1.56	765	547	1313	481	150	632
7	LCC East (Gugera)	647502	3.13	2.00	5.13	718	399	1117	484	308	792
8	LCC West (Jhang)	588614	2.59	1.82	4.40	693	405	1098	439	309	748
9	Upper Jehlum	220094	0.89	0.70	1.59	604	432	1036	402	319	721
10	Lower Jehlum	614488	2.58	1.82	4.40	740	412	1152	420	297	717
11	Thal	773843	2.93	1.60	4.53	778	389	1167	379	207	586
13	Lower Bari Doab	675667	3.95	2.30	6.25	735	444	1180	585	341	926
14	Haveli	411711	2.65	1.32	3.97	814	437	1251	643	321	964
15	Mailsi	277956	2.19	0.96	3.15	918	492	1409	788	345	1132
16	Pakpattan	516233	3.74	1.95	5.69	838	491	1329	725	377	1102
17	Fordwah	173111	1.03	0.46	1.49	902	468	1371	596	267	863
18	Sadiqia	424850	2.54	1.24	3.79	954	465	1419	599	292	891
19	Abbasia	96139	0.45	0.21	0.66	946	449	1394	469	220	689
20	Bahawal	299776	2.14	0.99	3.13	935	461	1396	713	330	1043
21	Qaim	17121	0.14	0.06	0.20	912	501	1413	809	349	1158
22	Panjnad	551926	4.16	1.86	6.02	993	494	1487	754	338	1092
23	Dera Ghazi Khan	368546	1.65	0.83	2.48	854	472	1327	448	226	673
24	Muzaffergarh	331764	1.50	0.77	2.27	843	434	1278	452	232	683
25	Rangpur	139769	0.72	0.37	1.08	809	435	1245	512	263	776
29	Pat/Desert	157786	1.06	0.62	1.67	1356	526	1883	670	391	1061
31	Begari	340641	2.30	0.65	2.96	1330	474	1804	676	192	868
32	Ghotki	368335	2.29	0.50	2.79	1132	574	1706	621	137	758
33	North West	309093	1.17	0.34	1.50	1317	492	1809	377	109	486
34	Rice	209695	1.37	0.39	1.76	1307	488	1795	653	186	839
35	Dadu	236605	0.72	0.41	1.13	1278	519	1797	305	174	479
36	Khairpur West	130299	0.59	0.40	0.99	1126	590	1716	451	308	759
37	Khairpur East	182528	0.90	0.50	1.40	998	584	1582	495	272	766
38	Rohri	1E+06	4.66	2.71	7.36	1065	581	1646	446	259	704
39	Nara	882491	3.04	1.71	4.75	1085	612	1697	344	194	538
40	Kalri	258592	0.52	0.23	0.75	1030	553	1582	201	88	289
41	Lined Channel	220137	0.84	0.26	1.10	1116	491	1607	382	117	499
42	Fuleli	360604	1.36	0.33	1.69	1059	651	1710	378	90	468
43	Pinyari	322112	0.49	0.22	0.72	1114	473	1587	153	69	223

Appendix-II.D. Cropped area and net water requirement of irrigated area during 2002-03 (PARC 2004).

Crops	Cropped Area (million ha)				Water Requirement (mm)				Water Requirement (billion m^3)				
	Punjab	Sindh	NWFP	Baloch.	Punjab	Sindh	NWFP	Baloch	Punjab	Sindh	NWFP	Baloch.	Pakistan
Rabi Crops													
Wheat	5.521	0.853	0.316	0.311	400	450	420	350	22.08	3.84	1.33	1.09	28.33
Barley	0.032	0.011	0.027	0.017	375	375	375	300	0.12	0.04	0.10	0.05	0.31
Tobacco	0.018	0.000	0.027	0.001	475	475	475	475	0.09	0.00	0.13	0.01	0.22
Sugarbeet	0.000	0.000	0.007	0.000	600	600	600	600	0.00	0.00	0.04	0.00	0.04
Gram	0.387	0.017	0.022	0.008	280	300	280	250	1.08	0.05	0.06	0.02	1.21
Masoor	0.024	0.005	0.004	0.001	300	300	300	300	0.07	0.02	0.01	0.00	0.10
Mattar	0.022	0.062	0.002	0.005	400	450	400	400	0.09	0.28	0.01	0.02	0.39
Rapeseed	0.128	0.061	0.017	0.032	300	300	300	275	0.38	0.18	0.05	0.09	0.71
Onion	0.026	0.054	0.010	0.018	600	650	550	550	0.16	0.35	0.05	0.10	0.66
Garlic	0.003	0.002	0.002	0.000	400	450	400	400	0.01	0.01	0.01	0.00	0.03
Potato	0.102	0.000	0.010	0.003	600	600	600	600	0.61	0.00	0.06	0.02	0.69
Total Rabi	**6.263**	**1.065**	**0.443**	**0.398**					**24.69**	**4.77**	**1.85**	**1.40**	**32.71**
Khrif Crops													
Rice	1.512	0.488	0.061	0.164	1000	1100	900	1100	15.12	5.37	0.55	1.80	22.84
Maize	0.336	0.005	0.405	0.002	375	400	400	400	1.26	0.02	1.62	0.01	2.91
Millets	0.200	0.006	0.004	0.000	325	350	350	350	0.65	0.02	0.01	0.00	0.68
Sorghum	0.141	0.045	0.004	0.013	375	400	400	400	0.53	0.18	0.02	0.05	0.78
Cotton	2.208	0.543	0.002	0.041	650	650	650	650	14.35	3.53	0.01	0.27	18.15
Groundnut	0.019	0.000	0.003	0.000	375	400	400	400	0.07	0.00	0.01	0.00	0.08
Sesamum	0.046	0.001	0.000	0.001	325	350	350	350	0.15	0.00	0.00	0.00	0.16
Guar seed	0.061	0.009	0.002	0.001	229	229	229	229	0.14	0.02	0.01	0.00	0.17
Mung	0.166	0.003	0.009	0.002	300	300	300	300	0.50	0.01	0.03	0.01	0.54
Mash	0.036	0.001	0.002	0.001	300	300	300	300	0.11	0.00	0.00	0.00	0.12
Total Kharif	**4.724**	**1.103**	**0.491**	**0.224**					**32.87**	**9.16**	**2.26**	**2.14**	**46.42**
Mix Crops													
Sunflower	0.037	0.064	0.000	0.006	300	300	300	300	0.11	0.19	0.00	0.02	0.32
Tomato	0.005	0.006	0.015	0.006	500	500	500	500	0.02	0.03	0.07	0.03	0.15
Chillies	0.007	0.047	0.000	0.001	400	450	400	400	0.03	0.21	0.00	0.01	0.25
Vegetables	0.135	0.034	0.033	0.022	600	650	550	550	0.81	0.22	0.18	0.12	1.34
Fodders	1.732	0.230	0.103	0.033	457	533	457	457	7.92	1.23	0.47	0.15	9.76
Total Mix	**1.916**	**0.381**	**0.151**	**0.069**					**8.89**	**1.88**	**0.73**	**0.33**	**11.83**
Perennials													
Sugarcane	0.735	0.259	0.105	0.001	1200	1200	1000	1200	8.82	3.10	1.05	0.01	12.98
Citrus	0.171	0.004	0.004	0.002	1100	1100	1100	1100	1.88	0.05	0.05	0.03	2.00
Mango	0.054	0.047	0.000	0.002	1100	1100	1100	1100	0.59	0.51	0.00	0.02	1.13
Banana	0.002	0.025	0.001	0.002	1100	1100	1100	1100	0.02	0.28	0.01	0.02	0.33
Apple	0.000	0.000	0.009	0.038	800	800	800	800	0.00	0.00	0.07	0.30	0.38
Guava	0.051	0.008	0.003	0.001	1000	1000	1000	1000	0.51	0.08	0.03	0.01	0.63
Apricot	0.000	0.000	0.002	0.012	800	800	800	800	0.00	0.00	0.02	0.09	0.11
Peach	0.000	0.000	0.005	0.004	800	800	800	800	0.00	0.00	0.04	0.03	0.07
Pears	0.000	0.000	0.002	0.000	800	800	800	800	0.00	0.00	0.02	0.00	0.02
Plum	0.000	0.000	0.004	0.004	800	800	800	800	0.00	0.00	0.03	0.03	0.06
Grapes	0.000	0.000	0.000	0.013	800	800	800	800	0.00	0.00	0.00	0.10	0.10

Pomegranate	0.002	0.000	0.000	0.004	750	750	750	750	0.02	0.00	0.00	0.03	0.05
Dates	0.009	0.025	0.001	0.043	1000	1000	1000	1000	0.08	0.25	0.01	0.43	0.78
Almonds	0.000	0.000	0.000	0.009	750	750	750	750	0.00	0.00	0.00	0.07	0.07
Total Perennial	**1.03**	**0.37**	**0.14**	**0.13**					**11.9**	**4.3**	**1.3**	**1.2**	**18.7**
Total	**13.93**	**2.92**	**1.22**	**0.82**					**78.4**	**20.1**	**6.2**	**5.0**	**109.7**
G. Total Area				**18.89**									
mm/Ha									**563**	**688**	**508**	**610**	**581**

Water Rights and Entitlements

By

Don Blackmore and Faizul Hasan

Country Water Resources Assistance Strategy
Background Paper # 6
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Water Rights and Entitlements

ABBREVIATIONS AND ACRONYMS

ACE	:	Associated Consulting Engineers
AWB	:	Area Water Board
BCIAP	:	Balochistan Community Irrigation and Agriculture Project
BCM	:	Billion Cubic Meter
BMIADP	:	Balochistan Minor Irrigation and Agricultural Development Project
BOD	:	Biochemical Oxygen Demand
CCA	:	Canal Command Area
CRBC	:	Chashma Right Bank Canal
ECNEC	:	Executive Committee of National Economic Council
FGW	:	Fresh Groundwater
FO	:	Farmer Organization
GCA	:	Gross Commanded Area
GDP	:	Gross Domestic Product
GOP	:	Government of Pakistan
GPCD	:	Gallon Per Capita Per Day
IBIS	:	Indus Basin Irrigation System
IRSA	:	Indus River System Authority
IWT	:	Indus Water Treaty
LCC	:	Lower Chenab Canal
MAC	:	Million Acres
MAF	:	Million Acre Feet
MGD	:	Million Gallons Per Day
MIS	:	Management Information System
MT	:	Million Tonnes
NDP		National Drainage Programme
NESPAK	:	National Engineering Services of Pakistan
O&M	:	Operation and Maintenance
OFWM	:	On Farm Water Management
P&D	:	Planning and Development
PID	:	Provincial Irrigation Department
PIDA	:	Provincial Irrigation and Drainage Authority
PPSGDP	:	Punjab Private Sector Groundwater Development Project
PWP	:	Pakistan Water Partnership
SCARP	:	Salinity Control and Reclamation Project
TMA	:	Tehsil Municipal Administration
UNDP	:	United Nations Development Programme
WAPDA	:	Water and Power Development Authority
WSIPS	:	Water Sector Investment Planning Study
WUA	:	Water Users Association

EXECUTIVE SUMMARY

This paper discusses the issues that need to be addressed and principles that should guide the development of an efficient water rights system. It comments on current state of water rights and entitlements of Pakistan and takes a "Good Practice" approach for addressing the issues.

The issues have been systematically addressed in this paper at different levels of entitlements:: International Level, National Level, Canal and Distributaries Levels and at Individual Level. At the individual level, both surface and groundwater issues have been discussed. The issues of groundwater, flood irrigation and hill torrents, water requirements of cities and towns, industry and the environment have also been discussed in detail.

In Pakistan, the water rights are clear at international level and to an extent at national level too, but there is still a lack of clarity of water rights at canal, distributary and individual levels. Various water rights issues, for both surface and groundwater, which have erupted mainly due to lack of clarity of water rights, have been addressed alongwith their possible solutions.

At international level, the major issue raised by Pakistan is the design of Baghlihar Dam and Kishan Ganga Dam projects that contravene the articles of the treaty. The suggested option for this issue is to appoint a neutral expert on treaty matters by the two countries, India and Pakistan. The World Bank, being a neutral agency, can play an effective role in this regard.

At national level, the main issue is the lack of trust among the provinces. Various suggested options have been given as confidence building measures among the provinces. The proposed solutions are: strengthening of Indus River System Authority (IRSA), activation of the Common Council of Interest (CCI) and establishment of the telemetry system at regulator basis. In addition to this, five components have been identified that are needed for effective management of the inter-government water sharing agreement among the provinces. These components are: stable treaty/agreement, well trained technical secretariat with sufficient resources, access to the knowledge necessary to run the business, integrated across the natural resource areas that are likely to have a significant impact on the performance of the business, i.e. water/pollution/environment; and arrangements for transparent governance and community participation to ensure confidence in decisions.

At canal and distributary level, the identified issues are: lack of clarity of water rights, inequitable distribution of irrigation water, unreliable irrigation supply, inaccurate discharge measurement arrangements, and inadequate capacity of irrigation system. The suggested options for these issues have been give as: establishment of 'clear water sharing agreement' between the canals within a province, establishment of 'Register of Water Rights' at canals and distributaries, revision of Head-Discharge relationship tables at the heads of canals and distributaries, revision of canal water allowances, enhancement of the capacity of irrigation system, lining of irrigation channels in saline groundwater areas and provision of more storages of water to ensure reliability of irrigation supplies.

The issues identified at individual levels are: water shortages at tail ends, lack of monitoring the channels, invalid entitlements and new allocations, conjunctive use issues, and external influences. The proposed options have been suggested as: lining of watercourses, appointment of adequate trained staff, establishment of 'Register of Water Rights' (in phased manner by the year 2012), conversion of discharge measurement from time-based to volumetric unit (by the year 2010), development of the mechanism for conjunctive use of surface and groundwater, and development of the mechanism for realistic water pricing.

Some common issues of various levels and other issues related to the groundwater, water requirement for cities and towns and the environment, and ongoing institutional reforms under National Drainage Programme (NDP) have been discussed in detail. The main issues are: lack of trust among various users and state agencies, lack of inter-agency coordination, institutional issues, financial issues, environmental issues, legislative issues, waterlogging and salinity issues, groundwater depletions, saline water intrusion, secondary salinization and alkalization of soils, groundwater pollution, needs for water of the growing population to represent a competing demand for water, needs for water of the mega cities more than twice the present size, providing health security, by safe drinking water, providing safe disposal of the sewerage and industrial effluents, provision of adequate water allocation for livestock, plants, and birds, protection of wetlands, and slow progress of on-going institutional reforms under NDP. The options for these miscellaneous issues have been suggested as: taking measures for Effective Inter-Agency coordination, taking measures for Continuation of on-going institutional reforms under NDP, preparation of a comprehensive water law, preparation of the regulatory framework for groundwater usage, establishment of groundwater institutions, arrangements of providing adequate drinking water supply water to the cities/towns, conducting a study to determine the allocation of water for livestock, plants and birds, taking improvement measures for providing safe drinking water to the people, arrangements for safe disposal of the sewerage and industrial effluents, and establishment of a basin-wide body for monitoring of the ecosystem.

What is important, however, is that the various suggested solutions alone will not significantly change the water supply challenges facing Pakistan. Governments will need to ensure that there is an effective water rights system in place at all levels if its objective is to enhance production from within the current water resource base. On the available information, regulated water supplies may at best grow a small amount but are more likely to reduce.

WATER RIGHTS AND ENTITLEMENTS

1. Introduction

This paper discusses the issues that need to be addressed and principles that should guide the development of an efficient water rights system. It comments on the current state of play with water rights and entitlements within Pakistan as detailed in this paper and identifies a number of opportunities for the World Bank through its programmes to make a contribution to strengthen arrangements. The paper takes a **"Good Practice"** approach rather than to strive for **"World's Best Practice"** which may not be realistic at this time.

A properly developed and managed water rights system is fundamental for an effective and efficient water management. It is particularly important for a system which is being managed for water scarcity. This is certainly the situation applying in Pakistan for both its surface and groundwater resources.

In Pakistan, water allocation and water rights systems date from historic times. Over the years, there have been radical changes in water use, its distribution and social environments. Existing water laws do not cater for the requirements of present day needs and environments when water is becoming increasingly scarce resource in the country. A number of problems and issues have emerged for all water use categories and at all levels: international, inter-provinces, intra-provinces among canals, at the distributary and watercourse/individual levels for which existing water rights system does not provide sufficient grounds for water use efficiency, and is not commensurate with the actual water use against the formal water rights and entitlements. The situation desires to address these issues from water-rights perspective for efficient use of available water resources of the country for different water use categories at various levels.

Although, Pakistan has significant natural water resources (Box 1.1), but these resources are inadequate for agriculture production as well as for domestic, industrial and other uses. Out of these available water resources, about 88 percent of water is used in the agriculture sector and remaining 12 percent is used for domestic, industrial, mining, livestock, fisheries development etc. Hydropower is the non-consumptive use of water which is cheapest and environmentally the cleanest way of generating electricity.

Pakistan's economy mainly depends upon agriculture which is the largest sector providing alone 25% to GDP and generating over 70% of total foreign exchange earnings. About 60% of the country's work force derives employment from agriculture, out of which about 54% is employed directly in farming. Due to the arid to semi-arid climate, agriculture is almost consuming 91% of water and wholly depends upon irrigation. Pakistan possesses the largest integrated irrigation network in the world covering 80% of the total cropped area of 20.80 million hectares (51 Mac).

Population of Pakistan stands at 145 million and is likely to increase to about 221 million by the year 2025. Projected food requirements have been estimated based upon population growth and the requisite caloric needs. The per capita consumption of food and fibre, thus calculated, indicates the projected water requirements at the farmgate, as shown below and have been graphically depicted in Figure No. 1.1.

Projected Water Requirements in Pakistan

Sectors	Existing Water Uses Year 2003 (MAF)	Projected Requirements Year 2025 (MAF)	Additional Water Requirements (MAF)
Agriculture at the Farmgate	100	128	28
Water Supply and Sanitation (Municipal & Rural)	4.5	10.5	6.0
Industry	3.5	4.8	1.3
Environment	1.3	1.7	0.4
Total	**109.3**	**145**	**36.3**

The irrigation system was mainly designed to utilize the waters of the river Indus and its tributaries. It has 3 major storage reservoirs: Chashma and Tarbela on Indus river and Mangla on Jhelum river, 19 Barrages, 12 Inter-river Link Canals, and a network of canals divided amongst 45 independent canal commands supplying water to about 107,000 watercourses (WCs). Around 90% of the domestic food is produced from irrigated agriculture. Unfortunately, the performance of our irrigated agriculture in the past decades remained unsatisfactory resulting in increased food bill and socio economic deterioration of the masses, which needs to be improved upto the desired level to meet the domestic as well as export food demands.

The poor performance of irrigation system is manifested through number of problems which can be broadly divided into three categories.

- Structural Problems: These problems emanate from physical deterioration of the system. i.e. poor maintenance of the canal system.

- Financial Problems: these are manifested in the form of lack of financial resources to operate and maintain the irrigation system.

- Institutional Problems: These cover the poor performance of organizations, irresponsiveness of existing laws and inefficient water rights to meet the present requirements.

The institutional problems are considered to be the main contributor to the overall deterioration of irrigation system. Respective developments in the system, have not been made properly as per need of water uses required at various times, and therefore the above problems have been accumulated with the passage of time.

Keeping in view the developments occurred in irrigated agriculture including, particularly, the increase in culturable canal commanded areas; considerable increase in cropping intensities (from 75% to 120% on average basis); introduction of water intensive crop varieties; improvement in the knowledge of irrigation science; and awareness of social norms of societies, the government of Pakistan had formulated a strategy for the management and development of water resources with the available scarce resources. The main objectives of the Government of Pakistan to formulate the strategy are:

- Overcoming scarcity by augmentation and conservation;
- Restoring productivity of land by control of waterlogging and salinity and floods;
- Managing quantity / quality of drainage effluent;
- Implementing an integrated flood control and management programme;
- Groundwater management by tubewell transition, aquifer monitoring and management;

- Promoting beneficiary participation in development initiatives; and
- Enhancing performance of water sector institutions.

The above last two objectives of the strategy consist of the following inter-linked actions:

- Restructuring of the Provincial Governmental Irrigation Departments (PIDs) by transforming them into autonomous Provincial Irrigation and Drainage Authorities (PIDAs) under law;
- Establishing the Area Water Boards (AWBs) on each canal command;
- Actively promoting formation and development of Farmers' Organizaitons (FOs) upto the distributary level in each AWB;
- Formalizing water markets, and legalizing individual proprietary rights, if possible; and
- Strengthening federal agencies, including the all important Water Wing of the Water and Power Development Authority (WAPDA), to better implement their federal responsibilities on regular basis by realizing continuous improvement in the system.

Out of the above inter-linked parts, the first four relate to **'Water Rights and Entitlements'**. In order to follow this strategy, a proper system is essential to document the **water rights and its owner** so that investments to use an allocated resource may be made with confidence and the recorded rights on given resource serves as the basis for **"Accounting"**.

The term "water rights", like "property rights", is an umbrella concept which includes several kinds and levels of rights such as rights of ownership, control and management, use and alienation. These many types of rights may be held by a single rights-holder or simultaneously by several individuals and collectivities such as water users association, village communities, or the State. These various kinds of water rights may be grouped into two broad categories of rights: "rights to use water" and "rights to regulate, control and make decisions". Proper management of a right-based system is very much essential to fairly address and control over these two broad categories of water rights.

Generally, water in Pakistan is allocated according to the land ownership and made available to the farmers through *warabandi* system. The trading of canal water is considered illegal and participation of the farmers in water management authorities is not allowed under the Canal and Drainage Act, 1873. Legislation is, therefore, required to develop water property rights which are economically and socially desired. Ownership rights are necessary to realize efficiency gains, improve equity of distribution, legitimate water sales, reduce deficit and promote long term investments. Lack of individual water rights does not give tail end users legal basis for any formal claim or loss of canal water resulting from miss-appropriation by head reach users. As a result, tail end farmers resort primarily to groundwater exploitation to meet their crop water requirements.

Legislation is also required to develop water property rights which are economically and socially desirable. Ownership rights are necessary to realize efficiency gains, improve equity of distribution, legitimate water sales, reduce deficit and promote long-term investment. Lack of individual water rights gives no legal basis to tail-end users for any formal claim or loss of canal water resulting from misappropriation by head-reach users. As a result, tail-end farmers resort exclusively to groundwater usually of poor quality due to lack of freshwater recharge. This creates heavy and unnecessary pressure on groundwater resource leading to secondary salinization of lands located at the tails of channels. Water rights for landless farmers (tenants and share croppers) could ideally be part of a rural poverty alleviation strategy aimed at providing income generating assets to the rural poors.

In order to systematically address the water rights issues, different levels of entitlements have been considered for water resources of Pakistan. Generally, the entitlements need to be established at following range of levels:

- Common river level between countries – International Level
- River basin level between provinces within a single country – Inter-Provinces Level
- Inter basin transfers between river system – Intra-Provinces Level
- At the individual landowner level for both surface and groundwater – Individual Level

There should be a need for equitable access and conjunctive use management at the interface between surface and groundwater.

Box 1.1: Water Resources of Pakistan

The major exploitable water resources of Pakistan are:

- Surface Water Resources (river flows and rainfall), and
- Groundwater Resources (useable groundwater aquifers and useable layers overlying saline water).

Surface Water Resources:
River Flows:
Pakistan has three (3) major river basins with the following average annual flows:

Indus Basin	138.0 to 145.0[1] MAF
Mekran Coastal Basin	3.0[2] MAF
Kharan Closed Desert Basin	0.8[2] MAF
Total	**141.8 to 148.8 MAF**

Out of the total available annual flows in the Indus Basin, 105[2] MAF is already being used through a system of storages and distribution network. Average annual escapage below Kotri, the last barrage on the Indus River, going to the sea, is 35 to 38[3] MAF. Indeed, a provision has to be made for certain flow requirements below Kotri Barrage to meet the requirements of local population, the ecological needs and biodiversity of the coastal area for which a study is to be made under the Water Accord of 1991.

Assuming a provision of 10 MAF for uses downstream Kotri, a tentative figure (indicated in the 1991 Accord), the additional available flow is about 20 to 25 MAF, excluding further uses by India as follows:

A.	Annual Average Flow Below Kotri (Post Tarbela) 1977-2001	35 to 38 MAF
B.	Requirement Below Kotri (Tentative 1991 Accord Figure)	10 MAF
C.	Likely Uses in the Headwater Areas both on Eastern and Western Rivers	3 to 5[4] MAF
	Balance Potential (A-B-C)	20 to 25 MAF (at canal headworks)
	Equivalent availability at farmgate or nakka:	13 to 15 MAF

Rainfall:
Monsoon and Westerly currents are the two main weather systems that contribute to rainfall over Pakistan. Average annual rainfall over Pakistan is 11.4 inches.

Aside form the useful components of rainfall that occurs on the farmlands or finds its way to the main river system, hill torrents bring in floods of short durations but of high magnitudes.

The total development potential of hill torrents is estimated as approximately 17[5] MAF of which 5 MAF has already been conserved through the construction of more than 500 structural interventions such as delay action dams, dispersion structures, retaining walls, etc. Approximately 3 MAF is considered a reasonable quantum for further harnessing by the year 2025.

Groundwater Resources:
The aggregate groundwater potential after full development of surface water resources is estimated to be approximately 56[6] MAF of which 42[7] MAF is being currently used annually through more than 700,000[7] tubewells installed and operated by the farmers themselves, and about 5,000 public sector operating tubewells.

It has been estimated that a further potential of some 6 to 14 MAF exists in the development of Pakistan's groundwater resources.

(1) The average value depends upon the period over which the average is calculated and whether exceptional low and high values are disregarded or not. Some consider this value as low as 123.5 considering average flows as unreliable in view of the large variations in flow form year to year.
(2) Master Planning of Hill Torrents of Pakistan – NESPAK, 1998.
(3) 35 MAF refers to the average escapement from years 1976-77 to 2003-04 without disregarding exceptionally high and lean years. 38 MAF refers to the average of the same period after disregarding exceptionally lean and high years.
(4) The Indus Waters Treaty Pakistan & India, 1960.
(5) Master Planning for Flood Management of Hill Torrents of Pakistan – NESPAK, 1998.
(6) Groundwater Development Potential of Pakistan, IWASRI 1998.
(7) Exploitation & Regulation of Groundwater of Pakistan ACE, Halcrow 2003.

Source: Pakistan's National Water Resource Strategy (2002) by Ministry of Water & Power.

2. Evolution and Current State of Water Rights in Pakistan

Pakistan has a long and proud history of water management. It has relatively little storage capacity compared to the volumes of water diverted for consumptive use, primarily, in irrigated agriculture. It is largely a **"Run of River System"** with the major storages providing modest re-regulation capacity compared with the average annual flow of their rivers. As per current irrigation practices, irrigation allocation to individual farmers is on a roster system which was designed for deficit irrigation. The irrigation season is split into the wet/monsoon (Kharif) and the dry (Rabi) seasons.

The hierarchy of surface water rights starts from the international level where Pakistan receives its water from India through the western rivers Indus, Jhelum and Chenab under the Treaty 1960. Pakistan also receives water from Afghanistan through Kabul river that joins Indus river at the place of Attock city, downstream of the Tarbela Dam. The surface water is formally apportioned among the provinces through Water Accord 1991. Each province distributes its water through barrages into canals according to individual canal requirements. Canal water is further distributed into minors and distributaries to finally providing the surface water at the head-outlets of watercourses which are connected to the farmgates of the farmers as end users.

The groundwater has not such type of hierarchy and it is directly available for use to those farmers who have their lands in fresh groundwater zones.

The evolution and current state of water rights for different water resources of Pakistan has been briefly described as follows:

I. Surface Water Rights

There are different levels of distributing the surface water in Pakistan which are described hereinafter.

(i) Water Rights at International Level

After creation of the Independent Islamic State of Pakistan, the objectives of the Government radically changed with increased emphasis on equitable distribution, social welfare and easier access to justice. Rapid increase in population has resulted in heavy pressure on land and rise in the value of irrigation supplies. People have become more enlightened and conscious of their rights. Simultaneously, a dispute on sharing of common river water erupted between India and Pakistan. This could not be settled through bilateral negotiations and, therefore, international mediation had to be sought. At that time, both the countries had to utilize the common river waters as their informal water rights. It was finally resolved with the signing of the **Indus Waters Treaty** in 1960 as a result of protracted negotiation through the World Bank (Box 2.1). Thus the Treaty had established the formal water rights of India and Pakistan over the common river waters of the two countries.

(ii) Water Rights at Inter-Provinces Level

The distribution of Indus waters among the provinces, remained a long outstanding issue since 1922, before Independence. As many as six committees/commissions, appointed by government, two before Independence and four after the establishment of Pakistan, went into the question of apportionment but could not help resolve it. However, the provinces used to get their shares as informal water rights until resolution of this long outstanding issue. Quite apart from the continuous injection of position in the relations among the provinces, the longer term consequences of this delay ere extremely serious, considering the scale of the irrigation system of Pakistan. Upon realizing the seriousness of this issue, the Federal Government with mutual

cooperation of all the provinces had ultimately reached to a consensus accord on the apportionment of the waters of the Indus River system, which constitutes the lifeline of Pakistan. In this way the formal water rights of the provinces have been established through **Water Accord, 1991** (Box 2.2).

The Council of Common of Interests (CCI), which is a constitutional body for resolving issues between the centre and the provinces as well as between the provinces, meeting under the chairmanship of the then Prime Minister, approved the accord in Islamabad on 21st March, 1991, and decided to set up an **Indus River System Authority (IRSA)** for its implementation (Box 2.3).

(iii) Water Rights at Canal and Distributary Levels

The provincial share of Indus waters is diverted through barrages and weirs into main canals which further distribute water into branch canals, minors and distributaries. The Provincial Irrigation Departments operate the irrigation system above the outlets, installed in the distributaries. Each season, the Water and Power Development Authority (WAPDA) of the Federal Government estimates water availability for the following season. Provincial Irrigation Departments (PIDs) inform WAPDA of provincial water demands at specific locations. Accordingly, WAPDA releases water from reservoirs to meet demands as closely as possible. Limited reservoir capacity of the system does not allow full regulation of rivers for irrigation.

The river supplies are mainly dependent on rainfall and snow melting. Water shortages have occurred during the recent years inter alia due to drought period. The shortages from rivers as well as reservoirs are shared by the provinces and users in accordance with Water Accord, 1991. The shortages are equitably shared amongst the various provinces and canal system. Generally, the distributaries are run on rotational basis by fortnightly canal closure. Water allocation, during the drought period, is carried out as at all other items, by Indus River System Authority (IRSA) amongst the provinces. However, water users also convened committees involving Irrigation Department, Agriculture Department and their own representative to evolve crises distribution plans. Such steps combined with higher use of groundwater, led to some 20% increase in wheat production, which is admirable besides reaffirming the need for better water management.

In the past, the canals were fed depending on the availability of water in the rivers. The supplies are made on perennial basis i.e. around the year for both the cropping seasons i.e. Kharif (April to September) and Rabi (October to March) to the areas that were relatively more productive. The supplies were only interrupted during the canal closure during Dec-Jan for 3-4 weeks for annual maintenance and repairs of the canals. In other areas where lands were less productive, the supplies were made on non-perennial basis during Kharif season only. However, one additional watering is provided to these areas in October for sowing of Rabi Crops.

At the time of introduction of canal supplies, the irrigation intensities were generally kept about 70 to 80 percent on perennial canal systems. However, with the passage of time, the intensities have been to over 120 percent. Also, the water requirements of crops considerably increased due to the introduction of improved varieties of crops, with much higher yields. The gap is being met by additional water released in the canals and private tubewells installed by the farmers at farm level.

The laws governing the irrigation water allocation within canal commanded areas, were developed by the British over a century ago. Under these laws each unit of Culturable Command Area is allocated a certain rate of flow of water termed as '**Water Allowance'** which is the main factor of establishing the formal water rights for a particular canal**.** Its value

is generally a compromise between demand and supply. The main objective of canal operations is to achieve as much equity as possible and to ensure water rights of the tail end users. The canal irrigation system is providing surface water to each canal as per sanctioned "Water Allowance" which is different for each canal command (Box 2.4). The carrying capacity of distributaries and watercourses within a canal command is designed on the basis of this allowance. A distributary is expected to operate at its full supply level and watercourses served by the distributary are constructed in such a way that all of them draw their designed share of water concurrently.

(iv) Water Rights at Individual Level

The canal water allocations in the chak (watercourse command areas) are assigned on the basis of the land holdings of individual shareholders, who are supplied water on weekly basis through outlets according to their turns which is known as ***'warabandi'*** whereby the weekly time duration is fixed for each shareholder. *Warabandi* is a rotational method for equitable distribution of available water in Chaks through fixing turns according to a predetermined schedule specifying the day, time and duration of supply to each shareholder in proportion to the size of his landholding in the watercourse/outlet command. Any breach in the schedule (*wara-shikni*) is penalized under the law by imposing fine. The shareholder is generally independent in resorting to the cropping pattern, intensity of irrigation as well as distribution of the share of canal water allocated to his lands.

Two types of *Warabandi* are practiced in Pakistan. The *Warabandi* that has been decided by the farmers solely on their mutual agreement, without formal involvement of any government agency, is known as *Kacha* (unregulated) *Warabandi* which establishes the informal water rights of the farmers. Whereas, the *Warabandi* decided after field investigation and public inquiry by the Irrigation Department is called *Pucca* (regulated) *Warabandi* which establishes the formal water rights of the farmers.

(v) Special Water Rights in Balochistan

The water rights in Sindh, Punjab and in NWFP are more or less the same as described above at canal and distributary levels as well as at individual level. However, the situation of water rights in Balochistan province is somewhat different from the other provinces. Water rights in perennial irrigation systems in Balochistan are usually well-defined at the family level and they are expressed in fixed time shares of the original irrigation cycle. To distribute water rights, different mechanisms have been utilized to determine the size of individual water shares. In many community irrigation systems, individual water rights are derived from the initial contributions to the development of the water resources, such as a *kareze*. In irrigation schemes that depend on the base surface flow in perennial rivers, the water rights were distributed according to existing land rights in the irrigable area. There are also community irrigation systems in Balochistan, where the water rights have not been distributed permanently among the individual shareholders and their families.

In many community irrigation systems throughout Balochistan, special water shares have been established for different purposes. A common special water share is given to the local water bailiff, locally called *mir-i-aab* or *rais*, as a compensation for his services, which normally include the organization and supervision of maintenance work, supervision of water distribution, arbitration and/or collection of cash contributions. However, the sizes of special water shares for water bailiffs varies considerably. Permanent or temporary special water shares could also be established, which are leased seasonally or annually to raise money for collective purposes, such as repair damaged irrigation structures or for the construction of a village mosque.

II. Groundwater Rights

Groundwater has gradually acquired a vital importance in the agricultural economy of Pakistan as it supplies over 40 percent of the crop water requirements of the country. Fresh groundwater in Pakistan is, however, not an independent resource. Initially, its occurrence was closely linked to the geological development of the Indus Basin. As the Indus Basin was formed by the deposition of alluvial material in a subsiding valley, filled with trapped sea water, fresh groundwater recharged the upper deposits by a number of mechanisms including rainfall and seepage from rivers. For the last about 150 years, however, these natural processes of recharge have been supplemented and accelerated by canal irrigation system including recharge from the irrigated fields. The vast groundwater aquifer underlying the Indus Plain and co-existing with a huge surface water canal system, is now an asset of immense value for Pakistan as a natural resource. However, it must be managed in an effective and sustainable manner, such that it is neither allowed to remain so close to the ground as to cause waterlogging and associated land salinity, nor it should go down by over pumpage to a level that is beyond the reach of the common man.

Presently, there is no comprehensive legal framework which defines groundwater rights. However, some irrigation and drainage laws, framed time to time, give general consideration to groundwater.

According to Irrigation and Drainage Act 1873, all water resources including groundwater belong to State. Although, the Act provides detailed regulations about the management of canal water but it is silent about the management of groundwater. The Water and Power Development Authority Act 1958, extends WAPDA's Control over groundwater in any region in the country. However, this is for controlling the waterlogging and salinity.

The Punjab Soil Reclamation Act, 1952 provides control of all groundwater uses except domestic and livestock to the Punjab Soil Reclamation Board. Although, this act provides basis for licensing and installation of tubewells, and authorizes the Board to close down the tubewells in case of their negative use, but these laws were never implemented and the Board has ceased to exist.

Under PIDAs Acts, the PIDAs have the authority to manage all surface and groundwaters. However, detailed regulations has not been framed for the groundwater. The review of above mentioned laws indicate that the groundwater has been considered as National resource and the State Organs are authorized for its management.

Practically, the groundwater is considered to be the property of overlying landowners to the extent that they can install tubewell anywhere on their land where they like. Moreover, they can pump too much groundwater to the detriment of others. Further, they have freedom to sell groundwater at their own rates to the other farmers.

III. Water Rights for Flood Irrigation

Flood irrigation, locally known as *sailaba* or *manda sailaba*, is widely practiced in the country and different techniques have evolved over the centuries to utilize flood water for irrigation. Flood events normally have a short duration with a rapid rise and swift recession to zero flow. The flow magnitude is extremely variable between events and there is little uniformity in the number of events that may occur in any given year. Consequently, the inter-annual variability of flow volumes is great and flood irrigation is associated with a high degree of uncertainty.

The basic principle involves the diversion of flood water from the river to the command area, where it is conveyed into large bunded basins to a depth of 2 to 3 feet and allowed to infiltrate

into the soil. Suitable soils for flood irrigation are deep and fine textured and they have a high moisture retention capacity in order to store sufficient water within the soil profile to mature a drought tolerant crop, such as wheat and sorghum. Because of the short flashy nature of the floods, the volumes of water that have to be diverted are considerable in order to irrigate a sizeable area.

The water rights of the users have been developed in the country under two methods of diversion. The first method consists of the construction of a bund or *ghanda* across the river to increase the upstream water level and divert the flow into the flood channel. Usually, there is no provision of a spillway and as the flood rises the bund is either deliberately breached or fails due to overtopping. The second method uses a spur constructed partially across the river to divert a portion of the flood flow into the conveyance system.

Large flood flows normally breach the *ghanda* or wash away the diversion spurs before sufficient water has reached the command area and it is often not possible to re-build the diversion structure during the same flood season. Consequently, only a limited portion of the total command area can be brought under cultivation.

Both of these water rights methods require considerable labour input by the farmers to maintain and/or to reconstruct the bunds after every major flood. The frequent reconstruction of the diversion structure and the operation and maintenance of the large distribution system, which often extends over an area of many thousands of acres, requires a strong and effective organization among the farmers. Costs are normally shared on the basis of benefits received, which depends on the elevation of individual land holdings and their proximity to the water rights.

In the major flood irrigation areas, complex relationships have evolved between villages sharing the same flood source. Often agreements are made to ensure that the upstream abstractors, who take the spate waters first, are obliged to deliberately break their bund after a certain period of time, releasing the remainder of the spate flow for diversion, in turn, by the communities further downstream.

Within individual flood irrigation schemes, regulations for water rights have evolved to govern the distribution of available flood water in order to ensure an equitable distribution. In the past, these rules were strictly enforced by the traditional rulers to safeguard the individual water rights. However, the declining power of tribal leaders has led in some areas to a breakdown in the traditional operation rules, which is depriving downstream users of their share of the available flood water and they are often forced to seek redress in the courts or appeal directly to the local administration. The problem is further aggravated by the increasing use of tractors and bulldozers, allowing farmers to build higher and stronger bunds than was previously possible with simple oxen drawn dam scoops. Therefore, the situation is alarming for the water rights of downstream users.

Another type of water rights which has been practiced for hundred of years in Balochistan province or in terms of water harvesting, locally called *khushkaba*. It is basically a small scale version of flood irrigation where localized surface runoff is diverted into basins. In this system, the risks involved are considerable because the catchment areas tend to be very small, although it is nonetheless more reliable than just rainfed (*baranai*) agriculture.

IV. Water Rights for Hill Torrents

In tribal areas of the country, the historical water rights of uncontrolled flows of hill torrents were based on "*Saroba-Paina*", a system in which the farmers at the head reach had the right to divert water up to their full requirements, and then passing the water on the lower riparian.

In Pakistan, The hill torrent's water rights were established long time ago (Box 2.5). There are two types of hill torrent channels relative to their historical water rights.

(a) Channels with rights (*Haqooq* Channels)

(b) Channels without rights (Non-*haqooq* Channels)

The cultivators at the head of the channel, have first right of diverting the flows to their fields. Generally, they have embankments all around with heights varying from 3 to 5 feet. On filling the first channel with required water, the remaining water is allowed to flow down to the second structure which is built across the bed of the main channel. Again, the flows are diverted into the diversion channel(s) and subsequent beneficiaries irrigate their fields with water available along both the banks. On filling the second channel with required water, the remaining water is allowed to move downstream by breaching the earthen embankment built across the bed of the main channel or through other structures built at the site. This process continues till, either, all the fields have been filled with water, or flows of the channel is exhausted.

It has been observed that the structural interventions, designed and constructed across the flow on some of the hill torrents, are based upon the criteria of progressive utilization of water flows from upstream to downstream as per "*Saroopa-Piana*" water rights system. It has a subsequent smaller structure like apron because of reduced frequency in flow of hill torrents. Sometimes, it has been experienced that subsequent freshets are further received after few days of receiving the first freshet but the beneficiaries at the head water areas do not require further filling of their fields. Thus, they allow water to flow to the downstream areas. These higher flows moving to the downstream, sometimes results in damage to the structures because of their inbuilt design for smaller flows.

Therefore, it is recommended that the downstream structures in the bed of the channels be designed and built to bear the pressure of progressively Probable Maximum Flood (PMF would be extremely high and not practicable. This is likely to provide safety to downstream structures with some higher cost. Trade offs for additional safety and costs can be decided during design stage. The whole arrangement will be helpful in securing the water rights of all the beneficiaries of the hill torrents.

V. Water Rights for Cities and Towns, Industry and the Environment

The water supply and sanitation sector in Pakistan is characterized by extremely low level of coverage particularly in the rural areas (Box 2.6). Potable drinking water and sanitation facilities have merged as one of the most critical issues adversely affecting health and increase in poverty, particularly in rural areas of Pakistan. Most pressing issue is the water security for meeting basic provision of water supply and sanitation (Box 2.7). Combination of safe drinking water and hygienic sanitation facilities is precondition for health and success in the fight against poverty, hunger, child health and gender equality. It is also the human right and personal dignity of every women, man and child to have safe drinking water and improved sanitation facilities. Inspite of this born right, 35% population of Pakistan, 15% in urban and 45% in rural areas are without access to potable water.

The water supply systems in the urban centres of Pakistan are based on either utilization of surface water or groundwater abstraction through tubewells. The cities which depend on surface water for their drinking water needs include among others the Federal Capital Islamabad, Karachi and Hyderabad. The water supply systems of Lahore, Peshawar, Faisalabad, Quetta and Abbotabad are mostly dependent on the groundwater source.

Almost all the cities depending on surface-supplies face moderate to acute shortage of water, whereas the situation in Lahore and Peshawar can be considered somewhat satisfactory due to the presence of a high yielding aquifer.

The rural areas, depend on groundwater for domestic water supplies wherever usable groundwater is available, but in irrigated areas underlain by brackish water, canal waters are used to satisfy the domestic requirements. Outside the canal areas, where the groundwater cannot be depended upon, rural water supply is dependent on the available stream flows in the upland areas or on rainfall collected in natural depressions, such as "*Tobas*" in the Cholistan desert. In such arid locations the local populace is constrained to travel long distances to procure drinking water which is a task assigned to women.

It is estimated that present water demand for domestic and industrial uses is approximately 3,032 MGD (million gallons per day) whereas the available water for the purpose is about 2,369 MGD. Therefore, there is a net deficiency of 22% of total water requirement.

In addition to the water requirement for agriculture and people with increasing population, water demand is also increasing for livestock, plants and birds. Indus valley is one of the six main internationally accepted migration routes of birds. There are at least 14 major lakes of national and international importance. The apprehensions are that the reduced flooding and discharge of polluted drainage effluent into these water bodies may adversely effect wetlands ecology.

Box 2.1: Indus Waters Treaty (1960)

Under the Indus Waters Treaty, India was given to the exclusive use of three eastern rivers (Ravi, Beas and Sutlej), while the western rivers (Chenab, Jhelum and Indus) were earmarked for use by Pakistan. A system of 2 storage dams, 8 inter-river link canals and 6 barrages were constructed as replacement works under the Treaty to transfer water from western rivers to the eastern rivers canal system which had been earlier stopped. The construction of storage dams and link canals enabled the operation of the Indus irrigation systems in an integrated and improved manner, with better control and efficient river water utilization. As a result, the canal head withdrawals in the Indus Basin have increased considerably.

Source: Associated Consulting Engineers (Pvt.) Limited, 2003. Final Report on Study of Water Rights and Selected Canal Commands, Ministry of Water and Power, Islamabad, Pakistan.

Box 2.2: Water Accord (1991)

There was an agreement that the issue relating to apportionment of the waters of the Indus River System should be settled as quickly as possible. In the light of the accepted water distributional principles, the following apportionment was agreed to:

Province	Water Distribution					
	Kharif		Rabi		Total	
	MAF	BCM	MAF	BCM	MAF	BCM
Punjab	37.07	45.70	18.87	23.27	55.94	68.97
Sindh*	33.94	41.85	14.82	18.27	48.76	60.12
NWFP	3.48	4.29	2.30	2.84	5.78	7.13
Balochistan	2.85	3.51	1.02	1.26	3.87	4.77
Total	77.34	95.35	37.01	45.64	114.35	140.99
Civil Canals** (NWFP)	1.80	2.22	1.20	1.48	3.00	3.70
G. Total	79.14	97.57	38.21	47.12	117.35	144.69

* Including already sanctioned Urban and Industrial uses for Metropolitan Karachi.
** Ungauged civil canals above rim stations.

Under Section 14 (b), the record of actual average system uses for the period 1977-82 would form the guideline for developing future regulation pattern. These ten daily uses would be adjusted pro-rota to correspond to the indicated seasonal allocations of the different canal systems and would form the basis for sharing shortages and surpluses on all Pakistan basis.

Balance river supplies, including flood supplies and future storages, shall be distributed as 37% each to Punjab and Sindh, 12% to Balochistan and 14% to NWFP.

The need for certain minimum escapage to sea below Kotri to check sea intrusion was recognized. Sindh held the views that the optimum level was 10 MAF which was discussed at length, while other studies indicated lower/higher figures. It was, therefore, decided that further studies would be undertaken to establish the minimal escapage needs downstream Kotri.

All efforts would be made to avoid wastages. Any surplus used by province would not establish a right to such uses.

Source: Associated Consulting Engineers (Pvt.) Limited, 2003. Final Report on Study of Water Rights and Selected Canal Commands, Ministry of Water and Power, Islamabad, Pakistan.

Box 2.3: Indus River System Authority (1992)

The Water Accord necessitated the creation of an Indus River System Authority (IRSA) for its implementation. The Authority was established in December 1992. It consists of 5 members, one each to be nominated by each Province and the Federal Government from amongst engineers in irrigation or related fields. The first Chairman was the member nominated by the Government of Balochistan to be followed by the nominees of the Government of NWFP, Punjab, Sindh and Federal Government and thereafter in the same order. The term of office of the Chairman is one year. The functions of the Authority are as follows:

- Lay down the basis for the regulation and distribution of surface waters amongst the provinces according to the allocations and policies spelt out in the Water Accord;
- Review and specify river and reservoir operation patterns and periodically review the system of each operation;
- Coordinate and regulate the activities of WAPDA in exchange of data between the provinces in connection with the gauging and recording of surface water flows;
- Determine priorities with reference to sub-clause © of clause 14 of the Water Accord for river and reservoir operations for irrigation and hydropower requirements;
- Compile and review canal withdrawal indents as received from the provinces on 5daily or, as the case may be, on 10-daily basis and issue consolidated operational directives of WAPDA for making such releases from reservoirs as the Authority may consider appropriate or consistent with the Water Accord;
- Settle any question that may arise between two or more provinces in respect of distribution of river and reservoir waters; and
- Consider and make recommendations on the availability of water against the allocated shares of provinces within three months of receipt of fully substantiated water accounts for all new projects for the assistance of the Executive Committee of National Economic Council (ECNEC).

Source: Associated Consulting Engineers (Pvt.) Limited, 2003. Final Report on Study of Water Rights and Selected Canal Commands, Ministry of Water and Power, Islamabad, Pakistan.

Box 2.4: Main Canals Off-Taking from Surface Water Storages/Diversion Works

Sr. No.	Surface Water Storages/Diversion Works			Off-taking Main Canals			
	Reservoirs/ Barrages/ Headworks	River	Designed Capacity Cusecs (Cumecs)	Canals	Designed Discharge Cusecs (Cumecs)	Water Allowance Cusecs/1000 Ac	CCA (MAc)
A.	**Main Reservoirs**						
1	Tarbela	Indus	9.7 MAF	1. Pehur Main Canal 2. Pehur High Level Canal	250 (7) 250 (7)	5.00 10.00	0.0434 -
2	Chashma	Indus	Provided Under Serial No. 5				
3	Mangla	Jhelum	5.34 MAF	1. Upper Jhelum Canal	1,900 (54)	3.03	0.541
B.	**Barrages/Headworks (Above Rim Stations)**						
1	Amandra	Swat	55,000 (1,557)	1. Upper Swat Canal	3,380 (96)	9.00	0.279
2	Munda	Swat	DNA	1. Lower Swat Canal	1,940 (55)	11.00	0.123
3	Warsak	Kabul	DNA	1. Warsak Canals (L&R) 2. Kabul River Canal	500 (14) 450 (13)	2.50 9.85	0.119 0.077
C.	**Barrages/Headworks (Below Rim Stations)**						
4	Jinnah (Kala Bagh)	Indus	950,000 (26,900)	1. Thal Canal	11,000 (311)	3.18	1.473
5	Chashma	Indus	950,000 (26,900)	1. Chashma Jhelum Link 2. CRBC (Peharpur)	21,700 (614) 4,879 (138)	- 4.62	- 0.350
6	Taunsa	Indus	950,000 (26,900)	1. Taunsa Punjnad Link 2. Muzaffargarh Canal 3. D.G. Khan Canal	12,000 (340) 7,300 (207) 8,800 (249)	- 6.36 6.36	- 0.714 0.729
7	Guddu	Indus	900,000 (25,485)	1. Ghotki Feeder 2. a. Desert Pat Feeder b. Pat Feeder Canal 3. Begari Feeder	8,500 (241) 12,900 (365) 6,700 (190) 15,000 (425)	6.23 9.75 7.50 9.75	0.852 1.047 0.459 1.002
8	Sukkar	Indus	1,500.000 (42,475)	1. Nara Canal 2. Khairpur East Canal 3. Rohri Canal 4. Khairpur West Canal 5. North West Canal 6. Rice Canal 7. Dadu Canal	13,640 (386) 2,700 (76) 11,200 (317) 1,900 (54) 5,100 (144) 10,200 (289) 3,200 (91)	2.90 4.98 2.84 3.97 3.93 19.07 4.42	2.643 0.335 2.604 0.304 0.928 0.520 0.549
9	Kotri	Indus	900,000 (25,485)	1. Akram Wah (L.Channel) 2. Fuleli Canal 3. Pinyari Canal 4. Kalri Beghar Canal	4,100 (116) 13,800 (391) 14,400 (408) 9,000 (255)	5.04 11.42 13.13 4.33	0.487 0.929 0.786 0.604
10	Rasul	Jhelum	850,000 (24,066)	1. Rasul Qadirabad Link 2. Lower Jhelum Canal 3. LJC Feeder 4. Rasul Power Channel	19,800 (561) 5,300 (150) 5,430 (154) 3,570 (101)	- 2.84 - -	- 1.499 - -
11	Marala	Chenab	1,100,000 (31,144)	1. Marala Ravi Link 2. Upper Chenab Canal	2,000 (57) 4,100 (116)	4.80 2.73	0.160 1.445
12	Khanki	Chenab	800,000 (22,650)	1. Lower Chenab Canal a. LCC(East) b. LCC(West)	 8,143 (231) 3,300 (93)	 2.84 2.84	 1.877 1.157
13	Qadirabad	Chenab	900,000 (25,481)	1. Qadirababd Balloki Link & LCC Feeder	18,600 (527)	-	-
14	Trimmu	Chenab	650,000 (18,406)	1. Trimmu Sidhnai Link 2. Havaili Canal 3. Rangpur Canal	11,000 (311) 5,244 (148) 2,700 (76)	- 3.00 4.80	- 0.179 0.347
15	Balloki (Ren.)	Ravi	225,000 (6,370)	1. Balloki Sulemanki Link-I & II 2. Lower Bari Doab Canal	18,500 (524) 7,000 (198)	- 3.33	- 2.379
16	Sidhnai (New)	Ravi	167,000 (4,728)	1. Sidhnai Mailsi Link 2. Mailsi Bahawal Link 3. Sidhnai Canal	10,100 (286) 4,000 (113) 4,500 (127)	- - 3.00	- - 0.872
17	Sulemanki	Sutlej	325,000 (9,202)	1. Eastern Sadiqia Canal 2. Fordwah Canal 3. Upper Pakpattan Canal	4,900 (139) 4,000 (110) 4,500 (187)	3.60 3.60 3.60	0.937 0.425 1.261
18	Islam	Sutlej	388,000 (10,987)	1. U & L Bahawal Canal 2. Qaim Canal	5,400 (153) 600 (17)	4.00 5.50	0.648 0.042
19	Punjnad	Punjnad	700,000 (19,819)	1. Punjnad Canal 2. Abbasia Canal	9,000 (255) 1,100 (31)	4.20 4.20	1.339 0.110

Source: (i) Revised Action Programme for Irrigated Agriculture – Main Report, Volume – I, Table 5.1 (1979). DNA: Data Not Available.
(ii) Irrigation Directory of NWFP (1981), Survey and Research Organization, Planning Division, WAPDA.
(iii) Water Resources of Pakistan by Dr. Nazir Ahmed (1993).

Box 2.5: Hill Torrents of Pakistan

In view of rapidly increasing population of Pakistan, there is growing pressure to use all water resources including the of hill torrents. Government of Pakistan is very keen for harnessing the floodflows of hill torrents, so as to minimize the flood damages and to use these flows for development of sustained irrigated agriculture in these regions. Water rights management of hill torrents would serve as a platform to initiate other development activities in these regions. Clear water rights of hill torrents would unlock the gateway for a full range of development of complementary resources in these areas. Communication system, mineral resources, industry, education and other sectors of the economy would get an impetus due to development of water and land resources of the hill torrent basins.

Major constraint in the use of floodflows is that quantity and distribution of rainfall, both in time and space, are unfavourable for agriculture: annual rainfall is low, uncertain and patchy. Flows are generally laden with high silt charge which in some areas preclude their management through dams/reservoirs. Paradoxical as it may sound, inspite of deficiency of water, major part of floodflows is lost resulting in serious damage to the areas. Flashy floodflows, in the light of uncertainty of their occurrence, add complexity to their economic management.

Studies carried out for conservation of water and landuse potential of hill torrents indicate that in 13, out of 14 major hill torrent areas, there is large scope for development of both land and water resources. In Pakistan, the overall land and water conservation potential has been determined as shown in the following table.

LAND AND WATER CONSERVATION POTENTIAL OF HILL TORRENTS IN PAKISTAN

		Culturable (Hecatres)	Acres)	Average Annual Water
Federal	Northern Area	60,700	149,929	0.94
	A.J. Kashmir	33,600	82,992	0.40
	FATA *	178,700	441,389	4.50
	Sub-Total Federal	**273,000**	**674,310**	**2.84**
NWFP	D.I. Khan	419,000	1,034,930	0.80
	FATA *	178,700	441,389	4.50
	Hazara, Kabul & Bannu	442,300	1,092,481	2.10
	Sub-Total NWFP	**1,040,000**	**2,568,800**	**4.40**
Punjab	D.G. Khan	349,700	863,759	0.85
	Pothowar	220,800	545,376	1.86
	Rachna & Chaj Doab	-	-	-
	Sub-Total Punjab	**570,500**	**1,409,135**	**2.71**
Sindh	Khirthar Range	279,300	689,871	0.30
	Karachi	64,560	159,463	0.09
	Sehwan & Petaro	207,000	511,290	0.39
	Sub-Total Sindh	**550,860**	**1,360,624**	**0.78**
Balochistan	Indus Basin			
	Kharan	1,060,500	2,619,435	0.79
	Makran	2,781,500	6,870,305	3.00
	Sub-Total- Balochistan	**4,679,900**	**11,559,353**	**7.86**

* FATA is located in NWFP, but is under administrative control of Federal Government, hence FATA appears both in NWFP and Federal Areas. However, in grand total, it has been counted once.

In Pakistan, four hill torrent areas have been studied in great detail which are: (i) DI Khan Hill Torrents in NWFP, (ii) DG Khan Hill Torrents in Punjab, (iii) Khirthar Range Hill Torrents in Sindh, and (iv) Indus Basin Component Hill Torrents in Balochistan.

In these, hill torrent areas, a number of water conservation and/or utilization structures have been constructed. Land parcels have been developed for irrigated agriculture in the close vicinity of water conservation structures. Generally, the modes of flow are: (i) Diversion Channels, (ii) Karezes, (iii) Tubewells, (iv) Open/Dug wells, etc. and various types of structures which have been constructed are (i) Dispersion Structures, (ii) Diversion Embankments (Salais), (iii) Delay Action Dams, (iv) Storage Dam, (v) Floodwalls, and (vi) Flood Diversion Channels etc.

Various irrigation practices in different hill torrent basins are being used. Irrigation practices are largely varying from one area to another depending upon a number of factors. In-depth study of existing irrigation have been used in evolving and recommending optimal use of water resources likely to be available after the construction of conservation structures. The most frequently used method is to impound the embarked fields to a depth of 3 to 4 feet and use the soaked fields for sowing and raising the crops with the help of additional freshets.

Box 2.6: Estimated Water and Sewage Flows

Presently only 80% of the urban population has access to the piped water supply where as 11% of rural population is benefiting from this facility. The following shows the present water supply to various selected cities of Pakistan.

Sr. No.	City	Population (1998)	Water Supply Rate (gpcd)	Water Supply Total (mgd)	Sewage Flow Ratio (%)	Sewage Flow Rate (gpcd)	Sewage Flow Total (mgd)
1	Islamabad	525,000	80	4,200	80	64	3,360
2	Karachi	6,269,265	60	55,616	80	48	44,492
3	Lahore	5,063,499	80	40,508	85	68	34,432
4	Faislaabad	1,977,246	50	9,886	80	40	7,909
5	Multan	1,182,441	50	5,912	80	40	4,730
6	Hyderabad	1,151,274	50	5,756	80	40	4,605
7	Gujranwala	1,124,749	50	5,624	80	40	4,499
8	Peshawar	988,005	60	5,928	80	48	4,742
9	Quetta	560,307	40	2,241	80	32	1,793
10	Sargodha	455,360	40	1,821	80	32	1,457
11	Sialkot	417,597	45	1,879	80	36	1,503
12	Sukkur	329,176	50	1,664	80	40	1,317
13	Mardan	244,511	50	1,223	80	40	978
14	Kasur	241,649	40	967	80	32	773

Source: Ministry of Environment, Local Government & Rural Development, 1999.Existing Municipal Waste Water Treatment Facilities in Selected Cities, Interim Report.

Box 2.7: Water Supply and Sanitation in Pakistan

Annual expenditure for safe water and sanitation is hardly 0.25 percent of GDP, which is attributable to lower ranking of Pakistan in the comity of nations. Proper investment can lead to improved health, better education, income, food production, employment, independence, safety/security of rural women etc.

Water supply and sanitation issues in Pakistan can be broadly categorized as access, equity and quality of water supply and sanitation. Major challenge has recently been introduced in water supply and sanitation sector through the introduction of Devolution Plan.

Traditional public service delivery mechanism has been abolished and new Tehsil Municipal Administration (TMA) has been introduced with primary responsibility for planning and implementation of sector related activities. The Devolution Plan has introduced major restructuring of public sector entities previously responsible for water supply and sanitation. Tehsil has been made primary responsibility level for the sector. The potable drinking water sources available at the provincial level is given as under:

Source	PUNJAB			SINDH			NWFP			BALOCHISTAN			NATIONAL		
	Urban (%)	Rural (%)	Total (%)	Urban (%)	Rural (%)	Total (%)	Urban (%)	Rural (%)	Total (%)	Urban (%)	Rural (%)	Total (%)	Urban (%)	Rural (%)	Total (%)
Tap in House	45	7	18	58	6	29	51	33	27	69	13	20	50	9	22
Tap Outside House	4	1	2	6	1	3	11	11	11	8	5	5	5	3	4
Hand Pump/ Motor Pump	49	85	75	26	54	42	24	19	20	5	9	8	38	65	57
Dug Well	1	4	3	2	13	8	13	19	18	13	42	38	2	11	8
River/Canal/ Stream	0	2	2	0	23	13	2	27	23	2	31	27	0	12	8
Other	0	0	0	9	3	5	0	0	1	3	1	1	3	1	2
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

3. Characteristics and Advantages of Well Defined Water Rights

The specification of clear or well-defined water rights has all the merits of property rights, but water rights are often more difficult to define. Water, unlike land, varies in its availability over time and space. Water is extremely valuable when scarce and of negative value when in excess and scarcity can change to excess in matter of hours. The proper management of well-defined water rights will ensure security and certainty in water distribution system.

The problems in the definition of water rights are generally covered under the following headings:

- Choice and implementation of the appropriate legal framework;
- Establishment and recognition of the institutions necessary to define and enforce water rights;
- The relative priorities and various consumptive and non-consumptive water uses like: domestic, agriculture, industry and environmental uses; and
- The priority to be assigned to historic uses in relation to new demands.

The characteristics that are important in any water rights/allocation system are as follows:

- The rights are sufficiently well defined for the holder to understand their right;
- The entitlement is defined both in terms of its **security** as well as its **reliability;**
- They are enforceable at law;
- The arrangements under which the rights can be modified are transparent to all parties; and
- They can be traded or exchanged.

Security as it is used in this context means that the water right/entitlement is specified in an appropriate legal framework with the necessary supporting legislation .Reliability is the amount of the entitlement that one can expect to receive from year to year in response to changed rainfall and runoff conditions. In many systems there are a range of different water rights reliability to meet different uses ie an urban supply vis a vis an irrigation supply.

The advantages of a well defined set of water rights are:

- Individuals can exercise their abilities to maximize output by knowing that their entitlements are not going to be diminished by the ad- hoc actions of others;
- Individuals can proceed with longer term capital investments, by knowing that their rights are secure;
- Conflict at all levels is minimized as all participants understand their water rights;
- Provides a stable basis for water trading thus improving market performance; and
- Enables the Political and management groups involved in water management to focus on productive tasks rather than wastage of significant resources on ongoing dispute resolution.

The Pakistan water supply situation faces the following future challenges that need to be accommodated in any Water Rights/entitlement system:

- <u>Demand</u>: Demand has far out stretched supply and there is more land available for irrigation than there is water to service it effectively.

- Irrigation Investment: The irrigation system is showing real signs of decay and will require significant investment in its rehabilitation and without an effectively managed water rights system much of this investment could be wasted.

- Surface/Ground Water Management: The heavy reliance on groundwater to supplement surface water supplies will remain as an integral part of any effective water supply system for Pakistan. Given they are already integrated into the farming system it will be important to ensure that they are managed in the same water right /entitlement system. Having one element regulated and the other unregulated will ultimately result in the collapse of parts of the agricultural system reliant on irrigation.

- Climate Change: Early advice on the impacts of climate change is that there is likely to be less, rather than more, water available in the future. While this is still contestable there is nevertheless some early warning signs that need to be noted. There is evidence that the some of the glaciers of the Indus system are reducing in size. The system has been "mining" the glaciers for the past decade or so (rough data).

- Population Growth: Increasing population will continue to stress the water supply system.

- Urbanization: The expected continuation of the urbanization of the country will result in the need for some redistribution of water resources.

- Sustainable Rivers: The demand for a stable allocation to maintain the integrity of rivers and their dependant eco system is also likely to increase.

- Community Confidence: There are many groups in the irrigation industry who have lost confidence in the current water allocation and management system evidenced by ongoing conflict at both the Province and individual level.

All of the above drivers indicate that the system will be under increasing pressure to be able to manage **scarcity** more effectively.

It is clear that Pakistan has moved from the development phase of its major water resources (even though there may be further development but they will be minor as compared with the existing investment) to the management phase of water resources development. This will demand more contemporary management of all sectors of the water cycle. A foundation issue will be to ensure that the water right/entitlement system can meet the challenges that now confront the water supply system for Pakistan. Without an effective system it is certain that other investments in the system will be less effective than they should and could be.

The main principles that would govern a successful water rights system in Pakistan are proposed as follows:

- Water rights should give the priority: first, right to drinking water for life; second, right to basic domestic needs for survival; third, right to agriculture use for food and fibre; fourth, right to industrial use; and fifth, right to environmental use;
- Water and land should remain permanently attached for the agriculture use of water;
- Water rights should be well-defined with clear specifications of the entitlements;
- There should be individual clear understanding of the water rights with an easy excess to their entitlements;
- Introducing equitable water distribution system with reliability of stated water rights;
- Assuring supplies at tail ends of the system for stated entitlements;

- Establishment of the register of water rights linked with water accounts;
- Developing a mechanism of transfers between different entitlements;
- Execution of 'Clear Water Sharing Agreements' among canals within a province, as well as among the distributaries within a canal command as has been done in Water Accord, 1991;
- Development of a mechanism for realistic water pricing;
- Development of an active conflict resolution mechanism;
- Accurate discharge measurement arrangements;
- Conversion from time based supply into volumetric supply in phased manner;
- Exercising high efficiency and productive use of entitlements;
- Suitable water laws with practicable trading rules;
- Regulatory framework for groundwater usage;
- Exercising conjunctive use of fresh and groundwater;
- Provide prompt justice to the affectees;
- Reliable communication system on regular basis;
- Capacity building of the provincial irrigation institutions; and
- Establishment of telemetry system on permanent basis; and
- Assuring post-completion measures for each and every mechanism introduced in the water rights system.

The above discussed characteristics and advantages of a well-defined set of water rights and proposed main principles for governing a successful water rights system have been considered as a 'Good Practice' approach in Pakistan.

4. Issues and Options

Clear and secure water rights, with optimum use of water resources, are fundamental to many aspects of country's economic development. Secure water rights encourage a long-term interest in maintaining the productivity of water resource and encourage the associated private investment to improve facilities, thus augmenting benefits, often without public cost. Secure water rights also avoid the wasteful use of water resource in trying to establish a claim over water disputes.

In Pakistan, the water rights are clear at international level and to an extent at national level too, but there is still a lack of clarity of water rights at canal, distributary and individual levels. Various water rights issues, for both surface and groundwater, which have erupted mainly due to lack of clarity of water rights, have been described hereinafter alongwith their possible solutions.

I. Surface Water

(i) International Level

Although, there exists international practices for sharing the water of common rivers between the countries, but the case in between India and Pakistan is somewhat different than others. After creation of the Islamic Republic of Pakistan in 1947, the issue of sharing the water of six different rivers by the two countries was finally resolved with the signing of the Indus Waters Treaty in 1960 after protracted negotiation through mediation by the World Bank. According to the Treaty, three eastern rivers have been given to India and three western rivers have been going to Pakistan to exclusively utilize their waters by the respective country. Due to less awareness of the environmental considerations at that time, proper importance could not be given to the downstream environmental flows in the treaty on three eastern rivers.

With the passage of time, India has started some development projects like Wullar Barrage at Jhelum river, Kishan Ganga Dam at Neelum river, and Baghlihar Dam Project at Chenab river. The design of these projects contravenes the articles of the Treaty. Therefore, these projects are objectionable to Pakistan as lower riparian. Pakistan has raised many times the issue with India at various levels but still the satisfactory response for the remedial measures is not received.

Following options and improvement strategies are proposed to address the above issues:

Possible Improvement of the Indus Waters Treaty, 1960

Possible improvement in the Indus Waters Treaty 1960 is required to address the clear water rights of both the countries for permissible consumptive and non-consumptive uses by India on the three western rivers under the present environment so that regular un-interrupted supplies to Pakistan can be ensured as lower riparian. Environmental flows to Pakistan on the three eastern rivers may also be considered in the treaty. For these purposes, World Bank can play an important role to rectify the issues between the two countries.

Need of a Neutral Expert on Treaty Matters

In order to check the future disputes, a Neutral expert is needed for treaty matters who can meet at least once in a year with both the countries. An annual report may be issued by the expert on performance of both the countries on Treaty matters. This will also be helpful in strengthening the relations between India and Pakistan. The best possible option is the World Bank, which is a neutral agency to play an effective role on Treaty matters.

(ii) National Level

The Apportionment of Water Accord 1991 established the water sharing arrangement between the Provinces of Punjab, Sindh, NWFP and Balochistan. It was a major step forward and represented a real commitment from Governments to work together. It established the "province" entitlement and the arrangements under which future allocations would be made. It recognized that the system was largely a 'run of river' system and established arrangement for sharing on a daily basis between the Provinces.

There are, however, many areas of the water accord that are challenged and contestable particularly with regard to distribution of flows in drought conditions and those needed for environmental flows to the lower provinces. Future focus on the provisions of the agreement and tension is likely given the stated intention in some provinces that would result in an increase in canal head diversion by about 17 MAF to 131 MAF. There is no conflict resolution provisions contained within the accord so the renegotiation is likely to be difficult and time consuming undertaking.

Lack of trust among the provinces has badly affected the water rights of all the provinces. All disputes have emerged by loosing the confidence on each other. Most of the water resources development projects could not be finalized due to this element of mistrust among the provinces. The dispute on sharing the water shortages during the past six drought years has further accentuated this crisis of confidence. Therefore, the lack of trust is the greatest issue in the context of water rights improvement among the provinces.

To provide a framework for discussing the effectiveness of inter-government water sharing agreements, the following five components, that are needed for effective management of the agreement, have been identified:

- Stable treaty/agreement;
- Well trained technical secretariat with sufficient resources;
- Access to the knowledge necessary to run the business;
- Integrated across the natural resource areas that are likely to have a significant impact on the performance of the business, i.e. water/pollution/environment; and
- Arrangements for transparent governance and community participation to ensure confidence in decisions.

A brief review against the above five components are given below:

- Stable Treaty/Agreement: The current agreement could be consider as a "bare bones" agreement. It contains the minimum of detail and processes that would be considered adequate for the scale of the activity undertaken under its umbrella. Aspects of the agreement continue to be contested. It would benefit from a detailed revision, however, this needs to be weighed up against the risk of opening up the agreement to protracted debate. The agreement would be sufficient for the time being and it would be more productive to invest in other areas of activity and revisit the agreement at some time in the future or if the Provinces agreed it was in their collective interest to do it sooner.

- Well Trained Technical Secretariat with Sufficient Resources: The resources available to the IRSA are totally inadequate if it is to perform effectively. A review of the resourcing requirements should be undertaken as a part of the assessment of the future institutional arrangements for water management in the Indus Basin. However, there are a range of functions that will be needed which are currently under resourced. These include an effective water data management system, sufficient real time data acquisition assets, a

stable modeling environment, clear arrangements to separate the policy arrangements from managing the day to day operations. A suggested approach to start work on these issues is given in the conclusions.

- Access to the Knowledge Necessary to Run the Business: The IRSA has very limited access to the knowledge resources for effective management. It has no model of the system to help with decision making and accounting of each provinces water allocations.

- Integrated across the Natural Resource Areas: It is narrowly focused on operations and it neither contribute to the broader water policy debate nor get involved in the assessment of the natural resources of the basin even those with a direct impact on its business.

- Transparent Governance: The IRSA provide reports to the governments and some information to the general public via newspapers. It has no direct interface with the community.

The areas which would benefit from attention as a first step towards good practice for river basin authorities are:

- Establish a database of the critical water related information;
- Enhance the existing operational data network and associated assessment and reporting arrangements;
- Establish a modeling environment, appropriate for the situation in this basin. It should have both predictive capacity and hence be able to inform future policy and also have sufficient clarity to inform operational decisions. The models could also be used as the accounting mechanism, if appropriate care is taken in their design and creation;
- Have governments agree on the two or three key natural recourse threats to the Basin's water management and ensure that investment is progressively made in understanding and managing these threats. The most likely threats are salinity, urban and industrial pollution and changes to water dependent ecosystems;
- Modify the structure of the authority so that the medium to long-term policy arrangements are separated from the day to day operational activities. This will require the Commission to be selected and structured differently and to be supported by a well resourced technical secretariat that carries out the day to day operation and reporting; and
- Establish an open and comprehensive water reporting system. In the first instance, it should be able to report on the daily, weekly and annual flow and use characteristics of the basin. Given the importance of water to Pakistan, consideration could be given to establishing a water and weather media channel on the television networks given their broad coverage to the general community. It would provide a very high level of transparency to the process and it will be proved to be an effective confidence building measure.

In addition to the above initial steps, the following solutions of the issues are recommended:

Active Conflict Resolution Mechanism

Pakistan has always faced water shortages in the form of drought and may continue to do so, except in the monsoon period. Although IRSA was created to facilitate the provinces in distribution of their shares but the provinces have hardly accepted its decisions. Therefore, in order to utilize the surplus flood waters in an effective manner and to increase the water storages, there is a need to develop provincial consensus on water conservation and development strategies while removing the prevailing misgivings.

Despite the existence of IRSA and the constitutional provision of "Council of Common Interest", there is a lack of sound conflict resolution mechanism among the provinces. Such a mechanism for effective confidence building needs to be evolved on practical and sustainable basis. For this purposes, IRSA is required to be further strengthen to facilitate the provinces on routine matters in a more effective manner and Council of Common Interest should be allowed to play its role in resolving inter-provincial conflicts by developing consensus on such resolutions.

Effective Discharge Monitoring System

The installation of the telemetry system, at dams and barrages, on the location of main water distribution points will be helpful for transparent water distribution among the provinces. Currently, the system has been installed and fully operational at 23 locations in the country. The Federal Government has also decided to expand the system to canals and asked the provinces to recommend a pilot project for the installation of telemetry system on any one of their canals. At this stage, one should realize that the post completion measures of this system at all the stations are essentially required to keep the system operative on regular basis.

(iii) Canal and Distributary Levels

All major catchments in the Indus Basin are inter-linked by an extensive channel network. There are established arrangements to share the water between Provinces but what is less clear is whether there are well developed and highly specified arrangements to share the water between sub-catchments and major canal systems. It is important that there are clear and transparent arrangements for the sharing of water as this will have a significant impact on the reliability of supply to individual systems and to individual landowners This particularly important given that major diversion and irrigation infrastructure is still being constructed and commissioned even though exist allocations are contested.

A number of issues have been identified which are directly or indirectly related to existing poorly defined water rights at canal and distributary levels. The issues and their solutions have been briefly discussed as follows:

- Lack of Clarity of Water Rights: At canal and distributary levels, water rights were defined in terms of "water allowance". These water rights were very well institutionalized to meet the irrigation requirements in the past but with the passage of time, the requirements have changed and in the present socio-environment situation these are required to be re-defined to satisfy the users and for better use of water. Due to lack of clarity of water rights, the present irrigation system has become inefficient even with exercising the ongoing institutional reforms. The principle of equitable distribution of water and certainty in water supplies have been eroded due to number of factors. The farmers are not relying on the canal irrigation at the tail end of the system. The agriculture productivity has been very much affected and increasing disputes among various users and state agencies have been observed.

- Inequitable Distribution of Irrigation Water: An irrigation system is considered to be fair if it is more productive and efficient. Equity in water allocation and distribution has many dimensions and levels such as inter-canal and intra-canal equity, inter-distributary and intra-distributary equity, and inter-watercourse and intra-watercourse equity. Generally, the canals, distributaries and watercourses receive more discharge at their head reaches, than the tail ends of the system. The growing inequities in canal water distribution has been identified as being major issue that reflects the imbalances in water rights system. A number of studies have documented the nature and extent of the emerging problems.

The issue has become increasingly severe over the last two decades, and is the outcome of many factors. Increasing water demand, deferred maintenance, siltation of channel prisms, excessive withdrawals by outlets, and illegal water extractions all contribute towards the increasing inequity in the system. This has eroded the confidence of the tail users in the integrity of the system. Confronted with the canal water shortages, the tail end farmers have been forced to use marginal quality groundwater without the proper mixing required.

Another important aspect of the issue concerns inequity in access to the use of groundwater. These inequities arise from two fundamental causes. The first relates to the natural occurrence and random geographic distribution of groundwater quality in the country, while the second factor stems from the scale of economies. The farmers in saline groundwater areas are virtually deprived of groundwater use in the context of currently available technologies, whereas the farmers in the fresh groundwater areas are greatly benefiting from the conjunctive groundwater use. With regard to the scale of economies, the uneven distribution of land holdings with predominance of sub-economic farms, compounds the equity of access to the groundwater. The small landholders suffer the worst as they do not have the resources to install tubewells, or money to purchase expansive tubewell water.

- Unreliable Irrigation Supply: The most important constraint in the irrigation system performance relates to the overall scarcity, stagnating water availability, and large variations in the seasonal river inflows. Low water availability during critical crop sowing and maturing periods, and limited storage capacity hampers efficient system operation.

  Pakistan, as a whole, is facing problem of overall water scarcity and its irrigation is based on the distribution of available water. Recent studies have concluded that for most of Pakistan, irrigation will continue to be constrained by overall water availability. Therefore, it is obvious that water resources in Pakistan are quite limited when compared to the future demand projections and water rights are to be defined in a way to distribute the scarcity and not the abundance as done in the past.

  As against the rapidly escalating water demand, the overall water availability is stagnating, as no new projects to enhance the canal supplies have been undertaken after the construction of the Tarbela Dam in 1976. Private tubewell development, which has been instrumental in conjunctive groundwater use, also appears to have touched the peak in some of the freshwater aquifers. The water availability as per historic water rights at the farmgate, compared to the population, which more or less matched the population growth up to the mid 1980s, is stagnating and has started lagging behind the population growth. This state of affairs poses a serious concern to the sustainability of irrigated agriculture in the Indus basin and, therefore, redefining the water rights are needed.

- Inaccurate Discharge Measurement Arrangements: Accurate measurement of discharge at the channels heads and other water distribution locations is not observed properly. Generally, the Head-Discharge relationship is not updated at the channels. This causes inequity in water distribution and inaccuracy in the water accounts. Therefore, proper discharge measurement should be the prime objective of the water rights management in irrigation system.

  Inadequate Capacity of Irrigation System**:** The design considerations and capacities of the canals and distributaries, which were fixed for low cropping intensities, are not compatible with the present requirements. With completion of the Mangla and Tarbela

Dams, and the construction of various inter-river link canals, more water is available to distribute among canals. Simultaneously, reclamation of the new lands for irrigated agriculture required more water for which the capacitates of the canals and distributaries are needed to be enhanced.

Therefore, the inadequate capacitates of the system pose a major constraint in meeting the current irrigation requirements, particularly during peak demand periods when the system performance suffers serious setback. The head-end farmers are getting water more than their water rights in order to mature the sown crops, whereas the tail-end farmers are suffering with water shortages and, therefore, not getting their due water rights.

The suggested options to resolve the above issues are given as under:

Clear Water Sharing Agreement between the Canals within a Province

Clear water rights and equity in distribution of water are required at all the levels. Among the provinces, the apportionment of water has been resolved by Water Accord 1991. Within a province, the same pattern should be adopted to distribute water among the canals within a province as well as to distribute the water among distributaries within a canal command.

The clear agreements among the canals, within a province, and among the distributaries within a canal command are required for creating a healthy and transparent environment in the canal irrigation system. These agreements will be prepared and monitored by the following responsible agencies:

Agreement Levels	Responsible Agency
Agreement among Canals within a Province	Respective PIDAs
Agreement among Distributaries within a canal command	Respective AWBs

Establishment of the Register of Water Rights at Canal and Distributary Levels

Register of water rights is an official Register(s) that record(s) the water rights of individuals or an entity showing their entitlement and actual utilization of surface water (retail or bulk) in terms of quantity, timing and duration of allocation corresponding to their respective culturable command areas and which contains the information of their land holding, season-wise crops and revenue accounts.

The register of water rights is required to be established at both the canal and distributary levels. It will register the withdrawals at the head of each canal and distributary. In fact, for proper accounting of the entitlements of water rights in a canal command, the register of water rights are required to be established at every transaction point in a canal command. A typical schematic diagram for establishment of the register of water rights at various transaction points in a canal command has been shown in Figure 4.1.

The outlets are the most important points in a distributary, where withdrawals of the outlet and entitlements of the farmers will be documented in this register.

Revision of Canal Water Allowance

The realistic water requirements of the canals are required to be re-calculated keeping in view of various factors under the present situation. The water allowances are, therefore, required to be revised accordingly.

Adequate Capacity of Irrigation System

The canals and distributaries were designed earlier to meet the then requirements. Therefore, modernization of the system has become essential to cope with the present requirements. Modernization is the process of improvement of an existing system to meet the enhanced needs, default internal to the system itself. Hence, modernization is necessary to cope with the external events.

Accurate Discharge Measurement Arrangement at Canals and Distributaries

In order to maintain the accurate water account, proper discharge measurement arrangements are to be ensured at the heads of canals, distributaries and watercourses. Mostly, the Head-Discharge relationship tables available at the heads of canals and distributaries are old. The fresh calibrated and updated discharge measurement tables are to be provided at the head of each canal and distributary.

(iv) Individual Level

As institutionalized in Pakistan, "*warabandi*" is a rotational method for distribution of irrigation water with fixed time allocations based on the size of landholdings of individual water users within a watercourse command area. It correctly presupposes an overall shortage of irrigation water. The primary objective of this method is to distribute limited supply in an equitable manner over a large command area. For *warabandi* to achieve this main objective, it needs to be supported by a set of physical and institutional conditions, which form the environment of *warabandi*, transcending the boundaries of the tertiary system in which *warabandi* is actually applied. As the system has been designed with minimum control to allow "free flow" of water into the outlets, these conditions require that the rate of flow of water in the canal system is uniform, so that each water user receives his share proportional to the irrigated land owned by him. This is achieved by maintaining distributing points at a predetermined water level. It is designed in such a way that all the outlets on a distributary are operated at the same time entitled (based upon land coverage) flow of water into the watercourses so that the *warabandi* roster is not disturbed.

The principle of equitable water distribution underlying the design of *warabandi* is eroded by an increasing variability in the canal water flows as well as by the non adherence to standard operation rules, both of which are in turn related to a combination of physical and institutional factors. Poor maintenance-related deterioration of the canal system, and operation deviations introduced by some influential water users characterize practical field situation. In fact, these have deteriorated the essential conditions of a *warabandi* system. The irregularities that occur in the operational conditions above the outlet, are bound to induce corresponding behavioral effects related to *warabandi* operations below the outlet.

The various issues identified at the individual level, are mainly due to insecure, poorly defined, and unclear water rights. The secured well-defined water rights will encourage the users investments with confidence. Secure water rights are particularly beneficial for smaller farmers, who have been most vulnerable to reductions in their water allocations over time and who have few other sources of collateral.

The issues identified at individual level alongwith their possible solutions have been given hereinafter:

- Water Shortages at Tail Ends: The complaints of water shortages at tail ends are oftenly registered in the water rights system. The main aim of a perfect water rights system is to provide water to the tail end farmers according to their due water rights. Unfortunately, this aspect is not properly managed at individual level of irrigation system in Pakistan. In

most of the areas, the tail end users are partially or completely ignored in providing their due share but they are bound to pay the water charges.

- Lack of Monitoring the Channels: The irrigation channels are not being properly monitored by the responsible staff because of the lengthy channels and inadequate staff is deployed for this purpose. Inadequate operation and maintenance funding for the channels is one of the main reason. The influential and head reach farmers are misusing this opportunity in tempering their outlets, illegal pipe siphoning, and sometimes by breaching the channels which deprives the downstream farmers of their dude water rights.

- Invalid Entitlements and New Allocations: The soil and Reclamation Act, 1952 provides the facility for sanctioning the new water entitlements to the reclaimed lands for agriculture. On the other hand, some existing entitlements are not valid because of the non-existence of their allocation basis. For example, the allocation for gardens is valid until the gardens exist on the ground. Therefore, adjustments of such water rights entitlements should be monitored on regular basis.

- Conjunctive Use Issues: Generally, the farmers tend to cover more area to achieve higher cropping intensity than is optimum for fully sustained agriculture to meet with the crop consumptive use, resulting in lower crop yields, degradation of land in the long run through higher gross income in the short run. This situation has been substantially mitigated in areas underlain by fresh groundwater through which the farmers supplement the supplies to crops for better yields. However, proper regulation of the groundwater use is required to supplement the surface water in fresh groundwater zones. On the other hand, enough water rights are required to compensate the farmers having their lands on saline water zones.

  In fresh groundwater area, the farmers have an advantage to supplement supplies by their own privately installed tubewells in their lands, even though the quality of water and the element of absence of fertile silt content, is a disadvantage to some degree.

- External Influences: Irrigation systems are an integral part of the total institutional framework of any society. Irrigation management, therefore, has to be considered in the broader perspective of the socio-economic and political conditions, as well as the prevailing law and order situation. As in many developing countries, there has been a general decline in the discipline of the society in Pakistan. On the canal systems, this has been manifested by frequent violations of law by the more powerful and influential users. This has resulted in a general weakening of the irrigation agency performance and control, and there morale of the staff is declining. This has ultimately resulted the ignorance towards the water rights of poor farmers.

The proposed options to resolve the various issues are given as under:

Measures for Water Shortages at Tail Ends of the System

The water rights system must ensure the rights of the tail end users of the system. The possible way is to monitor the use of water by the head and middle reach users, to check the levels of the outlets at head and middle reaches for which tempering of outlets should be rectified. The lining of watercourses will be very helpful in mitigating this issue. The establishment of the register of water rights will also assist in checking of these shortages.

Regular Monitoring of Channels

Adequate trained staff is required for proper monitoring of the channels that can watch the hydraulic structures, canal banks, water thefts, and specially the outlets tempering on regular basis. In case of observing any fault, it should be reported immediately to the concerned responsible agency for taking necessary action on time.

Register of Water Rights

Register of water rights at watercourse level, will become a basic document of water rights which would provide a basis of actual water utilization and may make the water as marketable and tradable commodity. It will also provide a reference in case of disputes related to water and revenues between different users and entities. However, the other registers of water rights at minor, distributary and canal off-taking points will provide a complete account of water for a canal command as a result of which the actual water utilization and losses for a particular reach may be calculated.

Regular Monitoring of the Entitlements

Adequate trained staff is required for proper monitoring of the entitlements that can regularly watch for cancellation of the invalid temporary entitlements and verify for sanctioning the new allocations. These changes should be reflected in the register of water rights.

Conjunctive Use of Surface and Groundwaters

The surface and groundwater resources need to be used in a conjunctive manner, wherever and whenever possible, for the maximum benefit to be obtained from limited water resources. This is successfully happening in the Indus Basin Irrigation System (IBIS) to some extent but the mechanism by which it takes place need to be strengthened and expanded further.

Mitigation of External Influences

The rules and regulations for equitable distribution of water should be followed indiscriminately. Following measures are suggested:

- The staff in water sector institutions should be inducted on purely merit basis;
- Transfers and postings should be made on merit basis following the rules and regulations;
- Penalties should be fixed and strictly observed for misusing the powers; and
- Penalties should also be fixed for those who are exerting the pressures on poor farmers and government officials.

Reliable Irrigation Supply

After ensuring the due rights of users, the next important objective of water rights system is to ensure the reliability of irrigation supplies. The irrigators must get their water at all the time of their requirements. To fulfill this condition, sufficient water is required to be made available to meet the irrigation demands, which is difficult with the present available water and constant drought conditions. This situation warrants for water conservation and use of groundwater wherever it is feasible. With the rapid population growth, merely meeting minimum food needs will require substantial improvements in water-use efficiency. The water conservation can thus play an important role in sustaining agricultural development.

The most important attribute that requires consideration for water conservation is the quality of groundwater. In fresh groundwater areas, the water losses contribute to the groundwater storage and are recycled. The overall system efficiency of water use in such cases may be very

high, effectively approaching to 100 percent. In saline water areas, however, the seepage losses represent irrecoverable water loss to the system. Thus, there is a need to implement a phased programme for lining of irrigation channels in saline groundwater areas; starting with the seepage control in the most problematic reaches involving high filling, porous soils, and high water tables.

More storage of water can provide more water to canal and could be helpful in mitigating the issue for which the country is facing problem in these days and finding the way for possible arrangement.

Therefore, the possible option of mitigating the problem is the conjunctive use of groundwater in fresh groundwater areas, lining of canals and watercourses in saline groundwater areas and construction of more reservoirs.

Possibilities of Moving from Time Based to Volumetric Discharge Measurement

It is important to note that discharge at canal and distributary level is measured in volumes (cusecs or cumecs), whereas the water distribution at the watercourse level is in times (in hours and minutes). This situation needs to be realized and possible measures should be adapted to improve the water rights system. These measures can be taken in a phased manner so that users can understand the system with the passage of time, and practically may become adaptable by the users.

In the first phase, the existing water rights of individuals, reasonably defined by area and times, should be documented without reasonable registry system. This may be targeted by ending the year 2005.

In the second phase, the clearly defined water rights of individuals, should be documented with proper registry system. This may be targeted by ending the year 2008.

Simultaneously, as part of the second phase, the process of converting the outlet discharge measurement system, from time based into volumes, will take place by installing the modern volumetric discharge measurement devices at the outlets. This may be targeted by ending the year 2010. The above process has been shown in Figure 4.2.

In third phase, the well-defined water rights of individuals, converted into volumes, should be documented in volumetric unit with systematic registry system. This may be targeted by ending the year 2012.

(v) Common Issues of Various Levels and Suggested Options

The issues, which are common at various levels, have been addressed as under:

- Lack of Trust among various Users and State Agencies: Lack of trust among various users, especially mistrust of small farmers on the large farmers and mistrust of the farmers on the state agencies, is at the heart of the water rights issues in Pakistan. All disputes stem from the crisis of confidence. The small and medium farmers have the apprehension over the large farmers of using more water. The small and medium farmers have an understanding that the irrigation department is not equitable distributing the water, therefore, providing more water to the influential farmers. Therefore, there is a need to develop the confidence building measures at all the levels. Delays in justice and poor accountability have also shaken the confidence of the farmers on the state agencies.

- Lack of Inter-agency Coordination: Under the provisions of the Irrigation and Drainage Act, the Provincial Irrigation Department are responsible for all aspects of distribution and use of irrigation supplies, including on-farm use. However, in practice, the O&M responsibility of the Irrigation Department virtually ends at the head of the watercourse, and the OFWM Directorate is responsible for watercourse and other on-farm improvements. On the other hand, the Agriculture Department extension services is mainly concerned with the use of non-water inputs.

  The irrigation management has a number of other provincial and federal agencies, which have a role in irrigation management alongside the Irrigation Department.

  WAPDA is responsible for managing river storages, inter-provincial link canals and constructing major water resources development projects.

  Revenue Department/Civil Administration is responsible for collection of the revenue assessed by the Irrigation Department. The civil administration and police also help to check water theft cases and to fight flood emergencies.

  Finance/P&D Departments: The P&D Department coordinates, approves and finances the development projects, while the Finance Department coordinates and controls the O&M budget allocations.

  An effective mechanism for inter-agency coordination and liaison is, therefore, required for optimal utilization of water resources and proper implementation of clear and well-defined water rights system.

- Institutional Issues: Irrigation institutions are broadly defined to include both, the rules and organizations. Rules include both, purposely established formal rules (laws, regulations, and procedures) and socially-evolved informal rules (practices, norms, customs and conventions). In view of this perspective, the irrigation rules become as important as organizations in influencing the water rights system being implemented by the irrigation agencies.

  Reviewing the performance of irrigation institutions in Pakistan, Bandaragoda and Firdousi (1992) have observed that these institutions appear to remain conspicuously static. Their changes lag behind those that have taken place in resource base and technology over the years. For this reason, the relevance and adequacy of the current institutional set-up is perceived to be outdated in the context of the changed environment and socio-political transformation. To sustain water rights system, therefore, much greater attention is needed for adaptations in the institutional framework in keeping with the social and environmental changes.

  The main institutional factors that influence irrigation performance relative to the water rights in Pakistan include:

  - The overriding effect of socially evolved informal institutions over the application of formal rules and management decisions;
  - The obsolescence of irrigation rules, codes and procedures;
  - The declining relevance of organizational structures in the light of changed circumstances; and
  - The low value attached to the validity and reliability of information and to the necessary awareness relating to proper irrigation management.

The field observations and interactions with agency staff point toward at least fours main causes relating to the problem of conflicting institutional influences and declining irrigation performance.

- An increasing work load for all levels of irrigation officials;
- A rapid process of politicization of the administrative and social environment;
- A resultant change of attitudes and values toward the application of formal rules; and
- A situation of declining law and order in the field.

The officials who have been given responsibility through formal rules to act against unauthorized irrigation, cannot, in fact, cope with the task, as they either do not get adequate administrative and political support to apply the rules or get entangled into the vested interests. Due to the rapid politicization process since independence, the bureaucratic power intended by the formal rules has been substantially eroded. Consequently, the existing formal rules and implementation mechanisms have lost its significance. Staff supervision, disciplinary action, and legal and administrative measures for punitive action have all declined in their quality and effectiveness.

- Financial Issues: The main issues under this heading include inadequate operation and maintenance funding, inappropriate distribution of budget allocations, rise in maintenance expenditure of public tubewells and flood works, escalating expenditures on establishment, un-realistic *Abiana* rates, and a widening gap between the expenditure and cost recovery.

- Environmental Issues: Despite the implementation of a number of drainage projects, over 30% of the gross commanded area in the country is waterlogged, and about 14% is considered highly waterlogged. Although irrigation water is relatively free of salts, repeated irrigation and the rise in groundwater levels has been mobilizing the dissolved salts, resulting in the build-up of salinity. The estimation is that about 6% of the gross canal commanded area is severely salt-affected and another 8 percent is moderately affected.

  Over-exploitation of Fresh Aquifers is also an emerging threat that faces the irrigated agriculture in Indus Basin. Groundwater extraction through tubewells not only supplies additional water, but also provides flexibility to match surface water supplies with crop water requirements. Due to the rapid development of groundwater by the private sector, there is a danger of excessive lowering of watertables; impending threat of secondary salinization due to use of groundwater of marginal quality, and intrusion of saline water into fresh water aquifers. A study by Nur-ud-Din and Nazir (1990) has reported that watertables in some canal commands have already gone down considerably. A study by the Consultants has estimated recharge and pumpage in various canal commands in the Upper Indus Plain. These initial estimates appear to confirm the emerging problem.

  Besides the potential impact of saline drainage effluent on wet lands, there is environmental concern about the disposal of saline effluent into the evaporation ponds, or back into the river or canal system. Evaporation ponds can, in any case, deal with only relatively small amounts of water, especially as evaporation rates tend to reduce as salinity reaches a high concentration. Such ponds are a hazard, particularly when subject to rainfall or storm water inflows that could cause them to overtop, or spread. Lateral seepage and the contamination of groundwater and low lying land is another problem.

The main water quality concerns include:

- Disposal of untreated industrial and municipal effluent into rivers, drains and irrigation channels. This results in degradation of surface water quality. The untreated industrial effluent is particularly harmful because it contains toxic substances also. The dissolved and suspended salts in the industrial effluent ranges from 5,000 ppm to over 450,000 ppm;
- The addition of salts by irrigation supplies. A study by the World Bank reported by Mellor et al. (1994) indicates that irrigation water with an average salt content of 200 ppm adds 0.690 tons per acre of CCA per year, of which 75 percent is added to the groundwater. Slightly more than one-half of the total salts end up in fresh water aquifers, which explains its declining quality. The accumulated salts on soil surface affect land productivity;
- Disposal of the pumped saline water into the drains, canals, rivers. This affects the quality of the surface water, particularly during the low-flow river regime; and
- Disposal of untreated effluent from the cities and towns into water bodies (drains, canals and rivers). The pollution loads from the major cities include 443 Ton BOD/day from Karachi, 247 Tons BOD/day from Lahore and 42 Tons BOD/day from Multan and Rawalpindi/Islamabad.

- Legislative Issues: Legislation is also an important key issue relating to the water rights without which the implementation of rights is impossible. Many different categories of water rights exist in Pakistan, yet legal cover in most cases is absent. There are large numbers of provincial acts passed from time to time to cover the water-related needs. The Punjab Canal and Drainage Act 1873 is the pioneer among these acts and similar laws enacted later on in the other three (3) provinces, there are also four (4) Provincial Soil Reclamation Acts pertaining to waterlogging and drainage, Water Users Association Ordinances of 1981 and 1982, PIDA Acts of 1997, and a host of city development legislations covering, inter alia, domestic water supply. At the Federal level, WAPDA Act of 1958 and IRSA Act of 1992 provide guiding principles for development and distribution of water. The existing laws have overlapping and conflicting provisions in many provincial and federal laws.

  Therefore, there is a need to add, delete and modify various provisions, and to cover the drastically changed conditions and ground realities. Preferably, all water-related provincial laws should be combined into one comprehensive act, which would make the laws concise and clearer, more-readily understandable and less susceptible to misinterpretations.

The possible solutions of the above common issues of various levels have been given as under:

Confidence Building Measures

Lack of trust is main reason for dispute of water distribution among provinces. Following confidence building measures are suggested to resolve the measures:

- The funds for water related projects should be fairly distributed;
- Telemetry system should be installed at the transaction points along the irrigation channels;
- Register of water rights should be maintained at all water transaction points;
- The representation of small provinces in water related institutions should be given due consideration; and
- The chairmanship of IRSA should be rotated among the provinces.

Effective Inter-Agency Coordination

Proper inter-agency coordination is needed to make the water rights system efficient, successful and sustainable in future. The main agencies involved are Ministry of Water and Power, Planning Commission, Finance Division, Provincial Irrigation and Agriculture Departments, Provincial Planning and Development Departments, and Provincial Finance Departments, and newly transformed irrigation agencies like PIDAs, AWBs, FOs, etc.

Institutional Measures

The institutional reforms of provincial irrigation departments are under process. The PIDs are being transformed into PIDAs for improving the operational efficiency. At the provincial level, PIDAs have been established under National Drainage Programme. The management at the canal command level is being decentralized from PIDAs to Area Water Boards (AWBs). At the distributary level, Farmers Organization (FOs) are being formed to play an increased role in the management. The FOs will have water delivery contracts with AWBs and will be responsible for water distribution, rehabilitation, assessment and collection of revenue. The water rights of FOs are still require to be formalized under institutional reforms.

Financial Measures

In the water rights context, there should be realistic pricing of water to meet the operation and maintenance cost of the system. The assessment of *Abiana* should be on realistic grounds. Cost recovery should be collected efficiently and timely. It is important to note that farmers will be willing to pay the realistic price of water, if they are timely getting their due rights. The sustainability of the system is very much dependent on the collection of *Abiana* recoveries and hence, proper attention is required to be given for monitoring the *Abiana* collections.

Environmental Measures

Water logging and salinity, over-exploitation of fresh groundwater, disposal of drainage effluent, and water quality are the main concern in water rights system which should be properly observed to meet the desired standards.

Legislative Aspect

Although, there are a large number of provincial acts and ordinances passed from time to time to cover the water rights aspects of various uses in Pakistan, but these legislations have not fully covered the composite well-defined water rights system. The existing laws have overlapping and conflicting provisions in many provincial and federal laws. Therefore, there is a need to add, delete and modify various provisions and to cover the drastically changed condition to define clear water rights based on the ground realities. There is also a need to enhance delegation of powers and organizational capacities of the newly created autonomous Provincial Irrigation and Drainage Authorities (PIDAs). There is a need for effective regulatory bodies to exercise proper management and quality controls over the well-defined water rights system.

II. Groundwater

The unchecked and unregulated use of groundwater in the country has given birth to a number of problems which have surfaced mainly due to absence of effective groundwater laws and institutions, which are briefly discussed as follows:

- Waterlogging: The groundwater hydraulic system was in a state of dynamic equilibrium before the introduction of perennial canal irrigation in Pakistan. The recharging of groundwater reservoir and balanced discharge was considered over a moderately long

period of time and there was not a long-term rise or fall of watertable. The natural hydraulic equilibrium was changed by the introduction of canal irrigation system. The introduction of canal irrigation system caused additional factors of recharge which resulted in rise of watertable in and around the commanded areas. The rise of water levels remained continue and until 1960, the rising of watertable had become a hazard and it was reached to such levels that a considerable area of the country was subjected to menace of waterlogging and salinity. According to an estimate, 40% of total irrigated area became under waterlogging followed by salinity.

In order to control the hazard, the government had launched the 'Salinity Control and Reclamation Projects (SCARPs)'. Nearly 45 SCARPs have been completed by now. However, 17% of the irrigated areas of country is still waterlogged (watertable is less than 1.5 meter etc).

- Salinity: Salinity is always followed by waterlogging. According to soil salinity survey (1977-79) in the Indus basin, covering 16.72 million hectares, 11%, 6% and 8% area was found saline as lightly, moderately and severely respectively. Similarly, 38% of total surveyed profiles were found affected by salinity and sodicity.

- Groundwater Depletions: Although, the rising of watertable has been a continuous problem, but acceleration in groundwater use has lead to a problem of falling the watertables in many areas.

  A NESPAK study (1991) shows that pumping exceeds recharge by 8.45 MAF in Punjab.

  SCARP monitoring organization (SMO) has maintained a network of 6700 observation wells in the canal commands of Pakistan where watertable depths are measured twice a year. According to SMO, the area under watertable depth of 1.5 to 3.0 meter has decreased from 39.5% to 30.2% during the period from 1978 to 1999, while area under watertable depth more than 3 meter has increased from 48.6% to 52.5% from 1978 to 1999. Similarly, there is a trend of falling watertable in 26 canal commands out of 41 canal commands.

- Saline Water Intrusion: Possibilities of saline water intrusion in FGW areas from adjacent SGW areas also exist in the Indus plains. Some areas located in the near vicinity of down gradient of saline zones are threatened with the potential hazard of saline water intrusion. SMO has maintained the water quality data of public tubewells with respect to space and time. According to SMO, the quality of large number of useable water quality tubewells deteriorated with passage of time. For example, in the areas of SCARP-III and SCARP-IV, the percentages of fresh water tubewells have been decreased from 81% to 73% and 90% to 76% respectively.

- Secondary Salinization and Alkalization of Soils: Nearly, 70% of tubewells in the country are pumping water which is unfit for irrigation. The application of such water to soils is causing the salinization and alkalization of soils.

- Groundwater Pollution: In Pakistan, under extremely poor conditions of municipal facilities, including disposal of human and other municipal wastes, there is a growing use of fertilizers, pesticides, and insecticides in agriculture. Untreated industrial wastes are being disposed into drains and ponds. The chance of groundwater pollution with municipal, agriculture and industrial pollutants have greatly increased. As such, proper record of the nature and extent of this pollution is not available which needs to be carried out.

In order to address the groundwater issues, well defined strategy needs to be evolved. The strategy should involve:

- Detailed information on groundwater potential in various parts of the country through a sound monitoring system;
- A legislative-cover (law or bylaws) under which the institution, responsible for groundwater management/regulation, should be able to take necessary actions/interventions in the critical areas;
- Establishing an institutional set-up to carry out necessary tasks from policy making to field level implementation; and
- Awareness and active participation of groundwater users.

The following initial steps are recommended:

Drafting of Comprehensive Groundwater Act

There is a need to draft a comprehensive groundwater act in the country. Following legal principles should be considered as the guiding principles:

- Groundwater as public property (shared resource);
- Usufruct right in groundwater;
- Non-exclusive usufruct right in groundwater;
- Transmission of scarcity value of groundwater to all; and
- Penalties for mis-users.

Establishment of Proper Groundwater Institutions

There are mainly two approaches being followed for institutional development. One is centralized approached with government as main player in management of the resource. There are government offices from top to bottom to carryout the management task. Such approach is mauled with inefficiency, corruption, bureaucratic actions and is being discarded all over the world. The other is highly decentralized approach with local community as main player in management of the resource. There is worldwide tendency to develop such institutions. In many advanced countries, these local control institutions are successfully working to respond the groundwater management issues. Although, Groundwater Management Districts (GWMDs) in western united state is the classical example of such local control institutions but Pakistan has its own environment. There is a general failure of government institutions. Although, community institutions are being developed but their independent working is still in formative stage. There is need to develop the mix type of institutions involving the government and local community. Such institutional arrangement is proposed in Figure 4.3.

The proposed institutional set up relies more on community institutions with government's role confined to technical support and facilitation. The heart of this set up is District Groundwater Board.

(a) District Groundwater Board

The District Groundwater Board is the key organ of proposed institutional setup. It will be established in each district with District Nazim as Chairman of the Board. It would have elected members equal to number of Tehsils. These will be elected from the WUAs or Farmer members. There will be three nominated members namely, District Officer from OFWM, District Officer from Soil and Water Testing Laboratory and District Officer from Agriculture Extension. The responsibilities of the Board will be to develop policies, programmes, rules, regulations, management plans and monitoring of quantity and quality of groundwater in the

district. All the legal and administrative powers will be given to DGB for implementation of its actions. The board will be semi-government type institution.

(b) Water User Associations (WUAs)

WUAs fall below the DGB. These will implement the Board's actions and will participate in decision making of board through its elected members. These will also take part in participatory monitoring of groundwater quantity and quality and would provide feedback to the Board for its actions. These will be village level organizations.

(c) Groundwater Cell

At provincial level, Groundwater Cells will be created in agriculture department. These Cells will be supported by the Consultants. The responsibility of the Cells will be to provide technical support to DGB and take care of scale problems.

(d) Working Group on Groundwater

The working group on groundwater will be a provincial level organization. It will be a policy making and coordinating body. It will provide policy guidelines to DGBs and coordinate among various agencies which are involved in groundwater. The composition of working group will be as follow:

Minister for Agriculture	Chairman
Secretary Agriculture	Member Secretary
Secretary Irrigation	Member
Director General EPA	Member
Director General IWASRI	Member
Director General OFWM	Member
Director General NGWC	Member
PCRWR/Representative	Member
Groundwater Specialist	Member

(e) National Groundwater Council

This will be national level institution dealing with groundwater. It will provide technical support to provincial and district level institutions. It will also take care of scale problems. The policy and legal guidelines will also be provided by this institution. The present SMO may be converted into this council. It will be headed by DG and will be under WAPDA.

Groundwater Management

Some provisions exist for the management of groundwater but they are inadequate for the situation that Pakistan now finds itself. Paper No. 5 for Groundwater Management describes the groundwater situation in Pakistan and that detail is not repeated here.

There is no conjunctive use philosophy incorporated in the managements of groundwater resources. Good practice in groundwater management is mitigated against by the underlining belief that groundwater ownership is attached to the land above it. This approach has been abandoned in almost every case where groundwater resource is scarce.

Any change to this arrangement will need careful consideration and management. Progressive implementation is recommended with the most stressed areas being targeted as to review the groundwater acts and design a regime suitable for the current situation in Pakistan that would allow for progressive implementation. The regime would need to separate land ownership from groundwater and establish appropriate arrangements for managing restrictions. It is

unlikely that individual measurement of every bore would be used initially. It is more likely that a system of restrictions based on drawdown would be used. It is not proposed that a fully conjunctive use regime be implemented in the early stages but any modifications to the Acts should enable this to occur over time, if needed.

III. Flood Irrigation and Hill Torrents

The main issue with respect to water rights in flood irrigation and hill torrents is the equitable distribution of water between upstream and downstream users. The existing customary water rights favour the upstream users in any case of excess and shortage of flood water. Hence, the downstream users suffer in both conditions.

There is a dire need of clearly defining the water rights for protecting the requirements of downstream users. Therefore, the suggested solution of the above issue is to redefine the water rights for both flood irrigation and hill torrents.

IV. Cities and Towns, Industry and the Environment

According to 1998 Census Report, the population of Pakistan is 131.51 millions with urban and rural population 30% and 70% of the total population respectively (Table 4.1). It is anticipated that by the year 2025 the urban population would increase by 130 percent while the rural population instead of declining, would again be 11 percent higher. However, the urban population will increase out of proportion. Thus, the urban water supply and sanitation, requiring centralized systems would have to be greatly expanded. Similarly, industrial water use would also go up significantly. It is estimated that domestic and industrial water uses would account for 15 percent of the available water resources as against the present 3 percent. These additional requirements would represent a severe competition with other demands. Therefore, security for the future water rights for domestic and industries uses is required to be provided on top priority.

The future domestic and industrial water supplies would have to depend largely on the groundwater, as at present, where this source accounts for 70 percent of the supplies. This would place a great challenge for the water rights management, particularly, to manage the groundwater aquifers, which are already fully exploited and whose water quality is threatened by degradation.

The use of water for agriculture and people will have serious implications on the water rights for environment. The main areas of impact include water quality, water pollution, waterlogging and salinity, regulation of groundwater abstraction, disposal of saline effluent, etc. These areas have been discussed in the previous sections in the context of water rights.

There is a need to provide adequate water allocation for livestock, plots, birds alongwith the protection of wetlands to improve and sustain the ecosystem and environment.

The key issues relating to water rights for cities and towns, industry and the environment have been summarized as under:

- Meeting the needs for water of the growing population, which would represent a competing demand for water;
- Meeting the needs for water of the mega cities more than twice the present size;
- Providing health security, by the provision of safe drinking water;
- Providing safe disposal of the sewerage and industrial effluents;
- Provision of adequate water allocation for livestock, plants, and birds; and
- Protection of wetlands.

Following options are suggested to address the issues:

Adequate Water Supply for Drinking Water

Proper planning is required to arrange adequate water supply for drinking water to the cities/towns keeping in view the growing population needs. This will require the data collection from provincial local government departments, such as Public Health Engineering Departments, Water and Sanitation Agencies, and Municipalities etc.

Improvement Measures for Drinking Water Quality

Proper planning is required to setup water treatment plants to provide safe drinking water to the people. Frequent chlorination of water is required, particularly, where water is stored in the open ponds/tanks. Cleaning of water ponds/tanks should also be done on regular basis. Separate ponds should be provided for animals.

Safe Disposal of the Sewerage and Industrial Effluents

Proper arrangements are required to treat the sewage and industrial waste water before disposal into water ways and water bodies.

Monitoring of the Ecosystem

A basin-wide body should be setup to monitor ecosystem in the wetlands and to make recommendations for its improvement and sustainability.

Protection of Natural Resources and Environment

A study should be carried out to determine existing and future basin-wide water requirements to sustain existing and future ecosystem and environment and to recommend water allocation for natural resources and environmental protection.

Allocation of Water for Livestock, Plants, and Birds

A study should be carried out to determine existing and future water needs of livestock, plants and birds in the country and to recommend water allocation for this purpose.

5. Review of Water Rights Reforms under NDP and Suggested Options

The on-going NDP constitutes the first phase of the 25 years perspective plan which was prepared with a view to restore environmental sustainable irrigated agriculture in Pakistan as a whole with special focus on the Indus Basin. This was foreseen to be achieved through the following three specific interventions towards:

- Minimizing saline drainable surplus;
- Eventual evacuation of saline effluent from the Indus Basin to the Arabian Sea; and
- Improvement in operational efficiency at the provincial level through a package of institutional reforms based on establishment of Provincial Irrigation and Drainage Authorities (IDAs) in place of the existing Provincial Irrigation Departments, Area Water Board (AWBs) and Farmers' Organizations (FOs) at the distributary canal command level.

Institutional reforms is an important objective of NDP. The nation-wide programme of institutional and policy reforms, launched under the NDP to involve the farmers and the private sector in the operation, maintenance and management of irrigation and drainage infrastructure, is aimed for the establishment of autonomous organizations at the level of the four provinces and at the level of all 43 canal systems as well as at distributaries and minor canal levels. The institutional reforms envisaged that:

- Provincial Irrigation Department would be transformed into autonomous, self-accounting and self-financing Provincial Irrigation and Drainage Authorities (PIDAs)
- Below the PIDAs, financially self-accounting Area Water Boards (AWBs) would be created, preferably along canal commands, for managing and operating the irrigation and drainage systems.
- Below the AWBs, Farmers' Organization (FOs) would be formed at minor or distributary level.

The status of implementation of the Institutional reforms as end of October 2004 is briefly described hereinafter[1].

Sindh: Sindh has made the considerable effort to implement the institutional reform as described in NDP. SIDA was established in 1998 under which 3 Area Water Boards (AWBs) have been formed, 196 FOs have been organized, and 154 distributaries/minors have been transferred to FOs out of which 116 FOs have started the collection of Abiana (Table 5.1). The performance of FOs in terms of management of system, assessment and collection of Abiana shows positive change.

Punjab: Progress in the Punjab is slow and it has made certain changes in the institutional reforms programme as envisaged in NDP. The revised PIM model adopted by the Punjab Province involves a joint management period of 2 years before the transfer of systems to FOs. Under the reform component, PIDA and one Pilot Area Water Board (AWB) at LCC East has been established in the year 1997 and 2000 respectively. At the lower level, 365 Nehri Panchayats/FOs have been established, out of which 158 are in Pilot AWB, 140 are outside AWB and 67 are for lining of canals. Punjab PIDA has provided training and capacity building to 126 Nos. of Nehri Panchayats through its social mobilization and training cell headed by the Deputy General Manager and Training Coordinator. There is an understanding that after

[1] The progress on implementation status of the institutional reforms have been taken from the office of Office of the Chief Engineer, NDP, WAPDA, Sunny View, Lahore.

completion of the training, capacity building and joint management period, Irrigation Management Transfer will be made to 32 Nehri Panchayats before December 2004. The amended rules for FOs and pilot AWB have been cleared by the Punjab Reforms Committee.

NWFP: NWFP has also expressed interest in continuing the reforms and has taken important initial steps to empower FOs to collect and retain Abiana. The FIDA was established in 1997 and the pilot AWB has been notified in Lower Swat Canal System. Against the target of 116 FOs in the Pilot AWB, 24 FOs have been established and transfer agreement signed with 19 FOs.

Balochistan: The reports have shown that the government of Balochistan remained out of NDP from January 2001 to September 2003. The progress on implementation of the Institutional reforms in the province has been very slow and there is no significant progress to report so far. Judhair and Gandhaka distributaries located in Pat Feeder and Khirthar canals respectively were identified as pilot schemes for the formation of FOs and an AWB for Pat Feeder and Khirthar Canals was notified in August 1998 however it is not fully functional.

The data on PIDAs, AWBs, and FOs established under NDP in different provinces is summarized in Table No. 5.1

In order to meet the future water requirement with its continuous rising demand, the Government of Pakistan realized that this emerging situation can only be resolved by involving the actual water users in making decisions for better water distribution, operation and maintenance of distributary/minors and revenue (*Abiana*) collection, which will ensure the users water rights. It is expected that this will encourage the farmers in making their investments with full confidence and ultimately support the surface water pricing at more realistic level. This will considerably reduce the gap between the revenues and the O&M costs, which is not only a financial burden on the provincial governments but the later is naturally not providing sufficient funds for adequate O&M of the system. The GOP's decision to introduce the participatory irrigation management approach, is an important factor to improve the existing situation to satisfy the users with self-assurance for their water rights.

In view of the foregoing discussion, it is desirable to follow the 'Good Practice Approach' rather than 'World's Best Practice'. The ongoing institutional reforms should be critically reviewed and examined to identify the suitable activities for future programme. Milestones should be realistically fixed for each activity. The existing problems and bottlenecks should also be quickly attended by the responsible agencies.

Effective coordination cell at higher level, preferably in the Ministry of Water and Power, should be created with adequate funds, staff and logistic support. Periodic follow-up meetings, preferably on quarterly basis, should be regularly conducted in the provinces on rotation basis. These meetings should have the participation of Federal, Ministry of Water and Power, Finance, Planning Commission, Food and Agriculture, representatives of Provincial Governments, Irrigation and Agriculture Departments and donor agencies etc.

6. The Way Forward

In order to efficiently develop and manage the water rights system of Pakistan and to ensure quality as well as availability of water to meet the growing needs across all sectors, there are a number of proposed short/medium/long term actions at various levels that need to be taken, which are outlined below.

International Level

1. Improvement of the Indus Waters Treaty, 1960, if possible.
2. Appointment of a neutral expert on treaty matters.

National Level

1. Strengthening of Indus River System Authority (IRSA).
2. Activation of the Council of Common Interest (CCI).
3. Establishment of the telemetry system on regular basis.

Canal and Distributary Levels

1. Establishment of 'Clear Water Sharing Agreement' between the canals within a province.
2. Establishment of 'Register of Water Rights' at canals and distributaries.
3. Revision of Head-Discharge relationship tables at the heads of canals and distributaries.
4. Revision of canal water allowances.
5. Enhancement of the capacity of irrigation system.
6. Lining of irrigation channels in saline groundwater areas.
7. Provision of more storages of water to ensure reliability of irrigation supplies.

Individual Level

1. Lining of watercourses.
2. Appointment of adequate trained staff.
3. Establishment of 'Register of Water Rights' – in phased manner.
   1st phase: Documentation of the existing water rights of individuals, reasonably defined by area and times, without reasonable registry system – by ending 2005.
   2nd phase: Documentation of the clearly defined water rights of individuals, with proper registry system – by ending 2008.
   3rd phase: Documentation of the well-defined water rights of individuals, converted into volumes, with systematic registry system – by ending 2012.
4. Conversion of discharge measurement from time-based to volumetric unit– by ending 2010.
5. Development of the mechanism for conjunctive use of surface and groundwater.
6. Development of the mechanism for realistic water pricing.

Other Proposed Actions (Common at Various Levels)

1. Taking measures for Effective Inter-Agency coordination.
2. Taking measures for Continuation of on-going institutional reforms under NDP.
3. Preparation of a comprehensive water law.
4. Preparation of the regulatory framework for groundwater usage.
5. Establishment of groundwater institutions.
6. Arrangements of providing adequate dinking water supply water to the cities/towns.
7. Conduct a study to determine the allocation of water for livestock, plants and birds.
8. Taking improvement measures for providing safe drinking water to the people.
9. Arrangements for safe disposal of the sewerage and industrial effluents.
10. Establishment of a basin-wide body for monitoring of the ecosystem.

What is important, however, is that a process be put in place to improve the system so it meets a best practice approach to water rights and their management.

In this regard, it is important to note that a critical first step is to record the current rights of individuals and resolve any outstanding disputes. This will enable individuals to have a clear understanding of their entitlements within the current water management regime.

The current time based allocation system, if adequately documented, could provide a stable base for management in the short to medium term. The time based, rather than volume based system, has been used for 120 years and is a surrogate for a volume based system. In some areas it will be sensible to convert to a volume based system, particularly as new technology is introduced (raised beds or micro-irrigation). The current water rights system provides no incentive to reward good on-farm water management behavior. If an irrigator saves water then he can either apply it to his land or reduce his rostered time. The system could be enhanced to enable efficient irrigators to be rewarded by being able to trade the unused part of his water right. It is not suggested that there be a blanket move to a volume based system as the necessary administrative pre-conditions do not exist. However trials should be incorporated in selected areas as they move to self management and look for way to enhance performance.

There are already informal water trading systems in place and these will continue. A volume based system will enhance water trading opportunities as individuals become clearer about both the security and reliability of their allocations.

Engineering solutions alone will not significantly change the water supply challenges facing Pakistan. Governments will need to ensure that there is an effective water rights system in place at all levels if its objective is to enhance production from within the current water resource base. On the available information, regulated water supplies may at best grow a small amount but are more likely to reduce.

Table 4.1: Expected Water Requirement and Sewage Flows for the Projected Population under Various Planning Horizons

Sr. No.	Year	Population (Million)			Water Demand (MGD)					Sewage Flow (MGD)		
					Urban		Rural		Total	Urban	Rural	Total
		Urban	Rural	Total	Rate (gpcd)	Demand	Rate (gpcd)	Demand		80% of Water Demand		
1	1998	42.91	88.60	131.51	50	2146	10	886	3032	1716	709	2425
2	2000	45.91	91.60	137.51	50	2296	10	916	3212	1836	733	2569
3	2005	54.27	97.80	152.07	50	2714	10	978	3692	2171	782	2953
4	2010	64.34	102.37	166.71	50	3217	12	1228	4445	2574	983	3556
5	2015	76.60	105.13	181.73	50	3830	15	1577	5407	3064	1262	4326
6	2020	90.81	104.76	195.57	50	4541	18	1886	6426	3632	1509	5141
7	2025	105.96	102.10	208.06	50	5298	20	2042	7340	4238	1634	5872

Source of Population: PWP, 1999, Pakistan Country Report: Water Vision for 21st Century.

Table 5.1: Province-Wise Implementation Status of Institutional Reforms

Province	Activity	Target	Achievement	Remarks
Punjab	• PIDA	• One	• One	Partly functional.
	• AWB	• One	• One	LCC East Pilot AWB. Expected to be fully functional in July 2005.
	• FOs/NPs	• 89 Nos.	• None	In Pilot AWB.
			• 140 Nos.	Outside AWB.
			• 67 Nos.	Formed for lining of canals.
	• Transfer of systems to FOs	• TBD	• TBD	TBD = To be determined.
	• Abiana Collection through FOs		• 3 Nos.	In Fordwah Sadiqia Canal Command.
Sindh	• SIDA	• One	• One	Functional for three AWBs.
	• AWB	• One	• Three	Nara Canal, Ghotki Feeder & West Bank Canal AWBs.
	• FOs	• 166 Nos.	• 162 Nos.	Nara Canal Command.
			• 13 Nos.	Left Bank Canal Command.
			• 12 Nos.	Ghotki Canal Command.
			• 9 Nos.	Outside the AWBs
	• Transfer of systems to FOs		• 154 Nos.	
	• Abiana Collection through FOs		• 116 Nos.	
NWFP	• FIDA	• One	• One	Partly functional.
	• AWB	• One	• One	Swat Canal Pilot AWB.
	• FOs	• 116 Nos.	• 24 Nos.	
	• Transfer of systems to FOs		• 19 Nos.	Only agreements are signed.
	• Abiana Collection through FOs			
Balochistan	• BIDA	• One	• One	Not functional.
	• AWB	• One	• One	-
	• FOs	• Not specified	• None	
	• Transfer of systems to FOs		• 40 Nos.	Under Balochistan Community Irrigation & Agriculture (BCIA).
	• Abiana Collection through FOs			

Source: Progress Report of the Provinces available in the Office of the Chief Engineer, NDP, WAPDA, Sunny View, Lahore.

Figure No. 1.1: Projected Water Requirements in Pakistan

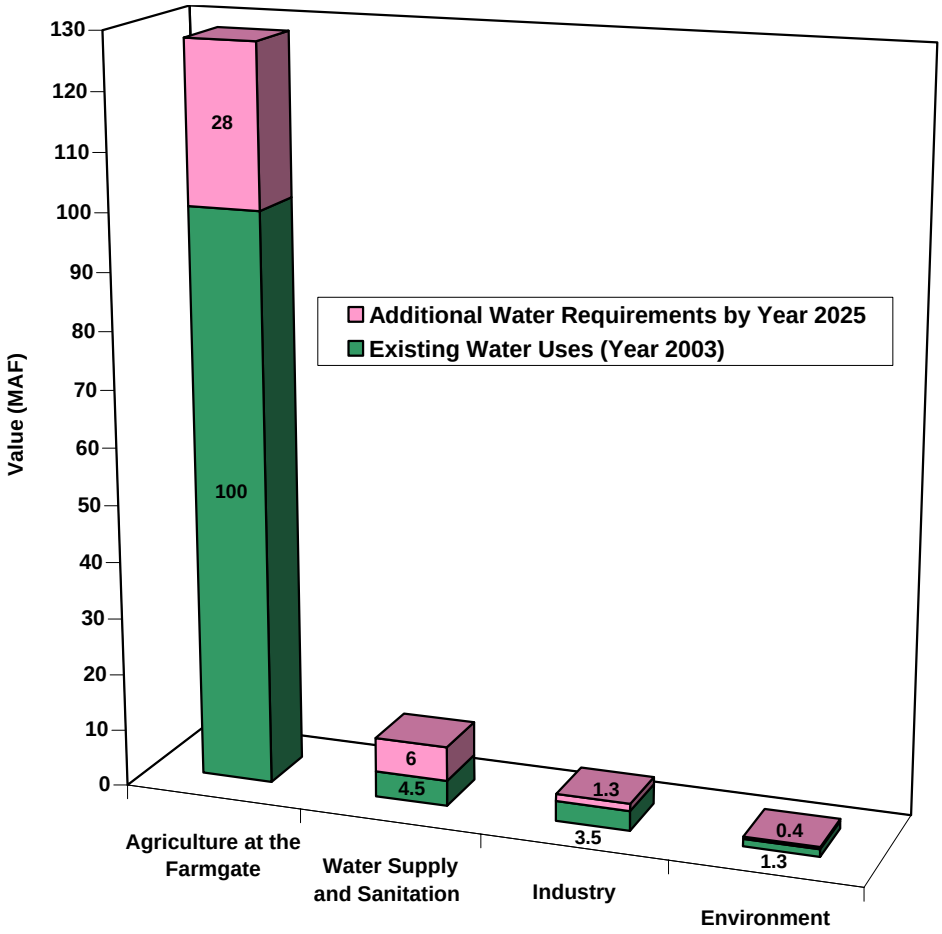
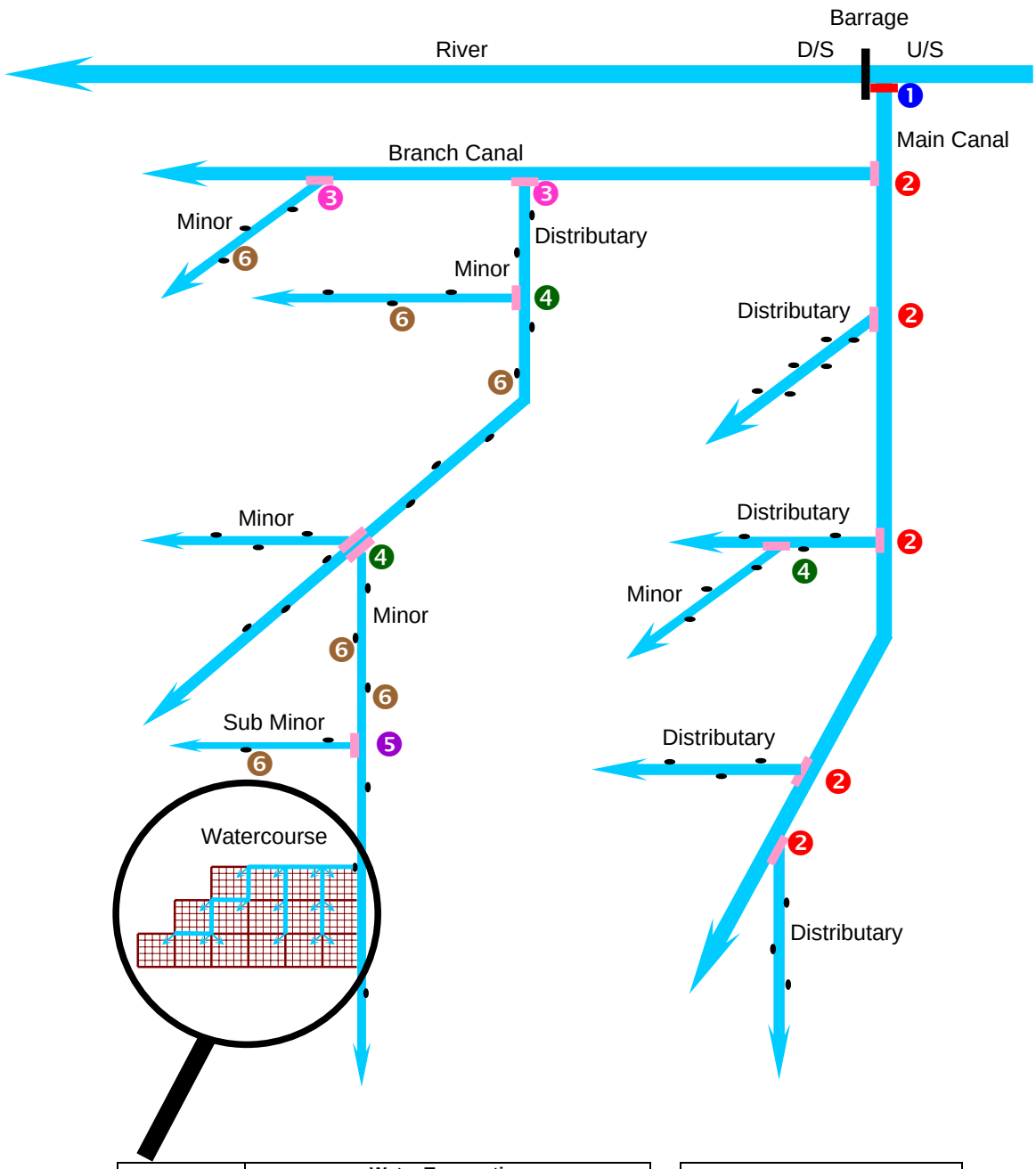


FIGURE 4.1: IRRIGATION SYSTEM OF PAKISTAN

WATER TRANSACTION IN A CANAL COMMAND

(Typical Schematic Diagram)



Transaction Point	Water Transaction	
	From	To
1	Barrage	Main Canal
2	Main Canal	Branch Canals/ Distributaries
3	Branch Canal	Distribuatries/ Minors
4	Distributary	Minors/ Watercourses
5	Minor	Sub-Minors/ Watercourses
6	Sub-Minor	Watercourses

LEGENDS			
	Barrage		
	Head Work		
	Head Regulator		
	Mogha/ Outlet		
	Field		Turnout

Figure 4.2: Process of the Establishment of Register of Water Rights and Conversion of the Discharge Measurement from Time Based into Volumetric System

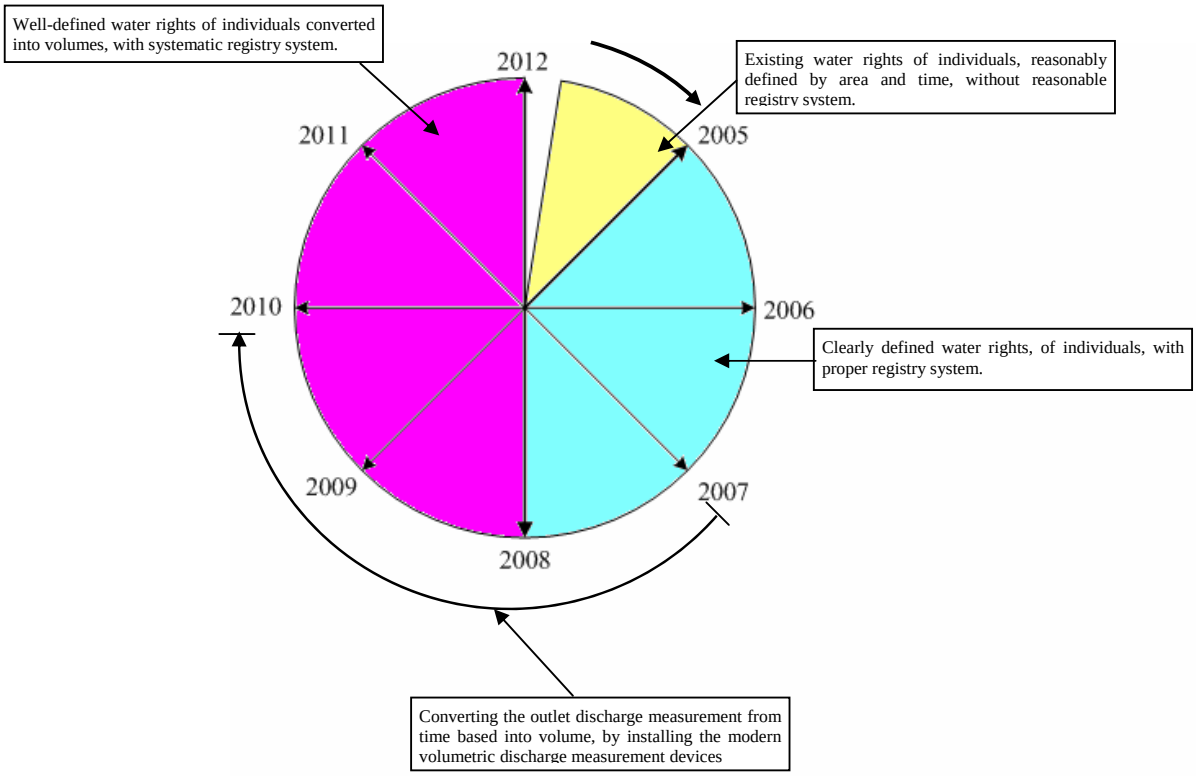
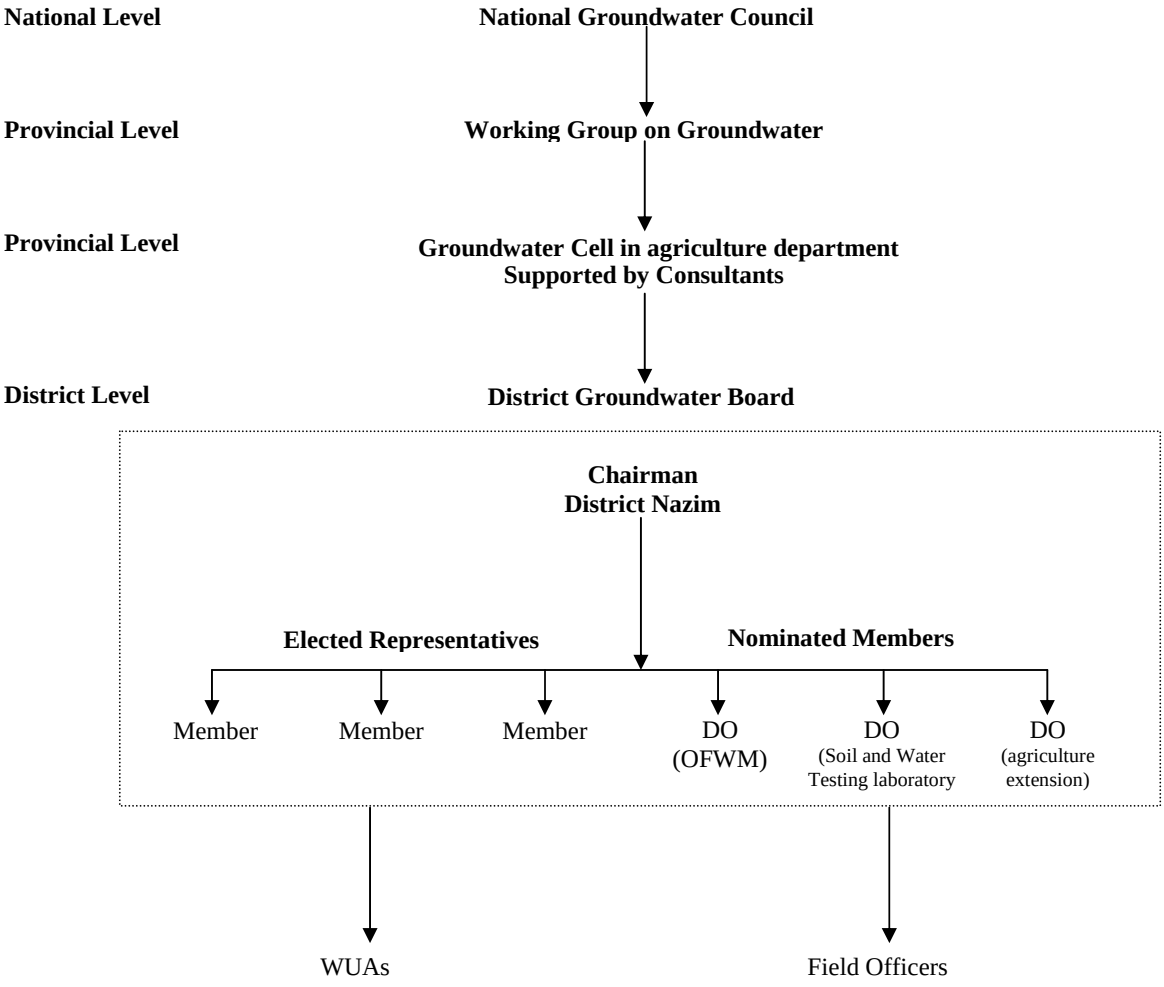


Figure 4.3: Proposed Organization Setup For Groundwater Management



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Sustainable, Accountable Institutions

By

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Country Water Resources Assistance Strategy
Background Paper # 7
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SUSTAINABLE, ACCOUNTABLE INSTITUTIONS

Sardar Muhammad Tariq and Shams ul Mulk

1. CURRENT STATUS

Pakistan carries a long and rich history of dealing with irrigated agriculture along with cultural and religious practices. Cities and villages had community wells conveniently located to serve urban and rural dwellers. In more arid region of the country, the source of water has been quite at a distance. Similarly biological sanitation was generally practiced in both rural and urban areas. In urban areas the human and animal excreta was usually collected in Municipality Bins and carried to the open fields for natural decomposition which was in turn collected by farmers and used as manure for their crops. The irrigation system was managed by Irrigation Department, while water supply and sanitation, as the system entered modern era, with the introduction of piped water supply, was the responsibility of Municipalities which employed technical people to design, construct and maintain infrastructures. Both institutions were in the public sector fully governed by the civil services rules. These institutions worked quite satisfactorily as long as population was small and water was in abundance. However, rapid increase in population put everything out of grip – institutional capabilities, delivery services, infra-structural arrangements, aquifer, ecosystem, cost recovery, etc.

The water resources development and management closely followed the growth in all sub sectors. With the looming grain shortages due to rapid population growth, the Government realize the critical importance of the agriculture sector and the need to achieve food self-sufficiency. Special efforts were, therefore, made to increase water resources to enable expansion of cropped area and increase productivity. Massive investments at the Federal and Provincial levels went into the construction of infrastructures for sharing and delivering surface water to the expanded areas and installing a large number of tubewells in the sweet water zones. This paid dividend and soon Pakistan achieved food autarky. Presently Pakistan's irrigated area accounts for only 22.5% i.e. 18 Mha out of 79.6 Mha total landmass. This 22.5% irrigated area supports Pakistan's agriculture which is its single largest sector of economy. Agriculture accounts for 25% or more of GDP, although its share in the GDP has been decreasing over the years as other sectors expanded, still 68% of the rural population depends on agriculture, which employs 46% of the labour force and accounts for 60% of foreign exchange earnings. Similarly in other sub sectors Pakistan has made tremendous progress and inspite of its meager finances, put in maximum

endeavors to catch up in providing services to rapidly growing population particularly in the urban areas where massive rural population migrated.

Pakistan started from a water affluent status where per capita availability was around 5,650 m^3 in 1951, which has now declined to around 1,300 m^3 and is hampering the health and well being of the population and affecting the economic activities of the poor. Accessing adequate clean water is one of the principal concerns in both urban and rural areas with appalling sanitation conditions. Similarly salinization and aquifer depletion are threatening ecological balance, once fertile lands have been laid waste due to salinization. Some massive efforts indeed were put into combating twin menace of waterlogging and salinity. These efforts at high cost did arrest and in many cases reversed the situation and once non-productive land was brought back under production. However, these efforts in the other areas did not lost for long and wide spread water pollution resulted in increased water scarcity, poorer public health, lower agricultural yields, and a declining quality of aquatic life in lakes, rivers and costal waters. The poor are often landless and farm marginally productive areas. Forests are depleting, biodiversity is being adversely affected, catchment areas are deteriorating, flooding is frequent and groundwater recharge is diminishing. Watershed and ecosystems are being severely degraded. The pollution of water bodies has increased the incidences of water borne diseases in rural and urban areas alike. The urban poor are compelled to spend disproportionately large part of their scarce disposable income on water from private vendors. With falling rural economy, continuous migration to urban cities has created large slums without water and sanitation facilities.

Water security therefore, is a rapidly growing issue. The threat of inadequate safe water is real. Storages created to provide better management facilities are fast depleting - at the same time, water is key development ingredient that impacts on variety of factors that sustain and enhance life. As a critical natural resource, the issues connected with managing it are inherently diverse and complex. They involve questions of allocation and distribution, equity, conservation, pricing, regulation, education, participation and sustainable use. With Pakistan's rapid population growth, shifting agricultural economy to industrialized economy, increasing environmental degradation and pollution and the specter of dwindling resources, stakeholders are now emphasizing the need for integrated water resources management in a comprehensive and holistic manner. It is widely recognized by water users that Pakistan lacks effective policies to regulate water allocation and conservation – legislation to grant users rights to water and to empower the users to protect and advance their rights is absent. Responsibilities for managing water are fragmented. Though evolution in institutional arrangements has been taking place, there is still general lack of institutional capacity to deliver services and manage water resources efficiently. The way forward therefore, is to bring about effective legislation changes, adopt

more holistic approach to resources management and involve communities for a renewed process for improved resources use, delink land from water, introduce more clarity in the entitlements, initiate process of correcting water prices for all sub sectors.

1.1. Prevalent Legal Framework for Managing Surface and Ground Water

The edifice on which water governance is based is the old Canal and Drainage Act of 1873 amended from time to time. Under this Act, the Government was entitled to use and control for public purposes the water of all rivers, streams, lakes and natural collection of water or natural drainage channel and water storage or conveyance works including storage reservoirs, canals, embankments, and hydraulic structures, all water courses, drainage works and movement of vessels in the water ways. The Act provided comprehensive governance pattern and gave extraordinary powers to the canal officers for complete control over infrastructures and their development. Levying water charges, power to hear appeals and give decision, prepare water schedules and even supply water to cities and towns and impose penalties for violation of the Act. The scope of the Act was further enlarged to include legislation for ground water, environment, fisheries etc. but the ownership of both surface and ground water remained with the owner of the land and was transferable whenever a transfer of such land took place. Under Pakistan's Constitution, water resources management and development within a Province still remains the responsibility of the Provinces, and to large extent is still being governed under framework of Canal and Drainage Act of 1873, revised by the Provinces according to their legal requirements. However, with the formation of Provincial Irrigation and Drainage Authorities (PIDAs), Area Water Boards (AWBs) and Farmers Organizations (FOs), together with devolution plan the whole governance pattern is in state of transition (but not without facing some serious transitional problems). Devolution process is a welcome step where local elected governments with popular community support would form future governance pattern, but definitely need both management and technical skills for developing a strong, responsive and transparent institutional framework.

At the national level, the development and distribution roles are divided between two predominant institutions. The development role was assigned to Water and Power Development Authority (WAPDA) in 1958 under an Act, which now has a long and impressive history of water resources development in Pakistan alongwith development of power sector and combating twin menace of water logging and salinity. In earlier stages, WAPDA along with Provincial representation, was also responsible for regulation and apportionment of water between the Provinces. However, the distribution aspect of water was later taken away from WAPDA and Indus River System Authority (IRSA) was created

under an Act of Parliament to distribute water and resolve disputes among Provinces.

1.2. Governance pattern in management of water from trans-boundary to the local level.

1.2.1 Trans-boundary:

Trans-boundary water management is the responsibility of Commission on Indus Waters headed by Commissioners in both India and Pakistan to ensure Indus Waters Treaty of 1960 is followed in letter and spirit. Regular hydrological data is exchanged between the two countries in addition to the visits on regular basis of the Commission of one country to the other to physically observe and see no violation of the Treaty whether structural or non-structural is taking place in either of the country. The Treaty also provides an elaborate mechanism for resolving disputes, bilaterally and in case solution is not achieved then any party can request for arbitration.

1.2.2 National level:

At National level, when water enters the country, the role of its management, development, regulation and distribution becomes the responsibility of two different institutions under the prevailing arrangements. Whereas WAPDA as federal autonomous body is responsible for water resources development, operation and maintenance of large inter-Provincial infrastructures, upkeep and safety of these structures, hydro and thermal power development and its distribution (this part of WAPDA is being unbundled presently), and tackling water logging and salinity, the regulation and determining shares of each Province is being done under Inter-provincial water apportionment accord of 1991 by IRSA formed under an act in 1992.

1.2.3 Provincial level:

The water management within a Province for all sub sectors of water is handled by various Provincial departments on fragmented pattern with little inter-departmental coordination, though each sub sector has contributed enormously. Water for irrigation purposes was handled by Provincial Irrigation departments which now are under the process of transformation into Provincial Irrigation and Drainage Authorities (PIDAs) by involving Farmers Organizations. Further changes are in process whereby most of the control on water management would get transferred to local elected governments under the devolution plan which would include water supply to rural and urban areas including drainage and environment.

1.3. Role of WAPDA and IRSA

1.3.1 WAPDA:

WAPDA was created to develop Pakistan's water and power needs on a unified basis. Its role as a major development institution became over-dominant when it was assigned to undertake some of the largest civil engineering projects in the history of the world to provide Pakistan with hydraulic infrastructures and water storages which became absolutely essential under International Water Treaty of 1960. Going back into history of creation of WAPDA, a more autonomous body was absolutely essential at the National level to execute mega projects. With the assistance of foreign consultants and on-the-job training of WAPDA's local engineering, financial and administrative staff, WAPDA as an institution was developed into an efficient, technically sound and competent institution with no match within the country. Governments both at the National and Provincial levels looked towards WAPDA for taking over new challenges in water and power sectors. As a result WAPDA was assigned the responsibility to combat the twin menace of water logging and salinity in all the four Provinces together with extending power transmission and distribution system. When WAPDA took over the energy sector in Pakistan, the total energy generation capacity was 119 MW which today stands at 17,713 MW. WAPDA under its Vision 2025, plans to add another 12,350 MW by 2015 to meet anticipated power shortfall. Similarly transmission lines were extended from 6,881 KM to 357,884 KM and consumer numbers increased from 0.31 million to 12.4 million and number of villages electrified increased from 609 to 70,449. So in general words the performance of WAPDA matches and even exceeds any other similar organization in the world. However, as is true for any other institution, WAPDA rapidly grew to a size and with diversified responsibilities and services that it became difficult for WAPDA to maintain its efficiency particularly as a service provider. Reference is to WAPDA's role of power distribution and revenue collection. It was therefore, required to carefully look into WAPDA's future role and where possible it should be unbundled to improve its efficiency, revenue recovery, transparency and financial sustainability. The final step in this direction was to split Power Wing of WAPDA into distribution companies, generation companies and transmission companies. This process has been through a transition period of transformation from public sector entity to a corporate entity and finally into a private sector entity. National Energy and Power Regulatory Authority (NEPRA) has also been created to provide a legal and governing framework for the companies with the Electricity Act as legal framework. Similarly to attract private investment and provide one window operation, Private Power Investment Board (PPIB) has also been created to establish level field for both local and international investors.

WAPDA as it stands today still remains the only responsible institution to undertake mega projects both in water and power sectors. It is a fact that WAPDA's overall performance has declined over the years along with decline in its technical and management competency due to encroachment in its autonomous status by both administrative ministries and politicians. Inspite of these factors, WAPDA still on merits, remains the only efficient institution at the national level for handling mega projects in foreseeable future. But under scarce water situation and growing population, the management of water for all sub sectors would get more prominence and importance in order to reduce disputes among various competing demands and within sub sectors. Whereas institutional reforms and strengthening would be required in sub sectors, WAPDA's role at the national level would also need to be looked into – along side WAPDA's role of water resources and hydropower development, its future role will shift with more emphasis on operation and maintenance of inter-provincial infrastructures including national storage reservoirs, watershed management and protection of major rivers from pollution.

1.3.2. Indus River System Authority:

Indus River System Authority was formed under an Act of Parliament in 1992 with a clear mandate to ensure equitable distribution of water between the provinces in accordance with the Inter-Provincial Water Apportionment Accord of 1991. The accord clearly defines shares of each Province based on their historical uses and provides fixed percentages of shares of each Province from future storages and shares from the flood flows and provides guidelines for sharing shortages and surpluses. The accord also emphasizes on development of future storages and recommends providing minimum flow downstream Kotri to protect biodiversity. IRSA consist of one member each from all the four Provinces of Pakistan and one member from the Federal Government. IRSA decisions in case of any dispute are based on simple majority. The term of the Chairman IRSA is for one year and members from each Province including Federal Member become Chairman on rotation. IRSA is assisted by a scanty secretariat staff. This institution seriously lacks technical competency and appropriate staff and office accommodation and is mostly dependant on the generosities of Federal Ministry of Water and Power with extremely meager budget to operate. IRSA's decisions are mostly challenged by the Provinces. The institution as it stands today is deficient in many ways and needs urgent attention in case it has to become an effective institution to resolve water disputes between the Provinces which are expected to grow greater in numbers and complex in nature as demand for more water increases.

1.4. Role of Local Government in Water Management:

Pakistan carries a long history of centralized role in water resources development and management in almost all such sub sectors of water. Whereas irrigation was mostly developed and managed under the framework of Canal and Drainage Act of 1873, water supply and sanitation was handled by the Municipalities, Town Committees in urban area and were managed by Local Governments or Public Health Engineering departments in the rural areas. Medium and mega cities now have water and sanitation authorities. All these institutions within a Province are characterized by centralized decision-making in terms of all major decisions regarding the fixing of water rates, collection and assessment system, operation and maintenance etc. The centralized system of decision-making was fueled by the failure of the Government to invest in local level institutions and the incapacity of local level institutions to regulate and mediate new and emerging problems. The Local Government institutions were unable to fill the void that existed at grass root level. The local government system in Pakistan consisted of representative institutions at the level of districts and union councils. Local councils were designed to serve as agencies for development as well as to carry out the basic functions of Local Government. Although wide powers of revenue generation and development were accorded to the Local Government institutions in Pakistan, in practice, this system of Local Government became disempowered specially in the rural areas. The development functions assigned to the local councils were too vast and their revenue base severely constrained, especially in the rural areas where public voices where weak. In addition these councils did not receive the support of democratically elected governments who saw them as potential threats and remained financially weak and incapacitated and lacked the essential links at the village level resulting in an institutional vacuum at the grass root level. However, in 1990's there was a realization that the state system had failed on several accounts including Basic Democracy Programme where elected representatives were given finances to undertake development programmes at the grassroots levels. This Programme also had its natural death due to lack of transparency and overwhelming bureaucratic control. The indicators of social sector development pointed to the failure of the public sector to deliver access to basic services. Pakistan widely is faced with such serious problems of economic and social development that it is rethinking its future strategy based on public participation in planning and development with active involvement of NGOs. This reconsideration coincides with the search by the donor community for alternate institutional arrangements in the face of failures of many of its programmes and projects delivered through the public sector. The devolution plan of the Government is a step in the right direction but would require acceptance of democratically elected bodies at the higher level of Provincial Assemblies and the Provincial Governments. In addition Local and District Governments would need tremendous efforts to enhance their technical and management capabilities to meet new and complex challenges of water

management and with the involvement of much larger cross section of stakeholders from all water sub-sectors.

In the agriculture sector to cater for additional needs of food and fiber and to remove major bottlenecks from the existing Provincial Irrigation and Power Departments, Provincial Irrigation and Drainage Authorities (PIDAs) Acts were promulgated in all the Provinces in 1997 to improve the performance of irrigation and drainage system. Under PIDAs creation of Area Water Boards (AWBs) and Farmer Organizations (FOs) were to be created in all the four Provinces. To initiate the process of decentralization, five canal commands, two in Punjab, and one each in Sindh, NWFP and Balochistan were selected as pilot areas for forming Area Water Boards. The objective for initiating pilot project in each province was to ensure their smooth working and after removing the initial teething problems, AWBs should be formed to eventually cover all canal commands in all the four provinces. The enunciated objective of AWBs was to improve upon existing water utilization judiciously and with in a period of 7 to 10 years should become fully operative as a self-supporting and financially self-sustaining units and take over planning, design, construction and operation and maintenance of irrigation, drainage and flood control structures within the unit. AWBs were also required to promote formation of Farmers Organizations (FOs) at the distributory/minor level for broader representation of stakeholders at the grass root level.

The basic idea of restructuring the irrigation departments into PIDAs was to ensure farmers participation and larger role in operation and maintenance of irrigation and drainage network. The farmers representatives nominated at water course level shall represent their respective areas on the Farmers Organization (FO) at distributory/minor level. The FOs shall then be represented in AWBs through these nominees: a real bottom up and participatory approach. This devolution in irrigation departments is still in its infancy with no clear cut legal protection, finances, education and incentives to manage water at the grass root level. In addition, these institutions at the grass root level lack experience in planning, implementation, record maintenance, revenue assessment/collection, decision-making and dispute resolution. These institutions need to be properly trained and prepared for undertaking their future role in water management, which is bound to get more and more complex as the resources get scarce against increasing demands, along side undertaking essential reforms in the irrigation utility and establishing transparent water rights. The Provincial Irrigation and Drainage Authority (PIDA), a more autonomous body created under PIDA's Act then the existing bureaucratic Irrigation and Power Departments have to put in place in all the four provinces as soon as possible. This would open up the way for the communities to start participating in their water management on more equitable and sustainable manner.

2. WAY FORWARD

Having looked into the existing legal framework and institutional arrangements in dealing with all the sub sectors of water, and having taken into account the changes brought about so far, it is apparent that Pakistan's Vision is based on firm grounds in managing water in future. The institutional reforms brought about in irrigation sub sector, the largest single consumer of national water resources, under PIDA's Act and Local Government Act and devolution plan, empowering communities and elected representatives at the grass root level is a marked change in improving services and reforming the institutions responsible for water management. Pakistan presently is in a state of transition where top-down approach is gradually being changed into bottom-up approach. Such an approach would be an ideal road map and way forward but would require myriad efforts to build capacity in the newly conceived institutions for which concerted efforts, awareness and education at each level of devolution plan would be required. A pertinent analysis of the situation and prevailing ground realities suggest that a period of transition from a minimum of 5 years to a maximum of 10 years would be required where close links between top-down – bottom-up need to be maintained to develop institutional capacity to deliver services and manage water resources efficiently.

The way forward must focus on those concepts and practices which are considered fundamental to improved water resources management and adapt principles which are not static and subject to adding specificity in the light of experience with their interpretation and practical implementation. The Dublin Principles are a particularly useful set of such principles and carry universal support. Pakistan, therefore, needs to follow these principles for its holistic approach for water management, based on participation at all spatial scale and assigning real value to the water for rational allocation. Charging for water means applying economic instrument to affect behaviour towards conservation and efficient water usage, would provide incentives for demand management, ensure cost recovery and would signal consumers' willingness to pay for additional investments in water sector. Similarly a holistic institutional approach needs to be adopted by creating a water sensitive political economy which would require coordinated policy making at all levels: from national ministerial to local governments or community based organizations.

The prerequisite would be to review present draft National Water Policy document. Since water policy would provide directions in formulating legal framework for better and effective governance pattern in future, the draft policy document needs to be reviewed by a Panel of Experts, who could amend it to the extent that the policy document provides future governance pattern which is practical and implementable in the local context and enables institutions to:

- Rationalize water charges in all sub sectors.

- Provide clear guidelines for water entitlements including groundwater.
- Enables community based organizations (CBOs) who can arrange future financing through social collateral.
- Provides guidance for separating land from water.
- Encourages water markets.
- Rationalize water allocation.

2.1 Institution to Construct Large Infrastructures and Future Role of WAPDA

At the National level, WAPDA has been the most efficient organization in implementing mega projects with the assistance of donor agencies and foreign consultants. WAPDA's in-house capabilities excelled in many ways and with its semi-autonomous structure had powers to take major technical, administrative and financial decisions. Under WAPDA's Act of 1958, WAPDA was empowered to develop water and power resources of Pakistan on unified basis. WAPDA's role still remains intact except the role of transmission, distribution and revenue collection which under the major reform process has been decentralized and assigned to corporate entities which are expected to become fully privatized in due course of time. WAPDA's future role therefore, needs to be looked into in the light of new concept of water development and management with more emphasis on efficient maintenance and operation of inter-provincial infrastructures including large storages.

2.2 Restructuring of IRSA and its Inter-Provincial Role

IRSA as a constitutional body is responsible for distribution of Indus Basin waters among Provinces based on the Inter-Provincial Water Apportionment Accord of 1991. It is unfortunate that a constitutional body has not been developed as an effective institution to resolve water issues between the Provinces – IRSA's members are proposed by Provinces without considering merits and generally lack the experience and technical competency required in water management; reservoir operations, monitoring, data analysis and have no experience of operating the distribution system based on telemetric system and to perform the duties mandated to them under the Act such as:

- To lay down the basis for the regulation and distribution of surface waters amongst the provinces according to the allocations and policies spelt out in the water accord.
- Review and specify river and reservoir operation patterns and periodically review the system of such operation.
- Determine priorities for reservoir operation for irrigation and hydropower.

- Issue operational directives to relevant authorities for releases of water from reservoirs.
- Coordinate and regulate the exchange of data between the provinces.
- Settle any question that may arise between two or more provinces in respect of distribution of river and reservoir waters.
- Consider and make recommendations on the availability of water against the allocated shares of the provinces within three months of receipt of fully substantiated water accounts for all new water projects for the assistance of the Executive Committee of the National Economic Council (ECNEC).

IRSA lacks adequate office space, financial support and secretariat facilities essential for its working. Provinces lack confidence in IRSA and often its majority decisions are contested. IRSA lacks legal power to have its decisions implemented. IRSA therefore, as an institution responsible to operate Indus Basin at the Inter-Provincial level and to resolve water disputes between the Provinces would need immediate attention and intervention for its improvement. IRSA would need a new Basin Model involving Federal Government, operating agencies – and which gives full economic aspect of water such as water for irrigation, energy, environment etc. The existing Indus Basin Model is obsolete and outdated.

The suggested reforms are:

- **Selection Criteria of Provincial Members:** Members having relevant qualification and experience of Hydrology, Hydro-meteorology, Reservoir Operations, Computers, Telemetry, etc should be hired through Provincial Public Service Commissions on merit for a specific period of 3 years. A panel of three members should be recommended and Federal Government should have the prerogative to select one.

- **Selection Criteria of Federal Member:** Member having vast experience of Basin Management, Water Laws, Reservoir Operations, Hydrology, Forecasting, Telemetry, etc should be hired through Federal Public Service Commission on merit for a specific period of 4 years. The Chairman of IRSA should always be the Federal Member.

- **Secretariat Office:** Secretariat office should be well equipped with modern telecommunication system, computers and headed by a fully qualified talented Secretary having at least MSc degree in water management and hydrology with experience in reservoir operations. Secretary should have enough technical staff for data collection, analysis, preparation of hydrographs, reservoir operational rule curves, water

availability forecasting and adequate administrative staff. The secretariat office should be fully trained to operate the New Basin Model.

- **Budget:** Adequate budget needs to be provided for the Members and the Secretariat Office to meet their full requirements including traveling to various storages and distribution points in all the four Provinces.

- **Legal Support:** IRSA's decisions should be legally binding on the Provinces and violation should have penal clauses and mechanism for realizing penalties.

- **Independent Status:** IRSA should be independent of any Federal Ministry.

- **Trust and Transparency:** IRSA should be subjected to independent audit every year. This would create trust and transparency in IRSA's distribution system.

- **Political Support: Role of Council of Common Interests (CCI):** As the scarcity increases due to increase in demand in all water sub sectors, the water management and distribution is going to become more complex and contentious. It is likely that some Provinces are not satisfied with IRSA's decisions and require redressal from higher body. Under Pakistan's Constitution (Special Provisions), a Council of Common Interests exists to resolve issues arising between the Federating Units. This Council consists of Chief Ministers of the Provinces and an equal number of members from the Federal Government to be nominated by the Prime Minister from time to time. The Prime Minister if he is the member of the Council, shall be the Chairman of the Council, but if at any time he is not a member, the President shall nominate a Federal Minister who is a member of the Council to be its Chairman. This council is directly responsible to the Parliament and is the best forum for resolving Inter-Provincial disputes. It is recommended that IRSA for its political support, should have direct access to CCI for Inter-Provincial water disputes which IRSA has failed to resolve. The endemic dispute is the sharing of shortages under clause 14(a) and (b) of the accord between the two major provinces i.e. Punjab and Sindh. Each Province interprets this clause to its benefits. IRSA needs to get this resolved through CCI.

2.3 International Experience in Managing Water on Single Basin Concept.

The idea of managing water on single basin concept, whether the basin covers one country or includes several countries is gaining momentum. Whereas there are hurdles in operationalizing single basin based on IWRM principles and sharing benefits rather sharing water in trans-boundary basins, there are equal difficulties in operationalizing IWRM principles on larger basins covering single country having a number of federating units. Similarly there are countries which have more than one river basins and each river has its own specific water related problems. With the concept of introducing IWRM in river basins, most of the existing basins are being revisited and new basins are being operationalized on IWRM concept. In trans-boundary river basins even water benefit sharing is moving much beyond and looking for broader cooperation among the basin countries with the object of:

- Benefit to the river
- Benefit from the river.
- And benefit beyond the river.

In all the continents, basin concepts for water management are either in existent or being introduced. There are mix stories of successes and failures, but moving beyond the concept of having absolute historic rights on share of waters to sharing water benefits would give direction to future way-forward in operationalizing single river basin concept with free trade of water for higher values even among the federating units.

Numerous international models are available to adopt but from Pakistan's perspective, the best model would be to analyze its own circumstances and move the river management from the present project-based management towards a resource-based water management. The Indus Basin offers three major problems: Floods where water is seen more as a problem than a resource; severe water pollution and silt load; and severe shortage with drying up of the downstream stretch. This would suggest that the Indus River should be managed based on minimum criteria for both quantity and quality starting from lower Indus Delta i.e. the downstream end. The downstream "bottom line" would be the minimum outflow necessary to keep the river mouth open to protect biodiversity. Each stretch will then be allocated an inflow from upstream and be responsible for leaving a certain outflow for the downstream river stretch. Cross sector controls should include both water quality and quantity. This would call for integrated management of numerous structures on Indus and its tributaries. Also within Indus Basin, the rivers would have thousands of intakes, the task that should be in the hands of the Provinces to ensure integrated water resources management to address cross sectoral water demands. IRSA's over all role would include operationalizing single basin concept to manage floods, severe water pollution and silt loads, and severe water shortages and drying up of the downstream

stretch. Indus on the average losses about 15 MAF of fresh water in its pervious and very wide bed – WAPDA under the new role of river management would be required to look into channelization of rivers to save this large amount of water losses particularly in the saline groundwater zone. Whereas the losses in the fresh water zones are some what useful for ground recharge which are conjunctively used to meet the crop water demand in addition to meeting domestic and industrial water requirements. Groundwater has played a major role in supplementing irrigation water and providing both urban and rural communities their drinking water needs in addition to meeting industrial requirement. This precious resource has been developed and in most cases has been overexploited and contaminated due to insufficient institutional control and absence of legislation. Groundwater, its proper management and quality control has to be included as a vital component at the national and provincial levels and legal framework has to be provided for its effective governance.

One has to be cautious of the fact that management of water on a single basin concept is not a new endeavor. It has been practiced in many countries since decades whether it has been a national basin or a trans-boundary basin involving many countries. There is not a single example where basin management has been free of problems. Even in most developed nations the process has gone through evolution and in many countries the evolutionary process is still not over. With a holistic approach on a single basin, the management models are being revisited and new standards and operational modes are being introduced with new emerging problems. Pakistan therefore, needs to look into both the success and failure stories of the developed world and draw lessons so that an accelerated process of water management on single basin concept can be adopted. Pakistan also needs to learn from international experiences and adopt a governance pattern which would be beneficial to its environment. The country therefore, needs Technical Assistance from the Bank to establish a Basin Model which facilitates operations, involves administrative and operating agencies and covers full economic aspects of water.

3. INSTRUMENTS FOR IMPROVEMENT

Pakistan's institutional structure is split into three tiers:

National
|
Provincial
|
Local Governments

Pakistan's Constitution gives full sovereign rights to manage and develop water resources within the Provincial boundary. However, the inter-Provincial water

apportionment accord of 1991, have allocated total National water resources to all the four provinces under an agreed formula. Provinces can now manage the accord allocation as they desired. However, in deciding surface water the groundwater has not been considered as it has been left to the provinces to manage their groundwater. The accord therefore fails to recognize the importance of groundwater in managing water on a basin concept with conjunctive use with surface water. This needs to be corrected in the National Water Policy.

At the National level, Pakistan still has not adopted an effective water policy. The National Water Policy remains in a draft form and still has to go through the Constitutional process of adoption followed by relevant water laws and acts to provide effective governance mechanism. Similarly creation of an apex body at the national level would be desirable for developing strategies, and for coordination and national planning regarding water resources. The apex body under some conditions may act to regulate and monitor the performance of lower tier organizations such as Provincial apex bodies. The national apex body can have representative from all the Federal Ministries dealing with water, agriculture, planning and environment. Apex body at the National level would be responsible to build strong coordination links between various ministries dealing with water. Similarly Apex bodies in the provinces would be responsible to provide strong coordination links between various provincial ministries dealing with water. WAPDA's role would be confined to development of National Projects in water and power, operation and maintenance of inter-provincial infrastructures where as IRSA's role would be water management and distribution among the provinces and carrying out all other responsibilities as defined in the IRSA's Act of 1992 and as outlined earlier in sub para 2.2.

At Provincial level the role of PIDAs, WUAs, FOs and Local Government would need to be strengthened with legal framework to empower these institutions for effective water management, pollution control, cost recovery, transparency and efficient service delivery based on participatory approach. The Provincial apex body would regulate and monitor the performance of lower tier organizations/ institutions with in the Province. The Provincial apex body will be responsible for the creation of effective coordination mechanism between different agencies. The emphasis here is on the coordination and not integration of different agencies. It should not be assumed that integration in the sense of organizational consolidation automatically leads to cooperation and coordination which in turn leads to the improved effectiveness in water resources management. Fragmented and shared responsibilities are a reality and going to prevail at the Provincial level. Therefore, the need of having a Provincial apex body to place on ground effective coordination mechanism to handle problems is desirable.
The devolution plan gives far reaching powers to the democratically elected Local Government. These Local council can play important governance role in

managing water with the participation of stakeholders at the grass root level. Presently these local councils lack technical, managerial and financial support to become effective. These bodies would need unqualified support to improve their structure and encourage participation of users. Experiences have shown that participatory management and turnover of responsibilities to users has improved efficiency, increased ownership, made service providers more responsive and accountable to beneficiaries, increased ability to pay with improved cost recovery and sustainability. Water Users Associations and Farmers Organizations who were made autonomous under PIDA's Act particularly in Sindh Province have been a clear example of operating and maintaining their water delivery structures on sustainable pattern with full cost recovery and better services. Such process would also create an investment friendly atmosphere to attract private investment in the water sector. It is therefore, desirable to create Community Based Organizations (CBOs) at the grassroots level in all sub sectors of water.

4. PRIORITIES AND SEQUENCES

The water sector reform process in Pakistan has a long history. Re-carving of Federal Ministries, creation of Central Engineering Authority, WAPDA and lastly IRSA has been institutional reforms which have taken place over the last 55 years of Pakistan's history. Similarly amendments in the Canal and Drainage Act of 1873 from time to time to provide legal framework to the Provinces in managing their waters, transforming Irrigation and Power Departments into PIDAs and devolution plan have created new institutions within the Provinces to legalize participation of elected members and users in the development and management of water resources and take over the responsibilities of abolished Public Health Engineering Departments. To sum up the institutional changes both at the national and provincial level have followed a systematic pattern matching with the change in demands and governance in each sub sector of water. In other paper, the prevailing issues/problems in each sub sector have been highlighted in details which clearly speak about the failure of these institutions to perform effectively. The generic causes of failure of institutions to perform effectively were:

- Short coming in capacity building.
- Lack of policies and legal framework
- Lack of public participation.
- Financial non sustainability
- Lack of political support

The way forward and actions recommended in the order of their priorities and sequence are:

i) Initiate nation wise debate and consultation on Draft National Water Policy and adopt it as soon as possible ensuring the policy covers all critical issues.
ii) After adopting National Water Policy, enact appropriate acts for effective governance of water sub sectors including groundwater and pollution control.
iii) Revise the role of WAPDA as suggested.
iv) Strengthen technically, administratively and financially IRSA as suggested.
v) Constitute apex body at the national and provincial levels.
vi) Strengthen the role of PIDAs.
vii) Accelerate the process of formulation of AWBs, FOs, and assist in their capacity building.
viii) Provide political, financial, managerial and technical support to Local Governments for planning, development and management of water resources with the participation of users.

These prioritize actions with the World Bank playing a powerful role of advocacy and demonstration and water users' associations as drivers with powers to operate and maintain their systems, collect fees, hire professionals and manage water rights could definitely bring about changes against prevalent political and social impediments. Similarly the World Bank with its comprehensive engagement with governments, has a comparative advantage, can use it more strategically to bring about vital changes required in IRSA, WAPDA and PIDA's and help the Government in adapting a comprehensive National Water Policy.

Once the National Water Policy has been adopted, it will act as a catalyst to pick up priorities and help sequencing implementation in order of priorities and would help in creating new institutions where necessary and reforming the existing institutions. The policy should help in institutional reform process to address the following issues:

(i) Financial sustainability of institutions.
(ii) Should clearly define the process in streamlining water entitlements for both surface and ground water.
(iii) Rationalize water allowances and pricing through a water regulatory authority.
(iv) Create trust and transparency.
(v) Infrastructure maintenance and development.

These five critical issues are the fundamental in reforming the institutions dealing with water and are discussed in more details:

4.1 Financial Sustainability:

(a) The Instruments and Institutional reforms/changes needed are:

- Create clear water entitlements for both surface and groundwater.
- Review functional analysis of Irrigation Departments and accelerate unbundling.
- Water charges increase in parallel with better infrastructure and service delivery.
- Institution for irrigated agriculture – merger of Irrigation with Agriculture Departments.
- Community Based Organizations (CBO) in farming sector to increase productivity – Financing through social collateral.
- Create water markets – delink water from land.

(b) Practical steps required over the next five (5) years:

- Empower water users to collect water charges.
- Prepare Asset Management Inventory and Plan.
- Improve infrastructures and their turn over.
- Resolve equity issues in current system.
- Improve services – system by system.
- Introduce High Value Crops and increase productivity per unit of water.
- Start in areas where productivity is high.
- Introduce participatory approaches at the grassroots level and all other levels.

(c) The Bank can play a positive role in the following::

- Bank's infrastructure investment should be linked with the process of improvement in the Management.
- Assist in capacity building.
- Provide Technical Assistance and International experiences.
- Bank should promote market driven water users and assist in building capacity.

4.2 Water Entitlements

(a) Instrument and Institutional reforms/changes needed are:

- In water distribution, the water entitlements are crucial and need to be streamlined for future management – clear individual entitlements need to be defined.
- Groundwater management needs to be vested in the state and must address the issue of groundwater entitlements.
- Free trade of water and creation of water markets would help resolve many issues.
- At macro level, Inter-Provincial Water Accord needs to be reviewed in the light of ensuring minimum flow for Biodiversity.

(b) Practical steps required over the next five (5) years:

- Draft Water Policy should be reviewed to address water entitlement issues along with other issues in much details.
- Groundwater management should be vested in the state.
- Rationalize allocation between canals for higher productivity per unit of water.
- Guarantee individual entitlements.
- Introduce information management system as a critical and essential activity.
- Capacity of grassroots organizations need to be built.
- Measurement tools need to be introduced.
- Create ground water committees for assisting in implementation of regulatory decisions.

(c) The Bank's role:

- Bank should support efforts in improving and creating greater clarity in the water entitlements at all levels.

- Expose professional and farmer organizations to practical International good practices.
- Support lending for more efficient groundwater uses and management including monitoring instruments and quality analysis.
- Provide Technical Assistance for analytical work and study tours.
- Bank should provide technical assistance in finalizing the draft National Policy.

4.3 Rationalize Water Allowances and Pricing

(a) Instruments and Institutional reforms/changes needed are:

- Introduce free water markets.
- Formalize water trade.
- Create linkage between water use and productivity.
- Create Community Based Organizations.
- Rationalize water as a scarce source.
- Use charges for water as an economic instrument.

(b) Practical steps required over the next five (5) years:

- Encourage and involve stakeholders.
- Create a water regulatory authority on pattern of NEPRA and OGRA.
- Facilitate water trading for higher productivity.
- Provide incentives for water conservations and higher productivity per unit of water.
- Conjunctive use of ground and surface water should be encouraged.

(c) The Bank's role:

- Help assist in introducing free water market.
- Assist in capacity building.
- Provide international experiences.

4.4 Create Trust and Transparency

(a) Instruments and Institutional reforms/changes needed are:

- IRSA's technical and management capacities need immediate attention so that trust between the provinces can be developed.

- Telemetry System to give real time data to Provinces.
- Independent audit of IRSA would create great trust and transparency.
- Transparency in allocation and distribution needed at all levels.
- Users' participation – Government must support user participation.
- Capacity building at both community and agency level.

(b) Practical steps required over the next five (5) years:

- Prepare register of entitlement.
- Readily available information.
- Installation of measurement devices and data dissemination.
- Formal Government policy for participation and supporting resources.
- Time bound management plan.

(c) The Bank's role:

- Funding assistance for installation of measurement devices.
- Support for transparent information system.
- Support audit of IRSA's management and distribution centers.
- Assist in establishing field laboratories for quality control.
- Support participatory approach in management and decision making.

4.5 Infrastructure

4.5.1 Maintenance

(a) Instruments and Institutional reforms/changes needed are:

- Develop asset management strategies.
- Prepare 5-year asset maintenance plan assigning priorities.
- Progressively install measurement devices for both surface and ground water.
- Prepare integrated package of rehabilitation plans. Large canals to on-farm delivery including water, land and environment with emphasis on ground water balance.
- Develop specialized agencies for specific maintenance functions and modernization objectives.

(b) Practical steps required over the next five (5) years:

- Prepare asset management strategy.
- Rehabilitation and modernization of Barrages.
- Identification of key irrigation areas for rehabilitation.
- Introduce new technology including modern equipment to reduce maintenance cost.
- Prepare cost effective maintenance packages.
- Initiate execution of rehabilitation and modernization of assets under a prioritized and phased programme.
- Institutional reforms and capacity building.

(c) The Bank's role:

- Provide access to skills and international practices.
- Fund the back log in rehabilitation and modernization.
- Assist in putting management system in place.
- Provide funds for obtaining specialized maintenance equipment.
- Provide technical assistance to carry out safety inspections and condition surveys of structures in operation.
- Provide laboratory facilities to carry out both destructive and non-destructive tests.

4.5.2 Development of Infrastructures

(a) Instruments and Institutional reforms/changes needed are:

- Develop a Basin Model to assess the effectiveness of additional storages.
- Create seasonal to yearly carry over storage capacity in a phased programme to combat high variabilities in the hydrological cycle.
- Continue simultaneously the development of storages, diversion and distribution structures.
- Provide water to the most deprived areas in all the Provinces.

(b) Practical steps required over the next five (5) years:

- Continue development of storage capacity.
- Side by side develop additional diversions and distribution structures.
- Develop infrastructures in Balochistan and NWFP Provinces to enable them to utilize their allocated shares in the apportionment

accord from the existing storages and storages to be created in future including shares out of flood flows.

- Provide drainage in critical areas.
- Channelize rivers in reaches where losses are high and groundwater is saline.
- Construct links to integrate Indus Basin particularly Upper Punjab with Indus River. This would facilitate IRSA in water management.

(c) The Bank's role:

- Fund large dams ensuring Bank guidelines are fully adhered.
- Fund infrastructures required for Balochistan and NWFP for diversion and distribution of water.
- Provide Basin Model for optimizing operations to encompass full economic aspects of water involving Federal Government; operating agencies etc and covering water for irrigation, environment and energy.
- Provide funds for periodic safety inspections of large dams and other mega water structures.

5. BANK'S INVOLVEMENT

The World Bank engagement in Pakistan has a long history of over half a century. The prominent role of the Bank became more obvious when it directly became a party to assist and resolve the water disputes between two sovereign states i.e. India and Pakistan in early nineteen fifties. Bank's assisted Indus Waters Treaty of 1960 to which Bank itself became signatory was a glaring example how water disputes could be amicably resolved. The treaty has been widely quoted internationally as a success story particularly while addressing trans-boundary water disputes. The involvement of the Bank increased manifolds after the treaty as Pakistan with a poor economic base needed huge amount of finances to undertake construction of massive infrastructures as a replacement works to store and transfer the waters of three western rivers towards east to provide irrigation waters to the areas served by the eastern rivers prior to the signing of the treaty. This not only provided tools for better water management but provided an impetus to the very economic base of the country and helped bringing about green revolution. Once agro-based economy of the country developed, it opened up other diversified avenues for development such as small and heavy industries, communications, agro-based industries, livestock, etc. With picking up of economic activities in other sectors, the Bank's portfolio also expanded to include vital support required for institutional reforms. There is also a long history of the Bank involvement in helping to bring about

institutional reforms in both water and power sectors with emphasis on human resource development. The Indus Basin replacement works financed by the Bank and its Consortium Partners provided training grounds for human resource development and with coincidence of oil economy picking pace in the Middle East, provided a life time opportunity to the trained man-power to get engaged in more lucrative jobs abroad particularly in the Middle East countries. It would not be out of place to mention that the remittance from the Pakistani labour force trained on the Indus Basin Projects exceeded many times the total investment on the replacement works itself. This is the magnitude of contribution a trained manpower can contribute to country's economy in addition to the direct benefits Pakistan accrued from investment in water and power.

As suggested under para 4, Bank's involvement is sought in many ways – the top of the agenda being heavy investment in large dams to create carry over storage capacity badly needed to combat high degree of variability in the Hydrological cycle. Side by side infrastructural development for diversion and distribution would also be required to take water where it is needed most. In addition massive technical assistance in management and capacity building would also be needed. There is a large back log of differed maintenance. Bank's financial support would be required in undertaking prioritized and sequenced packages of integrated maintenance and modernization plans. Bank's assistance would also be needed to provide access to best international practices in management, trust building, financial sustainability, water entitlements, creating water markets, water pricing and creating water regulatory authority. Bank's technical assistance would also be required in creating a Basin Model for future management and operation keeping in view all aspects of water economics.

5.1 Bank's Covenants for Assistance

Bank has been a firm financial partner and carries a long history of investment and received guaranteed return on its investments and has been generous at times of country's economic crisis to grant moratorium. Initially Bank's lending conditionalities and covenants have been quite lenient as the line department showed marked performance in completing the project on time and within the loan or grant amount. However, with the passage of time, the performance of executing agencies declined with some degree of non-transparency entering into financial discipline. This not only resulted in cost and time over runs but entailed damaging delays in the benefits. This provided lenders a leverage to adopt more rigid conditionalities. This more often resulted in a clash where project PC-1 which normally is prepared prior to the loan agreement, did not incorporate the loan covenants. To comply with the loan covenants not covered in PC-1s often resulted in serious Audit Paras and the executing agencies had to face embarrassing situations getting these audit paras settled and convincing the Auditors and Public Accounts Committees. On the other hand refusal to comply

with the loan covenants resulted in stoppage of disbursement resulting in contractors claims on delayed payments. Bank's future involvement would require looking into these anomalies and preferably getting loan covenants included in the PC-I.

5.2 Bank's Assistance in Improving Institutional Performance

This paper has described in detail the evolutionary process the institutional reforms have been going through over the country's history of more than half a century in all water sub sectors. The various institutions dealing with water at national, provincial and district levels and their present status have also been described in the earlier sections of this report. It has also been mentioned that the latest reforms are in the right direction and are based on holistic and participatory approaches but are in the transitional phase and would require both technical and financial assistance for their capacity building. At national level, WAPDA's and IRSA's roles in future and the improvement required in these two institutions have been suggested. It has also been mentioned that for better governance, a National Water Policy addressing all critical issues has to be adopted as soon as possible so that effective water laws/legislation could be promulgated to provide firm legal framework. Whereas additional infrastructures are required along with improving the existing ones to provide tools for better management and service delivery, tremendous efforts and support is equally required in strengthening of institutions managing water and involved in services. The Bank's role and assistance therefore, would be required to:

(i) To assist in finalizing the draft National Water Policy covering all critical issues as highlighted under para 4.
(ii) Assist IRSA in its capacity building, adopting revised engagement rules for its members and a technically strong secretariat with availability of adequate funds for its effective operational requirements.
(iii) Assist WAPDA in the performance of its new role as the Prime National Institute for development of water and power resources of the country on single basin concept and having effective control on national rivers, terrestrial services including management of forest and land in the watersheds, which are essential for moderating hydrological variability, reducing silt and conserving biodiversity.
(iv) Assist provinces in giving more autonomy to PIDA's and help form AWPs and FOs and provide technical support to the Local Governments in managing water.

5.3 Pragmatic Approach in Initiating Changes

Pakistan has already taken many steps in bringing about changes from time to time and various National bodies and Provincial Institutions have been through the process of reforms. What is now of crucial importance is to support these institutions where their roles have been modified based on practical requirements and help the new institutions under the devolution plan in building their capacities to handle complex water issues for future management based on principles of social equity, economic efficiency and environmental sustainability. The World Bank can act as partner in supporting realistic, prioritized and sequenced locally driven reform packages and in supporting appropriate infrastructure investments which are an essential complement to such reforms.

REFERENCES:

(i) Canal and Drainage Act, 1873.
(ii) Provincial Irrigation and Drainage Authorities (PISA) Act, 1997.
(iii) Water and Power Development Authority Act, 1958.
(iv) Apportionment of Waters of Indus River System between Provinces of Pakistan Accord, 1991.
(v) Indus River System Authority Act No. XXII of 1992
(vi) Devolution Plan, 2000.

ABBREVIATIONS

AWB	Area Water Board
CBO	Community Based Organization
CCI	Council of Common Interests
ECNEC	Executive Committee of the National Economic Council
FO	Farmers Organization
IWRM	Integrated Water Resources Management
IRSA	Indus River System Authority
NGO	Non-Government Organization
PIDA	Provincial Irrigation and Drainage Authority
PPIB	Private Power Investment Board
MAF	Million Acre Feet (equal to 1.233 Billion Cubic Metre)
NEPRA	National Energy and Power Regulatory Authority
WUA	Water Users' Association

Drinking Water and Sanitation Sector Review of Policies and Performance and Future Options for Improving Service Delivery

By

Khurram Shahid

Country Water Resources Assistance Strategy
Background Paper # 8
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1. ISSUES & THE CURRENT STATE OF THE RESOURCE & POLICY ENVIRONMENT

1.1 Evolution of the Institutional Arrangements for Urban & Rural Water Supply & Sanitation (RWSS)

Domestic (urban and rural) water supply accounts for only 5% of total fresh water use in Pakistan. Urban domestic water demand is 3.2 MAF, while rural domestic requirement is around 0.8 MAF making a total of 4.0 MAF or only about 5% of the total water usage {REF (1)}.This figure is similar to other South Asian countries such as India (5%) and Sri Lanka (3%). However, compared to the rest of the world, and in particular, the developed nations, these are very low figures indeed (see Figure 1)

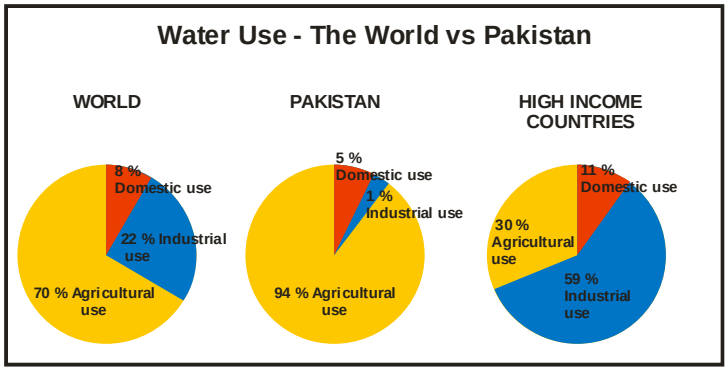


FIGURE1: Water use - Pakistan in comparison with the World

Source: UNDP's World Water Development Report, 2003

However two major factors, namely public health concerns, and a rapid growth in urbanization have forced potable water and sanitation to the top of the national agenda. This fact is reflected in Pakistan Water Sector Strategy (PWSS) and the National Water Policy (NWP).

Public Health Concerns

About 40% of hospital beds in Pakistan are occupied with patients with water related diseases, such as cholera, typhoid, hepatitis, diarrhea, dysentery, etc {Ref (2)} and about 60% of child mortality is associated with water related diseases {Ref (3)}. It can be argued that these figures are grossly overstated and only 10% of all deaths in developing countries can be actually attributed to unsafe water and poor sanitation. Nevertheless, poor water and sanitation is a major public health concern.

Water borne diseases are responsible for substantial human and economic losses. These include loss of millions of working hours of productivity annually, and associated costs for health welfare. Sickness of the main bread earner can have a severe economic impact on a poor household, and in case of contagious diseases, may even affect the whole community. Reduction in the occurrence of water borne diseases will go a long way in the efforts to alleviate poverty. In rural areas especially women will be chief beneficiaries of improved water supply and sanitation through health, productivity and safety related impacts. Hence sanitation, water quality and

quantity, and public awareness and education are of prime importance to Pakistan in implementing its Poverty Reduction Strategy (PRS).

Rapid Urbanization

The rapid pace of urbanization in Pakistan is a major concern as it is overburdening an already stretched urban infrastructure. In 1947, only 25% of population lived in cities. This figure has risen to 45% in 2004 and it is estimated that by the year 2020, more than 50% of Pakistan's population will be living in cities. This coupled with an increasing population base as a whole means that the issues relating to the drinking water and sanitation sector must be addressed on an urgent basis.

There are two sets of goals to which Pakistan is committed in achieving:

a. Millennium Development Goals: (1) By 2015 to reduce by half the proportion of people without sustainable access to safe drinking water, and (2) By 2015 to reduce by half the proportion of people without access to basic sanitation.

b. The Ten Year Perspective Plan (TYPP - 2001 to 2011): (1) To increase water supply coverage to 84% (96% urban, 75% rural), (2) To increase the sanitation coverage to 63% (80% urban, 50% rural) at the end of this 10 year period.

Based on PWSS and figures from Pakistan Integrated Household Survey (PIH) 1998 {Ref(4)}, on the water supply side, coverage in urban areas is 50% while in rural areas it may be as low as 40%. The figures for sanitation are worst. Only 40% of urban areas and 30% of rural areas have adequate sanitation.

With a rapidly growing population base especially in urban areas, to achieve these goals is no mean task. Figures 2 -5 show the increase in the level of service required in both urban and rural areas till 2015 to achieve these targets.

By any stretch of imagination, to achieve these goals is an enormous task. In a country where drinking water and sanitation sector has been long neglected and where weak institutions operating in financially unsustainable environment lack technical and financial resources, it will be an uphill task.

In order to appreciate the enormity of the situation and to see how improvements can be made, the following sections review the current state of the resource by looking at the organizational, legal and financial aspects concerning water and sanitation service sector in Pakistan.

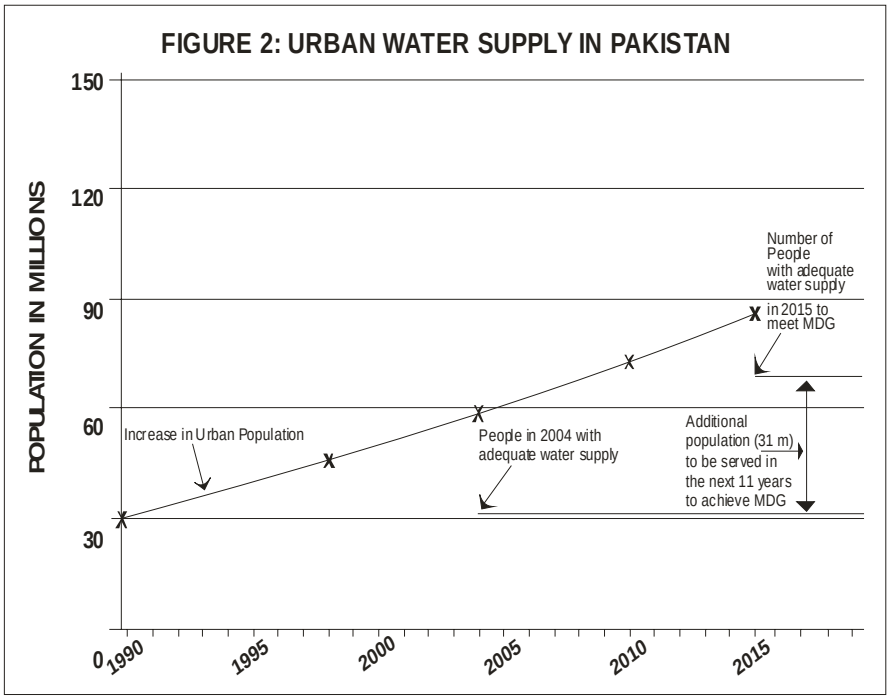


FIGURE 2: URBAN WATER SUPPLY IN PAKISTAN
POPULATION IN MILLIONS
150
120
90
60
30
0
1990
1995
2000
2005
2010
2015
Number of People with adequate water supply in 2015 to meet MDG
Increase in Urban Population
People in 2004 with adequate water supply
Additional population (31 m) to be served in the next 11 years to achieve MDG

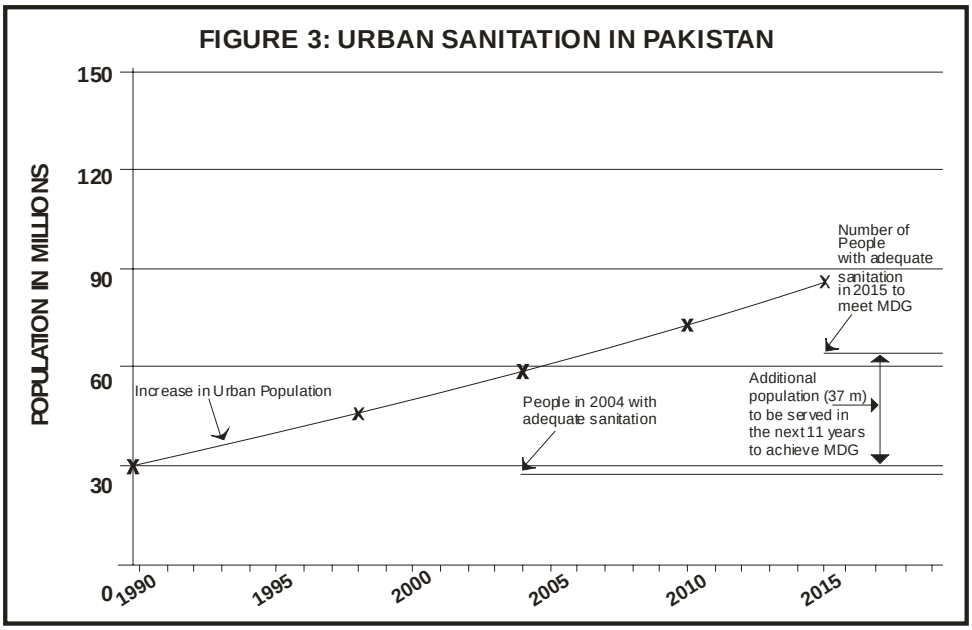
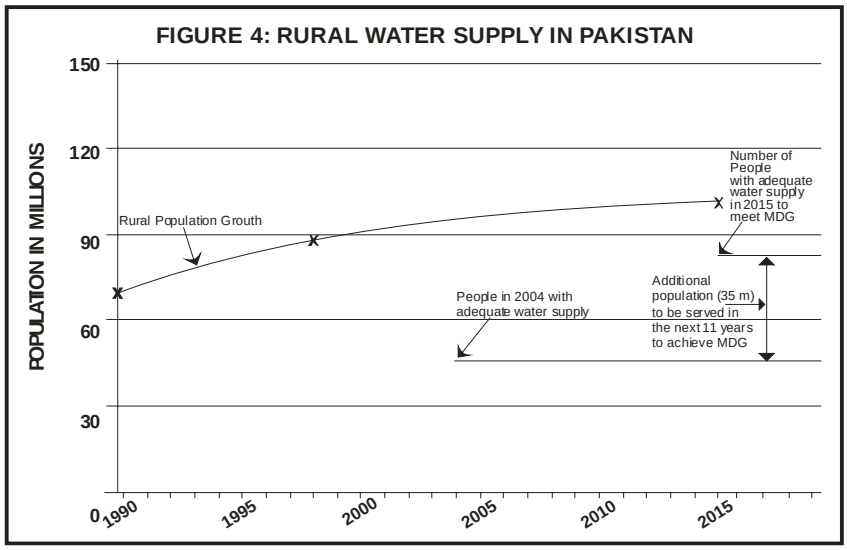
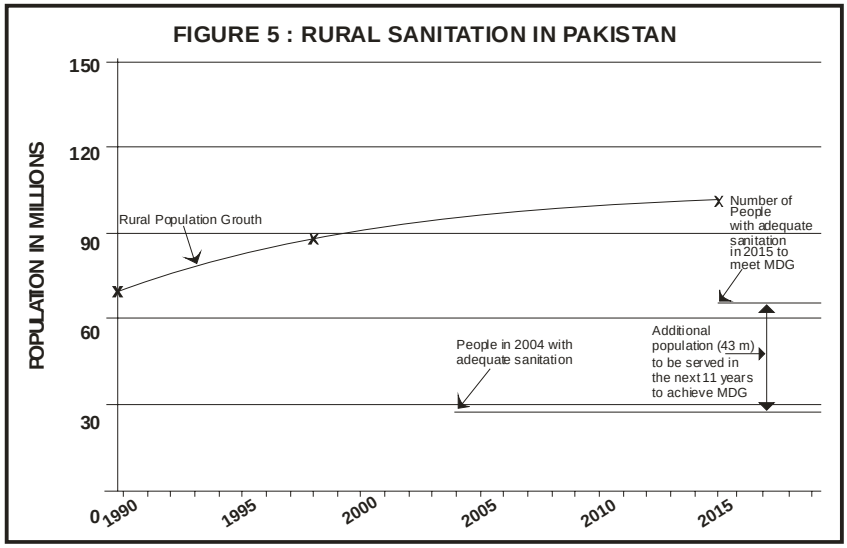


FIGURE 3: URBAN SANITATION IN PAKISTAN
POPULATION IN MILLIONS
150
120
90
60
30
0
1990
1995
2000
2005
2010
2015
Number of People with adequate sanitation in 2015 to meet MDG
Increase in Urban Population
People in 2004 with adequate sanitation
Additional population (37 m) to be served in the next 11 years to achieve MDG





1.1.1 Organization

Constitution

Under the Constitution of Pakistan, Federal Legislature has been empowered to make laws in respect of any matter given in the Federal Legislative List (FLL) while it can also make laws with respect to any matter contained in the Concurrent Legislative List (CLL). Provincial assemblies are empowered to make laws in respect of matters contained in the CLL as well as those not contained in the FLL or the CLL. As water supply and sanitation are not mentioned in either the FLL nor in the CLL, the four provincial government and CDA have exclusive jurisdiction to enact laws concerning them {Ref (5)}

The Formation of National Water Council, Nov 2004

In recent years, water has become one of the most debatable and controversial issues in Pakistan. Be it water allocation by IRSA[1] for provinces, recent deaths in Sindh caused by the supply of contaminated water, or controversy surrounding the construction of Kalabagh Dam, water has assumed a critical role in Pakistan's politics as well as economy. In view of this, in November this year, in accordance with the National Water Policy, the government decided to form a National Water Council (NWC) to take crucial decisions on water related issues and inter-provincial conflicts. The NWC will be headed by the Prime Minister and will have chief ministers of all four provinces, and other federal ministers as its members.

At the provincial level, Provincial Water Regulatory Commissions (PWRC) is being set up to handle all water related provincial matters including domestic water and sanitation. The constitution of PWRC is not yet finalized but it is envisaged that these commissions will be functioning by the end of this year.

As the formation of NWC and PWRC is a very recent event, it may take some time for these bodies to be functional. NWC and PWRC should help and assist the Tehsils[2] and the Districts[3] at the local government level to deliver better services by clearly defining the policies and providing guidelines as to how these bodies should operate to improve their efficiencies.

The Devolved Structure

Before devolution, the responsibility for the provision of water and sanitation services, in rural areas rested with the Public Health Engineering Department (PHED). In urban areas, it was the Development Authorities (DAs) or Water & Sanitation Authorities (WASAs) of the provincial governments that were primarily responsible for the provision of water services.

As per the Local Government Ordinance (LGO) 2001 water and sanitation are now assigned to tehsils or towns (except in the case of city districts where they are district responsibilities):

"Water and Sanitation Agencies coming under the control of District Government under the provisions of the Local Government Ordinance, 2001 functioning in a Tehsil, will be decentralized to the concerned Tehsil Municipal Administration (TMA). Water and Sanitation Agency or similar agencies functioning in a City District, will be decentralized to the City District Administration or, according to requirements of service delivery, may be decentralized to towns in a City District".

According to the findings of the ADB/ DFID/ World Bank study {Ref (6)} published in July 2004, the devolution process in water and sanitation has been facing many problems. Although covered by the same ordinance, the devolution process in each province tells a different story. This may be due to a number of reasons.

[1] *IRSA is Indus River Systems Authority*

[2.] *Tehsils are body corporate under Local Government Ordinance 2001. Tehsil Municipal Administration (TMA) are now responsible for delivering water and sanitation and other municipal services*

[3] *City District Government in Provincial Governments*

In many cases, TMA has little capacity to undertake and implement ongoing development schemes. PHED has been retained to complete on-going as well as new projects against the spirit of devolution. In other cases, there is lack of political will at the provincial level to give financial and other autonomy to the tehsils.

In Balochistan, PHED remains intact. In NWFP the devolution has not been to TMA level but to the Division level. Punjab has devolved PHED to the TMAs but has preserved the PHED structure with Superintendent Engineer (SE) in some areas which continue to implement donor and federally financed projects.

In Sindh, the PHED staff has been transferred to the local TMA level. However KW&SB has continued as an autonomous body in Karachi City District. XENs work with TMA staff but report to the Works & Services Department and are not accountable to the TMA.

In summary, devolution has not been implemented in full and certainly not in accordance with the spirit of the LGO. Many issues such as capacity and financial autonomy remain unresolved. Substantial amount of work is still needed to allow the system to operate without political interference and in a smooth coherent fashion.

1.1.2 Regulation & Policy Environment

The National Water Policy only exists in a draft form but is expected to be approved by the Federal Government soon. The Policy outlines the philosophy, guiding principles, and goals for an integrated approach to the water sector. Once approved, it will provide a single set of rules and regulations for Pakistan's future water management. The policy as applied to the municipal, & rural water supply and sanitation is reproduced in Appendix 1.

It is clear that drinking water has a very high priority attached to it both in terms of quantity as well as quality.

In order to achieve a financially sustainable urban water supply sector, it recognizes the need to promote private investment as well as the need to make efficiency improvements by reducing non-revenue water.

The Policy also recognizes the deteriorating water quality in surface and ground waters and the fact that water supplied by various service providers does not meet any international or national standards for potable water. There is an urgent need to address water pollution of both surface water and groundwater aquifers.

The Policy in this respect highlights the need to initiate a study to establish and implement a National Water Quality Monitoring Program which will establish water quality standards for potable water and develop regulations for effluent disposal.

As drinking water and sanitation is a provincial subject, only a few federal regulations have an impact on it. One such legislation is the Pakistan Environmental Protection Ordinance, 1983 {Ref (7)}, and the Pakistan Environmental Protection Act. However, as is the case with potable water quality, the effluent discharge standards stated in the legislation are not enforced as policing is weak and there are no incentives for polluters to pay. However, with the advent of WTO and the need for industrial units to

comply with ISO 14000 for effluent discharges, many industries are being forced to install effluent treatment plants or at least to pre-treat wastes prior to discharge.

The Water Policy stresses upon the need to engage the private sector in the delivery of urban water supply and sanitation services. There is however no federal or provincial legal framework to allow private-public partnership.

In the major cities of Pakistan, the responsibility of water supply and sewerage services by statue lie with:
KARACHI – Karachi Water & Sewerage Board (KW&SB), which after the LGO has been devolved to the City District Government Karachi (CDGK). In practice however, KWSB continues to operate as an autonomous body.
LAHORE – Lahore Development Authority (LDA) and LDA's Water & Sanitation Agency (WASA), now Lahore District Water & Sewerage Services after devolution.
FAISALABAD – Faisalabad Development Authority (FDA) and FDA"s Water & Sanitation Agency (WASA), now devolved to TMA
ISLAMABAD – The Federally controlled Capital Development Authority (CDA)
PESHAWAR – Peshawar Development Authority (PDA), now District Water & Sanitation Services
MULTAN – Multan WASA, now Multan TMA after devolution
SIALKOT – Sialkot Municipal Corporation, now Sialkot TMA

Each City District or TMA is expressly constituted as a body corporate with the power to acquire and dispose of real and personal property, to contract and to sue or to be sued. In each case there are restrictions with regard to the corporate bodies wanting to contract out its services. In the case of KWSB for example, it may, with the approval of Government of Sindh "grant licenses" to private companies. What can or cannot be licensed is not clear in the legislation.

1.1.3 Financing

The drinking water and sanitation sector suffers from under investment in both rural and urban infrastructure and total government budgetary allocations to the sector amounting to 0.2% of GDP or a mere 0.8% of total government expenditure on public health services {Ref (8)}.

The present sources of finance include; tariffs, urban property tax (proportion of), loans, and ad hoc grants and subsidies from the government. In major cities like Karachi and Lahore, water tariffs are the main sources of income contributing to over 80% of revenues. In other cities like Sialkot and Rawalpindi, where tariffs are low, property tax contributes to a significant portion of revenues. Ad hoc grants and subsidies are generally used for new capital projects such as the Karachi KIII water supply project which is primarily being funded as grant by the Federal Government.

Annual O&M budgets are unrealistic in that they are inadequate to maintain systems properly. No financial provision is made to cover asset depreciation or infrastructure renewal. As a result, when the infrastructures, due to lack of proper operation and maintenance, go into a state of disrepair, government ends up funding these as new capital projects.

There is generally no concept of self financing. Service providers rely on government subsidies or grants. As a result distribution systems are not extended and levels of service not improved. Only revenues from the Government from taxation fund such

extensions. Alternatively, funds are raised as loans from external funding agencies thus creating further debts for the Government.

As can be imagined, present level of revenue is insufficient to satisfy capital investment needs, improvement in efficiency of service, or expansion of coverage. As populations increase, the quality of service will undoubtedly continue to decline.

Due to this serious situation environmental degradation and public health suffering is inevitable unless something is done quickly.

Rural Situation

Historically, the PHED and the LG&RDD[4] are two principal departments which provide access to water supply facilities in rural areas. Hence up to 95% of the provincial government budget for water supply and sanitation was allocated to PHEDs which has been the principal player in the provision of these schemes in rural areas.

PHED was responsible for large/complex water supply and drainage projects. LG&RD on the other hand was involved more with solid waste, street paving, open drains outside the households, and hand pump based schemes. The share of LG&RD in terms of both funding as well as coverage has been very small.

The original mandate of PHED was to undertake these schemes, operate them for two years before handing them to Union Councils (UCs). This policy was revised in early nineties as UCs was unable to operate these schemes properly.

Most of these schemes were based on the use of Mechanical & Electrical equipment which resulted in high O&M costs and community participation was not a feature considered in the design and operation of these schemes. On average, PHED found it possible to recover less than 15% cost of operation and maintenance of these schemes with capital costs borne entirely by the provincial governments.

LG&RDD was established to activate rural development through community participation. It supplied hand pumps, household sanitation facilities and hygiene education programs under SAP[5] and other donor schemes. The funding it received was meager and again there was no concept of cost recovery.

The subsidized provision of hardware to households mostly ended up benefiting influential and the rich in the community and had virtually no impact on the overall coverage. Subsidy also undermined the efforts to encourage communities to take initiative and fund WSS on self help basis.

All in all, the public sector coverage in rural areas has been abysmally low (see Section 1.2).

[4] *Local Government and Rural Development*

[5] *SAP is Social Action Program*

The newer, more recent approach has been to involve communities and the private sector to create a partnership with the public sector agencies for the provision of water and sanitation services. There have been some small encouraging signs and successes of schemes such as the Agha Khan Rural Support Program and Sind Pilot Project or the RWSS project in Balochistan have demonstrated that by entrusting ownership to the communities and by capital and O&M cost sharing water and sanitation sector can be made sustainable.

Private sector has also a role to play but up to now its involvement has been limited. It can help in the production of low cost technologies and in the social marketing of sanitation and water treatment equipment. Small scale businesses can also increase capacity relatively easily depending on demand and deliver simple water treatment or sanitation equipment in quantities quickly. However such businesses may lack social equity – people who can afford will be able to drink safe water and the poorer people who don't will continue to suffer. Nevertheless the role of private sector cannot be overlooked.

Urban situation

The situation in urban areas is not much different. Pakistani cities have generally the lowest tariffs in the whole of Asia (see Table 1). However, collections are still low as service is generally poor and people are reluctant to pay for poor service.

Water and Sanitation Agencies (WASAs) which cover 44% of urban population in Pakistan are able to recover only 50 to 60% of annual O&M costs at best. This is an unattainable or sustainable situation considering these figure do not include any debt servicing or capital cost repayments.

As quality of service is poor customers switch to alternative options including installing borehole pumps and digging own wells. These results in a loss of revenue for the service providers, something they can ill afford.

On the positive side, the donor agencies are involved in public sector reforms, provision of technical assistance, and in encouraging improvements in service deliveries by capacity building and institutional strengthening. Using newer innovative approaches, they are funding capacity building and reform projects in all four provinces. ADB has funded projects in Punjab, DFID in NWFP, WB in Sindh and Netherlands Govt in Balochistan.

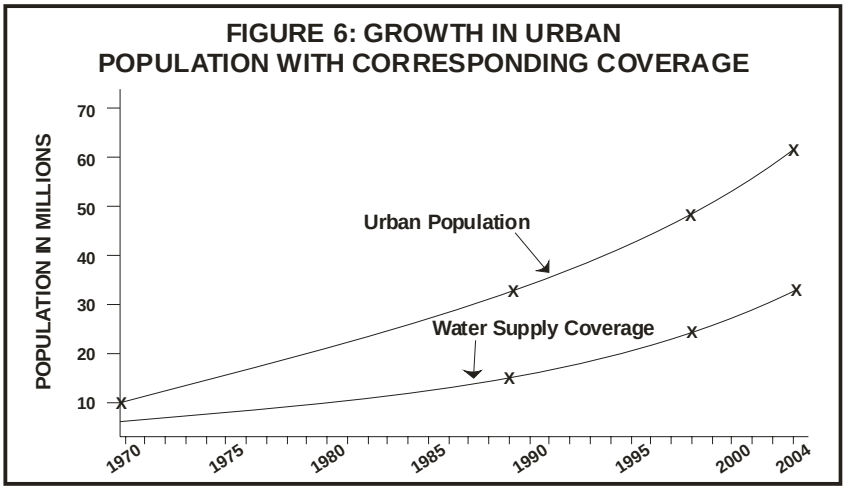
Section 1.4 discusses in some detail the current financial standings and performances of the main urban water service providers in Pakistan.

1.2 Evolution of the Level and Quality of Services Over Time

Urban situation

From a historic prospective there has not been a significant increase in levels of coverage in urban areas over the last 20 years or so. This can be attributed to an increase in urban population which has out weighed increases in new connections.

Figures 6 shows increases in urban population over a 30 year period and corresponding increase in the level of coverage provided. The current coverage level is approximately 60% of urban population {Ref (9)}. The widening gap between the urban growth and the level of service is apparent.



Rapid urban population growth in future will mean, at current levels, the deficit will increase from 40% to 82% unless coverage is increased.

As for the quality of service provided, the fact that despite very low tariffs, collection efficiencies remain low pointing to the fact that people are not satisfied with the quality of service provided and hence avoid paying.

In none of the cities in Pakistan there is a 24 hour 7 days a week water supply. The water quality is poor with recent studies showing that in almost all the cities in Pakistan water supplied fails to meet any international or national standard (see Section 1.4.2). People are exposed to high levels of microbiological and possibly chemical contamination.

The situation on urban wastewater/sanitation side is even worse. The sewerage system, where it exists, is usually in a state of disrepair and is a major contributor to groundwater pollution. The treatment facilities, where they exist, are usually non functional and ineffective (see Tables 3 & 4).

Rural situation

On the rural side, over 40m people do not have access to safe drinking water while 60m lack adequate sanitation. Of the rural population considered to have adequate supplies of water, over 50% is served by hand pumps, majority of which are privately installed and which often provide contaminated water.

Although historic figures are available for implemented schemes by PHED, these are probably a poor indicator of actual coverage as many schemes were never put into operation or do not serve the entire population for which they were installed. Some schemes are non-operational due to lack of funds for repairs and maintenance. Again, as is the case in the urban areas, coverage figures mask the poor quality of water being provided. In any case these figures do not cover households un-served by PHED.

Historically, several factors have had an impact on access to water and quality of services provided by the public sector agencies (e.g. PHED) entrusted with the responsibility of supplying drinking water to the rural areas. These include (1) the agencies were not given the task for sewerage or sewage disposal (as in the case of PHED), implementation or interpretation of policies dependent on politics, (3) inappropriate technologies were used.

It was therefore decided in early 1990s to adopt a uniform policy to implement RWSS schemes. On the basis of community participation in planning, design and implementation an important component of this new change was for the communities to pay for the O&M with PHED'S role limited to community training.

1.3 Incentives for Performance and Performance Levels in the Current System

Under the new devolved structure it is the TMA which is responsible for the provision water and sanitation services. As TMA is exclusively responsible (in the common district) for planning, capital investments, and O&M of all municipal services, there is a natural rationalization of agencies which in the past were empowered as service providers. The new devolved system is more accountable to the end users and provides a natural incentive for TMA to improve its performance and provide a better service.

The devolved system also removes the rural-urban divide creating space to achieve better financial and management efficiencies. As there is also provision in the LGO for TMAs to have complete fiscal authority, it provides TMAs an opportunity to be responsible and accountable to the citizens at the local level. It also allows them to plan for both short term and long term interventions ensuring most efficient use of funds to achieve service coverage targets.

In the LGO there is provision for TMAs to establish cost centers. The costing of services, by sectors and areas, will ensure that the TMA is fully aware of the nature / amount of subsidy for each service and will be able to make choices regarding the level and extent of services {Ref (10)}.

Perhaps the greatest incentives for TMAs to perform is the involvement and participation of citizens in the decision making and service delivery through Citizen's Community Boards (CCBs) sharing cost and management.

1.4 Utilities

1.4.1 Financing and User charges

As stated earlier, financing and levying user charges is the core issue in Pakistan, like it is in many other developing countries.

However, generally in Pakistan, charges are one of the lowest in the whole of Asia. No one can deny the "social" aspect of water but at the same time it has to be treated as an "economic good".

	Karachi	Lahore	Faisalabad	Average in Asia
Metered Water/m^3	0.16	0.05	0.11	0.24
Unmetered Water/month (based on 600 sq yard dwelling)	2.68	5.83	3.50	15.0
Sewerage Charge (average monthly)	2.40	2.40	2.40	7.00

Table 1: A SUMMARY OF TARIFFS IN PAKISTAN
Vs. AVERAGE IN ASIA (US$)

[Source: ADB "Water in Asian Cities" 2003, LDA, FDA & KWSB
Note: There are very few domestic meter supplies in Karachi or Faisalabad]

Despite the fact that Lahore WASA increased its tariff's by 40% in May 2004, it s estimated loss in the 2004-5 fiscal year is RS 750m {Ref (11)}. This is despite the fact that WASA's collection efficiency of about 80% is the highest in the whole of Pakistan. Tariff increases must allow for inflation and general increase in electricity costs as well as reflecting

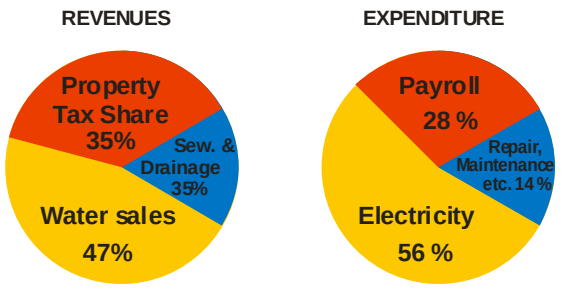
realistic O&M expenditure. This is not the case in Lahore WASA or any other Pakistani city.

Karachi Water & Sewerage Board (KW&SB) has a debt of over RS 46 billion {Ref (12)}. It's consumers are listed as around 1 million whereas recovery is from only 162,000 – less than 15% of the total.

The situation is similar elsewhere. The utilities in major urban centers continue to incur substantial financial losses. In some cases, cost recovery is as low as 50%. Operating losses are compounded by physical leakages, water theft, and poor billing and collection systems.

A look at Lahore WASA's budget for 2004-5 (Figure 7) shows that revenues are made up of water tariffs (47%), sewage and drainage charges (35%), property tax share (17%) and from miscellaneous sales (1%). Expenditure on the other hand shows 56% of costs go in paying electricity bills - unattainable situation.

Figure 7: Lahore WASA - Budget 2004-05



Source: LDA WASA Budget Handbook 2004

In 2003-4, Lahore WASA ran a campaign of discounts to encourage defaulters to pay the arrears. Up to 30% discounts were offered if the bill was cleared in the first month. Despite this, WASA failed to achieve its modest target as the defaulters failed to pay. They did not perceive they were getting the service they deserved from WASA.

Tariffs therefore have to be performance linked. Generally people do not mind paying for a good service but are loathe paying for a service which is not up to expectation.

Tariff increases have also to be realistic but at the same time affordable. In order to evolve a financially sustainable drinking water and sanitation sector, governments will have adopt and practice a "user pays" policy.

Karachi Water and Sewerage Board (KW&SB) increased its tariff three times prior to the proposed privatization in 1996. The tariffs were, and still are quite low and do not even cover O&M costs. However, due to pressure from some public groups and NGOs, government called a halt to

further rises. There has been no tariff increase in Karachi for the last 3 years.

Like Lahore WASA, KW&SB pays bulk of its O&M costs as electricity cost to Karachi Electricity Supply Corporation (KESC). KESC tariffs have increased as has the requirement to pump additional water. It is also interesting to note that in this year's budget, maintenance costs have been reduced so that funds could be diverted to paying of electricity bills!

Year	KW&SB Revenue RS (m)	KESC Billing RS (m)	% age of KESC Billing v/s KWSB Revenues
1992 - to 1996	3,448.70	1,386.23	40 %
1996 - to 1999	4,379.00	2,116.33	48 %
2000 - to 2002	5,938.00	4,851.53	82 %

TABLE 2: ELECTRICITY BILLS PAID BY KWSB COMPARED WITH ITS REVENUE

[Source: City District Government Karachi – Basic Facts 2003-4]

In both KW&SB and Lahore WASA budgets, the provision to pay debt is minimal. According to KW&SB, government departments owe them almost RS 3 billion as water charges. Consequently, KW&SB has stated that it cannot repay any of its debts due to financial constraints.

1.4.2 Availability of Raw Water of Good Quality

Apart from Karachi and Islamabad, most cities depend on groundwater as their source of raw water. Over the years, due to groundwater depletion and absence of pollution control, the groundwater quantity and quality has deteriorated to the extent

that in almost all urban centers, availability of good quality raw water has become a serious issue.

Karachi

Karachi receives its raw water from River Indus (over 80% of the supply) and the Hub Dam in Baluchistan (20% at best depending on rainfalls). It receives this water through a series of canals and lakes. Even after the commissioning of KIII project (which will enhance supply by 100mgd), there will still be a shortage of some 100mgd {Ref (13)}. The provincial government can allocate, out of its quota, more water for potable use but the existing infrastructure of canals and conduits is the limiting factor.

The low availability of water is not likely to change as groundwater has all but vanished and close by surface water sources are not reliable due to highly variable rainfalls. The main source for the foreseeable future remains Indus, but to enhance or augment quantity from this requires huge investment as water has to be transported from a distance of about 170km. As potable use of water is only a small fraction of the irrigational use, Indus water availability at source is not such a problem; but transportation certainly is.

Seawater is being considered as a possible alternative for some coastal areas but there are concerns regarding financial sustainability of desalinating water. Defense Housing Authority (DHA) is going forward with its plan to install a 3mgd desalination plant but other less affluent sections of Karachi may not be able to afford desalinated water.

An integral part of raw water quality and availability is the surface and groundwater pollution of water supplies. In the main Karachi industrial sites of SITE and KITE, there is no adequate effluent treatment provision. Likewise, on the municipal front, KWSB's treatment plants are either overloaded or non-operational resulting in untreated sewage being disposed off to surface waters. Success stories are few and far between, among which Orangi Pilot Plant (OPP) based on community participation, stands out and is well documented {Ref (14)}

Lahore

Main source of Lahore raw water supplies is groundwater. There are over 300 tube wells installed pumping over 300mgd of water. Over the last few years, water quality has become a serious issue as the existing sewerage system is in a state of disrepair and there is no sewage treatment facility. Wastewater is contaminating groundwater supplies in many areas of Lahore.

Other cities in Punjab

A recent study of 11 cities of Punjab shows excess of arsenic and fluoride concentrations in water supply systems of 6 cities namely Multan, Bhawalpur, Shaikhupura, Kasur, Gujranwala, and Lahore {Ref(15)}.

UNICEF has also conducted studies and concluded that the population of Punjab in main cities is exposed to high arsenic concentrations. A similar study by Environmental Protection Agency (EPA) on quality of sub-soil water in 14 districts of Punjab revealed that 85% of samples tested were unfit for human consumption.

Alarmingly, over 2million people are drinking unsafe water, some with high Arsenic concentration.

Islamabad

The capital city of Islamabad draws its drinking water from nine sources that have a total capacity of roughly 110 mgd. Simly Dam is the largest source of water supplying around 50 per cent of the total water. The remaining water comes from Khanpur Dam and 150 tube wells. The daily requirement of the city is 100 mgd but the water supply is much less. The average supply to the capital last year was about 50 mgd.

On average, the demand-supply gap is 35 per cent in Islamabad. Natural water scarcity is one reason but unsustainable consumption is also a key factor as during times of scarcity, despite water rationing, posh sectors are provided more water than others.

In Islamabad the per capita consumption of water is three times higher than in other cities. Rates of wastage are equally higher i.e. 10-12 million gallon water wastage per day, with physical leakages up to 45% and billing and collection inefficiencies accounting for the rest.

The quality of water in the twin cities of Islamabad and Rawalpindi is no better than the rest of the country. A survey carried out by National Institute of Health (NIH), revealed that 75% of water in Islamabad and 87% in Rawalpindi is unsafe for human consumption {Ref (16)}.

In almost all cases, the poor raw water quality is blamed on untreated sewage and industrial waste being discharged to water courses or open drains.

1.4.3 Obligations and Performance with Respect to Wastewater Discharge

There are National Effluent Quality Standards (NEQS) which are imposed by EPA. However, in the absence of an independent regulatory body, none of the service providers or utilities complies with these standards. However, with the advent of WTO and requirement to comply with ISO14000, most industries are being forced to consider some form of effluent treatment.

In most cases, nullahs and storm water drains are used to carry untreated sewage through urban centers. The untreated sewage flows into streams, rivers and irrigation canals resulting in fecal contamination. In Pakistan around 2,000 MGD of sewage is being discharged to surface water bodies {Ref (17)}.

In majority of cases, sewerage system consists of collection through old RCC pipes and drains. The sewage is disposed to the nearest water body by gravity or by pumping. In areas where sewerage system doesn't exist (as is the case in 40% in cities, 80% in smaller town and rural areas), sewage is discharged to the ground through soak ways, often without even passing through a septic tank. Collection at best can be estimated to be no greater than 50% with only 10% of treated sewage effectively treated.

CITY	POPULATION (M)	SEWAGE FLOW (MGD)
Karachi	10	450
Lahore	5	350
Faisalabad	2	80
Islamabad	0.5	35
Peshawar	1	50
Gujranwala	1	46
Hyderabad	1.1	46
Multan	1.2	50
Quetta	0.6	20
Sargodha	0.5	15
Sialkot	0.4	15
Mardan	0.2	10
TOTAL	**23.5**	**1,167**

TABLE 3: Quantity of sewage generated in major Pakistani cities

The extent of sewage treatment and the state of treatment facilities is summarized in Table 4. It is a sorry state of affairs and one in which all stakeholders must contribute and participate if environmental degradation and public health deterioration is to be avoided.

In certain cases, like Karachi's TP1 & TP2 treatment plants (ADB funded), inappropriate technology vis-à-vis biogas recovery and electricity generation system has been installed which has never been operated. KWSB struggles to operate even its simplest of lagoon based sewage treatment plant at Mauripur so how can it be expected to operate and maintain complicated technology involving combined heat and power (CHP). The staff was not trained to operate and maintain complex mechanical equipment and consequently the sludge treatment system has been abandoned.

In Islamabad, Activated Sludge Plants installed in Phases 1 & 2 are grossly overloaded. Phase 3, built by local contractors, has never been commissioned due to serious design flaws. CDA's untrained workers are

expected to operate these plants. Operator training and proper maintenance is a key if future capital investment is to be safeguarded.

In most cases, the treatment plants have been funded by external agencies with foreign consultants. There has been little attempt in the past to introduce appropriate technologies suited to the climate and the O&M culture of Pakistan. In some cases the treatment plants have been built without the completion of sewerage network and these plants are either under loaded or abandoned.

MAJOR CITIES	SERVICE PROVIDERS	POPULATION (M)	STATUS AND CONDITION OF FACILITY
Karachi	Karachi Water & Sewage Board	10	TP 1, 2 & 3 Non operational. Maripur being operated by semi private arrangement.
Lahore	Water & Sanitation Agency	5	Sewage treatment plants proposed but not implemented. BOOT advertised but lack of interest resulted in schemes being shelved.
Faisalabad	WASA and Municipal Corporation	2	One of the treatment plants functioning but not satisfactory. Three other plants proposed but none implemented.
Rawalpindi	Rawalpindi Development Authority (WASA)	1	No sewage treatment yet. A plant is planed under ADB loan for second phase of Rawalpindi Urban Development scheme.
Islamabad	Capital Development Authority	0.50	STP 1 & 2 grossly overloaded whilst STP 3 was never commissioned. French loan for STP 4 being utilized in 2005.
Quetta	Q. WASA	0.50	No sewage treatment facility exists.
Hyderabad	WASA	1	There are two treatment plants none of them functioning.
Gujranwala	WASA	1	No sewage treatment facility exists.
Peshawar	Peshawar Development Authority	1	Hayatabad STP none functional. Other plants in Charsadah and Warask being constructed.
Multan	WASA	1.2	No sewage treatment facility exists.
Sargodha	M. Corporation	0.50	No sewage treatment facility exists.

TABLE 4: Sewage Treatment in Major Cities of Pakistan

1.4.4 Industrial Users

There has been little or no incentives for Industry to treat their effluents. Although, like on the domestic wastewater side, regulations exist, absence of proper monitoring and policing has resulted in gross pollution of the environment.

Across Pakistan, the story of industry's gross neglect of the environment is the same. In Lahore, only 3 out of some 100 industries using hazardous chemicals treat their wastewater. BOD levels in water courses receiving these wastes are as high as 800mg/l and Mercury levels over 5 mg/l. Consequently hundreds of tons of fish are killed causing a loss of millions of rupees.

Major industrial contributors to pollution are petrochemicals, paper and pulp, food processing, tanneries, refineries, and textile industries.

In Karachi Sindh Industrial Trading Estate (SITE) and Korangi Industrial and Trading Estate (KITE), two of the biggest industrial estates in Pakistan, there is no effluent treatment plant and the waste containing hazardous materials, heavy metals, oil etc is discharged into river and harbor already polluted. The industrial pollution discharges combined with mangrove destruction are resulting in sharp decrease in shrimp and fish production.

There are however plans afoot to install Combined Effluent Treatment Plants (CETPs) in both industrial areas. ADB is looking to finance these. As with other plants, main issue will be of financing the operation of these plants. Each polluter must pay his share of the treatment cost based on hydraulic and chemical load of the effluent discharged to the CETPs.

In Faisalabad, one of the biggest industrial cities, there is little segregation of domestic and industrial wastes. Groundwater is being increasingly polluted and its salinity increasing. Industrial wastewater is discharged into public sewers without prior treatment. Pollutants include toxic chemicals, organic matter and heavy metals. There is reported leaching of wastes into ground water causing outbreaks of water borne diseases. There is a waste stabilization pond treatment plant treating 20mgd of flow. However, its operational efficiency is not known as there is no regular monitoring.

In Multan, a fertilizer factory discharges its waste untreated to cultivated land causing death of livestock and increasing risk to humans.

As water is relatively cheap and there is no effluent discharge policing, industry has no incentive to save or conserve water. More water it uses more wastewater it generates. Water conservation and better in-house management practices are an important “first steps” in controlling pollution. It is also important to note that NEQS specify only the concentration of effluents and thereby there is an incentive to use more water and dilute the effluents.

However, with the passage of time, metered water supply at realistic costs will ensure there is incentive for the industry to improve its in-house water management.

Apart from WTO mentioned earlier, other incentives to improve pollution control could be better pubic image. PSO (Pakistan State Oil) for example is using “green image” in its latest advertising emphasizing lower emissions levels from its fuels.

The UNIDO Report {Ref (18)} on Industrial policy and environment in Pakistan highlights the following main areas that need to be addressed if Industrial pollution is to be controlled.

- Strengthening of monitoring infrastructure
- Strengthening of staff capabilities for the effective implementation of environmental policies
- Procedural reforms for implementation of environmental laws
- Government support for regulatory agencies

Citizen groups can play an important role in the implementation of these policies. Public pressure and a simple “publish and shame” tactics can also be effective.

1.4.5 Performance of Utilities in Pakistan Relative to Those in Other Countries in Asia and Elsewhere

Figure 5 shows how Pakistani utilities compare with some of the better managed utilities in Asia.

As can be seen from main performance indicators, Pakistani utilities or service providers in the main cities compare unfavorably with other Asian utilities but their performance is not too dissimilar when compared to other South Asian cities.

For example, coverage in Delhi may be slightly better than that in Karachi but in both cases 24-hr availability is nonexistent. Delhi's NRW (>50%) is higher than Karachi (40%), and staff/1000 connections three times that of Karachi.

ADB in its report on water in Asian cities {Ref (19)} concluded that although there are signs of some improvements in terms of customer satisfaction, the trend in Asia is unsatisfactory. Utilities need to pay attention to the deterioration in financial management, gain coverage, and reduce NRW.

Compared to international standards where there is always a 24 hr supply, staff connections are as low as 3/1000 employees, NRW is down to 20%, and cost recovery is 100%, Pakistani performances in particular and Asian standards in general need to be improved colossally.

The next section examines possible ways in which service levels may be improved. There are no magic wands or miraculous solutions. There has to be an integrated approach by the sector in all aspects be it institutional, technical or financial, across the whole spectrum to improve delivery levels. Let's look at some of these aspects.

Indicators	**Osaka**	**Sh'hai**	**Seoul**	**Karachi**	**Lahore**	**Fais'ad**	**Isla'ad**
Population	2,611,528	10,500,000	10,330,000	10,947,000	5,063,499	1,977,246	600,000
Water production m3	1,379,030	4,946,904	4,030,000	2,193,182	1,822,500	454,000	190,680
Water coverage (%)	100	100	100	58	75	60	80
Sewerage access (%)	100	68	98	50	60	50	65
24Hr availability (%)	100	100	100	0	0	0	0
NRW (%)	7	17	25	40	45	70	45
Metered connections (%)	100	100	99	0.3	35	1	0
Staff/1000 connections	1.7	5.7	1.4	6.4	6	25	48
Revenue collection efficiency	87	94	93	54	80	65	40
Capital Expenditure from own budget	High	High	High	Low	Low	Low	Low
Average Tariff (US $)	1.37	0.1	0.49	0.07	0.05	0.11	TBA
Cost recovery	High	High	High	Low	Low	V Low	V Low

Table 5: How Pakistani water utilities compare with other Asian cities

[Source: Asian Development Bank "Water in Asian Cities" 2003]

2. OPTIONS FOR IMPROVING THE SERVICE DELIVERY

Like other South Asian countries, the provision of water and sanitation services in Pakistan is inadequate, inequitable, and highly inefficient. Provided mainly by the public sector, these services generally fail to meet water quality standards and are unable to provide adequate sanitation needs of a growing population base.

The core problem and some suggestions

In order to look at options for improving the delivery service, one has to look at the reasons why these service providers have failed to perform, or in a kinder context, the constraints under which they are expected to perform.

- Confusion of social, environmental, commercial, and political aims
- Poor management structures operating without clear policy guidelines
- High capital investment needs with low or no rate of return
- Resistance to achieving full or even partial cost recovery
- Decentralized water agencies with service responsibility but little resources
- Political interference at most levels of operation
- Non-existent regulator
- Lack of proper legal framework

Under these constraints/ existing ground realities in Pakistan, improvements in service delivery of potable water and sanitation must be linked to improvements in the following functions and areas:

Defining the Policy, aims and objectives clearly
Strengthening of institutions and capacity building
Improving financial sustainability
Making better and more efficient use of funds
Getting own house in order to attract external investment
Better water management practices - reuse, conservation etc

Better definition of policy, aims and objectives

There is a need to clearly define the policy, aims and objectives of the water and sanitation institution responsible for the services. All employees should understand these and work together in achieving the goals stated.

The policy should aim at providing first class delivery service with objectives including but not limited to:

- 24 hours water supply
- Water quality meeting National or WHO standards
- Extending supply network to areas particularly those with poorer population
- Increasing sewerage coverage with appropriate treatment and disposal provisions
- A shift from consumer type philosophy to one which is customer focus
- An efficient business like approach which should be transparent and equitable

Institution strengthening and capacity building

One of the limitations of service providers in Pakistan is poor public sector management and limited skilled human resources. Under the newly devolved structure, the TMA's and district governments will be involved in future development schemes as well as being service providers. It is recognized that it will take years for them to develop the necessary capacity required and that is only possible through a structured and sustained human resource development program.

In many cases institutional restructuring is required with emphasis on elimination of overlapping functional responsibilities. This needs to be coupled with capacity building efforts for provincial, municipal/urban management and TMAs.

In drinking water and sanitation sub-sector, like in many other institutions in other sectors in Pakistan, there is little incentive and motivation for workers to improve their performance. They complain of resource constraints and feel frustrated due to constant political interference. Although quite often true, lack of professionalism and motivation means that the workers accept the situation as fait accompli. instead of trying to improve their efforts. There is a need to enhance human resources management by evolving a system of merit based selection, training, performance evaluation and motivation.

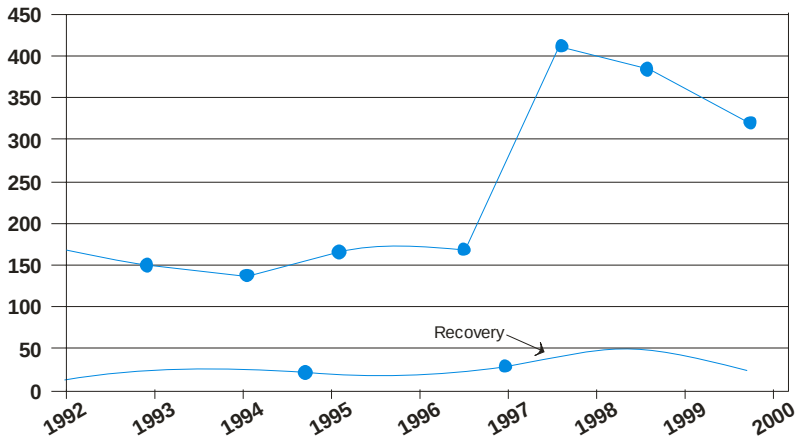
There should also be capacity within TMAs and districts to monitor the performance of staff as well as projects in which they are involved.

Improving financial sustainability

It is debatable whether the water and sanitation sector in Pakistan can be, or even should be, a commercially viable sector. However, there is little doubt that it should be a financially sustainable sector providing a quality service based on the principles of cost recovery.

To illustrate the wide margin between expenditure and revenue collection, Figure 8 shows the performance of Punjab PHED over the 10 year period 1992 – 2002. Between these periods, PHED recovered only about 15% of its recurrent costs. In Sindh and Balouchistan, the cost recovery figures are well below 10%.

Figure 8: Performance of PHED 1992 - 02



Sustainable cost recovery is essential in creating a stable framework to enable service providers to maintain an acceptable level of water quality and quantity, and to provide adequate sanitation facilities.

Initially, water service providers should aim to recover revenues sufficient to cover recurrent (operation and maintenance) costs leaving aside capital costs for renewing or expanding infrastructure.

In municipal water and sanitation, revenues generated from charges (connection charge, water tariff, property tax etc), should be covered by users as a group. The key to sustainable cost recovery is to recognize individual affordability and to use cross subsidization as a mechanism for ensuring that revenues are applied to the whole community.

Cost recovery is critical BUT at a realistic price

Contrary to belief, cost recovery (full or partial) does not necessarily mean total elimination of subsidies. Targeted subsidies will always be required in an effort to achieve a sustainable sector. Instead of subsidizing tariffs, usage or connection charges may be subsidized to help the poor section of the communities. The poor in any case pay more for water than they would if they had a piped water supply. The tankers and informal vendors charge way in excess of what a piped water supply would cost.

Achieving financial sustainability means reducing costs and increasing revenues.

Costs are reduced by better management, sound O&M, opting for least cost options, and better financial planning.

Revenues are increased by increasing billing and collection efficiencies, reducing NRW, better pricing, and improving the delivery service so there is more willingness to pay. Tariffs can be increased gradually from the current low levels as service is improved to a higher level equilibrium as people are more inclined to pay.

Making better, more efficient use of funds

Government of Pakistan only contributes about 0.2% of the GDP to this sub-sector for both urban and rural development. This equates to only 0.8% of total government expenditure on public health facilities. With this situation in mind, water and sanitation providers being mainly public sector organizations, there is a great constraint in providing the quality of service expected. However, whatever little funds become available, have to be spent in the most efficient manner. Emphasis must be on relatively smaller interventions that bring maximum benefits. These could include:

- Leakage detection and repairs in main distribution pipework
- A program for reduction in non revenue water including improvements in billing and collection and a drive against water theft and illegal connections

- Network analysis of the system and an equitable distribution of water
- Demand management instead of a supply orientated service
- A public awareness campaign aimed at better understanding between service providers and users. The need to levy charges and what the public can expect in return.
- Better training of O&M staff, specially in preventive maintenance

Getting own house in order for attracting external investment

Infrastructure investments are not keeping pace with the rapid urbanization. Moreover, there is need for further investment to keep the existing infrastructure intact by continuing rehabilitation and asset replacement. Most of the urban water supply and sewerage systems are old and decrepit. Physical leakages in water supply distribution systems are high, often accounting for the loss of more than 40% of water production. Underground sewerage network, likewise, is in a state of disrepair in most cities and towns resulting in sewage leakages and consequently pollution of underwater aquifers and water supplies. Government funding is limited and is competed for by numerous other sectors.

To satisfy, even a proportion of the capital investment requirements, finance are needed to be drawn from other sources. These sources include foreign aid, commercial loans, and private investments. However, investing in a financially unsustainable, totally inefficient organization is naturally not an attractive proposition. Lenders, be it multilateral donors or commercial banks will always prefer to invest in institutions which are properly managed and can offer a return, albeit small, on that investment.

In order to attract external financing, particularly from private investors, the service providers will have to get their own house in order. This implies better management practices, accountability, transparency, sound business plans, and generally a lean and mean machine wanting to improve its delivery targets but unable to do so due to financial constraints. There has to be a real “want” by the organization to do better and the employees from bottom up have to be motivated to deliver a better service.

Potential lenders and investors look at historic performance indicators and some evidence of improvement in service delivery before committing funds for capital needs. Hence, cost recovery is crucial and so is some evidence that the organization is moving towards financial sustainability.

Better water management practices

With limited financial constraints and a water resource problem across the country, it is imperative that the service providers move towards a better water management practices. Some of these are outlined in Water Policy and Water Resources Strategy. In addition, water conservation, re-use, and industrial water recycling are areas that are considered crucial in any water scarce country.

There should be a incentive based public campaigns emphasizing the need to conserve water at all levels. In households, leaking taps, tank overflows, irresponsible use of potable water for washing cars and watering lawns and plants

must account for a significant proportion of non revenue water. Water metering is a must but with an intermittent supply of water it is of little use. Intermittent supply is also a public health risk. However, in the current climate of minimal cost recovery, weak institutions, non existent regulation, and a gross under investment it is difficult to see how a 24 hour supply is possible in the short term in any of Pakistani cities (Lahore could be an exception).

Having examined the areas that require improvements, let us look at possible options for improving service deliveries.

2.1 The Role of Private Sector Partnership

There is a lot of misapprehension and misunderstanding about Private Sector Participation (PSP) in the provision of urban water supply and sanitation services. In this section we will discuss the need for PSP, the lessons learnt from past mistakes, and possible PSP models in the context of Pakistani cities.

Why involve the Private Sector?

Both the National Water Policy as well as Pakistan Water Sector Strategy highlight the importance and the need for PSP.

According to conservative estimates, RS200 billion is required in the next 11 years to achieve the MDGs. This level of investment is almost impossible from government sources and equally unlikely to come from international donations.

For governments to borrow money to finance water and sanitation capital works means further debt which most developing countries can ill afford. Traditionally multilateral donors such as the World Bank and ADB have financed majority of water related infrastructure in Pakistan. With very few exceptions, most projects have over-run on costs and time and in the absence of any significant cost recovery the government has found it difficult to repay the debts. The KWSB KII project for example took 5 years longer to complete than originally planned and cost twice as much as was originally budgeted {Ref(20)}. The Board has only recently started to repay some of its debt.

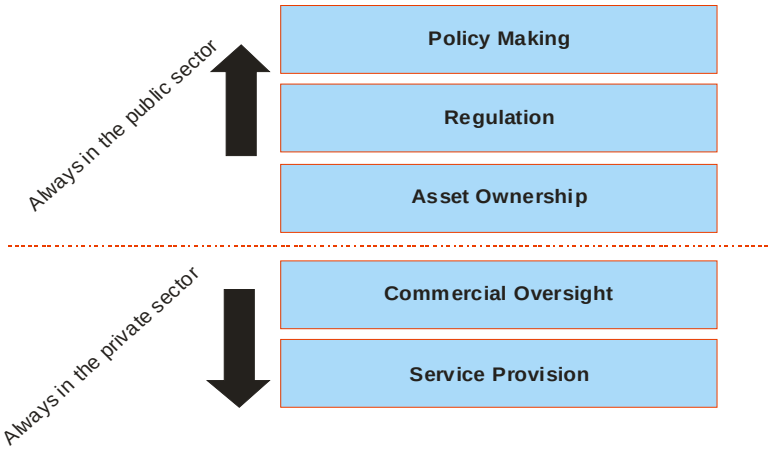
Private sector can raise funds through project financing and is able to execute projects efficiently in a timely manner thereby saving substantial costs. These savings in turn can be passed on to the consumers who end up having a quality service for which they pay realistic charges. That's the theory at least. Like anything else, there are conditions and requirements for PSP to be successful in any particular circumstance. Most critics of PSP fail to appreciate or deliberately ignore this aspect and instead blame the failures of PSP on the ideology itself.

The foremost requirement for PSP to succeed is that of a strong regulatory framework. The need for PSP is greatest where governments are weak and have failed to meet water needs of people. Unfortunately, the risks of PSP failing are also where governments are weak and are unable to provide proper regulation and oversight to protect public interests. It is up to the governments to define and enforce laws and regulations.

Equally important is a legal framework under which PSP contracts are negotiated and awarded. The legislation should be clear and unambiguous allowing both parties to enter into a contract which is fair to both and at the same time protects public interest. This requires provisions ensuring the quality of service and a regulatory regime that is transparent, accessible, and accountable to public.

The concept of PSP in the municipal water industry is still relatively new. We are still learning from past mistakes. There is no doubt that a rush towards "commodification" of water without considering its social value has failed to address some of the fundamental issues but, at the same time there is little doubt that without PSP the future needs of a growing urban population can never be met. PSP in this sector is here to stay and all we have to do is to tailor it to suit particular needs of a community bearing in mind constraints and limitations which are bound to exist in any situation.

Figure 9: Unbundling Water & Sanitation Sector Functions



PSP in Pakistan's urban water and sanitation sector

Apart from a very few O&M contracts outsourced for limited periods, there is no history of PSP in Pakistan's urban water and sanitation sector. In 1997, the World Bank carried out a sector study "Pakistan PSP in Urban Environmental Services" {Ref (21)} which partly formed the basis of failed privatization attempts in Karachi and Lahore.

In case of Karachi, the World Bank funded a study carried out by Paribas-Halcrow JV to privatize KWSB through a long term concession contract. The proposals had many technical flaws {Ref (22)} and did not address public concerns such as –

- omission of inequitable geographical distribution from analysis
- poor and low income household were not prioritized
- low water allocations for unconnected customers
- tanker supply mafia allowed to operate
- little expansion of the sewerage system

- Expansion of the sewerage system linked to new connections

Apart from such technical reservations, the need to increase water tariffs was not politically acceptable. The tariffs had been increased in three subsequent years but remained one of the lowest in South Asia. The government was pressurized by labor unions and NGOs (who merely wanted KWSB to remain in the public sector) and eventually the project was scrapped following a decision by Sindh High Court that water is a national asset and cannot be handed over to private foreign companies. The case is still pending in Supreme Court of Pakistan.

The attempt to introduce PSP in Lahore also failed due to ill conceived notions and the process adopted. In 1998, a multinational British company was invited to carry out due diligence and put forward proposals to privatize Lahore WASA. Unlike Karachi, no consultants were hired by Government of Punjab and negotiations took place behind closed doors and a deal was almost finalized when nuclear testing resulted in international embargoes against investments in Pakistan. In 1999 LDA again entered into negotiations with a private company, this time a German utility to privatize WASA but again this failed due to lack of transparency and an absence of legal framework. The World Bank, through IFC, is currently engaged in looking at PSP options again for the Government of Punjab. It is hoped that this time a proper technical and financial feasibility study will be carried out before embarking on any possible options.

There have also been similar attempts to introduce PSP in CDA Islamabad, Sialkot, and Hyderabad. None of these were properly planned and resulted in abysmal failures.

We can learn from past mistakes in Pakistan and also from around the world to structure PSP in Pakistan's water and sanitation sector in such a way that it is acceptable to public and makes economic and social sense to both public and private sectors. Some of the lessons learnt can be summarized in the following bullet points:

- PSP must ensure basic human needs for water. All residents in service area should be guaranteed a minimum quantity of water.
- PSP does not or cannot mean elimination of all subsidies. Some subsidies (albeit targeted) are important in the success of PSP
- Water tariffs should be affordable and if necessary cross subsidized
- Link gradual tariff increases to improvements in delivery services. Gradual increases.
- Improve distribution networks before new water supply schemes
- Strong governmental regulation is a must
- Water sources must be in government's control
- Water quality and effluent standards must form part of any contract
- Contract review and technical input essential
- Negotiations should be transparent and should encourage stake holder's participation
- Concessions contracts are not suitable in many cases for poorer countries and other forms of PSP, like management contracts should be explored first.

Possible PSP options for Pakistan

It is not advisable in the current climate to push privatization in the form of concession contracts in Pakistan. The reasons are obvious:-

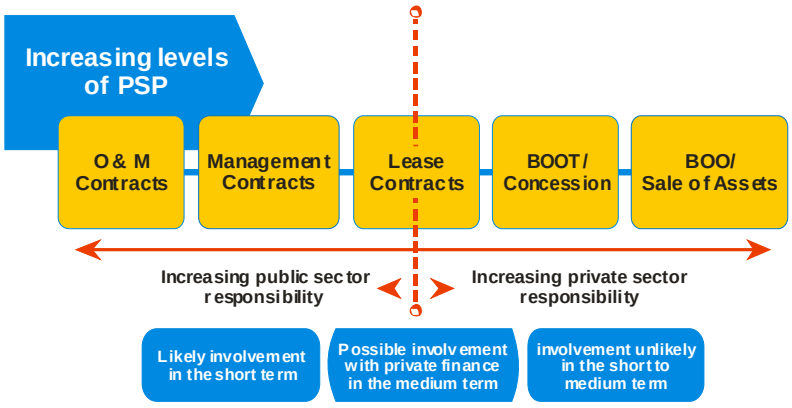
- None of the service providers offer an attractive proposition to potential investors and operators
- There is resistance from various levels including service providers themselves
- There is no proper regulatory body or legal framework
- There is little will to increase water tariffs
- Volatility of political and social climate deters long term commitment from investors

At the same time, it is a fact that letting private sector take care of *some* aspects of water and sanitation provision can help millions of people receive basic services which they lack at present. Like many other things it is a matter of striking a balance which is acceptable to all. Figure 10 shows PSP options ranging from service contracts to total divestiture.

In case of Pakistan with all the constraints and failed attempts to introduce PSP discussed earlier, some hybrid solutions may be more appropriate. These solutions endeavor to introduce the private sector for its technical and commercial expertise (e.g. in the case of private O&M) or for its technical, commercial, and financial expertise (as in the case of Private O&M plus financing).

In these hybrid models, asset ownership and regulation remains with the public sector and commercial risks taken by the private sector are limited and well defined.

FIGURE 10: POSSIBLE PSP OPTIONS FOR PAKISTAN



These contracts could be of relatively short term (3 to 5 years) so that PSP is gradually introduced and performance of the operator judged against deliverables.

Privatization of Karachi Electricity Supply Corporation (KESC) is a fairly recent event. It is encouraging in that it opens up other avenues and possibilities such as perhaps

combining water and power charges to improve collection efficiencies like in several other countries.

2.2 Options for Obtaining Raw Water

Whilst other papers will cover water resources management in general, brief discussion that follows focuses on the raw water availability with respect to potable supplies.

As will have been discussed elsewhere, water resources management faces immense challenges in Pakistan in face of variable availability and increasingly competitive uses of water. As industrial and urban sectors grow, there will be requirement for more water for these uses and reallocation from the agricultural sector will be required.

Groundwater

Majority of population of Pakistan depends on the groundwater source. Only in Karachi, Hyderabad and partly Islamabad significant amounts of surface water is used. Most rural water is also supplied from groundwater except in saline areas where irrigation canals are used as potable supplies. Over 50% of village water supply is through private hand pumps.

However, as described in earlier sections, increasing demand for both rural and urban water is putting additional pressure on groundwater resources. Most of the groundwater resources are already over exploited. The problem is not just over pumping and a declining water level. There are serious quality issues.

In Sindh for example, almost 95% of shallow groundwater supplies are contaminated with fecal coli form. In Karachi, chlorinated pesticides have been reported in shallow groundwater. In Thar and Mirpur Khas high fluoride concentration is a problem too.

Similar story emerges from other provinces. The potential for further development of groundwater is be limited.

Surface Water

Nearly 80% of river flows and 65% of precipitation occurs during the three monsoon months. Due to these high variations and lack of effective water management and silting of major dams, surface water as source for potable water supplies poses its own problems.

Furthermore, high turbidity and suspended solids in surface water do require sedimentation before filtration and disinfection. In the absence of proper sewage treatment and disposal facilities in majority of towns and cities, surface waters are being increasingly contaminated with fecal bacteria.

There is potential in Karachi to bring further surface water supplies from Indus. However, due to the limitations of the existing lake/canal feeder system, investments would have to be very high.

Islamabad is also looking into the possibility of augmenting its current supplies by bringing water from Ghazi Barotha. Again, the costs are going to be high and a more economical and better approach would be to reduce NRW as availability of water is not a problem in Islamabad.

Sea water

The use of sea water for desalination is a much talked about subject. In Karachi and now Gwadar, desalination has been mentioned as a possible resource. However, desalination schemes are capital intensive and require high degree of O&M. Such schemes can be considered if the private sector is willing to invest and participate. So far, despite many attempts, organizations such as KPT, Port Qasim Authority, KWSB have failed to attract the private sector. This may be due to perceived risks but also due to the fact that no proper feasibility studies have been carried out.

Rain Water

Water has been harvested in many places around the World since the dawn of civilization. In India for example, Rain Water Harvesting (RWH) dates back to the 15th Century {Ref (23)}. It is well practiced in both rural and urban areas.

RWH can take any form in which rain waters are collected, stored and subsequently used. Many communities have built special structures to collect water. In the Churu District of Rajhistan, one of the driest areas of the Sub-continent, RWH consists of a *kundi* system where a circular catchment area is created sloping towards the middle where a tank collects the rain water. To enhance the runoff and to reduce the permeability of the porous sandy soils, polymer based linings are used which are much more effective than the traditionally used clay, silt or gravel.

RWH lends its self to a decentralized, community based system of better water management. In areas such as Pakistan which benefit from a short term high intensity rainfall (monsoon), RWH can be viable option to augment rural water supplies.

RWH can also be effective in urban areas. In India, in large cities like Chennai, Bangalore and Delhi, it is mandatory to install RWH systems in newly constructed buildings. In some areas such as Indore, a rebate of 6%on property tax is offered as an incentive for implementing RWH.

Water Reclamation & Recycling

As per the Water Cycle, all water is eventually recycled. Water Cycle however has no time limitations. Water can return to the earth as snow or ice and glaciers may take hundreds of years to melt. Water precipitation may also be deposited on seas and oceans making its access for potable supplies limited to a very small population.

Water reclamation, recycling and use must be a central theme in any of today's water resources and management policies. Earlier sections dealt with the need for better water management. This management should start at home and spread through the whole spectrum of society including offices, schools, factories, golf courses, water parks etc. Everyone should be made aware of the need to conserve water.

In developed countries, water conservation and recycling is well practiced. Industrial users there have to pay water charges many folds more than domestic users. Also, to obtain maximum economic efficiency, they have to adopt policies for water conservation and recycling. In Pakistan however most industries do not even have their own internal water policies or water management procedures. Water is relatively cheap and if anything, is used to dilute effluents before discharge. One of the major water users in Pakistan is the textile industry. Water is used in many processes such as dyeing, bleaching, washing etc. Very few textile factories have water reclamation plants or water collection and re-use systems.

On the brighter side, Govt. of Sindh and (City District Govt Karachi) CDGK is currently undertaking a water re-use project through PSP by allowing the use of treated wastewater from its TP1 & TP2 sewage treatment plants to be re-used as process water for Sind Industrial Trading Estate (SITE). The contract is being let on a BOOT basis with the contractor guaranteed a "take or pay" scenario on an agreed tariff structure.

3. PRIORITIES & SEQUENCES FOR MOVING TOWARDS BETTER PRACTICES

One of the most important messages in World Bank's Water Resources Sector Strategy (WRSS) is for a "pragmatic and principled" approach with prioritized, sequenced, practical and patient interventions.

The first priority must be institutional reforms. There will always be an inertia to change. Wholesale reforms are not possible overnight. Devolution has provided an opportunity to move towards better practices. Here support both technical as well as financial is needed. Incentives to improve are already there.

For main urban centers, some form of private sector participation together with community participation in peri-urban areas is essential. However, a regulatory and legal framework must be in place for these initiatives to be successful.

Pakistan has finally recognized the importance of this sector and has both policy and strategy in place. It's a matter now of implementing these policies. MDGs or the goals listed in the TYPP are going to take time and a pragmatic approach is needed to realize this objective.

Institutional reforms will eventually lead to better coverage and improvements in service delivery. However financial sustainability is the key. Appropriate affordable charges must be made for the provision of the services. Elimination of subsidies in the short term is not the aim – better use of subsidies certainly is.

4. COMPARATIVE ADVANTAGE OF THE WB ENGAGEMENT & SUGGESTIONS

The World Bank can play a pivotal role in the development of the drinking water and sanitation sector in Pakistan. As highlighted in it's WRSS, water management and development are essential for growth and development. Pakistan is no exception.

Pakistan was once a water rich country but now struggles to meet its water demand. Mismanagement of the resource has not only resulted in water scarcity in parts but also a deterioration of the infrastructure. As evident from the foregoing sections, there are serious water quality and public health issues stemming from poor service delivery. The World Bank can assist in both development and management of water services, both in terms of infrastructure as well as in assisting institutions and service providers to move towards financial sustainability.

More specifically, the areas where World Bank could assist in this sector are:

- Improving in-house management, if required assistance in restructuring utilities and service providing organizations.
- Assistance in attracting private sector finance and know-how. IFC for example is currently involved in looking at options for Lahore WASA
- Assistance in reducing NRW including leak detection, rehabilitation or replacement of water distribution infrastructure, network analysis, asset mapping, billing and collection
- Assistance in implementing water quality monitoring program
- Water quality improvements including treatment plants
- Training of water and wastewater treatment operators

In Pakistan, there is a long and close Government of Pakistan / World Bank relationship in the water sector. The World Bank assisted in water projects in Chittagong and Dacca in the former East Pakistan (now Bangladesh) in early 1960s. Its involvement in Lahore dates back to mid 60s and in Karachi to early 1980s. More recently, the Bank has been involved in Rural Water Supply and Sanitation Project and Social Action Programs which had a significant water and sanitation component.

There was a high level Bank visit in November 2003 which led to broad definition of Bank's engagement in this sector. This has been refined in subsequent discussions with the Government of Pakistan.

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Political Economy of Water Reforms in Pakistan

By

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Country Water Resources Assistance Strategy
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POLITICAL ECONOMY OF WATER REFORMS IN PAKISTAN

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I. Introduction

The Indus basin is ecologically an arid region. While the northern mountain area, which includes some of the highest terrain in the world, has its own eco-system, the western mountain systems and the central and southern plains comprise a clearly arid environment, in terms of the amount of annual rainfall received. From about 20 inches in the parts of the Punjab bordering India, and receiving the western ends of the summer monsoon, the rainfall recedes rapidly to as low as five inches in the western parts of Pakistan. These low precipitation levels mean that rain-fed, or *barani*, agriculture, is not possible on a large scale in the Pakistan area. This is especially true of the central and southern plains, which are the heartland of agricultural production in this region. While rainfall remains an important ingredient in supplementing crop production, both for the spring (*rabi*) and autumn (*kharif*) harvests, the primary dependence must remain on irrigation systems. The management of water resources is, therefore, a critical factor in Pakistan's future sustainability. Gradient flow irrigation, delivered through canal networks, has been the major source of irrigated water in the past century. Since 1960 groundwater reserves, tapped through tubewells, have also emerged as a major source.

These irrigation inputs now have to be extensive enough, and effective enough, to support an extremely large, and rapidly expanding, population base. From a population level of 35 million in 1947, the country's population has almost quadrupled, to around 150 million by the early 2000s. The population growth rate is one of the highest in the world. This has been around, or even above, 3%. From this embarrassingly high figure, denoting a major relapse in population planning strategies, government sources have claimed that in the last decade the purported population growth rate first came down to 2.6%, and then to 2.1%. These neat downturns of 0.5% each time have not been accompanied by convincing explanations of their causes, either in terms of demographic behaviours (birth and death rates, life expectancy, infant mortality etc) or in terms of exogenous factors (war, famines, epidemics, disasters etc).

The high population level has begun to place major strains on the agricultural production systems, and thereby on the country's water resources. In the face of continuing constraints on rises in agricultural productivity, Pakistani agriculture is going into a deficiency mode. There has been a failure, really since the green revolution period of the 1960s, to dramatically increase crop yields and to sufficiently disseminate innovative processes and technologies in the rural sector. This has now combined with the perception of growing water scarcities to make an 'agricultural revolution' in the shorter term unlikely. Successful reforms in the water sector need, therefore, to be accompanied

by simultaneous improvements on the agricultural side, in production techniques, marketing efficiencies, and in research, education and extension.

The competing demands on arable land for both food crops and cash crops is coming from population increase, shift in demand towards higher protein food intake, and rising industrial and agro-processing demand for agricultural raw materials. Moreover, most of Pakistan's exports are agro-based; so agriculture has to deliver both for domestic consumption and export earnings. The loss of wheat self sufficiency in the 1990s, and the growing tendency for raw cotton imports, are worrying trends. So is the failure of import substitution in such major commodities as edible oils and tea. The move away from state intervention in commodity distribution will also require a period of adjustment, as market imperfections are ironed out (one example was the crisis in the internal wheat trade in 2004).

Thus, from physical, agronomic and demographic perspectives, the manner in which water resources are utilized will bear critically on the viability of the Pakistani economy and eco-system. These factors have profound political implications and impacts, just as they now entail complex management challenges. The nature and quality of the political and management responses to challenges in the water sector will be a critical factor in Pakistan's national development. The increasing complexity of the situation is indicated by some further developments. The country is now near, or has already reached, the physical limits of the system. The preferred option of the past, of extending canal irrigation to new lands, is not forthcoming on any extensive scale. Not only is easily accessible virgin land no longer available, but there is a serious constraint on water volumes, at least within the present utilization structure. Further increments will only be possible through qualitatively improved practices and strategic responses. The transition to these superior activity levels will again have a strong political economy dimension.

Two other developments involve again the relationship between demographic and politico-economic factors. One is the rising level of urbanization, and with it the accompanying process of industrialization. These segments will participate increasingly in water consumption; and their activities will impact on the quality of water resources. At a 30% level of urbanization, the urban population will reach close to 50 million, which is the scale of a medium-sized country. The intra-urban distribution of water between different social classes, as well as pollution safeguards and the appropriation of water for industrial use, will not fail to have political repercussions.

Second, given the high population growth rate, Pakistan's demographic structure is getting flattened out. There are larger numbers of younger people: those under 20 years of age are already over half the total population. This might not directly affect water issues, though education can be a competing budgetary item. However, having relatively more youth will place strains on employment generation, with large numbers entering the employment market annually. Within a short period they would also enter the reproductive process, keeping the demographic upturn spiraling out of control. Most of the population growth will occur in the rural areas; and the majority of younger people

will rely directly or indirectly on agriculture for their livelihood. Their productive absorption will pose further political and managerial challenges for decision-makers.

II. Historical development of Indus basin irrigation

Some insights from the historical development of the irrigation system in Pakistan will be instructive in understanding the political economy of the water sector. Before the advent of perennial irrigation in the 1880s, the traditional irrigation practices were confined to tapping seasonal inundations, through ponds or canals. Well irrigation also allowed for localized agricultural operations. The seasonal canals could be quite lengthy, but they could only command strips of land contiguous to the rivers. The vast land tracts left elevated above the flood plain remained uncultivated, and could at best support a semi-nomadic pastoral economy.

The inundation canals were mostly 'privately' owned; and this gave their proprietors significant social authority. Much of 'feudalism' or agrarian magnate power in the Indus basin was predicated on control of the water source, and thereby authority over irrigators. Well irrigation or barani agriculture provided more autonomy for village communities. Under British rule many of the private networks were brought under state ownership, especially where they came under the new perennial canal commands. The former 'water lords' were given handsome land compensation, or they benefited substantially from the extension of perennial irrigation to their landed properties. In some cases, where political or military services were deemed of significance, the private canal ownership was allowed to continue. This occurred with the privately owned canals in the Sargodha District of Punjab right up to 1947: only after independence were they incorporated into the Lower Jhelum Canal system.

The current structure of the canal irrigation network started taking shape from the 1880s, with the construction in the Punjab of the Sidhnai and Sohag Para Canals, in the Multan Division, and then the major perennial canal networks of the Lower Chenab, Lower Jhelum and Lower Bari Doab, and finally the Sutlej Valley Project in the 1920s. Two further works were the Upper Jhelum and Upper Chenab Canals, which under the Triple Canal Project brought water from the Jhelum and Chenab to the Ravi, for the Lower Bari Doab Canal. In Sindh the Indus river was tapped through the great barrages at Sukkur, Kotri and Guddu. In Punjab after 1947, the Thal region, in the Indus-Jhelum interfluve, was first accessed, and later the Indus right bank through the Chashma Barrage. Substantial canal extensions have also occurred in Sindh since 1947. Subsequent to the Indus Basin Treaty with India in 1960, further hydraulic works were completed, comprising dams, headworks and link canals, to bring the waters of the western rivers to the eastern ones diverted by India. This entire network, developed over the past century and a quarter, now comprises the largest contiguous irrigation system in the world.

The political economy dimensions of Indus basin irrigation followed from a fundamental distinguishing feature, in contrast to most of the irrigation activity in the region that became India in 1947. In the latter canal irrigation occurred primarily on already settled

lands, and it came as a supplement to barani and well-irrigated cultivation. In the Indus region, it was extended to virgin lands, only a small fraction of which were private proprietary holdings. In the Punjab, the very extensive barren tracts commanded by the new canals were categorized as Crown or State Waste Land: in other words they were appropriated as state property. The rights of the pastoral tribes to the land were not recognized. These areas were too sparsely populated for these indigenous people to provide the labour power for agricultural operations. They were also deemed to lack the agricultural traditions to make a success of cultivating new land.

The British administration then embarked on a vast process of agricultural colonization, by essentially introducing colonists from other parts of the Punjab to these 'canal colony' lands. Large numbers of non-Muslim colonists from eastern Punjab were selected, which created problems of return migration, and the associated mass killings, in 1947. The decision to confine the land grantees to the Punjab, rather than extend allocations to other provinces, was itself of great political significance. By contrast, elite Punjabis had been rewarded with large holdings in the United Provinces after they served the British in the armed struggle of 1857-58. Punjabi colonists have also been settled extensively in Sindh over the past century.

The social composition of the grantees of land gives further insights into the relationship between land, water and power. The majority of landholdings, as well as the greatest allocation of land, was reserved for smallholdings of up to 50 acres. While the 'peasant' element was tapped for these grants, the colonial administration almost universally confined the selection of grantees to the 'upper' segments of village society. These were the proprietary lineages that controlled land and power at the local level. They could be distinguished from the lower status 'service' castes, which were equally universally excluded from a proprietary or occupancy status in the new canal lands.

After 1900 this selection process worked within the framework of the remarkable Punjab Alienation of Lands Act. This Act listed hereditary landholding castes in each district, and forbade land transfers from 'agricultural' to 'non-agricultural' castes. This paternalistic legislative measure was designed to protect the 'agricultural castes', a vital political support group, from expropriation through purported rising indebtedness caused by commercialized farming, cash revenue demands, or conspicuous consumption. Further legislation, such as on mortgage foreclosure, was also directed at constraining the destabilizing impacts of the market economy, especially the displacement of traditional landowners by a new class of perhaps more investment oriented, 'capitalistic' farmers. The protective approach adopted by the British provides an intriguing contrast to the current return to market forces as a core ideology.

In Sindh, the peasantry had not replicated the post-Mughal achievements of its Punjab counterpart, in forcing social change through successful armed resistance. It thereby remained subject to agrarian magnate overlords, whose intermediary role was also recognized by the British, and who were further strengthened with the extension of canal irrigation to their proprietary lands. Provincial politics before and after 1947 were dominated by factional struggles within this oligarchy. It was not till the 1980s that this

was challenged, by urban politicians of the Muhajir community. New canal irrigated land was allotted to Punjabi settlers, as well as to military and civil officials. In the Frontier province, the larger landowners belonged to the Muslim League; but the smaller 'khans', especially from the sugarcane and tobacco belt of the Peshawer vale, were part of the 'Red Shirt' movement that before 1947 favoured ties with the Indian National Congress. Its leader, Abdul Ghaffar Khan, remained at odds with Pakistani ruling establishment. In Baluchistan, irrigated agriculture was not widespread, and ethnic distinctions continued, with a tribal Baluch southern part, and a more agriculturally progressive Pashtun dominated northern part.

The shoring up of incumbent landholding castes, and their further consolidation through irrigated land, was the hallmark of the political economy of the Indus basin through most of the twentieth century. These castes were also the predominant payers of land revenue and water rates. They also virtually monopolized recruitment into the military, at least in the colonial period, when over half the entire British Indian army came from the Punjab. Indeed, the military became a major participant in the emerging hydraulic society, through substantial land grants to military personnel, military farms, extensive horse-breeding schemes, and stud farms and remount depots for the cavalry. The landlord segment also received large areas in land grants, while the middle class could benefit from the expanding commercial and professional opportunities in this new agrarian frontier. On the basis of the resource allocations and economic growth, the colonial state was able to keep important stakeholders in a cooperative mode. This region had a minimal nationalist penetration, and political organizations remained at an elementary level, compared to the territories that became India. Consequently, the extant power structures enjoyed significant continuities into the post-colonial state.

Thus the political economy perspective on hydraulic society in the Indus basin reveals a complex interaction of state power articulation, hierarchical status, and resource absorption. There were clear benefit differentials between social classes. The mass of rural poor, while they did obtain new employment opportunities, were excluded from control over irrigated land. Under canal irrigation, both land and power, and thence access to state controlled resources, remained concentrated with upper rural elements. Any gains by an emergent commercial and professional middle class were quashed when it had to exit the Pakistan territory in 1947, on the basis of its predominantly non-Muslim composition. Institutionalized politics remained weak, in the face of a more personalized political mainstream of rural magnate electoral representation, based on upper peasant support. The civil bureaucracy was strengthened through control over irrigation management and land distribution; and the military gained authority through major absorption of landed resources. Both have remained important, if not vital, stakeholders in decision making.

III. Political and economic developments in Pakistan

A brief survey of political and economic developments in Pakistan will also help to highlight factors influencing the political economy of reform. Politically, developments in Pakistan over the past five and a half decades can be divided in roughly decennial

periods of alternating civilian and military rule. The period of civilian politics from 1947 to 1958 was followed by military rule under General Ayub Khan from 1958 to 1969. A brief period under General Yahya Khan saw the elections of December 1970, and the breakup of the country during 1971, with the formation of Bangladesh. This was followed by the Peoples Party government, under Zulfiqar Ali Bhutto, having gained an electoral majority in the remaining Pakistan. The PPP government was ousted in another military coup in 1977, led by General Zia-ul-Haq, with Bhutto executed on a murder charge.

In the second half of Pakistan's political development, the alternating pattern of military-civilian rule was repeated. Zia-ul-Haq remained as the military ruler till his accidental death in 1988. The next period, from 1989 to 1999, was one of civilian rule, with four elections and two governments each under Benazir Bhutto of the Peoples Party, and Nawaz Sharif of the Muslim League. All four were dismissed before they could complete their tenure, till finally Sharif was overthrown in 1999 in another military coup, with General Parvez Musharraf taking over as the new military ruler. Thus an inability to maintain democracy, and continuity of electoral politics, as well as an ongoing tendency by the military to take over power, has characterized Pakistan's political history.

The frequent recourse to authoritarian rule, and the inadequate opportunity for the development of democratic institutions, has substantially impacted on the nature and process of decision-making in Pakistan. Concentration in the structure of authority, and its converse of more widely based decision-making processes, will clearly also impact on the course and outcome of attempted reforms in the water sector. The lack of continuity of democratic activity has impeded power from being diluted beyond a fairly restricted segment of interest groups. A frequent criticism has been that this has prevented empowerment of the majority of people, and prevented reform strategies from representing the interests of major population segments.

Consequently, state policies and strategies have tended to serve sectional interests, whether class or regional. While they might have been of national benefit, and enhanced the general welfare, they remain suspect because of weak consensus building, consultation and transparency. Critics allege that even the civilian regimes of the 1990s were unable to throw off military-bureaucratic influence and pressures, and adopt autonomous decision-making along democratic lines. Therefore, the problem of credibility and legitimacy will need to be addressed if reforms are to gain acceptance and appear to be equitable. On the other hand, decision-making within a more democratic framework, as happened in the 1970s, has been criticized for having longer term deleterious effects on the national economy, and on both national and local institutions. As we shall see below, nationalization policies under the Peoples Party government were a reaction, and perhaps a corrective, to the wealth concentration and rapid industrialization strategies of the 1960s. However, they did harm the development of business groups, which fragmented the country's industrial structure; and greatly expanded public sector operations that ultimately proved highly inefficient

The manner in which different stakeholder interests can be mutually conflicting, and can at times end up in conflict, has been a feature of the political economy of Pakistan. Though a major region of agricultural production, with a sizeable capacity for exports of agricultural products, the Indus basin in 1947 had virtually no industry. Raw cotton was exported overseas, and to textile mills located in western India. There was only one sugar mill, no chemical or electrical industry, and virtually no hydro-electric power generation capacity.

In the 1950s, and especially after accumulated profits from the Korean War boom, the state tried to induce industrialization. Various facilitative policies were adopted to meet these new objectives, such as an overvalued exchange rate, subsidized finance, quotas and licenses, protected markets, raw material procurement subsidies, and public sector divestment of industrial assets to private business. In the conversion from mercantile to industrial capital, two significant business groupings emerged. One was the immigrant trading communities from western India that had settled in Karachi. The other was upcountry Punjabi commercial groups, many returning from Indian territory at partition. Accompanying this first industrial surge was stagnating growth rates both in agriculture and real wages, and little effort to strengthen the agricultural infrastructure. The crisis ensuing from a weak market, with overcapacity and under consumption, led on to the military coup of 1958.

Though initially expressing suspicion of business ‘robber barons’, the Ayub Khan regime became their avid proponent. The process of both industrial expansion and industrial wealth concentration intensified from the early 1960s, accompanied by generous foreign aid inflows. The emerging perception of the ‘twenty-two’ families, with oligopolistic control over large-scale industry, banking and insurance, soon became an emotive political issue. There was further disenchantment over stagnating real wages, restrictions on labour unions and political rights in general, and the squeezing out of the small and medium enterprise sector, as concessions appeared to be directed towards ‘big’ business. Even more seriously regional disparities and resource drains, especially in the case of East Pakistan, were becoming politicized.

Agricultural growth rates did revive in the 1960s, with such green revolution inputs as new high yielding crop varieties, farm mechanization and fertilizers. However, the benefits of these higher cost inputs mostly accrued to middle and large farmers. The landless labour work force in agriculture and agro-processing benefited from the green revolution, through the increased labour demand. This brought some degree of poverty alleviation, though there were no sizeable increases in real wages. The politically important landholding upper peasantry was squeezed by the higher cost structure of green revolution agriculture. Inability to afford these investments, as well as tenant expropriation under the pro-landlord bias of military rule, further distanced the smaller agrarian producers. Their margins were further affected by continued controls over agricultural commodity prices. These were seen as an implicit tax on agriculture, along with subsidies to industrial processors, especially with price controls on raw cotton, the largest cash crop. After 1965, the growth rate eased, following the war with India and

reduced foreign aid flows. A popular agitation in 1969 led to the resignation of Ayub, and elections in December 1970.

Not only did these elections lead to the dismemberment of Pakistan and the creation of Bangladesh, but they had long term ramifications for West Pakistan. The Peoples Party government, under Zulfiqar Ali Bhutto, was elected on an agenda that it then set about to implement. An extensive program of nationalization of large-scale industry, general insurance and banking was undertaken. These policies did manage to reduce the industrial assets of the larger business families, and dissuade them from further investment. Significantly, cotton textiles, the country's largest industry and a major procurer from agriculture, were not nationalized. During the 1970s private sector investment levels fell substantially, while the public sector emerged as the main investment source. Emergent business enterprise had made its wager with military rule; and obtained rapid and even abnormal profits thereby. It eventually suffered because it had failed to seek alliances with a wider social base, or propitiate populist or institutionalized politics.

Bhutto was able to put together a strategic alliance of disaffected stakeholders, each with its own political objectives. This alliance included large landowners of Sindh, the Punjab and Frontier peasantry, small-scale enterprise, industrial labour and urban intelligentsia. The wide canvas of institutional and economic reforms attempted had inevitable contradictions. Bhutto extended labour laws to the small-scale sector, a support group that he now alienated. Further nationalization measures highlighted the true nodes of power in Pakistan. This occurred with nationalization extended to the intermediate agro-processing sector: cotton ginneries, oil and flour mills were taken over. Additionally, public sector corporations took over procurement and distribution of the major agricultural commodities, such as cotton, rice and wheat. The true beneficiaries were intended to be agricultural owners, by removing the traders and processors that they feared in the forward extensions of the agricultural value chain. Bhutto needed the support of this powerful constituency for the 1977 elections, but this entailed a virtual counter-revolution against the market economy.

During Zia-ul-Haq's military regime, initial efforts to encourage private investment failed, despite various concessions. After 1985 investment did revive, but mostly in such low value added sectors as sugar and cotton textile commodity processing. Business weakness also prevented Pakistan from utilizing opportunities in emerging international industries, such as consumer electronics, computers, and later software development. Exports were stagnant, and remained largely cotton based. Power shortages also appeared, indicating the lack of adequate expansion in electricity generation, especially hydro-electric power. The war in Afghanistan required a conservative domestic agenda, to avoid destabilizing the 'home front'. This included suppression of political rights, and propitiation of religious fundamentalists. While the PPP's intermediate sector nationalization was reversed, both the privatization program and institutional reforms made little headway. State functionaries dominated the expanded public sector space; and from 1985 resource absorption included personalized politicians patronized by the regime. However, in this period Pakistan enjoyed growth rates above 6%, the highest in

South Asia. Contributing factors were lower international inflation, steeply enhanced aid and loan inflows, expatriate remittances, and underground drug profits.

During the civilian regimes of the 1990s, Pakistan's economic performance was less impressive. Growth rates fell to around 4%, below those of India. Adding to a bloated domestic debt, the international debt rose to over US$30 billion, creating repayment problems. Pakistan experienced sanctions for its nuclear program, and vilification over the Kashmir insurgency. With fiscal deficits reaching above 6%, new external loan conditionalities required structural reform and privatization initiatives. Both might have been long overdue, but the perception was unavoidable that their sources were international agencies rather than domestic constituencies. The decision-making segments, across different sectors, also enjoyed rental exactions from the status quo, and their impulse for reform was weak. Where top management did become converted to reform, convincing the middle and lower strata to implement change appeared problematical. Nevertheless, over the past decade major privatization has occurred, first in industrial assets, and then in banking and some parastatals. Reductions in subsidies, as with fertilizers, and the move towards user charges, as with energy pricing, may have been overdue, but they have also impacted on both agricultural and industrial production cost structures. With trade liberalization, fiscal reform and financial deregulation, Pakistan has more firmly embraced market oriented policies.

Perhaps the acceptability of these policies has been facilitated by the turnaround in economic conditions since September 2001. The anomaly is that in its initial two years, General Musharraf's military regime enjoyed domestic support, but was reviled internationally. After the post 9/11 invasion of Afghanistan, Musharraf gained strong Western support, but internal political decisions appear to have affected domestic acceptance. While poverty levels have also increased, serious opposition has been retarded through tangible benefits. These have been macro-economic stabilization, some relief from international debt, renewed remittance inflows, a turnaround in foreign exchange reserves, and declining interest rates from enhanced liquidity levels. Were there to be an economic downturn, the position of the regime would become much more precarious. It could adopt a more defensive mode, less willing to undertake reform. There might well be a 'window of reform' period in each regime's life cycle, during which the government's readiness and the people's acceptance is in synchronization. That is the optimal timing for the implementation of change. Otherwise, perfectly rational and reasonable reform programs can be delayed or derailed.

IV. Politico-economic role of stakeholders

One method of identifying stakeholders would be through the major subsectors and issues that run through the water sector. Within this 'horizontal' range there are a number of interacting interests, providing for a 'vertical' analysis. In the former, by far the most important subsector of the hydraulic system is surface irrigated agriculture, which comprises around 95% of water utilization. Other major subsctors HOW ARE THESE "SEGMENTS"? ISN'T THIS JUST A LIST OF ISSUES? are groundwater usage for agriculture; municipal and rural water supply and sanitation; water for industry; and

water for hydropower. There are a number of issues and policy concerns that interface with these subsectors, such as interprovincial and intraprovincial water rights and allocations; integrated planning and development of water resources; economic and financial management; flood management; drought management; drainage and reclamation; and pollution and environmental impacts.

Within the above major categories, there is a host of stakeholders and participants that in aggregate make up much of the Pakistani population. Their roles will be discussed in this and the following sections. Some of the players run across the different subsectors, while others play more focused roles. The stakeholders can be divided into institutional players and socio-economic groups. Among the former would be the federal government and national assembly, the military, the civil bureaucracy, the provincial governments and assemblies, the emerging system of local governments, the provincial irrigation management cadres, area and local water users associations, welfare or community development based non-government organizations, political and advocacy organizations, various pressure groups, business trade associations, and chambers of commerce.

The second segment is the socio-economic groups that have a stake in the water sector. In the rural economy the more important elements are the agrarian elites or larger landholders; the 'upper' peasantry of village-level landholding lineages; and the rural poor comprising landless service or wage-earning groups and subtenants. Rural entrepreneurs, either in trade or agro-processing, are also an important component of the rural economy. Another segment comprises the fishing community, both inland and coastal. In the urban environment are the industrialists and larger scale business, the small and medium scale enterprise that includes the 'informal' sector, the upper and middle income groups that have enhanced per capita water consumption, and the urban poor and slum dwellers. A more specific group are the 'technocrats', comprising engineers and life and social sciences experts, who are involved in both operations and analysis in the water and development sectors.

Among institutional stakeholders clearly the most influential is the federal government. As observed above, there have been major breaks in the nature of the federal government, with alternating periods of civilian and military rule. There is no easy correlation between either of these types and their policies towards the water sector. But the absence of a uniform system, and especially the frequent breaks in democratic values, has created a lack of continuity in the basis and format of decision-making. In a democratic system, political parties with contrasting agendas can create policy reversals when in power. However, the process for decision-making remains fairly uniform. This route is through legislative debate and enactment; and through broader information dissemination, public discussion and consensus building, with a view towards electoral accountability.

In Pakistan, then, a major facet of political economy has been the lack of consistency in the decision-making process. Nevertheless, this has not necessarily entailed a military-civilian dichotomy in strategies. Both, for instance, have to date failed to undertake construction of the Kalabagh Dam. Also, if military rule can be equated with policies less responsive to public opinion, the periods of civilian rule have also witnessed sub-optimal

democratic processes, such as lack of proper consultation, short term objectives, and policy preferences for sectional interests. Contributing factors could have been the regular interruptions to democracy, or the weakness of institutionalized politics.

The federal government has been seen by critics to have preferred large and capital intensive water infrastructure projects, mostly funded by international agencies, and thereby incurring foreign debt. This has involved a technical and engineering approach, working within a techno-centric paradigm. This certainly delivered in creating the contemporary structure of Indus basin hydraulic and energy resources. However, this approach also had its limitations, as it downgraded or ignored the social and political problems involved in water sector infrastructure development. Additionally, the very evident and widespread environmental impacts were also initially overlooked, but even their remedies were undertaken primarily as engineering solutions.

Arguably, a more balanced view would recognize that interventions have impacts both on ecology and communities, and this should lead to more integrated planning. A more socio-centric approach would incorporate these wider interests. It would entail sensitivity to community concerns and impacts, the acknowledgement that traditional forms of water utilization can also have value, and the readiness to involve localities and communities in water sector management reforms and infrastructure development. This could make any proposed changes politically acceptable, while community support would also facilitate implementation measures. Adopting such an approach would require attitudinal change among decision-makers and administrative cadres, especially those at the operating level. However, the stimulus for this needs to come from the federal government, and should start from the conceptualization and design phase of projects, rather than be added on as an afterthought.

In the light of the current drought and resulting water shortages in the country, there is an emerging awareness that the water sector deserves special attention. There is a growing realization that the country might become increasingly water deficient, and pressure on water resources will continue to rise. This could lead to inter-provincial friction, which in turn could have serious political repercussions. These risks have induced the government to prioritize water issues in its national strategy. For example, in November 2004 a National Water Council was established, essentially to coordinate decisions on the water sector and resolve water conflicts among provinces. The prime minister would head the council, which would include chief ministers of all four provinces, seven federal ministers, and experts from provinces, the Ministry of Water and Power, and WAPDA. With adequate political will, such an apex body can effectively manage national water strategy and help resolve issues in the future.

The federal government has also drawn up a national water policy, with the target year of 2025 to meet a number of objectives designed to ensure the sustainable utilization of water resources. The stated intention is to achieve a ‘blue revolution’ over the first quarter of the twenty-first century. There is due consideration to environment, quality of life, ability to pay, and participation of all stakeholders. The key policy recommendations include provision of safe drinking water, additional storage for year round crop

production and for overcoming drought years, additional hydro-power generation, prevention of saline intrusion into fresh groundwater, and development of a comprehensive water law. The new strategy is said to depart significantly from previous approaches in that it is based on demand management policies, rather than supply enhancement. Since different interest groups see the modality of the approach differently, the proposed reforms are politically highly charged.

The new policy, apart from identifying the key issues, adopts certain guiding principles put forward by international agencies such as the Asian Development Bank and the World Bank. If adhered to, they can be regarded as the federal government's future roadmap for the water sector. These guidelines require, insofar as is feasible, planning, development and management of water resources to be decentralized to appropriate levels; and delivery of specific water services to be delegated to autonomous and accountable public or cooperative agencies. These should provide water services for an appropriate charge, along with an independent body performing proper and effective regulatory functions. At least to the extent of stated intentions, the new policy redefines the roles of the public and private sectors, to replace the former where tasks can be more efficiently performed by the latter. The restructured public sector will then play a more efficient and cost effective role. It remains to be seen how comprehensively this transition can be actualized.

While recognizing that water is a provincial subject, the new water policy calls for an integrated and holistic approach to water resource management. Under the principle of integrated and unified river basin development, water resource plans would ensure sustainability through both conservation and efficiency of water resources, while also working towards their further development. On the institutional side, the federal government will retain control of WAPDA. Between the latter and the PIDs there have been various tensions in the past. This friction would be resolved by planning and operational functions devolving to the new provincial irrigation authorities, or PIDAs. Decentralized management, through area water boards, water users associations and farmers organizations, would be encouraged and extended. Other federal agencies, such as the Federal Flood Commission and the Chief Engineering Advisor, would be consolidated within a Federal Water Commission. On the legal side, reform would take the shape of a single Water Law or Act for each province, to consolidate the numerous laws enacted for the water sector over the past century and a half.

The new water policy also provides guidelines for sub-sectoral issues. Irrigated agriculture is the predominant user of water, and the task confronting the state is to reduce the emerging gap between rising food needs, food production capabilities and water resource availability. The new policy recognizes the need to improve the productivity per unit of water, through delivery and usage improvements. There should be equity in water distribution, decentralization of irrigation management, as well as economic water revenue returns. Agriculture should move through vertical expansion towards higher value export crops, without sacrificing foodgrain production. The federal government would need to play a major coordinating role to achieve such goals, with provincial governments providing the operational back-up. Similarly, in flood and

drought management there is need for further improvement. There has already been a sizeable investment in flood management works; but further resources are required, and monitoring and forecasting services need improvement. Drought has become a politically volatile issue in recent years, with strong community impacts, especially in non-irrigated areas. Separate drought management plans, for river basin, hill torrent and drought prone regions, need to be accompanied by better forecasting techniques and response strategies.

Groundwater extraction has also expanded considerably, and its conjunctive use with surface water is especially important for achieving higher cropping intensities. There is a contradictory function, of lowering the water table to avoid waterlogging, and of preventing aquifer depletion through over usage. The policy confirms withdrawal of the public sector from SCARP tubewells, which have been criticized for their capital intensive and inappropriate technology features, as well as high O&M costs. Further tubewell expansion will be left to the private sector, although there are already fears of unchecked expansion. This is leading in places to serious reduction in water table levels, and consequent threat of saline intrusion. Consequently, there have been calls for a regulatory framework, though its implementation remains problematical. Curtailing higher cropping intensities, and cultivation of moisture intensive cash crops like rice and sugarcane, in critical areas could be unpopular. Raising electricity charges, and switching from a flat rate to metered consumption, can help, but most users have already switched to diesel powered 'Petter' engines.

The provincial governments also represent important stakeholder groups in the water sector. One of the problems confronting water sector reforms in Pakistan is the absence of provincial realignments since 1947. The same four provinces exist now as they did at independence, although the population has quadrupled. The only temporary change was in the reverse direction: the Ayub Khan regime's decision to consolidate all four provinces into one unit. In India, the number of states has almost doubled since 1947, an acknowledgement of the arbitrary nature of provincial boundaries and identities under colonial rule. The Indian Punjab itself is now three states. The still intact Pakistani Punjab, by contrast, now has over 80 million people, larger than any country in Europe outside united Germany. Whether this lack of sub-national restructuring displays a 'reform malaise', or whether the four provinces continue to represent the optimal solution, the impact on the water sector is to have four very large and powerful entities, often at odds with each other. Water disputes and any lack of agreement can take on a dimension well beyond the merits of the issue, and also create stances from which it is difficult to retreat. At times the acrimony generated appears to threaten the integrity of the federation itself. A greater space is also provided to those who wish to politicize water issues, and to move the basis of discussion from the empirical to the pejorative. On the other hand, threatened communities, whose concerns might otherwise be overridden, can seek strength from a larger protagonist scale.

The provinces are also the level at which many of the strategies for water reforms will be coordinated and operationalized. The timing, pace and progress of most reforms could well be monitored at the provincial level. The restructuring of the PIDs and decentralization of irrigation management will rely largely on the provincial

government's reform commitment. Local power structures and stakeholders also tend to coalesce at the provincial assemblies for interest articulation. Also, the agreements on riparian rights and water discharges have taken the province, rather than the locality or the nation, as the basis of measurement. Therefore 'provincial shares' have become the primary basis of allocation. Often issues that have equally serious implications for intra-provincial as for inter-provincial impacts are only seen in the latter context. Thus, if the Kalabagh Dam is said to primarily benefit Punjab irrigation, it might have differential impacts, so that some parts of the Punjab might 'suffer' as much as areas in other provinces. Similarly, the denial of adequate flows to the Indus delta could be as much a consequence of the three upstream barrages in Sindh as those further upcountry. It does not appear that the provincial context and frame of reference will change in the medium term future. It would be interesting to project what form water rights and allocations, and conflict resolution processes, would take if Pakistan had, say, 12-15 provinces.

Alternatively, since existing provincial and many other over-arching structures are likely to continue in the foreseeable future, the goal for reformers should be to move the discussion of impacts and entitlements away from generalized parameters and towards the actual operative context. This 'drilling down' effect can remove much of the subjective and politicized elements of debate and disagreement, to be replaced with dialogue between the appropriate stakeholders involved in specific reform processes. This would be a more efficient method of identifying real problems, and then finding solutions for them, in the water sector. Treating issues as a function of politics or power need not necessarily lead to the optimal outcome for those affected. On the other hand, often the weak and the vulnerable are also the most voiceless. Therefore, to be credible the 'drilling down' approach must retain the capability to be sensitive to identifying and resolving real and actual issues, and not merely prioritizing those that have the most vocal protagonists.

V. Case studies of some significant water issues

Large dams issues

While the earlier large dams in the Indus basin, such as Warsak, Mangla and Tarbela, were constructed with relatively little political controversy, this is not the case with the latest proposed project, the Kalabagh Dam. Indeed the opposition to this project has become so intractable that, despite earlier approvals and feasibilities having been completed as far back as the 1980s, further work has not been undertaken on this project. Firstly, there is more resistance to large, capital intensive projects based on technical and economic criteria, that might not adequately incorporate impacts on communities and environment. Secondly, and equally significantly, there is the opposition from Sindh and NWFP that Kalabagh Dam will essentially serve Punjab's interests. While this controversy is not lacking in emotive positions and rhetorical statements, there are also weighty arguments on both sides, which also represent important stakeholder alignments

The case in favour of Kalabagh Dam is based on several considerations. Future demand for energy, food and fibres require another large storage dam on the Indus, and Kalabagh

is the best available site. Hydro-electric power is cost-efficient and renewable, and Pakistan is already suffering from high energy costs, especially after the high rates contracted with the private thermal power plants that rely on imported fuel. The dam will provide 11,750 million kwh, saving foreign exchange on fuel and agricultural imports. Agriculture needs additional water for irrigation, and this will be supplied to all four provinces, not just Punjab (in MAF: 2.1 each to Punjab and Sindh, 1.1 to NWFP and 0.7 to Balochistan). The dam will also enhance cropping intensities. Other dam sites, such as at Basha and Skardu, will take years for feasibilities and approvals, and might anyway be needed in addition to Kalabagh.

The major objections of NWFP and Sindh are also seen to be misplaced by the pro-Kalabagh groups. For NWFP they argue that the dam will neither affect Nowshera town nor drainage systems of Mardan, Pabbi and Swabi. Far more fertile land will be taken up by the reservoir in Punjab than NWFP, which will lose much more to the Islamabad-Peshawar motorway. Resettlement will also be in better habitats, with better services than these communities enjoy at present. Sindh's misgivings are seen as even less empirically valid, as it would lose no land, but instead obtain further water to irrigate an additional 0.7 million acres. Under the Water Accord of 1991, Punjab cannot arbitrarily redirect water. Nor is it empirically proved that inundation cultivation would be affected, or that sea water intrusion will increase, with adverse effects on mangroves and fisheries. The dam would also improve flood prevention and control capacity. Arguments against adverse social and environmental impacts, however, are by no means conclusive, and the controversy continues.

Large dams such as Kalabagh clearly have important beneficiary segments in Pakistan. Agriculturists would obtain a higher aggregate water supply, relieving to some extent water shortage and tail user concerns. An anomaly could be that, with more water available, farmers might yet again postpone the investments entailed in qualitative agricultural improvement and more efficient irrigation practice. Pressure on changes in irrigation management and water pricing could also be relieved. This could defuse political tensions in the rural sector. Since under current practice the larger landowners and irrigators can manipulate the system, they will stand to gain differentially; and can perhaps further consolidate the socio-economic and institutional status quo. Electricity consumers, both rural and urban, will benefit, though there is no guarantee that rates will be reduced. Greater supply can underwrite the rapid electrification of villages, with benefits to communities, groundwater users and rural industries. Spreading urbanization is creating new consumer demand, with mass expectations of electrical supply as a basic human need, and with enhanced consumption by the middle class segment, through growing numbers and declining real prices of electrical goods. Energy shortages and high rates have been a particular concern for industrial producers; and therefore the business community is an important protagonist. Because of perishable and seasonal goods and cold chain needs, agribusiness would especially require consistency of electrical supply.

Opposition to dams such as Kalabagh stem from a combination of political stances, substantive factors, and accumulated distrust. The Punjab is viewed by the smaller provinces to have arbitrarily appropriated national decision-making in the past, and to

have harnessed the federal government's weight and mechanisms to its own interests. This led to water sector decisions and strategies that had not properly represented the smaller provinces' interests. Even the earlier planning on the Kalabagh Dam failed to involve adequate discussion on provincial concerns, leading to a more protracted debate, if not a stalemate, when these were finally entertained. The dam issue has tended to become the rallying cry of whichever parties or groups are in opposition, putting the provincial and federal governments on the defensive. For example, the stance of the current provincial government in Sindh is not seen as credible, as it is accused of being installed by the centre and hence lacking a democratic basis. The dam issue thus threatens to be a focus for wider political positioning and potential conflict. Therefore, even if there is a technically valid case in favour of sufficient water availability for one or even two dams (a second one at Basha?), the country appears to lack the institutional capacity for conflict resolution, to pave the way for these storages.

Large dams have incurred criticism on substantive issues as well. If India takes its full entitlement of river water, and all systems losses and other demands are adjusted to averages based on years of lower flow, it is argued that there will be insufficient water for both the Kalabagh reservoir and sufficient outflow downstream of Kotri. Thus coastal, mangrove and delta environments will be affected, as well as fishing communities. Already high levels of salinity could increase further in Sindh, while further loss of sedimentation would harm agriculture. Reducing the natural flood systems means tampering with their regenerative and corrective functions. The high capital costs of large dams might prevent cheaper electricity rates, and push water rates upwards, negating benefits to production systems. The interest rates for constructing such dams might no longer be concessional, and might require going to private financial institutions. All these burdens would fall inequitably on the poor, as the country struggles to meet renewed debt burdens, through higher utility charges and indirect taxation. The additional water and energy resource would, however, be diverted inequitably to beneficiary groups and favoured regions.

These arguments have been potent enough to abort progress on large dams. International agencies, such as the World Bank, are also now more sensitive to environmental and community impacts of large infrastructure projects. The Pakistan government itself appears now to favour substituting a high dam, with reservoir, with a carry-over dam at Kalabagh, which would tap excess high flood water. A facility for hydropower without irrigation is another possibility. The final outcome might need to await the results of further elections that carry greater credibility, and constitute a more satisfactory transfer of power from current military rule to the peoples' representatives. However, it is not certain whether elected governments will be able to build the consensus for large dams like Kalabagh. They might also lack the will to take such major political risks, or they might not have the mandate to do so. Conversely, the completion of Kalabagh could confer an implicit legitimacy that becomes a driving force itself, as in China where the Three Gorges project is as much symbolism as it is public works

Institutional reforms in irrigation management

The provincial irrigation departments (PIDs) gained institutional significance with the introduction of perennial irrigation in the Indus basin during British colonial rule. With the extensive network of canals spread over Punjab and Sindh, providing gradient flow irrigation, a centralized irrigation bureaucracy, at the provincial level, served as an effective mechanism for water management. This structure worked reasonably efficiently when water and land resources were more plentiful, population less dense, and socio-economic problems less complex. The judicial process was also more effective, so that the state could credibly arbitrate over conflict resolution. Institutional reform arguments hold that this system was allowed to continue unchanged for over a half century into Pakistan's existence, as ground realities became more problematical. With declining administrative efficiencies, overstretched organizational resources, degraded service delivery, and unchecked corruption, there appears to be a glaring failure of centralized irrigation management. These compounded problems now demand a pressing reform agenda.

Regarding distortions, even at the colonial stage there were always misdemeanours and rent mechanisms. The subordinate bureaucracy was involved extensively in perquisites from agricultural owners. The larger and more powerful the latter, the more concessions they could obtain from corruption. This occurred in essentially two features: first, greater and inordinate access to irrigation water; and second, underassessment of water rates. This situation was exacerbated in Sindh, with more land under large landowners. The greater margins thus extracted could be expended on opulence and further political patronage. In Punjab most canal colony chaks comprised smallholding irrigators, but these 'dominant peasants' can also be collectively powerful, in either upholding or unhinging the extant power structure. Colonial administrators found they were failing to obtain the economic value of water, but held back from raising *abiana* rates for political expediency. Their extended efforts to introduce volumetric assessments were also defeated, as agriculturists colluded with lower officials to neutralize gauges and other devices, for water measurement at outlets. These problems continued under Pakistan, and since the mid-1970s revenue returns from irrigation started falling short even of O&M expenditure.

Increasingly over the past couple of decades, the government has had to grapple with the definition of irrigation water as a public or a private good. Agencies like the World Bank have argued that, unlike drainage, irrigation supplies no longer meet the two criteria of a public good. First, canal water is not 'nonsubstractable': there can no longer be nonrival consumption without a reduction of supply to others. Second, it is 'nonexcludable' only because of a decline in the authority of the irrigation agencies, or PIDs. The latter now allocate irrigation water inefficiently or unfairly, denoting that a bureaucracy cannot substitute for the market. Nor can publicly administered water markets be efficiently priced. The revenue agency is also not involved in O&M expenditure, reducing incentives to enhance returns. Direct government action in raising rates, removing rents and restoring authority, could involve coercion and have dire political repercussions. In short, the fundamental problems of the political economy of public irrigation need to be

resolved. Remedial measures and projects, focusing on mechanical, design and management factors, can address only the symptoms and not the underlying problems. The challenge before the government is to realign its earlier belief that, since the capital works of the irrigation infrastructure were public goods, this also applied to water supply for irrigation.

The alternative is to treat irrigation water as a private good, and allow market forces to determine operations, with suitable regulation. Water markets, recognizing water based property rights, would improve the balance between demand and supply, and reduce resource misallocation and rent-seeking behaviour. With decentralized management and proper pricing, water users would also be able to meet their O&M costs, thereby removing current deficits. Public utilities would replace PIDs, which would acquire a more regulatory function. Sustainable cost recovery through formal water markets could, in fact, reduce the total water charges paid by users, through informal water markets and rents. It would also enable the government to focus on planning, coordination and projects, through WAPDA and the federal Ministry of Water and Power.

Consequently, in the 1990s, after consultations with international agencies, the Pakistan government embarked on major institutional reforms. At the provincial level, the three tiered system of PIDA, AWB and FO was established, through the PIDA Acts (1997). The FO was to supply water to irrigators, be responsible for levying and collection of water charges, and make payments to the AWB. The operating public utility would be the AWB, with an average command area of 600,000 hectares. It would be established at the level of one or more canal commands, of which there are 43 in the Indus basin irrigation system. The AWB would manage and distribute irrigation water, through formal volume-based contracts with FOs, and trade water with other utilities. The PIDA would be responsible for such functions as province-wide water delivery, system maintenance and development, and sales of water beyond amounts contracted with AWBs. These significant innovations in irrigation management now need to go beyond the paper stage, and be widely implemented. In the Punjab, the canal command of the Lower Chenab Canal (East) was chosen for a pilot project to test out the reforms. Even these trials were conducted in a very limited and proscribed way, with the emphasis only on FOs, and not on the other two ingredients of the proposed restructuring, namely agency reform and water rights. The IWMI has also conducted pioneering experiments in organizing water users on one distributary (Hakra-4R) in Harunabad District, Punjab. In the LCC pilot area, an AWB and FOs have been functioning for around five years, though still without a full fledged devolution of functions and responsibilities.

The major challenge now remains for these reforms to be extended to other parts of the Indus basin irrigation system. With the PIDA process, it is vital that the top irrigation management, including the provincial secretary of irrigation, is strongly committed to reform. This will be tested with the transition from the pilot stage to the diffusion and institutionalization of the PIDA reforms to other canal command areas. If the advantage goes to the 'business as usual' sections, the reform process could be stalled. This indicates that the irrigation and provincial bureaucracies might well be perturbed by the loss of control. Decentralization of local government, on the other hand, has proceeded

apace, as has privatization of industrial and financial entities. The PIDA process requires time to input a number of functions, such as governance and strategic management, financial capacity building for revenue assessment and recovery, O&M functions, technical services, and a host of water market learning curves to achieve steady reductions in transactions costs. Even the early task of handing over physical assets to AWBs and FOs in good running order will require effort, especially at tail ends and poorly performing canals. Abeyance in the implementation process of the reform strategy carries grave costs.

Lack of progress might signify strong institutional and political economy constraints. The engineers and staff of the PIDs could be against these reforms, fearing they would entail dissolution of their service, and a breakdown in existing rent relationships. However, these functionaries could find reemployment within the new structure, and perhaps a more challenging work environment. With their extensive experience in irrigation management, agency staff could also become providers of private irrigation services. A market for these consultancy and operations skills would emerge, and irrigation managers would become adherents of change, if the reforms are institutionalized rapidly enough HERE MIGHT BE ESPECIALLY IMPORTANT TO STIMULATE AGENCY STAFF TO BECOME (PREFERRED) PROVIDERS OF PRIVATE IRRIGATION SERVICES??? Part of the performance downturns under PIDs was said to be the constant external interference and political pressures on departmental affairs and personnel. There could be concern that under the new system an 'oligarchy' of larger landowners and local politicians would continue manipulative practices. Another disincentive could be leaving the relative security of service with the provincial government, for more novel contractual work with more transparent and accountable institutions. A comparable example was the TIPAN (Transfer and Integration of Provincial Agricultural Networks) project in NWFP in the early 1990s, when a USAID US$60 million project failed to achieve its goal of integrating agricultural education, extension and research, owing to the resistance of extension cadres to leave provincial government employment, and the state's failure of political will to implement reforms to which it had signed on.

Elements within the rural community could have varying responses to the reforms. If it is indeed true that smaller agriculturists suffered inequity in water distribution, then they would support the reforms, unless there is a relapse to oligarchic control. The greater efficiency of water distribution would engender acceptance of reforms. An example of benefits, especially to tail users, was the improved canal flows from the post-2000 outlet rehabilitation work. Smaller irrigators will also be supportive if they obtain net gains: that is, the savings in rents and informal water market costs would exceed any enhancements in fees and water rates. Reform objectives should try to ensure this outcome. Institutionalization of property rights, if accompanied by long term reductions in transaction costs, can be a major stimulus for development. Another vital stakeholder is the rural masses. Short of militant action, the poor can have their interests represented through political organizations and electoral politics. They could become supporters of change, contingent on reduced threats to survival and sustenance; and reassurance that 'privatization' will not be economically harmful. Mass support can be won if the poverty

alleviation function remains a core strategic goal of water reforms, and is built into all levels of policy implementation.

Larger landowners could be the most opposed to change, since they have been gaming the system for decades. Clearly, they do exercise political influence, and benefit most from the deinstitutionalized politics that are currently in vogue. However, the attraction of contracted, formalized water rights, with capacity to purchase additional demand through efficient water markets, could prove an adequate trade off for the pressures of constant manipulative activity and threat of water conflict. Also, there is now, hopefully, a sufficient element of modernizing larger farmers who are making a transition to high value agriculture; and who approach agricultural production through capitalistic rather than feudalistic values. The support of this segment can be mobilized for the envisaged reforms, and might be invaluable not only for the demonstration effect of more efficient water usage, but for the civic consciousness of respecting water rights and entitlements.

Such adaptations will not be easy, but they are not unlikely. It might also not be possible to prevent the intermediary function from reappearing under any new or reformed system. However, the opportunity cost of reform acceptance and adherence can be raised substantially, if the administration can enforce regulations more strictly in the intervening period. The important institution of the lower bureaucracy could also realize, through greater strictures imposed now, that reforms can bring better opportunities for honest employment. There is no reason why the new water management bodies should not pay market rates to their employees, rather than the stunted real wages that induced corruption. This is now being done in SIDA in Sindh, though at present with mixed success. If the old ways begin to carry greater costs and risks, the new system will appear more attractive. Members of the provincial and national assemblies, as well as now the local government *nazims*, should be educated into becoming proponents of change: their enthusiasm for reform could be a factor in their nominations.

Institutionalizing reformed water management now requires a series of actions. At the chak or water course level, water users organizations need to be in place. In many cases these already exist, but they will need to be formalized and in other instances created anew. Thus to complete the transition, their creation needs to be supplemented and supported by their obtaining satisfactory water rights and entitlements, along with proper accountability of the service providers. The water users organizations will contract for water supplies from the FOs. The latter, at the distributary or minor level, and with management areas ranging from 5,000 to 20,000 hectares, also need to be established, given a legal status, and made operational. This will require a major capacity building exercise, since they will be responsible for collecting water charges, for reaching volume based contractual arrangements with AWBs for water supplies, for O&M of irrigation facilities, for resource mobilization and for dispute resolution.

In turn the AWBs need to be established, and a number of functions devolved to them. They will need to operate as financially self-accounting entities, with sufficient technical capabilities to monitor water supplies, and be able to provide technical support to FOs. All levels need to develop the representative mechanisms, and autonomous operational

capacity, envisaged within the governance frameworks of participatory irrigation management. Additionally, achieving equity and stability in water distribution, and transparency in all water related transactions, will themselves require time and patience.

Urban and industrial water demand and impact

With the rise in urbanization and industrial growth, the non-agricultural sector is an increasingly significant consumer of water resources. Agriculture uses up over 95% of freshwater diverted from rivers, but it also relies heavily on groundwater for further irrigation supplies. Around 45 MAF are pumped out of the Indus aquifer annually. In Punjab and NWFP both sole and conjunctive use of groundwater is important for raising cropping intensities. This competes with urban needs, with now a growing threat of over-exploitation and declining water tables. The government has considered adopting a regulatory framework for controlling groundwater usage; but these measures are difficult to enforce. They would, anyway, not be possible without stakeholder involvement and support, through user organizations, rights and self regulation. Depletion from over usage could also lead to long term aquifer pollution, through seepage from saline to freshwater reserves. Sindh lacks non-saline groundwater, and therefore urban water supplies rely on river water and inland reservoirs. In Balochistan the very rapid decline in groundwater levels near Quetta is nearing a crisis situation, adding to the drought conditions recently prevailing in the province. In the country as a whole, the majority of urban population lacks access to safe water and sanitation. Rivers downstream of cities are highly polluted through release of untreated sewage. Industrial effluents are also adding pollutants to the water system, with the administration finding it difficult to enforce existing national environmental quality standards. Agriculture itself adds large quantities of pollutants from fertilizers and pesticides into the water system.

The linkages between industrial needs and impacts and water quality and supply can be seen in the case of the sugar chain. Starting with one sugar mill in 1947, Pakistan now has over 80. Sugar mills are often a reward for political services and support. A large number are owned by politically important elements and owe their existence to political gratification. Also, in the 1990s the Nawaz Sharif government induced financial institutions to extend loans for sugar mills, to which Sharif's Ittefaq Foundries was a capital goods supplier. Sugar also seemed a relatively uncomplicated form of earning industrial rents. The Pakistani consumer had to subsidize the processor, since international sugar prices traditionally remained below domestic prices. However, beyond a low percentage of total cropped area, sugarcane production is not ecologically suited to an arid region like the Indus basin. Now, farmers need, or want, to grow enough sugarcane to feed 80 mills, creating excessive demand on both surface and tubewell water. Areas with critically low groundwater levels have large standing crops of sugarcane (as well as rice, the other water intensive crop). Shortfalls in sugarcane supply would create a crisis in the sugar industry, which has the second highest capitalization in the Pakistani stock market, as well as politically eminent stakeholders. Additionally, effluents from sugar mills are a significant source of water pollution, which is affecting human and livestock health. Clearly, on specific issues there are complex options facing

the administration, involving tradeoffs between environmental, hydraulic, social, agronomic and industrial priorities.

Regarding pollution from industry, efforts to control this problem will clearly incur opposition from business groups. Adding cleaning and filtration devices and other environmental control measures will add to the costs of business, and could be seen as a further damper on an already strained investment climate. However, socially irresponsible business behaviour need not be condoned, and here a process of consultation and education is required. The social costs of environmental damage can be far higher than the business costs of prophylactic action. Here even some transparent information can be a significant force for change. Many international buyers are also now requiring vendors to meet environmental quality standards, and move away from the use of certain chemicals. Nevertheless, monitoring of emissions and effluents remains a problem. Upcountry industrial estates are impacting groundwater, surface irrigation and drinking water supplies. Paper mills, textile dyeing and leather tanning pose particular problems, in places like Faisalabad, Sheikhpura and Kasur in Punjab. Karachi's industrial effluents are impacting coastal channels and the marine environment, which also receives considerable volumes of municipal effluents.

One of the more problematic areas in urban water management is the cost recovery issue of public utility services. The government has not kept up with the growing demand for urban water supply and sewage disposal capacity. Where such services have been provided, unplanned or illegal connections and disposal systems have proliferated. Recovering costs and revenues from these informal systems appears beyond the capacity of most municipal and water management authorities, as currently structured. It is difficult to monitor volume usage, while flat rates clearly over- or under-assess in most cases. Much of the urban growth is in informal housing with weak or irregular property rights, making it difficult to identify users even where a 'user pays' principle is established. Extending charges for water usage to the poor, and at rates possibly perceived as inequitable, can be politically volatile. However, the difficulty of securing returns can be a major disincentive in extending, maintaining or improving services. Apart from incurring health hazards, the poor might end up paying many multiples to 'tanker mafias' and informal suppliers, than they would have for regularized services.

A major upgrading, or new capacity, in sewage treatment plants is required. Local governments, like the ones at Lahore and Karachi, are acknowledging the urgency of this problem. The Nazims of both cities have recently stated that a sewage disposal infrastructure is a priority for their local authorities. There is a critical requirement for sanitation services from the urban poor and for the urban areas, or informal housing sector. Local governments see the provision of such services as a visible and effective means of showing performance, and winning electoral support. However, middle income and even some upper income housing schemes might lack proper sewage disposal facilities, a consequence of saving on initial infrastructure costs. The danger is that allocated funds might be diverted towards higher income areas, and away from lower income habitats, where they are most urgently needed and where their absence poses the most serious health hazards. Community development projects, like the one at Orangi in

Karachi, have proved an effective means of bringing sanitation facilities to the urban and rural poor. With their high levels of participatory development and community involvement, these projects should remain the focus, and the preferred partner, for providing a sanitation infrastructure in the informal housing sector.

Work on sewage treatment plants should be taken up as one of the earlier activities in the sequencing of reform. While local government budgets are expended predominantly on salaries, funds can be raised through loans or municipal bonds issues, or where feasible through local taxes. It will not be easy, or even possible, to incorporate the numerous informal and unregulated sewage disposal systems, for many of which no plans on paper exist, with trunk systems linked to sewage treatment works. Resolving such problems will require community acceptance and involvement, rather than the existing perception of an insensitive, inefficient and yet corrupt public apparatus bent on imposing techno-centric frameworks on community needs. The task of reformers and developers is to establish an understanding and consensus that the organizational basis of urban utilities needs to be restructured, perhaps as autonomous bodies as in Lahore, that they need to be financially sustainable, and that in providing efficient service they need to be responsive to community interest. They can link up with community development projects on contractual terms, and indeed encourage localities to develop their infrastructure on a self help, and yet coordinated, basis.

The issue of private sector involvement in the provision of water and wastewater services has also proved contentious. One view holds that there has been a failure to provide efficient services by public sector monopolies. These have been managed like government or municipal departments, lacking autonomous decision-making, resource allocation and human resource development. Failure to impose adequate tariffs means that these entities can no longer make the massive investments now required. Deferred maintenance has led to further system deterioration, with serious negative externalities. A large proportion of the urban population remains with poor quality and unreliable water supply, and inadequate sewage disposal. This has had major health risks, with water-based diseases now rampant in the majority of the population.

According to the market based approach, only strong financial viability, based on full cost recovery, can assure further investment. This requires private sector participation, as has already occurred in energy, telecommunications and transport in Pakistan, and in urban infrastructure services internationally. A regulatory framework can monitor private sector performance, service quality and tariff levels. Existing assets can be devolved, or new components can be added through build-operate-transfer/build-own-operate mechanisms. The government would need to have confidence in the private sector for performing these roles, and bringing in the sizeable investments that are required. Conceptually, this approach is already acknowledged in Pakistan's Private Sector Participation Strategy.

A critique of this approach acknowledges that public reforms are needed, but the answer to these does not lie in private sector involvement. It is feared that resources may be misapplied, to improve services to better off customers, while the poor could end up

paying far more for services that may in fact deteriorate in quality, or may because of the profit motive be withdrawn altogether. It is contented that under privatization better water quality or sewerage will not be extended to a greater proportion of the population than at present, but will simply meet the rising demand from more affluent segments. In addition to rapidly rising tariffs, which could be as much as 300% in real terms, the poor will have to bear the burden, through indirect taxation, of the existing public debt on these utilities. Their use, however, will be taken over by private agencies under long-term contractual guarantees. There is no assurance that there would be a reduction in leakages, or in theft by industrial, commercial or domestic consumers. Despite its new found monopoly, private equity might inject relatively little finance, with investment met through enhanced billing and further loans from international agencies, and even from commercial financial institutions at higher interest rates. Clearly, the reform process will need to address such apprehensions, and perhaps modulate the extent and pace of restructuring to make it politically acceptable and seen to be securing the public interest.

The new generation of infrastructure inputs will need to be based on choices which in the Pakistani environment would appear to be unconventional and innovative. In many countries, including developing ones, these methods are now a part of urban development strategies. Specific operations and services have been delegated to private sector companies, not only for the construction phase, but also for operations and maintenance, under a variety of contractual arrangements. These facilities range from garbage disposal to tollways that ease urban traffic congestion. Public management then moves into a more regulatory mode, rather than the earlier focus on operations. In a situation of relatively slow response from the public sector, to the rapidly growing and changing requirements of complex urban environments, this recourse to entrepreneurial services and infrastructure delivery could be a preferred option. Already in Pakistan there is the case of a large private airport at Sialkot, constructed entirely by the business community. Private power generation, and on a much larger scale health and education facilities, are other examples. The cellular segment of the telecommunications sector, which has now apparently outstripped the landline system in volume, has also emerged predominantly in the private sector. Therefore, a diversity of service providers, and new service delivery models, could also bring faster solutions to water sector problems. They could greatly expedite the critical implementation phase of reforms, by clearing operational bottlenecks that so often defeat prescribed goals and objectives.

VI. Moving reform forward and World Bank role

We have seen above that in the institutionally complex environment of Pakistan, reform proposals are accompanied by variable, contradictory and even conflicting viewpoints. There is consequently much difficulty in implementing a reform agenda, since political realities and considerations continue to impinge on economic efficiency criteria. The decision-making environment has to contend with competing interests, differing perceptions, unequal power relationships, and imperfect information. Therefore the outcome of reform policies usually depends on the interaction between supporters and opponents. This scenario is quite different from the assumptions of economists who feel that society should move towards market oriented models, through institutional reform

policies based on a rational process of objectives identification, options evaluation, and strategic choice. Such an approach can be too simplistic, or lead to strategic errors, if it fails to incorporate real world issues, and more specifically the role of interest groups, in devising a more pragmatic set of reform sequences.

Conversely, there are a number of archaic institutional structures extant in Pakistan that are overdue for transition. In an evolving socio-economic environment where new challenges and pressures continue to emerge, these incumbent processes become increasingly dysfunctional. While beneficiary interest groups can voice justifications for their retention, they could be not only outmoded but actually harmful to the country's interest and the people's welfare. They could, for instance, be arenas of corruption, of loss making operations, and of failed delivery systems. Reform proposals may appear radical only because for decades no change has occurred. Still, powerful interests may be aligned in their favour, and this will necessarily affect the reform process, though hopefully it should not continue to create misgivings about objectives. We can be reminded of these objectives by such flag posts as the three 'Dublin principles', from the Dublin Conference on Water and the Environment (1992). Their acceptance by the Pakistan government has also been reiterated in its new water policy. These three tenets are: (a) the 'ecological' principle, requiring the holistic management of water; (b) the 'institutional' principle, requiring that management be participatory, with responsibility at the lowest appropriate level; and (c) the 'instrument' principle, requiring that water be managed as an economic resource.

In terms of strategies that could be adopted to move the reform process forward, and how interventions can be prioritized, sequenced and structured, one proposition is that *reforms should be initiated only where there is a powerful need, and demonstrated demand, for change*. The reform process consists of several programs. In each of these the political interactions between different interest groups, and any conflicting objectives, should be assessed. The process should move forward in those programs where there is agreement among major stakeholders, and less controversy over impacts and outcomes. One of the clear areas of consensus is addressing the overall scarcity of water. Improving surface distribution and delivery, developing rainwater and inundation catchments, increasing groundwater recharge, and improved agronomic practice and crop substitution in high demand areas could be possible early strategies. Urban sewerage and water treatment systems also have a demonstrated demand and stakeholder acceptance, once the concerns over management and pricing of utilities are resolved. Improving river water quality through urban and industrial effluent controls can also be an area of early interventions, also entailoing improved interface between business and provincial and local governments.

Continued discussion where consensus is weak should aim to achieve a resolution of conflicting interests. Once bottom line agreements are reached, the next phase can be to explore practical options and seek modalities for possible interventions. The likelihood of success is greater if *expectations are kept reasonable* and *good rather than perfect solutions* are attempted. For sequencing, those reforms should be adopted early where *the chances of success are highest*, where social costs are unlikely to be controversial, and

where benefits accrue relatively early. To assess results it would be useful to evaluate the potential reform winners and losers, and the role of players in influencing reform performance. It is, for example, important that the controversy over dams not lead to an on-going deferment of construction activity. The government should try to bring this debate to a conclusion, seek quick agreement on which projects are acceptable, and then not delay work on the agreed sites. As emphasized earlier, actual progress or completion of a project can provide its own credibility and legitimacy. Another sphere of reforms, where measured and progressive achievements are preferable to waiting for ideal solutions, lies in the formalization of water rights and entitlements. Since this will entail micro-arrangements over numerous chaks and mauzas, work on this process should not be delayed. This needs to complement the other tiers of irrigation management decentralization, the setting up of AWBs. Work on these should occur concurrently, over the various canal commands, since the period allocated for experimentation and pilot projects is drawing to a close.

Public discussion should be undertaken to address *concerns about treating water as an economic good.* Fears and misgivings over this issue should be removed, whether these are held by the public at large, or articulated by institutional players, advocacy groups or political elements. Those areas should be identified where continued perception of water as a public good might be actually harmful to the community, carrying various disguised costs such as high informal charges or health hazards. The distinction should be made with certain programs where water resources can continue to be regarded as a public good, such as in the management of the larger drainage and flood control systems. The continued buoyancy of irrigated agriculture requires not only efficient and equitable distribution, but also financial sustainability. Over time the earlier profitability of the canal system, which existed during colonial rule, has been turned into major loss making operations. If a turnaround strategy is needed, this would entail organizational change and operational reprocessing. These considerations would also apply to urban water supply and sewerage systems. Obtaining a consensus for reform will depend on acceptance that successful solutions might require more than token adjustments.

It is important to understand that, *while basic principles apply, context is crucial, and reforms should be tailored to the reality of the problem*. The adaptability of the reform process to actual conditions and needs is critical for their success. This will reduce adverse impacts and increase acceptance. As new methods and structures are put into place, they should have the capability of responding positively, and in a problem solving mode, to real issues. Success of the reforms would lie in the degree of equity they instill. It might not in practice be possible to eliminate concessions to, or even the reintroduction of, existent rental and power relationships. However, sensitivity to the more vulnerable segments, and those most likely to suffer scarcity, should remain an important objective. This can bring popular backing, and presumabely greater longevity, to these transitions. How such understanding will be reached by decision-making structures will depend on the quality of capacity building. Decentralization itself will help with this process, as decisions will be made closer to the people and their needs. This will remain a complex problem, if the context is taken as a composite of historical, cultural, legal, institutional,

political, economic and hydrologic factors. The answer will lie not in seeking once-off solutions, but in acquiring the ability for ongoing adaptations to particular circumstances.

Reforms in the water sector in Pakistan have been thoroughly discussed in certain quarters. The reform process comprises several programs, which have different lead times and rates of progress. There are also varying viewpoints, conflicting interests and even paradigmatic differences in the approach to reform. There is an on-going debate on whether important parts of the sector, such as irrigated agriculture and urban water supply and sanitation, should move to a market-based approach. To some extent the destination has been arrived at, as represented in the government's new water policy. Again, there appears to be more agreement on *what* needs to be addressed, rather than *how*. The important question of *who* will carry out or accomplish the reforms is also not altogether clear. Having defined the desired outcomes, it is now essential to develop a road map, or a precise identification, of how these reforms will be carried out, and who will be involved in this enterprise. The political governments, at the national and provincial levels, and the executive branch, are normally expected to manage policy implementation. The emerging structure of local governments might also be future participants. Some of the transitions will require several years to implement, entailing the need for uniformity and consensus on the reform agenda across regimes.

Ultimately, politics decides what actions a country or society takes. In the past there have been major swings in national strategy, away from the market-oriented approach. The fact that roughly half of Pakistan's existence has been under military rule gives little clue as to which direction popular choice would take the country. The civilian regimes of the 1990s did maintain a steadfast commitment to market forces, and this could continue in the future with a more complete return to civilian politics, except if religious-oriented parties can succeed in stigmatizing Western influences. Therefore, a prerequisite for the success of the reform process will be continuity in the state's strategic directions. The certainty of such continuity would have been more plausible had these issues been discussed more comprehensively in the nation's parliament, or other representative forums The World Bank should endeavour that such a discussion and debate does take place, so that the outcome is seen as the product of popular support, rather than an arbitrary imposition. Perfectly rational and badly needed reforms can suffer if the process of adoption and decision-making is not transparent.

The World Bank can also help facilitate consensus building processes, by playing the role of a neutral broker between conflicting stakeholders. The Indus Basin Treaty between India and Pakistan in 1960 was itself the product of such a process. Where there appears to be deadlock, a negotiating process and mutual confidence building could still achieve results: the Kalabagh Dam issue could be one such case. There is also need for further improvements in information collection and processing, and publication and dissemination in forms accessible to users, so that discussion is based on empirically valid data rather than subjective approaches. For this the existence of independent but reputable research and analysis capacity within the country can be a productive input.

Another area that requires attention is the attitudinal change needed in state functionaries. Public servants need to get away from the notion that they should run operations, rather than play facilitative roles centred around regulatory activity. The political economy of these transitions will hardly be attractive to some segments, but there could be mounting opportunity costs in retaining the status quo. Recent privatization and local government transitions have assisted in this change of approach, and this momentum needs to be maintained. Decentralization of irrigation management can also succeed faster if PID functionaries can retool for the new work requirements with AWBs and FOs. The World Bank can help to run training programs for this, with the use of comparative cases where water markets have emerged. Therefore, training programs from induction onwards need to be reengineered to fit in with the changed environment.

An ongoing consultation with the three tiers of government, federal, provincial and local, needs to be maintained. Close monitoring of the progress of institutional reforms is also required. In areas where further assistance is required, or impediments or deadlocks appear, local and if necessary foreign expertise should be applied to maintain the momentum of change. Internal capacity building, and local outsourcing capabilities, are important to keep operations cost effective. Transparency is important in gaining public acceptance; and environmental safeguards, civil society concerns and poverty alleviation goals, should remain critical indicators. Equally, it is important that the tangible benefits of reform should begin to appear at the earliest, so that modernization is seen as an opportunity rather than a threat.

APPENDIX ONE: TERMS OF REFERENCE

(1) Analyze the historical development of the irrigation system, discuss the political economy of access to irrigated land, its impact on authority and power, and implications for prospective reforms.

(2) Analyze major political and economic developments in Pakistan, and establish the linkages between political and institutional processes, and their economic causes and outcomes.

(3) Assess the politico-economic role of major stakeholders, and their current and prospective posture towards water sector reforms.

(4) Examine through case studies of some significant water issues the role of particular segments and interests, and their likely future posture towards reform. These case studies should include at least three of the following: IRSA issues; large storage dams issues; Irrigation Departments reforms; urban and industrial water demand and impact.

(5) Discuss the strategies that could be adopted to move the reform process forward; and how interventions can be prioritized, sequenced and structured.

(6) Suggest how the World Bank could play a productive role in addressing the political economy issues that impact on reform, and how the reform process can effectively reconcile the positions and interests of different stakeholders.

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Pakistan: Evolution of World Bank Assistance in the Water Sector

By

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Country Water Resources Assistance Strategy
Background Paper # 16
March, 2005

Acronyms and Abbreviations

AAA	Analytical and Advisory Assistance
ADB	Asian Development Bank
AWB	Area Water Board
CWRAS	Country Water Resources Assistance Strategy
DCO	District Coordination Officer
ESW	Economic and Development Work
FGW	Fresh Ground Water
FO	Formers Organization
GoP	Government of Pakistan
HYV	High Yielding Varieties
IBDF	Indus Basin Development Fund
IBDP	Indus Basin Development Project
IBRD	International Bank for Reconstruction and Development
ICR	Implementation Completion Report
IDA	International Development Association
IRSA	Indus River System Authority
ISRP	Irrigation System Rehabilitation Project
KWSB	Karachi Water and Sanitation Board
LBOD	Left Bank Outfall Drain
MAF	Million Acre Feet
MDG	Millennium Development Goals
MOWP	Ministry of Water and Power
NDP	National Drainage Program
O&M	Operation and Maintenance
OED	Operations Evaluation Department
OFWM	On Farm Water Management
PCR	Project Completion Report
PER	Public Expenditure Review
PIDA	Punjab Irrigation and Drainage Authority
PIDs	Provincial Irrigation Department
PPAR	Project Performance Audit Report
RAP	Revised Action Plan
SCARP	Salinity Control and Reclamation Program
TDF	Tarbela Development Fund
TWs	Tube Wells
WAPDA	Water and Power Development Authority
WSIPS	Water Sector Investment Planning Study
WUA	Water Users Association

This paper was prepared by Usman Qamar (SASAR) and Reviewed by John Briscoe (SASAR)
Graphics and Tables contributed by Shabir Ahmad (SASAR)

Background

1. This paper has been prepared in the context of the Bank's Country Water Resources Assistance Strategy (CWRAS) for Pakistan currently under preparation. The paper reviews the evolution of Bank lending and non-lending assistance to the water sector in Pakistan. It examines the changes in the Government policy and development focus in the water sector since its creation, and identifies the logic for, and the drivers which led to, changes in the Bank's assistance. The paper draws on the conclusions and lessons documented in Project Completion Reports (PCR) and the Operations Evaluation Department (OED) Evaluation Reports and Performance Audits, and attempts to assesses whether in addressing water sector issues in Pakistan the Bank has been doing the right things and if it is has been doing things right, considering its comparative advantage *vis-a-vis* other donors. The paper covers irrigation, drainage and water resources development. Water supply and sanitation are included in a separate paper.

Overview of Bank Assistance

2. The World Bank has played a central role in the development of Pakistan's Indus Basin Irrigation System, the largest integrated irrigation network in the world. The Bank's partnership with Pakistan in the water sector dates back to 1952 when the first loan was approved for a water project in the then East Pakistan. In the 1950s the Bank's good offices were instrumental in the successful negotiations of the Indus Waters Treaty (1960) between Pakistan and India, which settled the division of the waters of Indus Basin between the two countries following Partition in 1947. After the signing of the Indus Waters Treaty the Bank helped to mobilize funds and administered the Indus Basin Development Fund (IBDF) during 1960-1967, which financed the physical works to implement the Treaty provisions, also known as the Indus Basin Development Project (IBDP). Subsequently, from 1968 onward the Bank administered the Tarbela Development Fund (TDF), which was extended to the post-Tarbela construction period during which extensive remedial works were implemented after the first impounding of the Tarbela reservoir. Thereafter, the Bank played a catalytic role in periodic major reviews of the irrigation and power strategy and funded parts of the resulting investment programs.

3. Altogether, the Bank has so far, supported 40 operations in the irrigation, drainage and water resources development with thirty six [1] IDA Credits (US$ 13,455 million in 2005 prices) and four IBRD loans (US$ 5,807 million). During this period, these subsectors constituted 16.5% of the total Bank lending to Pakistan. ***Annex-I*** and ***Annex-II*** include a complete list of Bank operations in the water sector and the sub-sectoral composition of its water sector portfolio since 1952. The major share of Bank's assistance in financial terms went to the IBDP and dams related investments (49.7 %), followed by integrated irrigation/drainage and stand alone drainage projects (27.8 %); flood rehabilitation (9 %); on-farm and command water management (6.7 %); system rehabilitation (3.7 %), groundwater (2.1 %) and small irrigation extension and rehabilitation schemes in Balochistan (0.9%). (***See figures 1,2 & 3***).

[1] *Including seven IDA Credits for the former East Pakistan for a total amount of USD 3,832 million equivalent*

Figure-1: Bank Assistance for Irrigation, Drainage & Water Resources Development

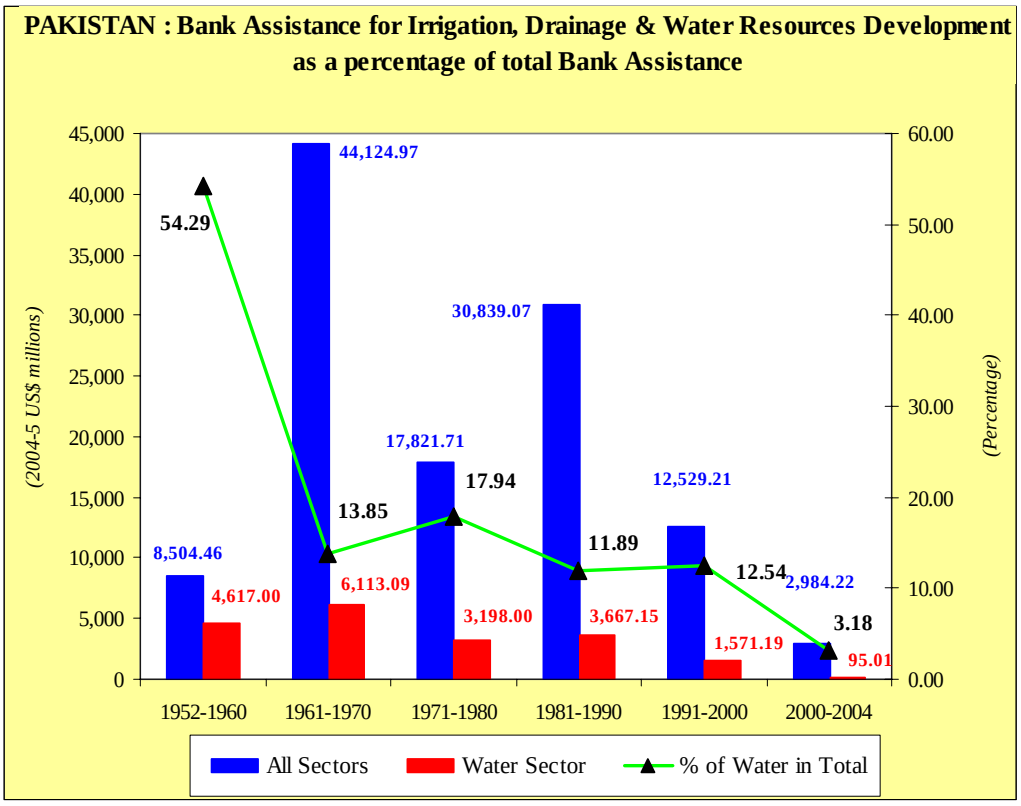


Figure-2: Subsector of Bank Lending in Irrigation Drainage & Water Resources Development

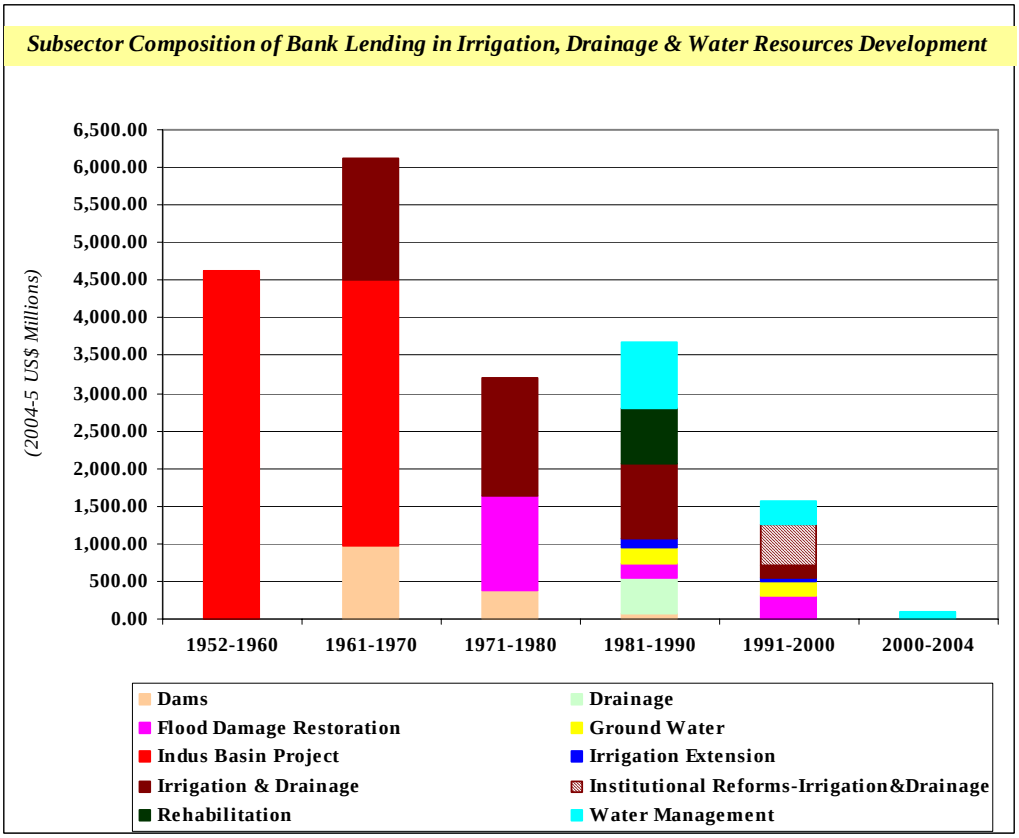
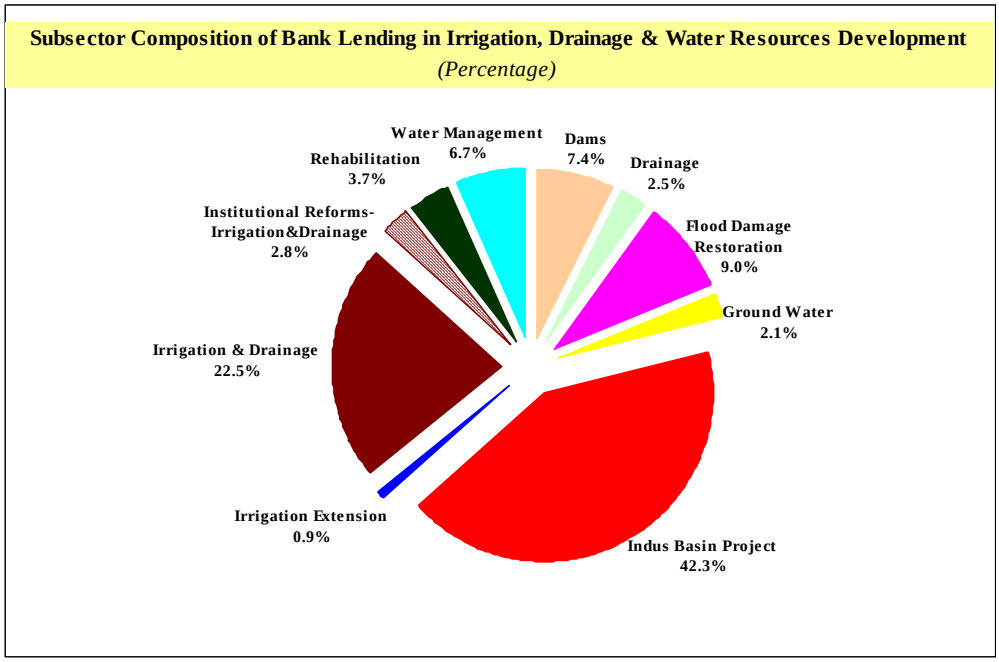


Figure-3: : Sub-sector of Bank Lending in Irrigation Drainage & Water Resources Development (Percentage)



4. Besides financing specific investments, the Bank also supported Economic and Sector Work (ESW) and provided Analytical and Advisory Assistance (AAA) that culminated in several major sector reports, including Water and Power Resources of West Pakistan: A Study in Sector Planning: (popularly know as the Lieftinck Report 1967); Revised Action Program (RAP) for Irrigated Agriculture (1979); the Water Sector Investment Planning Study (1991); Pakistan -- Irrigation and Drainage: Issues and Options (1994); and Accelerated Development of Water Resources and Irrigated Agriculture, prepared as part of the Public Expenditure Review carried out in 2003. In addition, several sector policy and planning studies, including a draft National Water Policy, 2002 and a framework for a Drainage Master Plan for the country were prepared through the technical assistance components of Bank assisted projects as well as various Trust Funds managed by the Bank, including the Bank-Netherlands Water Partnership Program.

Evolution of Bank Assistance

5. The evolution of the water sector in Pakistan, and the Bank's lending and non-lending assistance can broadly be divided into the following somewhat overlapping times periods.

1960 – 1975 -- the Post-Indus Waters Treaty Period

6. Prior to 1960, Bank's involvement in the sector was limited to seven projects in the then East Pakistan for irrigation, flood rehabilitation and water supply for a total amount of US$ *3,832* million equivalent (current prices). Following the Indus Waters Treaty, the focus of investments and the emphasis of Bank assistance was on meeting the water requirements of areas that were earlier served by the eastern tributaries of the Indus River (Beas, Ravi and Sutlej) whose waters were allocated to India as part of the Indus Waters Treaty. This was imperative to avoid a food grain crisis that could seriously harm the new nation. The 1960s saw the construction of major IBDP works, including the Mangla dam and a network of barrages and inter-river link canals and subsequently the Tarbela dam. It is worth noting that the Bank did not do an economic analysis of Mangla, because construction of the dam was deemed to be essential for the survival of the

country. Besides its role as the Administrator of IBDF[2], the Bank supported the IBDP through two IBRD loans and one IDA credit (***see Table-1***). The "twin menaces" of salinity and water logging and the need to provide drainage in many parts of the Indus plain were also recognized at this time. In response to these strategic threats, a public program using tube wells and surface drains was launched to lower the water table and reclaim saline soils. The 1960s witnessed the beginning of the Salinity Control and Reclamation (SCARP) program. The Bank supported this program through two IDA credits.

Table-1: Bank Assistance During 1960-1970

Sr. #	Financing	Description	Amount US $ (Current)	Amount US $ (2004/05)	Approval Date
1	IBRD	The Indus Basin Project	90,000,000	4,617,000,000	13-Sep-60
2	IDA	Khairpur Irrigation	21,154,434	1,085,222,464	29-Jun-62
3	IDA	Indus Basin Project	70,619,397	3,530,969,850	16-Jul-64
4	IBRD	Tarbela Dam Project	25,000,000	977,500,000	2-Jul-68
5	IDA	Khairpur Irrigation & Drainage	14,000,000	519,400,000	23-Jun-70
Total			220,773,831	10,730,092,314	

7. The 1960s might be termed the "hay days" of the water sector in Pakistan when massive investments in the sector coupled with the introduction of high yielding varieties (HYV) of wheat heralded the "green revolution". Agricultural growth, which was sluggish in the 1950s, (about 1.4%) and less than half the population growth rate, became the key engine of overall economic growth, and there was no major food grain crisis. This enormous achievement was fruit of the following two major initiatives:

- From the late 1960s through 1975 river diversion capacity was expanded from 67 Million Acre Feet (MAF) at independence to an annual average of nearly 104 MAF today; the Indus Replacement Works, foreseen in the Indus Treaty signed with India in 1960, including the Mangla Dam were completed and the Tarbela Dam was also constructed. This investment program expanded the Indus basin irrigation system, increased hydropower generation capacity, and increased cropping intensity on the Indus plain.
- Despite under-investment in research and development, pricing and subsidy policies set the stage for the introduction of improved and high yielding varieties of seed from the late 1960s as both fertilizer and irrigation water availability expanded (the "green revolution") – From 1970 to 1994/95 the value of wheat production, the staple crop, nearly doubled from 6.476 Mt in 1970-71 to 17.002 Mt in 1994-95.

8. The timely completion of the mega IBDP is acknowledged as a major feat of efficient project management by Pakistan, international cooperation and best practices. The Indus Basin Project Completion Note (May 1993) stated that:

> *"The Indus Basin Works have fulfilled their basic replacement objective (from the diversion of water to India) and provided a small increment of water; that the growth in water supply especially through tube wells, had*

[2] *Subsequently the Bank also administered the Tarbela Development Fund.*

a significant impact on agricultural production; and that the increase in power supply had been very cost effective."

9. Similarly, the Tarbela Dam Project Completion Report (1984) concluded that:

"*the entire Indus Basin Project stands as a monument to international cooperative effort, in a large part guided by the Bank. The immense system of replacement works consisting of Tarbela dam, six barrages and eight link canals was constructed during the period 1961-68 –two years ahead of the Treaty deadline… No other project of such size and complexity had been constructed in such record time."*

10. While the IBDP was a success on most accounts, the Tarbela PCR and OED's Project Performance Audit Report (PPAR) highlight some aspects that should have received more attention during the planning stages:

- Tarbela dam, the last of the IBDP works, was more than a Replacement Work, as additional water supplies were expected to become available. However, during the planning stage it was unclear as to how this additional water would be integrated in the national irrigation system for best use. Revised water allocation (water rights) among provinces and canal commands were not in place[3].
- Complementary investments in agricultural development[4] did not receive adequate attention;
- The development of institutional capacity to conduct research and training in Pakistan on water resources engineering and management was not an important area of Bank concern.
- The immense effort represented by the IBDP and Tarbela programs inevitably absorbed the major proportion of external aid as well as significant amounts of domestic resources. It also tended to divert attention away from downstream problems associated with the operation of Pakistan's enormous network of irrigation facilities and lack of adequate drainage infrastructure. As a consequence, over time, the water table underlying the Indus plain rose, leading to serious problems of water logging and soil salinity in certain areas.

The Post-IBDP Period (1975-1993)

11. This period can be sub-divided into two overlapping time frames:

- 1975-1985: Emphasis on addressing water logging and salinity problems through a Salinity Control and Reclamation Program (SCARP) and integrated irrigation and

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[3] *The OED PPAR for Tarbela dam also noted that "..agricultural benefits of Tarbela could be increased considerably if water supplies that are surplus to historical water rights could be allocated according to regional market demand (given enabling drainage investments in saline groundwater areas), rather than according to statute…". The inter-Provincial Water Accord was ultimately signed in 1991.*

[4] *While the Lieftinck Report (1967) had advocated Tarbela dam as the center piece of the IBDP, it had also pointed to the need for coupling water development with agricultural development if the full benefits of water development were to be realized. Complimentary programs were to include rehabilitating, modernizing and expanding the existing irrigation systems and modernizing agriculture by wider use of technical inputs, improving water regulation practices and on-farm water management, reducing subsidies, increasing water charges, providing drainage and water quality management, and strengthening infrastructural support for agriculture.*

drainage interventions (the concern of sustainability of irrigated agriculture was the main driver).

- 1979-1993: (Implementation of the of the Revised Action Program (RAP) for Irrigated Agriculture -- emphasis on system rehabilitation, water conservation, improved management, farmer participation, and sustainability (improved O&M and cost recovery through privatization of public tube wells: " the SCARP Transition program")

12. With the expected completion of IBDP and Tarbela dam in the mid-1970s, GoP shifted emphasis to resolving water logging and salinity problems, and in 1973, launched an "accelerated program" of water logging and salinity control (SCARP Program), building upon the success of the program of vertical drainage (through tube wells) and surface drains, started in the 1960 (e.g. SCARP I). Planning studies undertaken in the 1960s reinforced this approach, identified additional areas suitable for SCARP projects, proposed a major system of surface drains to dispose off saline effluent, and emphasized irrigation benefits that could be obtained from canal remodeling and from SCARP tube wells in fresh groundwater areas. SCARPs attempted to lower groundwater levels through tube well pumping and, to a limited extent, through tile drainage. Pumping from fresh water aquifers provided an additional source of irrigation water and enabled leaching of salts from saline soils. Over 12,000 public tube wells were installed and the program was generally successful in controlling water logging while supplementing irrigation supplies.

13. The SCARP Program, however, had it own problems. Its comprehensive approach to area development and emphasis on construction through WAPDA, tended unintentionally to divert attention away from water management, on-farm development, and related issues. Financial and other constraints slowed implementation, and establishment of large public sector tube well fields placed an on-going financial burden on operating agencies (provincial Irrigation Departments) that seriously restricted funds available for normal maintenance of the surface distribution and drainage system. In addition, this program had technical and operational problems. Tube well life was less than planned (10-15 years instead of the assumed 30-40 years) and because of plugging of screens and gravel packs, the capacity of most TWs decreased about 5 percent annually. Water tables were lowered and irrigation supplies supplemented, but efficient management of public tube wells proved elusive.

14. Furthermore, the addition of Tarbela water, while significantly increasing dry season cropping, tended to aggravate water logging problems in certain areas and brought in to focus concerns about overall efficiencies in the use of irrigation supplies. These concerns were heightened further by the demonstration under a USAID-funded research project that water losses in the system, especially at the watercourse level, were significantly higher than had been previously assumed.

The RAP for Irrigated Agriculture (1979)

15. Increasingly during the 1970s it was recognized that a more direct approach to the problems of management, maintenance, and efficiency in the operation of Pakistan's irrigation system was required, and further, that such an approach would need to be more closely attuned to the immediate constraints on agricultural production than in the past. Low *abiana* recoveries[5], rising SCARP O&M costs, inflation and pay commission awards resulted in major neglect of the surface irrigation system. Deferred maintenance began to accumulate and institutional weaknesses, manifested by poor quality of service delivery, also began to become apparent. By

[5] *Until the early 1970s abiana proceeds were sufficient to cover the full operation and maintenance (O&M) cost and a small percentage of capital cost. However, the then government did not increase abiana rates even in nominal terms and recoveries fell far below O&M expenditures.*

early 1980s accumulated deferred maintenance of the irrigation system had reached unsustainable levels. To help evolve appropriate policies and programs to implement such a new strategy to address emerging issues, a UNDP-financed and World Bank-executed study was mounted to prepare a RAP for irrigated agriculture.

16. While recognizing that programs to increase availability of water and other inputs will continue to be important, the RAP recommended in 1979 that greater priority be given to complementary measures designed to ensure efficient water use, in particular through farm-level programs and mobilization of private initiative and capital. The RAP also recommended better coordination between agriculture and water policies, improved water management at the farm and command area levels, discontinuation of new public investments in fresh ground water areas and privatization of public tube wells, and system rehabilitation. Recognition was given to the capacity of the farmer to respond to appropriate incentives as well as to the need to generate additional resources in both the public and private sectors to relieve acute resource constraints facing Pakistan.

17. Specifically, the RAP recommended: (a) investment policies that emphasized quick returns and that complemented existing facilities rather than expansion of irrigated area (rehabilitation, on-farm and watercourse improvements, essential drainage, and agricultural support services); (b) management policies that transferred relevant activities to the private sector (e.g., tube well development in fresh groundwater areas) and that strengthened GOP operating agencies; and (c) pricing policies that recognized continuing resource constraints and the need to provide appropriate efficiency signals to the private sector. The RAP recommendations in large measure were accepted by GOP and made part of the National Agricultural Policy in 1980.

18. ***Bank Assistance:*** During the 1970s, Bank assistance was devoted to completing the Tarbela dam including the remedial works that required special attention. In addition the Bank approved three drainage projects and a flood damage restoration project.

Table-2: Bank Assistance During 1971-1980

Sr. #	Financier	Description	Amount US $ (Current)	Amount US $ (2004/05)	Approval Date
1	IDA	Flood Rehabilitation project	35,000,000	787,500,000	12-Mar-74
2	IDA	Khairpur-II Irrigation & Drainage Project	14,000,000	182,000,000	24-Jun-76
3	IDA	Flood Damage Restoration	40,000,000	460,000,000	22-Feb-77
4	IDA	SCARP-VI	70,000,000	763,000,000	6-Dec-77
5	IDA	Tarbela Dam Supplement II	35,000,000	381,500,000	28-Feb-78
6	IDA	SCARP Mardan	60,000,000	624,000,000	23-Jan-79
Total			**254,000,000**	**3,198,000,000**	

19. During the 1980s, Bank assistance focused on implementing the recommendations of the RAP. There was a sharp increase in Bank assistance both in terms of number of operations and amounts committed for the sector, involving twelve operations with a total commitment of US$ 3.7 billion. Besides one operation for improved maintenance facilities for Tarbela, Mangla and Chashma Reservoirs, one flood damage restoration project, and one project for small irrigation schemes in Balochistan, the Bank supported drainage, on farm water management, system rehabilitation and privatization of SCARPs in fresh groundwater areas.

Table-3: Bank Assistance During 1981-1990

Sr. #	Financier	Description	Amount US $ (Current)	Amount US $ (2004/05)	Approval Date
1	IDA	On-Farm Water Management	41,000,000	323,900,000	16-Jun-81
2	IDA	Irrigation System Rehabilitation	40,000,000	316,000,000	4-May-82
3	IDA	Balochistan Minor Irrigation & Development.	14,000,000	110,600,000	11-May-82
4	IBRD	Reservoir Maintenance Facilities	10,200,000	74,460,000	15-Mar-83
5	IDA	Fourth Drainage Project	65,000,000	474,500,000	31-May-83
6	IDA	Command Water Management	46,500,000	320,850,000	29-May-84
7	IDA	Left Bank Outfall Drain – Stage I	150,000,000	1,005,000,000	13-Dec-84
8	IDA	On Farm Water Management II	34,500,000	231,150,000	6-Jun-85
9	IDA	SCARP Transition Pilot	10,000,000	63,000,000	8-May-86
10	IDA	Irrigation System Rehabilitation II	79,500,000	405,450,000	29-Mar-88
11	IDA	Private Tube well Development	34,400,000	184,000,000	11-Apr-89
12	IDA	Flood Damage Restoration	40,000,000	158,240,000	11-Apr-89
Total			565,100,000	3,667,150,000	

20. *In the drainage sub-sector*, three Bank assisted SCARPs (Mardan, Khairpur II, Panjnad Abassia) started in the early 1980s were completed. Further Bank assistance in drainage was focused on SGW areas and included one project in Punjab (Fourth Drainage) and one in Sindh (the Left Bank Outfall Drain, LBOD Stage-I). While the focus of all these projects was on providing drainage relief they were designed as integrated irrigation and drainage investments that sought productivity improvements in reclaimed areas.

21. *In water management*, the Bank supported two OFWM Projects and a Command Water Management Project. These projects recognized the need for giving greater voice to farmers in decision making at the watercourse level. Supporting legislation in the form of Water User Association Acts was promulgated in all provinces.

22. *In system rehabilitation*, the Bank supported two successive nationwide projects to rehabilitate the irrigation and drainage system. At the same time O&M funding was substantially increased with the help of grants from GoP and periodic increases in *abiana* charges were covenanted with the provinces. However, institutional and policy changes required to sustain O&M levels and improve O&M planning and effectiveness remained lacking.

23. The Bank also supported a program for "SCARP Transition" (disinvesting public tube wells in fresh groundwater areas) on a pilot basis in Punjab to reduce the public sector O&M burden[6]. A project to support private tube well development in fresh groundwater areas, with shallow water tables, was supported to avoid the need for further SCARPs in FGW areas.

24. In the 1980s feasibility and detailed design studies for Kalabagh Dam, the storage project that was envisaged to follow the construction of Tarbela Dam, were also started.

[6] *Expenditure on O&M of SCARP tube wells accounted for nearly 50% of the Punjab Irrigation Department's annual O&M budget.*

Assessment of Bank assistance in the Post-RAP Period

25. While Bank assistance during this period closely followed the RAP recommendations focusing on sustainability of irrigated agriculture and improving water delivery efficiency in SGW areas, the achievements were mixed, as explained below.

26. The OFWM investments were the most successful in terms of intended outcomes, including substantial "water savings", increases in cropping intensities and farm incomes (see excerpts from OED précis below). However, from an institutional development view point the achievements were modest. WUAs were generally non-sustainable mainly because they did not have a continuing responsibility for O&M of the system above the *Mogha*. The 3rd On Farm Water Management (OFWM) project Implementation Completion Report (ICR) observed that " For long term sustainability of the irrigation system, participation of farmers in irrigation management is necessary. Their participation could be enhanced if the farmers' organizations have a continuous crucial role in O&M of the system. They should be responsible for distribution of water and collection of revenue resulting from water charges. In Pakistan's irrigation system, this could be achieved by forming FOs at the secondary canal level i.e. distributaries/minors."

27. *The drainage investments in SGW areas* while solving local water logging problems, faced sustainability and environmental issues:

- Firstly, besides *off-farm drainage* these investments also supported investments for *on-farm drainage* –primarily a private good-- without requiring beneficiary contribution to capital cost. This gave the wrong signals to farmers that such investments would continue to be supported by the public sector. Furthermore it down played the importance of improved water management to reduce the drainable surplus caused largely by over-irrigation.
- Secondly, except for limited investments in tile drainage, most subsurface drainage was based on large capacity tube wells. This choice of technology while reducing the initial capital cost, resulted in several problems: (i) farmers could not maintain the large capacity tube wells; (ii) deeper groundwater being invariably more saline than shallower groundwater, environmentally safe disposal of drainage effluent became a problem; (iii) local drainage disposal solutions received inadequate attention[7]; (iv) the focus on vertical drainage, discouraged the development of local private industry for tile drainage (PVC resin and pipes, and contractors specializing in laying horizontal pipe drainage) that has been successfully developed on a large scale in other countries, e.g. Egypt.
- Thirdly, The projects involving surface drainage (e.g. LBOD Stage-1 Project) were not designed to handle storm water flooding nor was a system of flood management (flood warning or alarm system) part of the design. This deficiency has emerged as a major issue, particularly in the southern coastal district of Sindh (e.g. Badin) where recurring severe flooding has occurred on several occasions.
- Fourthly, most provinces defaulted on covenants requiring increases in water charges. The resulting low recoveries were highly inadequate for O&M, and drainage infrastructure remained the most poorly maintained part of the irrigation and drainage system.

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[7] *For example, the option of using evaporation ponds for saline effluent disposal was rejected based on the results of poorly sited evaporations ponds in SACRP VI. Evaporation ponds have been successfully used in countries such as Australia for disposing saline drainage effluent.*

28. *Privatization of SCARPs in Punjab* by replacing government owned and operated large tube wells with community owned and operated small capacity shallow tube wells was perhaps the most successful and path breaking investment supported by the Bank. Firstly, it greatly reduced the O&M burden of the government substantially reducing the O&M cost and recovery gap. Secondly, it broke the myth that water logging and soil salinity cannot be controlled by private and community tube wells without compromising small farmers access to groundwater. Thirdly it demonstrated that farmers can better meet their irrigation needs if they control the operation of tube wells.

29. *The investments in system rehabilitation* no doubt had short term benefits of reducing incidence of canals breaches and solving siltation and erosion in "problem" channels. However, due to the lack of essential institutional changes and adequate O&M, the situation reverted back to the pre-rehabilitation situation within 3 to 5 years. The rehabilitation investments primarily aimed at restoring the system to its original design without any element of modernization to covert the system from a largely supply driven run-of-the river system to a more demand driven system[8] intended for more modern agriculture. Additional control and flow measurement structures and an O&M regimes commensurate with its requirements were not supported as part of these investments. The latter would have essentially required a more fundamental institutional change with greater farmer participation and incentives as its center piece.

30. ***OED Observations:*** In 1992 OED carried out an ex-post evaluation of two OFWM and two ISRP projects. Experts from these evaluations are given below:

- *As approved, the four projects supported some of the most important priorities established in the RAP. But as implemented, they strayed from the program's agreed strategy:*

  -- They failed to give highest priority to improvements in saline groundwater areas. In these areas—which have no supplementary well water—the returns to controlling water tables and supplying more surface water are the highest.

  -- They came to be dominated by quantitative targets for watercourse improvement, regardless of the likely effects on water supply, water logging, and salinity.
- *The water "saving"[9] impact of the 9,860 watercourses improved under three of the four projects, plus that from canal lining under CWMP, totals about 2.0 million acre feet (MAF), or 2.3 billion cubic meters… .. Although this is only a little more than half the savings anticipated under RAP, it is nevertheless, more than a new surface storage dam at Kalabagh would provide (though that would have power benefits as well). This next proposed main storage site would provide an estimated 3.5 million acre feet at the mogha at a cost of US$3.5 billion (in a 1985 estimate).*
- *Canal rehabilitation and lining work in practice included significant capacity expansion contrary to the agreed program. This apparently occurred to allow the*

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[8] *Generally, original design criteria of the canal system had evolved to fit availability of water supplies in the rivers, to meet the objective of bringing to maturity the largest possible area of crops with the minimum consumption of water, and to operate at a low cost and with a limited number of technical staff. These resulted in low cropping intensities and low yields. While these irrigation schemes were historically very successful in generating agricultural surpluses at a time of low population densities and few technological demands, they have been less well adapted to the requirements of modern agriculture.*

[9] *It is important to clarify here that water losses in areas underlain with fresh ground water are not real losses as these losses simply recharge the aquifer for later usage. The only real savings in losses are those obtained in SGW areas.*

provinces to absorb additional water becoming available from Tarbela dam and to establish rights to that water before a formal allocation agreement took effect in 1991. In areas that could not safely absorb more water, the resulting increases in water logging and salinity have caused serious human and environmental problems.

- *Program designers had envisaged a farm credit approach, arguing that farmers would find improvements in their watercourses profitable enough to repay loans. But, because of performance problems in the credit system, the improvements relied heavily on construction subsidies. ..*
- *Vested interests and the perquisites of project activities distorted the incentives to participants, just as the efficient management of the system as a whole was undermined by political influence and rent seeking. ..*
- *The bundling of assistance for the four provinces together in these four projects may have been administratively convenient, and clearly facilitates the Bank's wholesaling of development assistance, but is likely to have reduced the overall impact of the assistance.*
- *Recent projects have had some worthwhile and widespread poverty alleviation impact, but have also provided at the same time, without any justification, large transfers of public funds to many of the rural elite. Differentiation would permit, among other things, a more efficient allocation of scarce resources, taking relative needs into account.*

The Post-Inter-Provincial Water Accord Period (1991—2005)

31. The beginning of the 1990s was marked by the conclusion of a long overdue Water Accord for sharing the Indus waters amongst the four provinces in 1991. A Water Sector Investment Planning Study (WSIPS) was also completed in 1990 to update the RAP recommendations and prioritize investments. The WSIPS emphasized the need for establishing a comprehensive and reliable Data Bank Network for water resources, agriculture, soils, etc. to guide investment planning; revitalizing institutional capacity in the provinces for investment planning; establishing a sector MIS; improving project approval and review processes; modernizing procurement processes; strengthening the local construction and consulting industries; and a training program for institutionalizing integrated comprehensive management of water resources.

32. However, by 1992 it had become clear that the RAP approach was not resolving the overriding problems of the irrigation system which remained in dire straits with problems similar to many other irrigation systems, including water logging and salinity, over-exploitation of fresh groundwater, low efficiency in delivery and use, inequitable distribution, unreliable delivery, and insufficient cost recovery system . It was realized that the RAP approach was not addressing the real underlying causes of the problems Pakistan's irrigation system was facing but rather trying to deal with the symptoms. With this realization, the Bank stopped new lending in the sector[10] till a far reaching new strategy to address the real causes was agreed with the Government. In 1994 the Bank completed a major sector study that resulted in the report entitled *Pakistan-Irrigation and Drainage: Issues and Options*. The key findings and recommendations of the of this report were:

- *In Pakistan, as in many other countries, government treats irrigation water as a public good, whereas it is a private tradable good, for which markets can operate. Lack of well defined individual property rights and the illegality of sales of surface water severely constrain informal irrigation water markets. Instead of rooting out the barriers to water markets, Government publicly administers irrigation water.*

[10] *Other than emergency assistance for flood damage and operations already appraised by then.*

Inefficient pricing of water, resource misallocation, rent seeking behaviour, and "illegal" trading is the result.

- *The Government had not even adequately met the requirements of an administered system. It had failed to make budgetary provisions for operations. Moreover, the public body responsible for irrigation maintenance was separate from (and had poor coordination with) the agency responsible for revenue collection. In the past, administrative discipline was adequate but it had gradually broken down and the cost of irrigation maintenance had vastly increased. Nor were there any measures available to restore discipline.*
- *Economic efficiency in irrigation delivery and use cannot be achieved, because of lack of the right incentives.*
- *Unlike on-farm drainage, off-farm drainage is a public good. Thus, off-farm drainage will have to be supplied by the Government. However, the underlying problem of inappropriate institutional framework will require reforms that will ensure autonomy, transparency, and accountability of present institutional set-up for drainage.*
- *Any water service that is not a public good should be commercialized and later privatized.*
- *Only with market-determined incentives for irrigation and on-farm drainage is a sustained improvement in performance possible. The government needs to remove barriers to a free market in water. Most important, the government will have to draw up enforceable property rights to water, without which any attempt to legalize and commercialize water markets would be futile. Property rights and legalized markets will make the opportunity cost of water transparent, leading to greater efficiency in use.*
- *The long-term option for the government will be to define individual water property rights, which are necessary to ensure equity in distribution. This would address the problems of tail-enders (that is, those at the tail end of the system who receive little or no water), while relieving pressure on ground water resources.*
- *As a first step toward individual water rights, Pakistan may like to aim for communal rights, which are legally and administratively easier to establish. User organizations can then translate these communal rights into enforceable individual rights of their members.*

The National Drainage Program (NDP) Experience

33. While endorsing, in principle, the main elements of the above strategy, in 1995/96 GOP proposed its own model for implementing the reforms that envisaged replacing the provincial irrigation departments (PIDs) with a three-tier institutional setup comprising autonomous Irrigation and Drainage Authorities at the provincial levels, Area Water Boards (AWB) at the main canal level and Farmer Organizations (FOs) at the distributary canal levels. PIDAs were to be established in all provinces while one pilot AWBs was to be established in each province with FOs at the distributary canal level. Supporting legislations in the form of PIDA Ordinances were passed and later endorsed by the Provincial governments as PIDA Acts. The emphasis was on organizations, not incentives and instruments, however. Water rights and entitlements that were advocated in the Bank's strategy paper were not on the immediate agenda. The Bank accepted the proposed model as a starting point for implementing the reforms as the center piece of the, misleadingly-named, NDP project assuming that a detailed strategy for implementing the reform

model and dealing with difficult political economy issues would be developed during the course of project implementation.

34. While a detailed evaluation of the NDP implementation experience is beyond the scope of this paper, suffice it to say that relative to its stated objectives and program targets, the implementation performance of NDP remained more or less unsatisfactory throughout and its outcomes have been modest. The main reasons for this unsatisfactory performance included, *inter alia*:

- Overly complex and ambitious project design that failed to address the realities of political economy embedded in the profound changes the reforms sought[11];
- lack of ownership, particularly by the PIDs who saw the reforms as a threat to their existence and monopoly on water distribution, and offered immense resistance and inertia to the changes the reforms sought to bring[12];
- lack of champions both at the working level and at the political levels (except in Sindh, and very recently in Punjab following changes in leadership);
- Focus on organizations not on instruments and incentives;
- Lack of attention to sequencing, prioritization and the "rules for reformers".
- lack of a detailed strategy for implementing the key elements of the reforms; the PIDA Acts envisaged a "stroke of the pen" conversion of PIDs into PIDAs but lacked important details[13] for implementing the reform strategy. Furthermore, the Acts, did not address the fundamental issues of legalizing water markets, or clarifying communal and individual water rights.
- the Bank's underlying assumption that transition plans, severance packages and change management arrangements would be defined and developed during implementation did not materialize due to constant distraction by other implementation issues and battles of turf and jurisdiction among the various participating agencies. Similarly, the expectations that more transparent volumetric measurements, bulk water sales and water charges based on volume would be introduced during implementation also did not materialize as they received far lower priority than the easier to implement rehabilitation works.
- From 1999 onwards, the prevailing drought and resulting water shortages dominated the water sector debate in Pakistan and the issues surrounding new storage proposals distracted Governments attention away from drainage and institutional reform issues.

35. In retrospect, a drainage project covering all the provinces and envisaging a major civil works component was not the right vehicle for implementing reforms that sought to focus on improving irrigation service delivery through participatory management, a system of property rights and incentives. A more focused irrigation project would probably have been a more appropriate vehicle.

36. Notwithstanding this overall unsatisfactory rating, the NDP did yield several positive outcomes. First, it helped to clear the backlog of deferred maintenance of the existing system (some parts of the irrigation and drainage system had virtually no maintenance for several years). Second, although the institutional reforms component had a mixed performance, the need for the

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[11] *For example, not including the PIDs as participating agencies in the project while seeking to replace them with alternative bureaucracies*

[12] *Opponents of reforms wanted to create the impression that "the reforms had failed"; however, the opposing view is that actually the "agencies failed to reform".*

[13] *With the exception of Sindh where the Bank had earlier approved an IDF grant for preparing an institutional development pilot project for the Nara Canal AWB.*

reforms has been endorsed at the highest levels of the GoP and Provinces, and Sindh made commendable progress. Third, it was instrumental in the completion of key policy and sector studies that have paved the way for introduction of a National Water Policy and a drainage sector strategy for the country. Fourth, the project improved the knowledge base by providing funding for institutions and individual researchers and contributing international experience through study tours and use of international panels of experts. Fifth, the project promoted farmer participation in the operation and maintenance of the irrigation system. Finally, the project provided a forum for the discussion of long term options for the sustainable development of the Indus River Basin, and as a consequence, has raised awareness of the importance of sound environmental planning and management.

Other Bank Assistance during the 1990s

37. Besides supporting the NDP project, Bank assistance included the projects listed below. Besides supporting a third OFWM project, of particular significance was the support for the Second SCARP Transition and the Punjab Private Sector Groundwater Development Projects[14] that completed the privatization of the remaining 6,000 SCARP tube wells in FGW areas of Punjab, providing substantial relief to its O&M burden; the Fordwah Eastern Sadiqia Irrigation and Drainage Project that successfully established the first pilot FOs in Punjab, who were handed over irrigation O&M and revenue collection responsibility in the Bahawalnagar area of Punjab; a Flood Damage Restoration Project; and a Community Irrigation Project in Balochistan. Although the preparation of feasibility and detailed design (including bid documents) for the Kalabagh Dam were substantially completed, implementation was not started because of environmental and political controversies.

Table-4: Bank Assistance During 1991-2000

Sr. #	Financier	Description	Amount US $ (Current)	Amount US $ (2004/05)	Approval Date
1	IBRD	On-Farm Water Management III	36,300,000	137,940,000	21-May-91
2	IDA	On-Farm Water Management III	47,300,000	179,740,000	21-May-91
3	IDA	SCARP Transition II	20,000,000	76,000,000	4-Jun-91
4	IDA	Fordwah Eastern Sadiqia Irrigation & Drainage	54,200,000	162,600,000	2-Jul-92
5	IDA	1992 Flood Damage Restoration	100,000,000	300,000,000	4-Mar-93
6	IDA	Balochistan Community Irrigation	26,700,000	61,410,000	26-Sep-95
7	IDA	Punjab Private Sector Groundwater Development	56,000,000	112,000,000	11-Jul-96
8	IDA	National Drainage Program	285,000,000	541,500,000	4-Nov-97
Total			625,500,000	1,571,190,000	

Bank Assistance After 2000 and Post-NDP

38. Following the mixed experience and outcomes of NDP, the Bank adopted an interim strategy till a new CWRAS is agreed with the government. This interim strategy has identified areas for partnership and mutually agreed with GOP and Provinces on the need to complement the reform agenda with investments in infrastructure. It distinguishes two possible scenarios: the

[14] *As part of this project, a draft framework for groundwater regulation in Punjab was also prepared.*

first one formed by interventions that could stand on their own merits and that could reap significant benefits for productivity enhancement, income generation, capacity building at the farm level, and to guarantee the safety of existing infrastructure (barrages); the second one ("high case" scenario) would seek progress in the articulation of the reform instruments (enforceable water entitlements and water rights, participation of stakeholders, transfer of responsibility over asset management, accountable institutions, water pricing and cost recovery policies, and environmental flows) so as to justify major interventions in storage, irrigation infrastructure, and long term solutions to inter-provincial drainage problems. With respect to irrigation, the overall strategy will be to un-bundle at the provincial level the support initially provided under NDP, and support the provinces that have demonstrated initial results and commitment.

39. In line with this interim strategy, the Bank approved On-Farm Water Management Projects for NWFP and Sindh that provide support for physical improvements at the on-farm[15], watercourse, distributary and branch canal levels as well as for the reforms initiated under the NDP project. In addition the Bank reallocated funds from the NDP Credit for Drought Emergency Rehabilitation and more recently approved a project for the rehabilitation of the Taunsa Barrage on an emergency basis.

Recent Sector Work

40. In 2003, as part of the Public Expenditure Review (PER), the Bank carried out a systematic review of public spending in the water sector and highlighted a series of strategic issues to be addressed by the Government and the Pakistan society. The review culminated in the Public Expenditure Management Vol II, entitled *Pakistan: Accelerated Development of Water Resources and Irrigated Agriculture, September 2003.* The main findings and recommendations of this review were:

- Pakistan has been living off the great expansion in irrigated agriculture since the late 1970s when the last major storage reservoir was completed. With the exception of two major drains to serve irrigated areas on the left and right banks of the lower Indus River, investment has been limited since that time mainly to *ad hoc* rehabilitation of canals and drains and salinity control tubewells.
- There is little doubt that water sector investment must increase substantially to meet urgent needs for modernization of the distribution system, groundwater management, controlling soil and water salinity, as well as improving governance and the accountability of the institutions responsible for irrigation water service. However, investment in infrastructure alone will not meet the challenges – key policy changes and institutional and governance reforms are at least as important.
- The major strategic issues facing Pakistan in the Indus Basin, include soil and water salinity; environmental degradation of the lower river and estuary; inter-provincial conflict over water allocation and management; vulnerability to drought and supply reliability; and pervasive inequity, inefficiency and low productivity.
- A "supply side" approach has long been the staple water policy in Pakistan, and as one might expect, new water supply (dams) and new canals dominate the current proposals for investment in the sector. But looking to the future, the combination of high population growth, persistent poverty, lagging growth in rural areas, and the looming constraints on *water resources suggests that water resources development and management in the next 40 years will be and must be by design substantially different than the past 40 years*. A genuine paradigm shift is needed

[15] *Including introduction of micro-irrigation technologies and piloting of volumetric water delivery and abiana on the basis of volumetric deliveries*

in the water sector in which water is "managed" from the mountain tops to the root zone of the Indus Basin.

- The strategy going forward must:
  - Modernize both the water infrastructure and the institutional and governance arrangements for water management, and improve strategic planning and the knowledge base that supports planning, policy analysis and investment (R&D, information systems)
  - Balance short-term and long-terms benefits, by making investments in both water infrastructure and water management, and in both supply and demand management
  - Better integrate irrigation, hydropower and agricultural development investment programs and policy;
  - Reflect a more rigorous economic, social and environmental analysis to ensure that project priorities and plans make the best use of the limited resource and fiscal space;
  - Be supported by a new consensus on water management and development that avoids the costly political conflicts of the past;
  - Choose judiciously among investments in supply expansion, system expansion, management, environmental sustainability, productivity and governance, and then sequencing these over time to achieve a timely and sustainable development program with real and substantial economic and social benefits.

"The Road Show 2004"

41. As a prelude to the preparation of Pakistan CWRAS, in November 2004, the Bank fielded a mission to articulate water sector issues and initiate preparation of a CWRAS for Pakistan in a participatory and consultative manner. Presentations were made to high level GoSindh and GoPunjab officials. Subsequently, similar visits were made to NWFP and Balochistan as well. During these interactions the Bank team indicated willingness to scale up assistance to the sector for investments in infrastructure at four levels of the irrigations system (National, Provincial, Canal command and Farm level) as well as for institutional and policy reforms based on the following principles:

(i) making water service organizations more accountable, transparent and accountable to users;
(ii) building more trust amongst stakeholders at all levels;
(iii) increasing water productivity;
(iv) ensuring environmental sustainability;
(v) improving financial sustainability (users pay at least for recurrent costs);
(vi) protecting **water rights** at all levels; and
(vii) recognizing that reforms are complex political processes and there is no single blue print or model that fits all provinces. ***A principled and pragmatic approach*** has to be followed.

42. In subsequent discussions with GOP, the mission also indicated Bank's willingness to consider engagement in developing major new Indus Basin storage provided: (i) there is political consensus, including an explicit and transparent procedure for implementing the 1991 Water Accord and sharing the benefits equitably; (ii) there is an agreed-upon Environmental Flow Allocation to the delta; (iii) Land Acquisition and Resettlement Policies and implementation plans are made consistent with good global practice; and (iv) these investments are accompanied

by institutional reforms and investments at provincial, canal command and farm levels to ensure better use of water. The Bank team also indicated willingness to provide support for:

- Establishing a **high-level apex body** (National Water Council) to forge a new consensus on water management, and adopt and maintain a coherent, forward looking policy framework for the sector (subsequently, approval of the draft National Water Policy that among others envisages the creation of this apex body was included as one of the triggers for the Second Poverty Reduction Strategy Credit (PRSC II).
- Assisting Indus River System Authority (IRSA) in achieving greater transparency in the implementation of the 1991 Water Accord.
- Supporting the establishment of a well staffed, professional, autonomous organization to provide the technical and analytical support to the political and policy making apex body.

Status of Preparation of the Pakistan CWRAS: Process Followed and Next Steps

43. The Bank is currently in the process of preparing a CWRAS for Pakistan. As part of this process some 16 background papers have been prepared by leading Pakistani professionals on key water sector issues, including Water, Growth and Poverty; Pricing and Finance; Human and Social Dimensions, Water and Environmental Sustainability; Water and Energy; Water balances and Evapo-transpiration; Water Rights and Entitlements; Sustainable, Accountable Institutions; Policies and Prospective Plans for Development and Management of Water Resources by the Federal and Provincial Governments; Drinking Water and Sanitation; The Political Economy of Reform; The role of Large Dams in the Indus System; Groundwater; Drainage and Salinity Management; Flood Management; and The Evolution of Bank Lending and Non-lending for Water in Pakistan.

44. A high level consultative meeting was held with senior government officials to discuss institutional issues as well as reform instruments. Subsequently, a stakeholder consultation workshop was held to obtain views on key sector issues and possible Bank's role from a broad cross section of professionals, government officials as well as civil society and NGO representatives.

45. In term of next steps, an annotated outline of the CWRAS will be discussed with senior government officials and stakeholders in May 2005 and thereafter a final Report will be prepared.

Emerging Future Bank Lending Program

46. While the CWRAS is still being finalized, the main areas of Bank support for the water sector have been generally identified. The CWRAS would assist Pakistan in addressing various "gaps" that exist, for example, in terms of: looming water shortages—learning to live with water shortages; institutional performance; asset management (O&M and cost recovery); trust and transparency at various levels (among provinces and water users at the head and tail ends of the system); and water productivity. The CWRAS recognizes that Pakistan needs to: (i) better manage, operate and maintain its large stock of existing hydraulic infrastructure (ii) modernize and safeguard its aging infrastructure against physical failures; (iii) build additional infrastructure; (iv) protect its water resource base (surface and groundwater) and environment against degradation and pollution; and (ii) vastly improve service delivery and water use efficiency, through a more transparent system of water measurements, entitlements and rights, decentralization, professional management, and empowerment of water users.

47. Bank support would focus on instruments and incentives for reforms rather than simply on organizations, programs and projects. It would be based on "principled pragmatism" recognizing that reforms and investments must proceed in parallel and the best should not be

allowed to become the enemy of the good. Broadly speaking, Bank assistance would support four pillars of the water sector: (i) Asset Management and Development; (ii) Water Resources Management; (iii) Service Delivery; and (iv) On-farm Productivity. The Bank would provide support through its various lending instruments, including budgetary support for policies and prior actions that address key issues (Development Policy Lending) as well as through specific investment lending for infrastructure and institutional reforms. The tentative lending program for the next three years would be as follows:

Punjab Irrigation Policy Loan (US$ 300 million) FY06-08: This 3 to 4 year program would support the reform program in Punjab's irrigation sector, built on four pillars: asset development and management; water resource management (including groundwater); reform of irrigation service delivery; and enhanced on-farm services to increase water productivity. Policy framework could include: (1) a medium term (ten year) vision of how Punjab wishes to change its management of water resources and irrigation services, including broad outcomes and targets; (2) short term targets of what can be achieved immediately in terms of the policy and institutional reforms and; (3) a medium term budgetary framework for the sector including analysis of fiscal space

Punjab Water Infrastructure Investment (US$ 150 million)—FY07: Several barrages in Punjab require rehabilitation and modernization to address problems arising from deficiencies which could lead to progressive structural failure and serious economic consequences. Besides physical rehabilitation, improvements and modernization, the project will also support institutional and organizational restructuring and capacity building, improved O&M regimes

Punjab Water Sector Irrigation Investment (US$ 100 million) **(FY08)**: The project would support institutional reforms in water resource management/ delivery of irrigation services in specific canal commands of Punjab through an "incentive-based approach". Farmers and farmer organizations will play a major role and would compete for a set of "rewards" for meeting specified “entry conditions” The "entry conditions" would relate to items like formation of farmer organization, commitment to implementing water entitlements, provider/user contracts, water measurement and monitoring. The "rewards" would be investments in capacity building, canal modernization, measurement devices, and on-farm services and possibly an option in which the farmers could choose "professional management.”

Sindh Water/Irrigation Sector Improvement Program (WSIP) ((US$ 140 Million) FY06/07: The project would improve water productivity through a reform agenda/investments leading to better management system that links canal command areas, the distributary and the watercourse level. Components include; (I) Capacity building; (ii) Civil Works; (iii) Agriculture and irrigation technology; and (iv) Management and administration

NWFP – Irrigation Sector Improvement Program (US$ 70 million) FY06/07: The project would improve water productivity through a reform agenda/investments leading to better management system that links canal command areas, the distributary and the watercourse level. Components include; (I) Capacity building; (ii) Civil Works; (iii) Agriculture and irrigation technology; and (iv) Management and administration

Balochistan Small-Scale Irrigation (US$ 40 million) FY07: The project would develop water resources through; (1) restoring and increasing water storage; (2) increasing productivity of water through more efficient use and; (3) developing capacity to formulate a water resources development plan using surface, groundwater and watershed management. Components include; (1) water mgt. infrastructure - restoring hydrological balance of Band Khushdil Khan (KK Band), construction of delay action dams and selected small-scale irrigation projects; (2) On farm water

management/ crop management- modernization of irrigation systems and subsidies for efficient on-farm irrigation systems/modern irrigation technologies and; (3) institutional development - among farmer, water users and different levels of government

Support for a Federal Project?.

Annex-I: Pakistan – Water Sector Assistance Statement of Loans/Credits/Grants, as of November 30, 2004

Sr. #	Description	Amount US $ (Current)	Amount US $ (2004/05)	Approval Date	OED Outcome Rating	Sub Category
1	Indus Basin Project	90,000,000	4,617,000,000	13-Sep-60	S*	IBP
2	Khairpur Irrigation	21,154,434	1,085,222,464	29-Jun-62	N/A	I&D
3	Indus Basin Project	70,619,397	3,530,969,850	16-Jul-64	S*	IBP
4	Tarbela Dam Project	25,000,000	977,500,000	2-Jul-68	S*	D
5	Irrigation Tubewells	14,000,000	519,400,000	23-Jun-70	N/A	I&D
6	Flood Rehabilitation Program	35,000,000	787,500,000	12-Mar-74	N/A	F
7	Khairpur-II	14,000,000	182,000,000	24-Jun-76	N/A	I&D
8	Flood Damage Restoration	40,000,000	460,000,000	22-Feb-77	N/A	F
9	Irrigation (Scarp-VI)	70,000,000	763,000,000	6-Dec-77	N/A	I&D
10	Tarbela Ii	35,000,000	381,500,000	28-Feb-78	S*	D
11	Scarp Mardan (Phase-I)	60,000,000	624,000,000	23-Jan-79	N/A	I&D
12	On Farm Water Management	41,000,000	323,900,000	16-Jun-81	S*	WM
13	Irrigation Systems Rehabilitation	40,000,000	316,000,000	4-May-82	S*	R
14	Baluchistan Agriculture Development	14,000,000	110,600,000	11-May-82	N/A	IE
15	Reservoir Maintenance	10,200,000	74,460,000	15-Mar-83	N/A	D
16	Fourth Drainage Project	65,000,000	474,500,000	31-May-83		DR
17	Command Water Management	46,500,000	320,850,000	29-May-84	S*	WM
18	Left Bank Outfall Drainage	150,000,000	1,005,000,000	13-Dec-84	MS	I&D
19	Water Management Ii	34,500,000	231,150,000	6-Jun-85	S*	WM
20	Scarp Transition Pilot	10,000,000	63,000,000	8-May-86	S*	GW
21	Irrigation Rehab II	79,500,000	405,450,000	29-Mar-88	N/A	R
22	Flood Restoration	40,000,000	184,000,000	11-Apr-89	N/A	F
23	Private Tubewell Development	34,400,000	158,240,000	11-Apr-89	N/A	GW

Sr. #	Description	Amount US $ (Current)	Amount US $ (2004/05)	Approval Date	OED Outcome Rating	Sub Category
24	On-Farm Water Management II	36,300,000	137,940,000	21-May-91		WM
25	On-Farm Water Management II	47,300,000	179,740,000	21-May-91		WM
26	Scarp Trans. II	20,000,000	76,000,000	4-Jun-91	S	GW
27	Fordwah Eastern Sadiqia	54,200,000	162,600,000	2-Jul-92	S	I&D
28	1992 Flood Damage Rehabilitation	100,000,000	300,000,000	4-Mar-93	S	F
29	Balochistan Comm. Irrigation	26,700,000	61,410,000	26-Sep-95	S	IE
30	Private Sector Ground Water	56,000,000	112,000,000	11-Jul-96	MS	GW
31	National Drainage Program	285,000,000	541,500,000	4-Nov-97	N/A	IR-I&D
32	NWFP On-Farm Water Management	21,350,000	27,755,000	12-Jun-01	UI	WM
33	Sindh On-Farm Water Management	61,140,000	67,254,000	20-May-04	UI	WM
Total		**1,747,863,831**	**19,261,441,314**			

Acronyms for Sub Category Column

D	Dams	IE	Irrigation Extension
DR	Drainage	IR-I&D	Institutional Reforms-Integrated Irrigation & Drainage
F	Flood Protection	R	Rehabilitation
GW	Ground Water	WM	Water Management
I&D	Integrated Irrigation & Drainage	WSS	Water and Sanitation
IBP	Indus Basin Project		

Acronyms for OED Rating Column

S	Satisfactory
MS	Moderately Satisfactory
US	Unsatisfactory
N/A	Not Available
UI	Under Implementation

Outcome Ratings have been taken from OED evaluation reports

Annex-II: Sub sector Composition of Bank Lending in Water Sector:

Dams:

Sr. #	Description	Amount US $ (Current)	Amount US $ (2004/05)	OED Outcome Rating	Approval Date
1	Tarbela Dam Project	25,000,000	977,500,000	S*	2-Jul-68
2	Tarbela II	35,000,000	381,500,000	S*	28-Feb-78
3	Reservoir Maintenance	10,200,000	74,460,000	N/A	15-Mar-83
Total		**70,200,000**	**1,433,460,000**		

Drainage (Stand Alone):

Sr. #	Description	Amount US $ (Current)	Amount US $ (2004/05)	OED Outcome Rating	Approval Date
1	Fourth Drainage Project	65,000,000	474,500,000		31-May-83
Total		**65,000,000**	**474,500,000**		

Flood Damage Restoration/Protection

Sr. #	Description	Amount US $ (Current)	Amount US $ (2004/05)	OED Outcome Rating	Approval Date
1	Flood Rehabilitation Program	35,000,000	787,500,000	N/A	12-Mar-74
2	Flood Damage Restoration	40,000,000	460,000,000	N/A	22-Feb-77
3	Flood Restoration	40,000,000	184,000,000	N/A	11-Apr-89
4	1992 Flood Damage Rehabilitation	100,000,000	300,000,000	S	4-Mar-93
Total		**215,000,000**	**1,731,500,000**		

Ground Water:

Sr. #	Description	Amount US $ (Current)	Amount US $ (2004/05)	OED Outcome Rating	Approval Date
1	SCARP TRANSITION PILOT	10,000,000	63,000,000	S*	8-May-86
2	PRIVATE TUBEWELL DEVELOPMENT	34,400,000	158,240,000	N/A	11-Apr-89
3	SCARP TRANS. II	20,000,000	76,000,000	S	4-Jun-91
4	PRIVATE SECTOR GROUND WATER	56,000,000	112,000,000	MS	11-Jul-96
Total		**120,400,000**	**409,240,000**		

Integrated Irrigation and Drainage:

Sr. #	Description	Amount US $ (Current)	Amount US $ (2004/05)	OED Outcome Rating	Approval Date
1	Khairpur Irrigation	21,154,434	1,085,222,464	N/A	29-Jun-62
2	Irrigation Tubewells	14,000,000	519,400,000	N/A	23-Jun-70
3	Khairpur-II	14,000,000	182,000,000	N/A	24-Jun-76
4	Irrigation (Scarp-VI)	70,000,000	763,000,000	N/A	6-Dec-77
5	Scarp Mardan (Phase-I)	60,000,000	624,000,000	N/A	23-Jan-79
6	Left Bank Outfall Drainage	150,000,000	1,005,000,000	MS	13-Dec-84
7	Fordwah Eastern Sadiqia	54,200,000	162,600,000	S	2-Jul-92
Total		**383,354,434**	**4,341,222,464**		

Indus Basin Project:

Sr. #	Description	Amount US $ (Current)	Amount US $ (2004/05)	OED Outcome Rating.	Approval Date
1	Indus Basin Project	90,000,000	4,617,000,000	S*	13-Sep-60
2	Indus Basin Project	70,619,397	3,530,969,850	S*	16-Jul-64
Total		**160,619,397**	**8,147,969,850**		

Irrigation Extension:

Sr. #	Description	Amount US $ (Current)	Amount US $ (2004/05)	OED Outcome Rating	Approval Date
1	Balochistan Ag. Development	14,000,000	110,600,000	N/A	11-May-82
2	Balochistan Comm. Irrigation	26,700,000	61,410,000	S	26-Sep-95
Total		**40,700,000**	**172,010,000**		

Institutional Reform – Integrated Irrigation & Drainage:

Sr. #	Description	Amount US $ (Current)	Amount US $ (2004/05)	OED Outcome Rating	Approval Date
1	National Drainage Program	285,000,000	541,500,000	N/A	4-Nov-97
Total		**285,000,000**	**541,500,000**		

Rehabilitation

Sr. #	Description	Amount US $ (Current)	Amount US $ (2004/05)	OED Outcome Rating	Approval Date
1	Irrig. Systems Rehabilitation	40,000,000	316,000,000	S*	4-May-82
2	Irrigation Rehab II	79,500,000	405,450,000	N/A	29-Mar-88
Total		119,500,000	721,450,000		

Water Management:

Sr. #	Description	Amount US $ (Current)	Amount US $ (in 2004/05)	OED Outcome Rating	Approval Date
1	On Farm Water Management	41,000,000	323,900,000	S*	16-Jun-81
2	Command Water Management	46,500,000	320,850,000	S*	29-May-84
3	Water Management II	34,500,000	231,150,000	S*	6-Jun-85
4	On-Farm Water Management II	36,300,000	137,940,000		21-May-91
5	On-Farm Water Management II	47,300,000	179,740,000		21-May-91
6	NWFP On-Farm Water Management	21,350,000	27,755,000	UI	12-Jun-01
7	Sindh On-Farm Water Management	61,140,000	67,254,000	UI	20-May-04
Total		**288,090,000**	**1,288,589,000**		

Acronyms for OED Rating Column

S Satisfactory
MS Moderately Satisfactory
US Unsatisfactory
N/A Not Available
UI Under Implementation

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Bank Assistance in the Water Sector: Water and Sanitation

By

Pervaiz Amir and Nadir Abbas

Country Water Resources Assistance Strategy
Background Paper # 17
March, 2005

Acronyms and Abbreviations

AJK	Azad Jammu & Kashmir
IDA	International Development Association
KWSB	Karachi Water and Sanitation Board
MDG	Millennium Development Goals
MGD	Million Gallon per Day
NDP	National Drainage Program
OED	Operations Evaluation Department
PSP	
WASA	Water and Sanitation Agency
WSIPS	Water Sector Investment Planning Study
WSS	Water Supply and Sanitation

Bank's Overall Involvement in WS&S Sector:

1. Water Supply and Sanitation (WSS) has been an integral part of the social sector investment portfolio of the World Bank. Starting modestly in 1960s, the bank's overall WS&S portfolio grew to 9% of total commitments in 1979. Subsequently, dedicated lending decreased to about 3% excluding WS&S components of non-dedicated lending categories. Currently the bank, world-wide, has 100 dedicated WS&S projects and another 150 non-dedicated projects with significant WS&S components. Lately, interest in the sector has renewed because three targets under MDGs depend on improving the coverage and quality of WS&S service delivery.

2. A 1992 OED sector evaluation concluded that sector objectives of providing efficient, sustainable service for all, with emphasis on the poor, had only been partially met under the bank's portfolio. A 2002 evaluation of Water Resources Strategy, reported insufficient documentation of sectoral impact on poverty, lack of evaluation of sector regulation, inconsistent pricing policies, and unclear sustainability of PSP. A 2003 OED sector evaluation noted modest improvement in the closed projects' ratings with very low sector rating among all rated sectors. The evaluation concluded that the bank's efforts to introduce effective regulation failed and pricing policies were inconsistently applied though PSP promotion results were encouraging. Overall, the sector's progress has been uneven. Major findings related to lack of monitoring performance indicators, lack of well-functioning quality and economic regulation systems, absence of strategies for achieving MDGs, importance of PSP, and need for special incentives for operators to serve the poor.

Bank's Involvement with WS&S in Pakistan:

3. World Bank's involvement, as well as its experience, in the WS&S in Pakistan, has been modest even compared with its overall world-wide engagement in the sector. Starting in late 1960s, the Bank has financed just five dedicated WS&S projects until 1999, five years ago focusing primarily on water supply rather than sanitation. The Bank has not financed any major sanitation project although there are new projects like the Punjab Municipal Service Improvement Project being appraised with possible Bank involvement in future.

4. Of the five Bank supported projects, just one project covered rural WS&S. Four projects were in the two largest cities of Karachi and Lahore. The results have been mixed at best, because, according to OED reports:

- There was a wide gap in management, legal frameworks and regulatory mechanisms hindering achievement of ambitious project objectives.
- The functions of service provision and regulation critically needed to be separated
- Strategies were needed to minimize political interference in operational and policy matters (especially employment)
- Capital cost contributions and cost recovery needed to be improved while protecting the interest of "the poorest of the poor". There were opportunities for market segmentation and differential pricing that could be exploited.
- The sanitation aspect in majority of the project was almost missing.

5. The following is a summary of the Bank supported WS&S projects based on various bank documents.

Lahore Water Supply Sewerage and Drainage Project (1967-72)

6. The main objectives of this relatively small Urban Water Supply Project were to rehabilitate and expand water supply, sewerage and drainage facilities at Lahore and to help establish an institutional capability to efficiently operate existing facilities and to develop capacity for long range program expansion. According to an OED report, revision of the scope

and design made evaluation and comparison with original appraisal difficult. Despite difficulties the long-run development objectives of water, sewerage and drainage were achieved.

Second Lahore Water Supply Sewerage and Drainage Project (1976)

7. Project objectives were to (a) continue with the improvement and extension of Lahore's water supply, sewerage and drainage system (b) develop an efficient public utility organization which would be competent to continue the implementation of a proposed ten year investment plan; and (c) develop an urban project which IA subsequently helped to finance. According to OED, the project was successful: the main project objectives were met and the physical components implemented. Tariff adjustments helped WASA to make good progress toward meeting revised financial covenants. Project illustrated the need to allow for sufficient time in project implementation schedules for institution building and human resource development. Great emphasis on dealing with physical implementation problems was at the expense of operational aspects. OED noted that Lahore is fortunate to have a 24 hour water supply and a comprehensive sewerage system. The service needs continue to grow as the city expands while requests for increase in tariff level are met reluctantly. The situation of Lahore, located on a sweet water aquifer and in close proximity to river Ravi with potential recharge, is unique and duplicating this model may be a challenge else where in the country.

Karachi Water Supply and Sanitation Projects (1983-1991)

8. Objectives were to (a) increase Karachi's water supply by 60 MGD (b) introduce system and household metering; and (c) strengthen the Karachi Water and Sewerage Broad (KWSB) through TA and Training. The project helped increase supply between 60-70 MGD. However success in controlling leakages was limited. Through installation of meters and repairs there was an improvement in revenue recoveries from bulk users but it had less effect on revenue from domestic consumers. Project increased long term quality and reliability of bulk supply to Karachi. However, KWSB still did not achieve financial sustainability and required subsidy. The project helped strengthen KWSB capacities to manage and execute large projects. The June 2000 OED observations on the project stressed the need for an adequate regulatory framework that provided sufficient management autonomy and a path for reform that guarantees sustainability, limitations of financial covenants and conditionality, and the need to incorporate in project design valuable local experiences, particularly when they specifically address poverty alleviation Overall, OED evaluated the project outcomes to be unsatisfactory with unlikely sustainability.

Second Karachi Water and Sanitation Project

9. The main objectives of this follow up project were to (1) increase potable water supply and reduce water losses (2) improve the financial viability of the Karachi water and Sewerage Board (KWSB) through increased revenues, cost reduction and increased operational efficiency; (3) improve the organization and management of KWSB; (4) improve sanitation in the City of Karachi, including its low-income and coastal area by increasing sewerage coverage and sewage treatment capacity.

10. An OED evaluation states that none of the four objectives were fully achieved (1) the water supply was increased but no reduction in losses is documented (2) The financial viability of the KWSB hardly improved it survived due to government subsidies throughout the 1990's. The operational efficiency and the intended reduction in water losses of KWSB were impossible to gauge since it chose not to meter domestic consumption. KWSB's organization and management did not improve even after reducing staff from 14,000 to 8,500 and some limited administrative improvements. The water supply quantity and quality are probably worse after completion of the project because of a rapid population growth in Karachi and especially among the low-income population. A significant short coming was the legal and regulatory framework. An effort was

belatedly made at behest of the Bank to involve a private operator but in the end these efforts came to nothing.

11. According to OED, the main lessons learned were that without a fundamental legislative and regulatory reform, including changed incentives and contracting of a private operator, the project was doomed from the start, financial covenants were ineffective if KWSB lacked the authority and means to comply with them, excessive politicization of the tariff setting and of the management added to the difficulties, the project design should have incorporated more of community participation especially under the sanitation component where Karachi had gained valuable experience from the well-known Orangi Pilot Project.

Rural Water Supply and Sanitation (1992-95)

12. This project covered all four provinces as well as AJK. As per OED, "it is difficult to measure the achievement of general project objective (of improving rural productivity and health particularly of women and children and reduce poverty and deprivation in rural Azad Jammu and Kashmir (AJK), Balochistan and Sindh, since the project failed to develop monitoring and impact indicators. There was success in implementing the hardware components, the software comments were scaled back considerably. In the three provinces only between half and two thirds of the institutional development assistance funds were actually spent.

13. The project was first IDA financed rural water supply project in Pakistan with a demand-driven approach incorporating significant community involvement—and with contributions from beneficiaries toward the capital investments. The new methodology required a change of mind-set of public schemes that had proved unsustainable. Indications are that roughly 95% of the water schemes built under the project are still operating three years after completion. In terms of short comings --- the program to expand sanitary excreta disposal programs did not meet the expected acceptance and fell far short of planned achievements.

14. OED in its review of the project noted the following lessons learned from this experience:

1. A demand-driven rural water supply and sanitation strategy based on strong community participation requires a longer time to take root than what is usually offered by one single project. The AJK component performed better than the Balochistan and Sindh components precisely because it enjoyed a century's old tradition of community participation whereas the other tow did not.
2. Changing the habits of excreta disposal implies a much greater effort than providing water supply. Symptomatically, the water supply investments performed much better than the latrine components.
3. Project objectives should be stated in terms that would allow quantitative monitoring of progress towards reaching them.

Recommendations for Future Sector Interventions

15. OED reports, based on the rather limited number of projects in this sector over the past 40 years, suggested:

- For the (specially other emerging) urban areas, there was a need for a comprehensive strategy for engagement applying very carefully the institutional lessons (including tariffs, cost recovery, regulatory apparatuses, legal framework, water rights). Opportunities existed for public private sector partnership and involvement of communities to finance a few smaller schemes and develop a sense of ownership ensuring long term sustainability.

- In those rural areas where community organizations were working well, the project inputs were fully utilized.

16. The WS&S sector has direct linkages with health, poverty, gender development, and economy. Efficient on-farm water management can help improve availability of fresh water for much needed domestic use. Prevention of pollution and contamination of groundwater and other sources of water through agricultural, industrial, and domestic use can help safeguard quality of water necessary for human consumption for all purposes. Improved drinking water supply leads to greater importance of improved sanitation. Investments in WS&S sector are critical underpinning for Bank's investments in so many other sectors for ultimate goal of human development.

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The Role of Large Dams in The Indus Basin

By

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THE ROLE OF LARGE DAMS IN THE INDUS BASIN

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Pakistan is a country with vast water resources that feed its irrigation system and produce 25% of its power supply. Irrigated agriculture on the Indus has been practiced for almost 3000 years-harnessing it through dam construction has resulted in widespread impacts on the economic, social, and political environment of the nation.

Large dams are an integral part of this system. Tarbela dam on the Indus was built as part of the Indus Basin Treaty and so was Mangla on Jhelum River. Apart from these two large dams a smaller capacity was developed at Chasma. These dams have served Pakistan's economic growth well; while these projects were carefully analyzed for their economic benefits (primarily power and irrigation) they were however undertaken as part of the treaty and not as independent investments. For instance in the case of Mangla dam no economic analysis was done and it was considered absolutely essential for national survival. At the time of Independence in 1947 the divide between India and Pakistan resulted in Pakistan as the lower riparian. In particular two major headwork's, one at Madopur on the Ravi and the other at Ferozpur on the Sutlej River on which Punjab's irrigation supplies were heavily dependent fell in Indian Territory, leading to administrative problems in regulation and supply of water. Pakistan lost 8700 (6.3 MAF) cusec water and this was primarily rendered to the Punjab (see table below). This amounted to 1.75 million acres of canal command area.

Table 1: Irrigation Works Lost to India as a result of Partition (000 acres)

River/Headwork	Capacity	Command Area (Gross)	Irrigated (K)	Irrigated (R)	Total
Ravi River					
Madohpur	2600	704	321	249	570
Sutlej River					
Ferozepur	6100	1043	321	236	577

Source: An appraisal of resources and Potential development, Supporting Studies, Harza 1963 and cited in Nazir Ahmed Chaudhry. Water Resources of Pakistan.

IBRD offered its good offices to help successfully negotiate the Indus Water treaty in 1960. According to the treaty the three rivers Ravi, Sutlej and Beas were allocated to India while Pakistan was given unrestricted use of Chenab and Jhelum. The treaty also provided construction of major link canals to compensate for the water lost in the eastern rivers. Pakistan was to receive assistance for construction of two large dams, 8 new link canal projects, six barrages, remodeling of three of the existing inter-river annals and irrigation system. The total cost of the project ran an unprecedented Rs. 124 billion. All projects were completed by 1970 while Tarbela dam was completed in 1976 (Fahlbusch, Schultz and Thatte, 2004). Thus, the two dams Tarbela and Mangla were instrumental in helping Pakistan develop the much needed storage of the waters lost to India and, their role in conflict resolution between India and Pakistan was phenomenal and provided Pakistan with its own independent large scale water storage reservoirs that were vital for the survival and sovereignty of the country.

[1] *Economist Asianics Agro. Dev. Islamabad. Research Assistance of Engineer Ghulam Ali and Mr. Muhammad Masud Aslam are gratefully acknowledged. Comments made by two anonymous reviewers are highly appreciated.

With almost three decades of uninterrupted service, these dams continue to support Pakistan's agriculture and hydropower needs but due to depleted storage capacity from sedimentation there is reduction in their capacity. There has been widespread development around the reservoirs resulting in export processing zones (i.e. Gadoon Amazi, Topi, Hattar area) improvements in the living standards of those impacted by inundation, especially those settled in the newly established townships and general prosperity in the vicinity of dams due to fishing, tourism and agriculture resulting from the seepage of reservoirs. Both Tarbela and Mangla have paid off the original investment several times over—the continued royalties support development activities of NWFP the main province where Tarbela was located while AJK gets its share for development funding through royalty from Mangla. The outlays are about Rs 6.0 billion for NWFP and Rs 1.0 billion for AJK annually. In the case of NWFP it is about 25% of the annual provincial budget[2].

The national benefits from Hydro power, irrigation and flood control help Pakistan run its industries, promote more equitable growth and allow it to expand agriculture in a planned manner. Despite doing so much good why are there apprehensions about dams? Are there serious alternatives to dams in Pakistan and have the options been carefully looked at or are dams simply promoted as the only option to serve as" engine of economic growth". These are current questions in minds of the Pakistani nation when confronted with potential new projects like Kalabagh and Basha. There is less disagreement on the likely benefits these investments will yield but more on the social costs in resettlement and those generated downstream. Furthermore, the question of trust and transparency is apparent and is partially embedded in the long history and socio-politics of the uneven inter-provincial development. Building of the trust and transparency has been recognized and the government has allowed debate on this issue. Clarity on sharing benefits, assurances that these entitlements will be maintained over time, and clear processes and mechanisms that create trust and transparency need to be set in motion with visible implication for water right/entitlements. Perhaps then can headway be expected on the question of dams.

This paper is concerned with the evolution, alternatives and options, political economy and the comparative advantage of the World Bank to address the future infrastructure potential and issues with respect to dams in Pakistan. It also gives some assessment of ways for the World Bank to productively engage in the infrastructure sector.

I. Evolution and Current Status of Large Dams in the Indus

The Indus Basin Irrigation System is the largest contiguous system in the world with a development history extending over 145 years. This system comprises 3 storage reservoirs, 19 diversion structures and 12 link canals that facilitate transfer of water from western rivers to eastern rivers. A major effort to develop infrastructure was taken after the successful conclusion of the Indus Basin Treaty between India and Pakistan negotiated by the facilitation of World Bank. As noted earlier as a result of losing 3 of its eastern rivers a crisis situation got created for the agriculture in Punjab—a total loss of 8 Million cusec water. Irrigated agriculture needs are most pressing during the winter season. Unless water is assured during this period Pakistan faces serious problems in growing its main winter crops wheat and sugarcane. Thus, compensation of the lost water was essential just to maintain the system. Pakistan desperately needed to ensure storage on the eastern rivers and major additional storage on the Indus to ensure continuity and develop its agriculture to stain a population growing at 3.5% at that time. It must be noted that the conflict arose during the period when green revolution technologies were being introduced in the preliminary stages. Besides servicing its existing areas Pakistan needed to expand area to increase production of its food and fiber crops.

[2] There is reluctance on part of Ministry of finance to provide any additional information on the royalty aspects of dams. Similar is the case for certain data requested from WAPDA. Such lack of general transparency in information sharing that should be in the public domain has been expressed as a cause of concern at different forums.

Irrigation and sustaining agriculture were the dominant concern and the prime focus of development initiatives. Hydro power was considered a byproduct.

The Indus treaty allowed the suspension of water flows from Eastern Rivers Ravi, Chenab and Sutlej; in return Pakistan received financial support under the IBIS to develop a large scale irrigation replacement/development program that allowed new barrages, canals, link canals and two large scale dams. Under the treaty two large scale storage reservoirs were allowed Mangla (on Jhelum) and Tarbela on river Indus. Mangla dam (storage 7.25/6.59 bcm and hydro 1000 megawatts height 116 m) was taken up first and completed in 1968. The gross storage of Mangla dam as a percent of the total mean annual run-off at Mangla is 23.55 of Jhelum and 4% of the whole Indus System. It is 15.44% of the Indus River at Tarbela and 7.15% of the total water availability. This was followed by Tarbela; the World's largest earth filled dam at that time was started in 1968 and completed by 1976. The height of dam is 485 ft length 97 km and gross storage is 14.3 bcm (11.6 MAF) while actual usable storage is 11.48 bcm (9.3 MAF). In the case of Tarbela about 70% flow is from snow and glaciers while 30% is from small rainfed catchments areas. This water flow provides a clean and hygienic environment and the incidence of water borne diseases in the Tarbela reservoir is minimal (WCD, 2000).

Similarly Mangla developed on river Jhelum has a designed capacity of 300 MW and a finally installed capacity of 1000 MW. The dam has a water spread of 256 sq km and a shore length of 400 km.

Both these dams have been in operation for almost 35 years. They were designed with the major objective of storage to supplement and regulate irrigation water supplies; hydro power generation and flood regulation were treated as incidental benefits. The basic studies under which these dams were conceived were the Lieftinck Report (1968) that had identified almost a dozen potential sites (Dhok Pathan, Sanjwal-Akori, Gariala, Kalabagh, Skardu, Ambahar, Bunji, etc). In terms of sequencing the Lieftinck report recommended the following in-service water year and capacity for each project as: Schwan-Mancar (1982, 1.80 MAF); Raised Mangla (1986, 3.55 MAF); Chotiari (1990, 0.90 MAF); Kalabagh (1992, 6.4 MAF) followed by Swat (2002, 2 MAF), Low Gariala (2011, 4.6 MAF and Skardu (after 2020, 8 MAF). Thus the major follow-up dam to Tarbela was envisaged as Kalabagh. Since, Tarbela no major storage has been developed and Kalabagh seem to be much delayed despite the fact that its feasibility and all other technical design and costing have been completed.

Besides these major reservoirs, a small regulatory reservoir capacity was developed at Chashma barrage (0.717 MAF storage, hydro power 184 megawatts) project completed in 1971. Since 1976 no major storage works have been undertaken on the Indus besides the Ghazi Barotha Hydropower project adjacent to Tarbela Dam which is a run of the river project. The planned generation capacity of this project is 1450 MW.

Table-2: Existing Capacity of Reservoirs.

Name of Reservoir	Gross Capacity (MAF)	Live Capacity (MAF)		Loss of liveCapacity (MAF)	MCL (ft)
Tarbela	11.62	9.68		2.01	1550
Mangla	5.882	5.341		0.814	1202
Chashma	0.87	0.717		0.28	649

Source: WAPDA, 2004

1.1 Present Status

The present status of the dams in 2004 was that Tarbela now has a reduced live storage capacity of 7.67 MAF (down 25%) and Mangla has a reduced storage of 4.253 MAF (down 20%).[3] The reduction in storage was envisaged in the design. The estimated remainder life of vital storage capacity for Tarbela is 50 years and that for Mangla is 56 years. This assumes that no further infrastructure is placed above the dam sites. In the case of Tarbela there may be some extension in the useful life of the dam if upstream developments at Basha or Bunji are undertaken. Some estimates suggest that a 40% slow down in the sedimentation of Tarbela could be expected. In terms of aggregates, the live storage capacity in the Indus Basin system is reduced from 15.74 MAF to 12.54 MAF with an accumulated reduction of 3.108 MAF or 24 %. The dams and monitoring organization of WAPDA estimates that by 2010 the accumulative loss in storage will be 32%. It is also worth noting that in 1970 with less demand for irrigation and power the nation had almost 20% more storage capacity. The situation over the past 35 years has obviously been reversed with population increases, expanded demand for power in the commercial and private sector uses etc. The present hydropower production figures average per annum during 2000-2004 for Tarbela are reported at 2383 MW and those for Mangla are reported at 1641 MW. The hydropower production at Chashma for the past 3-4 years has averaged 50.05 MW. Note that hydropower is a by product of the dam and the dams are operated to maximize the irrigation benefits. The hydropower is valued on ongoing tariff rates. There is minor difference in the commercial vs. private tariff structure. Similarly, valuation of the benefits does not take into account peak and slack period values that would help arrive at true shadow prices reflecting the opportunity cost.

Table 3: Schedule of Electricity Tariffs 2004

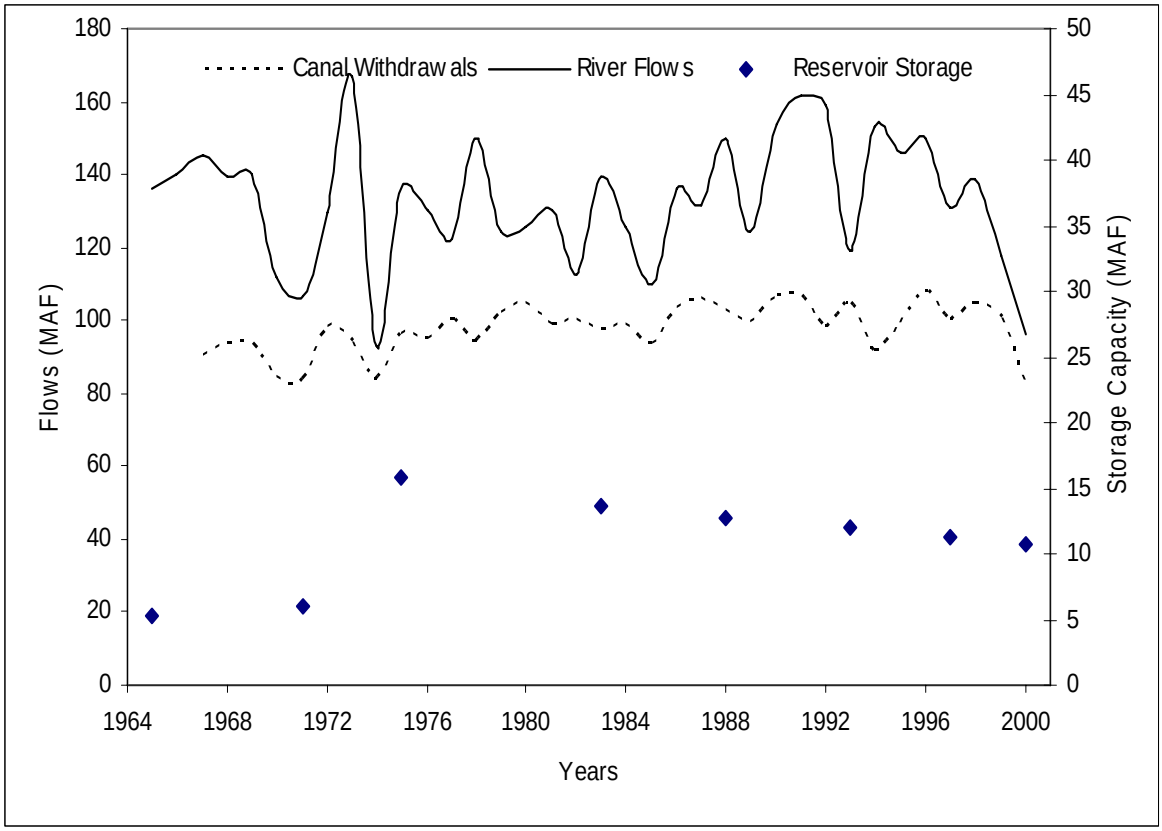
Tariff Category/ Particular		**New Tariff Rs. KWH**
Bulk Supply Tariffs		
c-1(a)	400 Volts upto 20kw	5.16
c1(b)	400 Volts above 20kw upto 500 kw	5.29
c-2(a)	11/33kw upto 5000 kw	5.09
c-3	66/ 132 /220kv-All loads	4.96
Agricultural Tube- Well Tariff-D		
D-1	Scarp	4.92
D-2 (1)	Punjab & Sindh	3.28
D-2 (2)	NWFP & Balochistan	2.8
Temporary Supply Tariff		
E-1(1)	Domestic Supply	6.55
Residential Colonies of Industries		
H-1	Residential Colonies with own transformer	6.16
H-2	Residential Colonies	6.19

Source: GOP Statistical Supplement Pakistan Economic Survey 2003-04 Islamabad Pakistan.

These dams will continue to provide electricity with the remaining run of the river but the loss of *storage capacity* will most likely pose extreme hardship for the agriculture sector. Pakistan's irrigated agriculture is heavily dependent on the waters from these two dams during early Kharif season (prior to start of monsoon) and to a much greater extent for Rabi crops particularly wheat and sugarcane. *For instance Tarbela waters are responsible for irrigating 22 % crop in the Punjab alone.*

[3] I would like to acknowledge the help of Engineer Sardar Tariq (former Member Water, WAPDA) in correcting and updating some of the figures with more recent estimates.

Figure: - 1 River Flow Trends in the Indus System

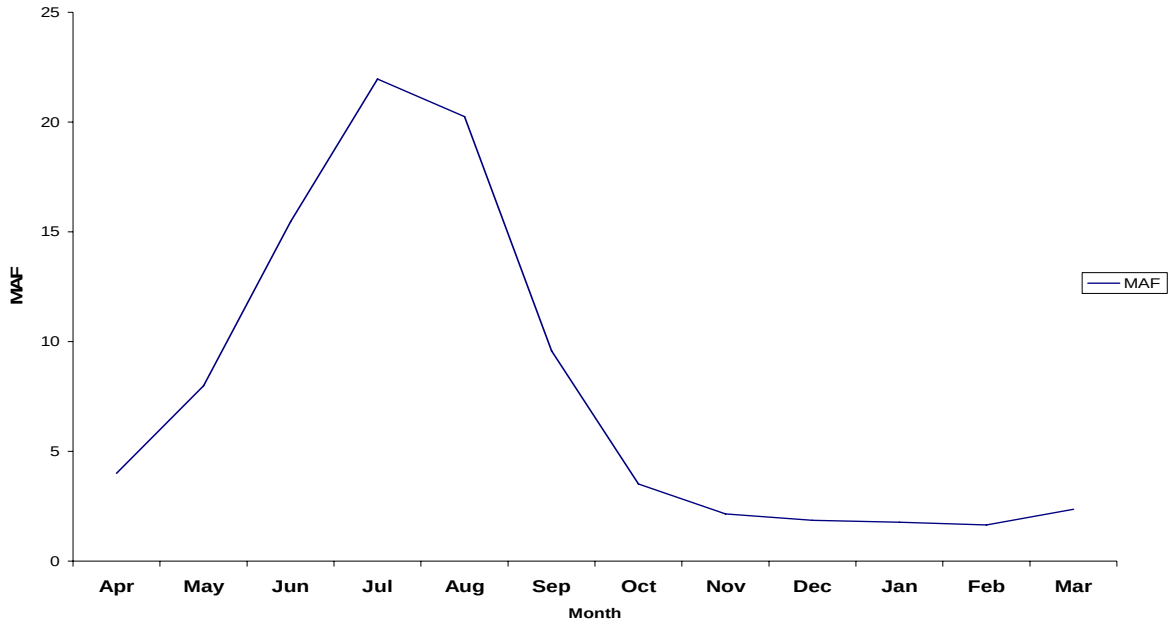


Source: Plotted based on WAPDA data.

It appears that by 2060 Tarbela will have completed its useful life and will only be providing a marginal storage of 0.98 MAF and same holds true for Mangla. This poses a serious problem of *reduced storage and most likely a catastrophic situation* would arise for the agriculture and non agricultural uses of water and overall economic development of the country. Leaving aside the political, economic and technical arguments --the single and irrefutable argument to obtain balance to the minimum level is to address the issue of replacement storage to cater for the lost capacity in the two dams.

Figure 2 shows the monthly flows for the Indus River. The bulk of water flowing in the river occurs during Kharif season (May to September). This is roughly 84% of the total flows of the river. The winter months show low flows. Floods arise in the river due to unusual glacial lake melt and landslide outburst often results in major floods in the river. It is thus clear that river flows are high during summer and low during winter. Thus water is stored during the months August to September and used mainly during the Rabi season. Dams continue to play a vital role to overcome Rabi deficiencies and regulate the supply to different canals.

Figure 2: Average Monthly Inflow of Indus River (Million Acre Feet)



Source: Ahmad, Nazir 'Water Resources of Pakistan' 1993
Note: Monthly inflow of Indus River average of 39 years (1937-75).
Total Inflow = 92.54

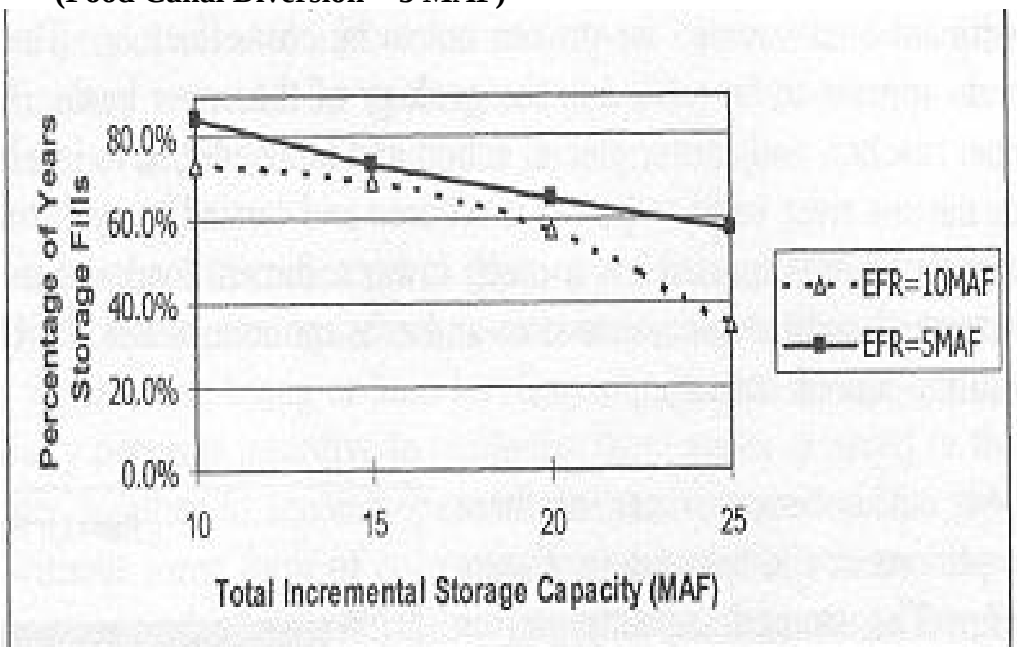
The construction of new reservoir (s) on the Indus warrants serious consideration for the following reasons:

1. Unless Pakistan puts into place a minimal capacity of 6 MAF it will suffer major water shortages for its Rabi crops. For example a dam like Kalabagh with 6.1 MAF storage covers about 2.43 million acres resulting in a gross irrigation benefit of about Rs 12.53 billion (in 1998 prices).
2. As noted earlier both Tarbela and Mangla help regulate waters of the Indus. The treaty allowed exclusive use of three eastern rivers to India this resulted in a loss of almost 8 Million Cusecs water in the Punjab. The two dams help relieve this water constraint. Water from the Indus is diverted to the rivers through a well established link canal system. In the event of no future dams and only attention to water management Pakistan will lose its capacity to regulate waters lost to India.
3. By losing storage capacity at Tarbela there will be a 6 MAF deficit that will be compensated by placing a new storage infrastructure below (Kalabagh) or above Tarbela (Basha). The net addition to storage will be 6.1 MAF from Kalabagh and 9 MAF Basha. The ability to regulate this water for the Rabi crop and to facilitate the early Kharif crop is the two important justifications made for added storage. Additional planned storages can help store water during the wet years for use in dry periods.
4. Pakistan has a hydropower generation capacity of almost 50,000 MW. Its present utilization of this potential is only 6492 MW or 13%. While hydropower is a byproduct of the storage it is an important source of power that continues to play a vital role in the country's economic development and reduces its dependence on costly raw energy imports.
5. Additional storages on the Indus also help in flood control downstream in the Punjab and Sindh provinces, thus saving valuable lives and property.
6. There have been some concerns raised about the reduced river flows and whether sufficient water would be available to fill the dams. The analysis under both Kalabagh and Basha

confirm that sufficient water is available for storage including minimum flows for use in the delta. The World Bank study on Public Expenditure Review (2004) concluded that there would be round 40 MAF available from current sources and through conservation efforts. A dynamic simulation model would clearly answer the what if questions related to climate change, state of glaciers, operations rules to be followed under different scenarios, effects on river morphology and the likes. The lack of such analytical capacity is a constraint. The available information supports the view that at least for the replacement storage there is sufficient water to store.

Recent drought in Pakistan has further aggravated the problem of reduced river flows and limited availability of stored water for the Rabi season. Reports that 47% less flows were available this Rabi crop obviously reduced areas sown under wheat (dependent mostly on canal irrigation) and delayed wheat plantation (after December) that drastically reduces yields. If, additional storage was available and more water saved during monsoon's this constraint would be greatly relieved. However, it must be noted that dams will not fill to maximum capacity each year. The probability of filling storage has been reported in PER (2004). The report states that existing Mangla storage has filled 28 out of 34 times but incremental storage of 2.9 MAF that is being created by raising the dam by 30 ft will have a reliability of only 72%. A further noteworthy aspect is that as the level of storage on the Indus increases the reliability of its filling declines. For about an additional 15 MAF the reliability is less then 75%. This is helpful in appreciating that the dams will not always fill to 100 % there will be wet and dry years. The key is to store the maximum water during dry years as it would likely have a much higher value then excess water during years when it were plentiful. Also note that to fill these dams only Kharif flows can be relied upon, Rabi supplies have been allocated under the Accord (PER, 2004).

Figure 3: Probability That Incremental Storage Capacity Fills (Food Canal Diversion = 5 MAF)



Source: Pakistan Public Expenditure Management, 2004
Note: Accelerated development of Water Resources and Irrigated Agriculture (Volume II) January 28, 2004

The climatic change data suggest reduced rainfall and higher mean temperatures (1.5 degree). Information on the glaciers situation is rather scanty. When these scenarios are considered it becomes even more important for the investors (Bank) to request additional analysis on water availability to fill the dams being proposed, accounting for such trends.

Table 4:- Present Status of Potential New Major Reservoir Infrastructure

Dam Site	Storage Capacity (MAF)	Power Capacity (MW)	Status	Design And Construction Period (Years)	Cost (M$ US) (2000)
Gomal Zam Dam	1.14	17.4	OG	4	167
Mirani Dam	0.30	-	OG	4	118
Satpara Dam	0.02	0.20	OG	3	10
Munda Dam	0.68	740	FS,DD,TD	9	750
Kalabagh Dam	6.10	3600	FS	8	5000
Sehwan	0.65	-	FS	7	610
Kurran Tangi Dam	1.20	1.20	FS	7	200
Raising Mangla Da	3.10	180	FS	5	883
Basha Dam*	5.70	3360	FS*	12	6460
Sanjwal & Akhori	3.60	TBD	C	12	600
Total	**22.49**	**9498.8**	**N/A**	**M/A**	**14338**

*** the August 2004 Basha feasibility report puts the total cost estimate at US $6.46 billion de to high cost of transportation, Transmission network, need to construct large road and bridges infrastructure.**

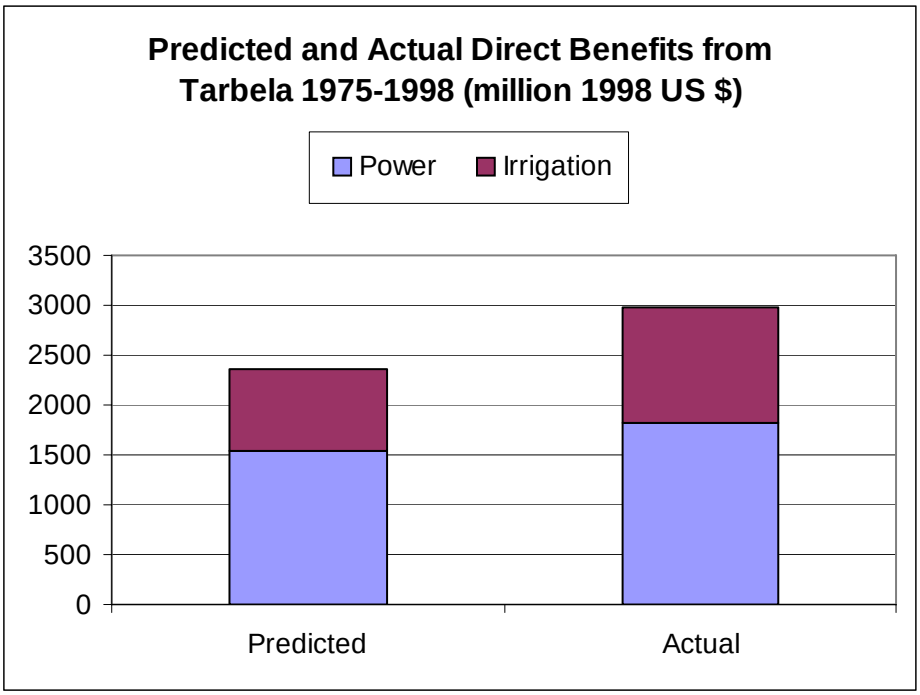
OG	Construction started/likely to be started shortly
FS	Feasibility Study ready
DD, TD	Detailed designs and Tender Documents ready
PF	Pre-feasibility study ready, FS, DD & TD to be prepared
C	Concept exists, PF, FS, DD & TD to be prepared.
TBD	To be determined
Costs	for most dams the costs are from the WAPDA Vision 2025
	For Munda and Sehwan, costs were determined in this Study

1.2 Direct Benefits of Dams in Pakistan (Irrigation, Power and Flood Mitigation)

Dams generate 4 types of economic outcomes direct/indirect benefits and costs. The direct benefits and costs are easy to lay hands on, an acceptable level of precision can be achieved in their estimation and consensus can be reached in different constituencies within a known level of risk. The two large dams in Pakistan have generated widespread economic benefits in the form of irrigation and power. Table- 3 shows that from Tarbela alone the aggregate (over 23 years) irrigation benefits (economic) in 1998 prices was US $ 1824 million (in 2005=US $3283.2 million) or almost 61% of the total benefits The remainder 39% benefits from power (base load) in 1998 prices were US$1163 million (in 2005=US $ 2093.4 million). The irrigation benefits from Tarbela were spread to about 8.7 million hectares in the Indus Basin System. This included additional supplies to 6.9 mha and replacement supplies to 1.8 mha. Before Tarbela was constructed there were considerable water shortages and application of water was only about three quarters of irrigation requirement (Lieftinck, 1968). Tarbela irrigation helped increase the canal irrigated area in the Indus from 10.1 mha in 1974/75 to 14.7 mha in 1997-98. The increase of 4.6 mha during post Tarbela period can be attributed to the additional supplies from Tarbela dam and enhanced diversion during high flow periods. The areas irrigated by tubewells increased from 2.8 mha in 1974-75 to 3.2 mha in1997/98 (only tubewell commands). Furthermore, within the canal command area of 6.9 mha in

1997/98, tubewells provided additional water to supplement the canal supplies; whereas in 1974 this facility was not available. [4]The benefits from Tarbela could have been higher provided the predicted yields at the time of appraisal were achieved. The Tarbela study noted "the actual yields of wheat, cotton and rice were much less then predicted during the Post Tarbela period both in the Punjab and Sindh provinces. However, Sindh, performed better then Punjab in almost every crop compared to he predicted yields".

Figure 4: Predicted and Actual Direct Benefits from Tarbela 1975 – 1998 (million 1998 US$)



Source: Tarbela Dam Study, 2000

In the case of Mangla aggregate irrigation benefits from its inception in 1967 to 2001 amount to Rs. 114.5 billion rupees while those from power total Rs. 137.5 billion during this period. The aggregate benefits equal Rs. 252 billion uptil 2001.

A series of alternative techniques to hydropower benefits estimated including shadow exchange rates, changes in oil and gas prices, dynamic benefits that include a quick response to peak demand, frequency/voltage control and synchronous condenser operation. Tarbela constitutes 38% of WAPDA's capacity (1998) and about 22% of the overall system including private installations. The Tarbela study assuming a $ 35 value of computed the present worth of computed benefits discounted at 8% to 1965 prices was about $ 60 million and in 1998 prices it was equivalent to US $ 310 million (in 2005=US $ 558 million).

Key findings of Tarbela study on Hydro Power Benefits

- Direct benefits of hydro-power from Tarbela were estimated at US $ 225 million and in 1998 price equivalent to US $ 163 million (in 2005=US $ 293.4 million).
- Economic benefits due to the dynamic impact of avoided greenhouse gas emission were also sizeable. These were calculated to be US $ 835 million in 1998 prices(in 2005=US $ 1503 million)..

[4] Irrigation and hydropower benefits of Tarbela are discussed in greater detail I the Tarbela Case Study. Special attention is given to the predicted and actually achieved benefits in terms of cropped area cropping intensity, cropping patterns etc.

- Tarbela has helped peaking and frequency regulation in the WAPDA system.
- Provided a 6 billion annual royalty to NWFP as per constitutional amendment.
- Tarbela had made feasible the construction of Ghazi Barotha no envisaged at the time of planning. Regulated Tarbela reservoir outflows contribute about 20% to the annual generation of that project (this was considered an unexpected benefit.

Besides these direct benefits dams have served as important devices for flood mitigation. During post Tarbela floods it was felt that the dam helped save loss of life and property to the tune of several billion rupees.

Table 5: Tarbela Dam Project Summary of Irrigation (Storage) and Power Benefits over the Period 1975-98

Benefits	Predicted Benefits ($ million)		Actual Benefits ($ million)	
	1965 Prices	1998 Prices	1965 Prices	1998 Prices
Economic:				
	296.6 (65)	**1533.6 (65)**	**352.9 (61)**	**1824.5 (61)**
1. Irrigation (storage)	**160.0 (35)**	**827.2 (35)**	**225.0 (39**	**1163.3 (39)**
2. Power	**456.6 (100)**	**2360.6 (100)**	**577.9 (100)**	**2987.8 (100)**
3. Total				
Financial:				
	408.7 (60)	**2113.0 (60)**	**375.4 (51)**	**1940.8 (51)**
1. Irrigation	**276.2 (40)**	**1428.3 (40)**	**356.1 (49)**	**1841.0 (49)**
2. Power	**684.9 (100)**	**3541.3 (100)**	**731.5 (100)**	**3781.8 (100)**
3. total				

Source: Tarbela Dam Case Study- a WCD case study by Asianics Agro-Dev, 2000.

Tarbela study noted that there are widespread indirect benefits and extensive multiplier effects. A dam similar to Tarbela constructed in India at Bhakra has been analyzed in greater detail for its impacts on poverty reduction with attention to some level of quantification. A quick look at Bhakra provides insights into the magnitude of contribution dams can have on agriculture productivity.

Poverty reduction-the Case of Bhakra dam-India

In an analysis of India's experience with dams (Bhatia, 2004) highlighted the significance of the Bhakra dam in India. The prima facie evidence suggests that developing irrigation from Dams like Bhakra helps in reducing poverty. In India, in un-irrigated districts (less then 10% area irrigated), 69% of people are poor, while in irrigated districts (more then 50% area irrigated), poverty level drops to 26%. According to this study irrigation water has helped rural and urban growth and significantly brought down poverty. In rural areas in 2000 the percentage of people below poverty line was only 6.3% in the Punjab and 8.3 percent in Haryana. It is noteworthy that as a result of the irrigation canals and power from Bhakra dam both the States (Punjab and Haryana) meet about 70% of the all India food requirements. It has been estimated that for a multipurpose dam like Bhakra for every one rupee of direct economic impact 0.9 rupee of indirect economic impact has been estimated. The poorest of the poor have benefited more from irrigation and power then the other households. In Bhakra it is estimated that agriculture labor gained a 65%increase in income as compared to a rural average increase of 38% under the "with project" scenario compared to situation if the project had not been undertaken.
Pakistan's case with Tarbela has been similar. While the WCD Tarbela case study clearly identified the impact of the dam on improving irrigation flows particularly during Rabi it did not conduct detailed quantification. There were substantive gains recorded in improvement of crop, livestock and forest productivity based on changes in overall multipliers. The Bhakra case provides some quantification of impacts which would be quite similar in Pakistan also.

1.3 International Experience:

The World Commission on dams as part of its global review states that---large dams have also provided substantial socio-economic benefits through the delivery of water, electricity and flood control, as well as various ancillary services. Interestingly many of these benefits extend beyond the *time frame* proposed in the original documents. Same has been the case with Tarbela dam. Such dams generate direct benefits that can be submitted to direct economic analysis. The indirect benefits related to improvement of environment, provision of drinking water, facilitation in navigation, tourism/parks, natural habitat reserves for birds etc are often not estimated but still perceived as valuable amongst those groups they benefit. The biggest indirect benefit that impacts the whole economy (rural and urban) is the multiplier affects of added irrigation water and cheap power on the production and consumption sectors. The widespread backward and forward linkages created in the process help stimulate economic growth and consequently reduce poverty. Similarly there is major concern about the social impacts of large dams and the human costs they generate due to displacement, health and cultural heritage. A listing of some of the key benefits based on international experience is provided in table-3. Since the two primary benefits of dams are irrigation water and power and perhaps flood control, the ancillary benefits of employment generation, revenue generation from tourism etc must also be noted. Other indirect positive impacts on agriculture are difficult to quantify like improvement in the air and water quality of the area, social development impacts on rural education, health, civic services etc.

The Looming Concern of Social Costs!

Large dams have many social benefits, together with direct and indirect economic benefits but they too have many social costs. The fact that most of the costs have to be paid by those who do not directly share the benefits raises some difficult questions. Where, after the payment of compensation and the rehabilitation of project affected persons, such persons still remain worse off than they were prior to the project, there is a question of justice. Is it just to penalize a group of innocent people just because the projected affecting them is considered to be in the larger public interest? Most enlightened societies reject such a trade-off, even where the number of people benefiting might be larger than the number being penalized. International good practice now requires that those adversely impacted by large infrastructure projects are treated as “the first beneficiaries of such projects”.

The planning of a dam cannot and should not be conducted in isolation; it has to be a part of the larger economic, social and environmental plan for the region and the country. The process of deciding whether a dam should be built in a particular location and with particular specifications should be a part of the process of deciding how to provide goods and services to the people of a region and to help solve some of their main problems.

Study of the social, economic and environmental situation of a country, and within a country of each state and region, identifying their major assets, potentialities and challenges needs to be undertaken as part of appraisal. A development plan must therefore be built, taking into consideration the existing assets, in order to use the existing potential to meet the existing challenges.

At the national level, some of the relevant challenges might include: the challenge of providing drinking water to all the citizens, of increasing incomes and agricultural production and productivity, of preventing floods and the devastation they cause, and of providing power to homes and industries; and possibly also, the challenge of protecting people, especially the poor, from social and economic insecurities, from injustice and from environmental degradation. For specific regions and areas, some challenges might be more important than others. For example, in a semi-arid and industrially underdeveloped region, there might be a great need to improve agricultural productivity; in a fast-growing industrial belt there might be a great demand for power. In the case of Pakistan with almost 60% of the villages still needing to be electrified cheap hydropower can provide widespread relief to the rural populace-create new opportunities and bridge the widening poverty gap.

Likewise attention to the rural industries can create social wellbeing to groups even outside the direct agriculture domain. The non agriculture classes in the rural areas are the most prone to rural poverty (Darosh, 2004). By expanding hydropower accessibility major impacts can be realized in employment generation. While the overriding concern to develop storage in Pakistan is to sustain and expand agriculture in the undeveloped regions, hydro power generation would be integrated into the overall rural development process—this may modify the reservoir operation rules and allow for seasonal trade-offs. A valid example is that Tarbela dam in Pakistan helped overcome the enormous load-shedding problem in the month of June. The occurrences of load shedding have been greatly reduced.

An indication of **multiplier impacts** in the post Tarbela period is provided in table 6. The direct multiplier affects on agriculture are noted at 2.39. While the direct effects on the non-farm rural sector through production can be lower as reported by Darosh, 2004. Mellor, 2001, notes based on a survey of 23 countries that addition to employment in the agriculture-stimulated local non-farm sector could be as high as 58%. This is a key point to note for benefits (like dams) that both directly and indirectly impact the dominant rural economy, as in the case of Pakistan. Under this scenario one would continue to operate dams that provide irrigation to achieve growth in agriculture (presumably **shifting** to high value), generate power to run urban and rural industries with high multiplier affects and consequently generate more jobs which would be a very important economic benefits given the rising high unemployment (Rural=6.94%; Urban=9.9% in 2003, Pakistan Economic Survey, 2002/3)

Table 6: Output Multipliers for selected Sectors of the Pakistan Economy (1984-85) (1965 as 1.0)

Sector	**Multiplier**
Agriculture	
Farm Input manufacturing	1.97
Agriculture (Farming)	2.39
Manufacturing	3.00
Transport, Storage and Communication	1.82
Wholesale and Retail(Trade)	1.32
Rest of the Economy	
Manufacturing	2.63
Transport, storage and communication, wholesale and retail trade	2.00
Mining and quarrying service	2.85
Public administration and Banking	2.18
Households	3.01

Source: Tarbela Dam Case Study, 2000

It is important that benefit analysis goes beyond direct benefits and includes indirect benefits, and that these are clearly evaluated in relation to direct and indirect costs. The distribution of benefits and firm gurantees of their continuity later are the main sticking point and organizations including governments often tend to either ignore these aspects or simply undermine their extent. Likewise addressing the social costs requires careful analysis to ensure that those hurt in the process are adequately compensated under acceptable norms. This may be the root cause of majority of conflicts related to construction of new dams.

In the Pakistani case ignoring the social costs has almost brought the whole question of new replacement storage to a halt. Kalabagh dam has been under consideration for the last 35 years; even in the 1990's startup of construction activities was also seen**. A political stance taken by lower Riparian Sindh** regarding lack of trust on Punjab in protecting its historical rights and non agreement on the environmental flows in the Indus are key sticking points for the stalemate with Kalabagh. These aspects and perceived social costs upstream and downstream are in the forefront of the"trust and transparency" issue. Many engineers simply do not take into account the huge social costs that are generated in terms of displacement, down stream impacts, reduction delta flow etc. Likewise few acceptable or negotiated mitigation measures have been identified or discussed at an appropriate level to reinforce trust and transparency.

At times social costs are highlighted without giving due attention to the benefits different groups will receive- creating an environment of confusion and uncertainty. For example the stored water at Kalabagh would give both Punjab and Sindh almost 2 MAF each for agriculture. Given the that dynamics of sociology amongst rural and urban groups debates multiple issues at any given time (politics, social unrest, economics, religion etc)—core issues that confront the nation like "major water crisis" are swayed by group that are least vulnerable to the direct consequences of the proposed dams. Most NGO's representing the anti dams lobby are from urban Sindh with minimal appreciation of the core agriculture issues in the rural areas and at the macro level. However, international interests in the name of "save the rivers" help instigate the intelligentsia to oppose water storage on grounds that they represent the larger interest of society. The noise is often based on regional grievances focused on specific development problems i.e. Indus delta, historically low productivity in the Sindh agriculture for reasons like feudalism, weak land reforms, labor and capital /endowments productivity, and also water shortages (and in many cases excessive application of water that has resulted in widespread water logging and salinity etc.). Political parties like Awami National Party (ANP) that unexpectedly lost out in the last elections are reorganizing around the dam's issue to stage a comeback in the NWFP province. Similarly, by agitating decisions and deliberately delaying action on decisions the costs of large scale projects reaches astronomical levels (Amir, 2002).

For example Kalabagh started with an initial estimate of US$ 2.65 Billion in 1987 again re-calculated at US$ 7 billion (1998) and in 2002 at over US $ 6 billion (minor difference in final estimates due to changes in design features) The same fate can be expected for other dams in the pipeline when decisions are deferred for want of political consensus. There will be newer social groups like "Basha Bachao" on the same lines as Narmada Bachao in India. The cost of waiting, debating, reopening of issues already settled may have some justifications. But on economic grounds these play havoc with the lives of people who will end up paying these rising costs for decisions not taken at the right time. Holding any nation hostage to the political whims of a select group and then expecting everyone to share the burden of debt counts for poor decision making and is **bad and costly governance.**

The **Indian experience** with new dams is worth noting and relevant to Pakistan. India had 42 large dams by early 20th Century and 1950 an additional 250 had been added. During the period 1970-1989 a large number of large dams had also been built. Given the wide temporal and spatial variations saving water seems to be the main justification for this large scale dam building.

Within an International Perspective Pakistan seems to have much lower per capita storage then other countries. Along with other social indicators that allow international comparison of development per capita availability of storage is equally critical-especially during periods of extreme stress (droughts)

Figure 5: Storage per person (m^3)

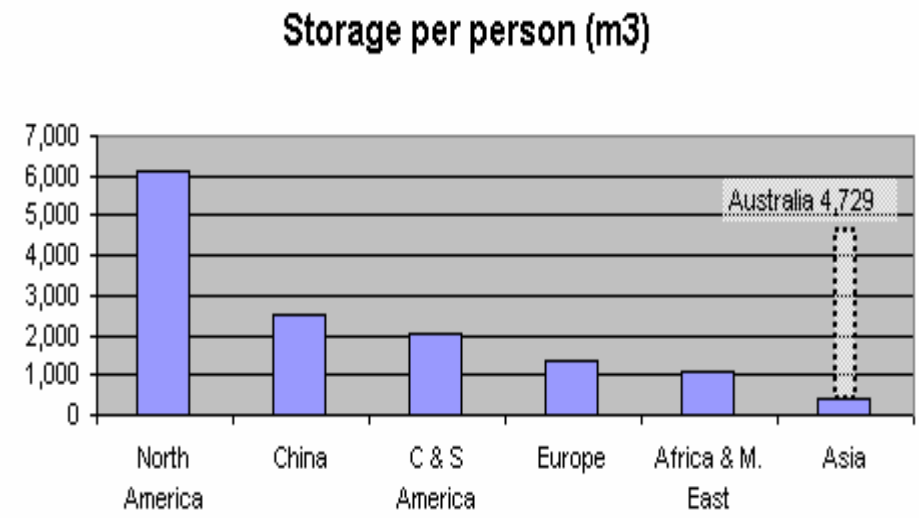


Figure 2: Endowments of water infrastructure
US and Australia have ~5000 m3/cap;
China has 2,400;
India has 130 m3/cap
Pakistan has 118m3/cap

Source: Pakistan Road Show- Multimedia presentation to the Federal ad Provincial Governments in Pakistan. J Briscoe, 2004

An assessment until 1997 suggested that dams provided additional water and helped in the increase of food grains from 51 million tones in 1950 to 200 million tones by 1997 (Iyer,2003) Dams played an important role along with other agriculture inputs like fertilizer, seed, pesticides credit and machinery. Assessment suggests that anywhere *from 10-30 percent* of the increase in production can be attributed to the water stored in the dams. The government of India rates this figure to be much higher (based on comments made on the WCD report prepared for India). Likewise in India about 21,891 megawatts of electricity comes from dams out of a total generating capacity of 89,000 MW in 1998. Almost one third comes from run of the river schemes. Therefore, India has benefited significantly from the dams it has used to harness its water resources. However, there is a feeling amongst some circles (Iyer, 2003) that contribution to floods has been rather modest, even public water schemes have not been specifically built into the large dams constructed in India.

After halting the works on the Narmanda dam and a several year's intense litigation the nation decided to put the issue on one side not necessarily agreed upon by all concerned (Iyer, 2003) After hearing both sides the Indian Supreme Court ordered that the works on the dam be resumed and rejected the appeal of the Narmanda Bachao campaign in favor of this dam. **India has currently embarked on a major expansion of its hydro capacity in line with its goal of rapid economic transformation. With US $ 102.3 billion reserves and vigorous economic growth rate of 8.3%, India can afford to take on large infrastructure projects**. However, it must be noted that there are regional disparities and differences that either facilitate or hamper construction of large scale infrastructure. The gains from such investments are also variable according to the region where investment in large infrastructure is made. The more important aspect of water management is now realized and concerted efforts are being made to develop the needed macro-micro management systems for efficient water resource management in India (Indian WCAS, 2005)

Dams are recognized as important vehicles of economic development in India but so is the pressure to look at alternatives and a growing enchantment with the large resource outlays—high variations on estimated and actual costs and benefits, political economy marred with corruption and vested interests, environmental concerns and widespread feeling that resettlement of the displaced people is unbalanced and often unfair. Some of these concerns have led to abandonment of projects in the Silent Valley Project in Kerala. While the Narmada project is on track many Indians feel that this dam has altered the way people now think about such large mega-project—far beyond the realms of costs and benefits but what they mean for a large segment of the society in the basin they are to operate. The views expressed in press and amongst various political parities are rather polarized. There seems to be very little opposition from elected officials regarding infrastructure development. The political parties are aligned on overall development goals of the nation and tend to reflect the development aspirations of the nation as opposed to regional interests

1.4 Other important issues and impacts with respect to dams

In continuation with the aforementioned discussion there have been other issues and associated impacts of large dams, including sedimentation, environmental impacts, changes in minimum flow needs etc. These are addressed bellow

1.4.1 Sedimentation: All dams have a finite and productive life after which it becomes uneconomical to maintain the dam-especially for storage or irrigation purpose. Rates of sedimentation determine how long the dam will silt-up before it is no longer economical to operate. According to the TAMS consultants report (1998) some 200 million tones of sediment is re-deposited in the Tarbela reservoir every year. Their survey in 1997 revealed that the sediment profile was about 2 miles beyond the limit line after which these sediments would pose a serious threat to the tunnel intakes. Based on a number of modeling exercises taking into account seismic likelihood over 10 years with a return period of between 3 to 35 years such a flow slide would seriously hamper the irrigation and power supplies. The WCD report on Tarbela (WCD, 2000) concludes that the total sediment volume deposited in the Tarbela Lake since the commissioning of the dam as 2.76 bcm (1974-1999). This reduced the gross capacity of Tarbela by about 23.7% and the live capacity by about 17.8% in year 2000. The originally designed life of Tarbela was 50 years. It was calculated that over 50 years the storage at Tarbela would be *reduced to 1.2 bcm. Current estimates give the dam a life of 85 years.*

Likewise for Mangla is sedimentation problem, it is estimated that in 1997 the delta pivot point was only 4.9 miles from the main embankment dam while two years earlier the pivot point was 6.1 miles—the later probably due to the reservoir being drawn down to a level of 1043 ft (Tams, 1997). The various studies also conclude that the damage to turbines is likely to be less in the case of Mangla then Tarbela as sediments are finer and the seismic hazard lower.

There have been several quarters lodging criticism regarding the sedimentation problem- down streamers contending its seriousness is overblown to justify another dam. A review of almost 8 studies and independent research suggests that the present estimates of WAPDA are in line with the independent studies conducted elsewhere and the results do not vary widely.

Raising Mangla (work has started on this project) and building Kalabagh or Basha in 10 years time is necessary just to maintain current storage volume. The present status of various dam and storage is presented in table 2. Feasibility study for Basha was completed in August 2004 and others like Akori to be started soon. Amongst all dams the only complete feasibility/design that is ready for implementation is that of Kalabagh but there is no provincial consensus on this dam to date.

APPREHENSIONS

As part of controversy on Kalabagh Dam, a number of apprehensions/doubts have been expressed both by upper (NWFP) and lower (Sindh) riparian provinces. Most of these are based either on lack of information or hear say. In addition, there have been reservations in the mind of some quarters without any apparent rhyme or reason. Consequently, the Project has been thoroughly reviewed and revised/modified to remove the apprehensions and doubts, which in the pat may have blocked its implementation. As part of controversy on Kalabagh Dam, a number of apprehensions/doubts have been expressed both by upper (NWFP) and lower (Sindh) riparian provinces. Most of these are based either on lack of information or hear say. In addition, there have been reservations in the mind of some quarters without any apparent rhyme or reason. Consequently, the Project has been thoroughly reviewed and revised/modified to remove the apprehensions and doubts, which in the pat may have blocked its implementation

The apprehensions and the factual position, in the light of critical examination/supporting studies, are presented in the following.

Apprehensions of NWFP

i. It is feared that historic flooding of Peshawar Valley including Nowshera town would be aggravated in the event of recurrence of 1929 record flood.
ii. Drainages of surrounding area of Mardan, Pabbi and Swabi plains would be adversely affected by the reservoir thus creating water-logging and salinity.
iii. Operation of Mardan SCARP would be adversely affected.
iv. Fertile cultivable land would be submerged.
v. Large number of people would be displaced.

Answer.

1) a. In the modified design of the project the reservoir conservation level has been lowered by 10 feet from 925 to 915 feet above mean sea level (MSL) thus eliminating the need for construction of any protective dyke near Nowshera. At maximum conservation level of 915 feet, the back-water effect of Kalabagh lake would end about 10 miles downstream of Nowshera (refer Illustration-I). A state-of-art computer based study, backed by physical modeling in Pakistan, has established that recurrence of record flood of 1929 would not affect the water level at Nowshera even after 100 years of sedimentation in reservoir (refer Illustration-II). It may be noted that this completely ignores the effect of Tarbela reservoir, which is now factually providing relief by attenuating flood peaks. It is also notable that flood **warring** system at Tarbela provides a minimum of 48 hours advance warning before the arrival o large flood peaks.

b. Real causes of flooding at Nowshera and Peshawar Valley upstream entrance of Kabul River at Nowshera into confined channel at the end of Peshawar valley; and backing effect of Attock Gorge downstream through which Indus River has to pass after its confluence with Kabul River (refer illustration

I. Before the confluence, Indus River flows through a wide valley of over 8,000 feet and is then forced to pass through 1000 feet wide gorge for 5 miles. This constriction forces the river water to back up thus raising flood levels in Kabul river upto Nowshera. Whereas Kalabagh should not adversely affect flooding in Nowshera and Peshawar Valley above, an upstream dam on Swat River could provide effective assurance against this chronic inherent problem. Consequently, Munda Dam multi-purpose project is being included in NWRDP.

ii. Lowest ground levels at Mardan, Pabbi and Swabi areas are 970,962 and 1000 feet above MSL respectively, as compared to the maximum conservation level of 915 for Kalabagh (refer Illustration-III). This maximum Kalabagh reservoir level would be maintained only for 3 to 4 weeks during September and October after which it would deplete as water is released for Rabi crops and power generation (refer Illustration-IV). Ultimately it would go down to dead storage level of 825 feet by early June. This operation pattern of reservoir, by no stretch of imagination, could block the drainage and thus cause water-logging or salinity in Mardan, Pabbi and Swabi areas.

iii. The invert level of main drain of the Mardan SCARP is higher than maximum elevation of 915 feet. Thus, these drains would keep on functioning without any obstruction.

iv. Total cultivable land submerged under the reservoir elevation of 915 feet would be 27,500 acres (24,500 acres in Punjab and 3000 acres in NWFP). The submerged irrigated land would be only 3000 acres (2,900 acres in Punjab and 100 acres in NWFP). It may be noted that about 1,000 acres of irrigated land acquired for Mardan SCARP alone.

v. a. The estimated population to be affected by the project would be 83,000 with 48,500 in Punjab and 34,500 in NWFP. A liberal resettlement plan would provide alternate irrigated lands to the affected families. The affected population would be resettled along the reservoir periphery in extended/new model villages with modern facilities of water supply, electricity, roads, dispensaries, school and other civic amenities. **The affectees would enjoy an improved environment.**

b. Another major incentive provided for the affecters in this case, not previously practiced in Pakistan, would be to fully compensate the frames for the land on the reservoir periphery above normal conservation level of 915 feet

that could be flooded once in five years. This land would remain the property of the original owners for cultivation with the only undertaking that they would not claim any damages to crops for occasional flooding.

c. The comprehensive resettlement package proposed for Kalabagh is in fact most innovative and attractive then those previously adopted for Mangla and Tarbela Dams. The basic objective being that "the end of day", the affectees should find themselves in a better socio-economic environment.

Apprehensions of Sindh

i. The anxiety that the project would render Sindh into a desert.
ii. There would be no surplus water to fill Kalabagh reservoir.
iii. High level outlets would be used to divert water from the reservoir.
iv. Cultivation in riverain (Sailaba) areas would be adversely affected.
v. Sea water intrusion in Indus estuary would accentuate.
vi. Mangrove forest, which is already threatened, would be further affected adversely.
vii. Fish production and drinking water supply below Kotri would be adversely affected.

Answer

i. Dams don't consume any water. Instead these store water during flood season and then make it available on crop demand basis for the remaining dry periods of t years. The real demonstration of this came after full commissioning of Tarbela Dam in 1076. During pre-storage era of 1960-67, average annual canal withdrawals of Sindh were 35.6 MAF. After Tarbela the corresponding figure rose to 44.5 MAF with over 22 percent increase in the Rabi diversions alone increased from 10.7 to 15.2 MAF. It is estimated that after Kalabagh, canal withdrawals of Sindh would further increase. A indicated in Illustration-V, most of this increase would come in regarding desertification of Sindh defies even the basic logic of a storage reservoir.

ii. A. WAA of 1991 has allocated, on the average, about 12 MAF additional supplies to the provinces almost all of which is in Kharif season. On the other hand, factually the surplus water is available only within 70-100 days flood period. It is estimated that to provided additional allocated water over the year, a storage of about 3.6 MAF would be needed (out of this, 2.2 MAF would be in the early Kharif season of April to July).

iii. Initial studies have indicated that construction of high level outlets at Kalabagh is economically unviable. Notwithstanding this, if any province wants to build, then its share of water would be strictly governed by WAA, 1991.

iv. a. An impression is also prevailing that with Kalabagh Dam, riverain areas of Sindh, commonly called " Sailaba" would got out of production due to control over floods. It can be appreciated from configuration of riverain area (refer Illustration-VI) that "Sailaba' crops are grown on the land adjacent to main river and the creeks. Though crops are sown on the soil moisture soon after the floods, these need more than one watering to mature. As a result 'Sailba' lands give poor yields. Consequently, frames are generally required provide irrigation facility through shallow tube wells or lift pimps. Prime movers on these tube wells have to be removed during the flood season to avoid damage.

b. Sindh presently 660,000 acres of 'Sailaba' cultivated area form Guddu Barrage to sea. This area is initially sown due to the moisture provided by flooding with river stage of 300,000 cusecs and above.

c. Flood peaks above 300,000 cusecs would still be coming after Kalabagh, without much detriment to the present cultural practices, while large floods would be effectively controlled. This would, in fact, be conductive to installation of permanent tubewells to provide perennial irrigation facility in riverain areas. Towards this end, a separate scheme is being included in NWRDP.

v. a. The fear that present extent of sea water intrusion in the Indus Delta would be further aggravated by Kalabagh is not substantiated by factual data. Studies indicate that presently the total effect of Indus estuary is only limited to the lower most portion of Delta and gets dissipated below Garho and Chowgazo gagues heights at Garho are completely insensitive to Indus discharges of upto 700,000 cusecs (refer Illustration-VIII). Therefore, the sea water intrusion, which seems to be at its maximum even now, is unlikely to be aggravated further by Kalabagh Dam.

b. Another apprehension is that sea water intrusion into existing aquifer system would cause serious quality deterioration. The groundwater contained in the aquifer is effectively saline as far north as Hyderabad. Therefore, intrusion of sea water along shore line of Delta is of little consequence. This is further supported by the fact that there is southward oriented groundwater gradient throughout this aquifer. Considering the very low transmissivities of the aquifer in Delta region, upward sea water intrusion can be almost ruled variety.

vi. a. Out of the total Out of the total 1.53 million acres(MA) tidally inundated historic Indus Delta, Mangrove forest cover an area of almost 0.32 MA In this forest, spreading from Karachi in the west to Rann of Kutch in the east, 95% of the population now consist of a salt tolerant variety.

b. Extent of the Extent of the active delta area (as distinct from the historic delta area described above) is about 294,000 acres. Out of this, the mangroves cover only 7,400 acres or 2.5% of the area. Most of the remaining area is in form of mud-flats. The reason for this area being too small could be a combination of factors. Recently, NED University of Engineering and Technology has carried out a study titled " What Really Threatens us and Our

Mangroves" This brings out that reduction in mangroves in essentially due to frequency of tidal inundation being too small instead of fresh water reduction caused by upstream abstractions, which started with Sucker Barrage in 1932. Other major causes are uncontrolled overgrazing and cutting due to extreme population pressure of Karachi.

c. Therefore, in order to revive the mangroves, real need is for replanting salt tolerant varieties with provision for controlled doses of fresh water. Obviously, this possibility would be much enhanced with an upstream storage facility like Kalabagh.

vii. a. A recent study has shown that there is no clear evidence to suggest that fisheries stocks in the river reach below Kotri have declined due to progressive reduction in the surface water supplies. On the other hand, fish production has been constantly increasing as indicated by statistical data. As such, Kalabagh Dam is unlikely to have any adverse effect on fish production in the areas.

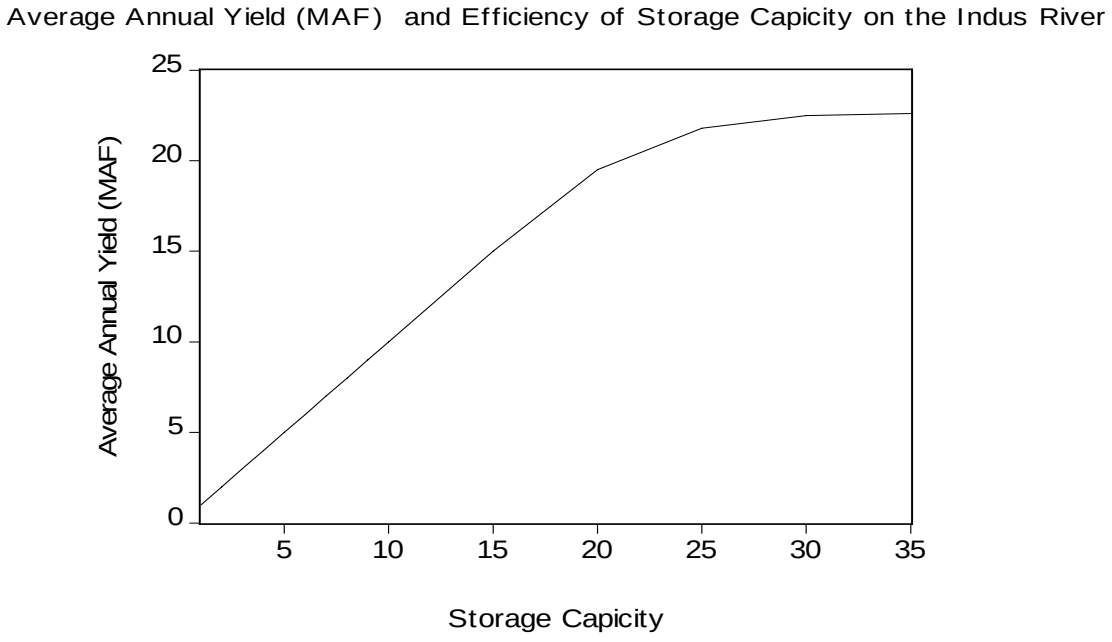
Source: www.infopak.gov.pk/public/kalabagh_Dam

b. In the riverain area downstream to Kotri Barrage, groundwater is predominantly saline or brackish and as such unsuitable for either irrigation water supply. After Kalabagh, winter supply in the river would improve thus assuring more drinking water

The government has responded to the major apprehensions of both Sindh and NWFP on the Kalabagh issue and has allowed for public to comment on its answer to each concern (see boxed text from GOP website). This type of transparency in sharing information is step in the right direction for developing trust on important national issues.

It seems that the earlier proposal of Lieftinck to look at additional sites following Tarbela have not been acted upon despite the passage of almost 35 years. Figure 1, shows the potential yield and storage developments in a yield /storage curve over time. The study states" it will be possible to fill reservoir to the extent of 2 MAF on the Jhelum while on the Indus it will still be possible to fill reservoirs with total love storage capabilities in excess of 15 MAF every year on the Indus". While several low and high level scenarios have been proposed for river flows in the future the fact remains that with depleting storage due to sedimentation there is a widening gap between the overall river yields and storage built on the Indus.

Figure 6: Storage Yield Curve



Source: World Bank, (Leiftnck Report). 1968

ii. Environmental Impacts: There was rather minimal attention to environmental impact assessment of the two large dams on the Indus. Firstly, the emphasis on environmental awareness and analysis received attention only in the last decade or so and secondly when considering Tarbela and Mangla emphasis was centered around direct benefits and direct costs often ignoring the whole array of indirect benefits and costs especially the environment. According to WAPDA (see Tariq: 1993) the major environmental impacts were on resettlement, irrigation, power generation, flood mitigation and ground water. The minor impacts listed are wildlife, flora and fauna, navigation, climate forest, fisheries, sedimentation, water quality etc. The present studies available through WAPDA and IUCN fail to provide a quantitative assessment about the impacts. The isolated "loss in values" estimation are also only on parts of Indus river and conducted as case studies. There is an important **data gap** that needs to be filled

Both dams have impacted populations directly resulting in some form of resettlement. Along the newly created lakes there have been certain dwellings that were destroyed and new ones created. The nearby surrounding environment has benefited in terms of new flora and fauna. Both due to rise in water table that directly resulted in sprouting of plants, shrubs and trees these biotic changes directly enhanced growth and the areas prospered. In certain areas government has designated game reserves. High value vegetable and fruit tree production has been established alongside the dam site near Tarbela creating a vibrant agriculture with the result that land prices increased almost 150-200 times from pre-Tarbela dam construction in some areas.

Wild life including teals, pintails, mallards, common pochards, tufted ducks, pheasants, quail etc have found refuge in the area. Due to substantial flow and reservoir variations there has been less above surface aggradations in the upstream narrow gorges of both reservoirs. Tarbela and Mangla serve as sanctuary to migratory birds (Duder, Mufti and Tariq, undated)

The lake formation also alters traditional small boat navigation in the area. New types of motor boats and launches became available and provide services to local population in the Tarbela area.

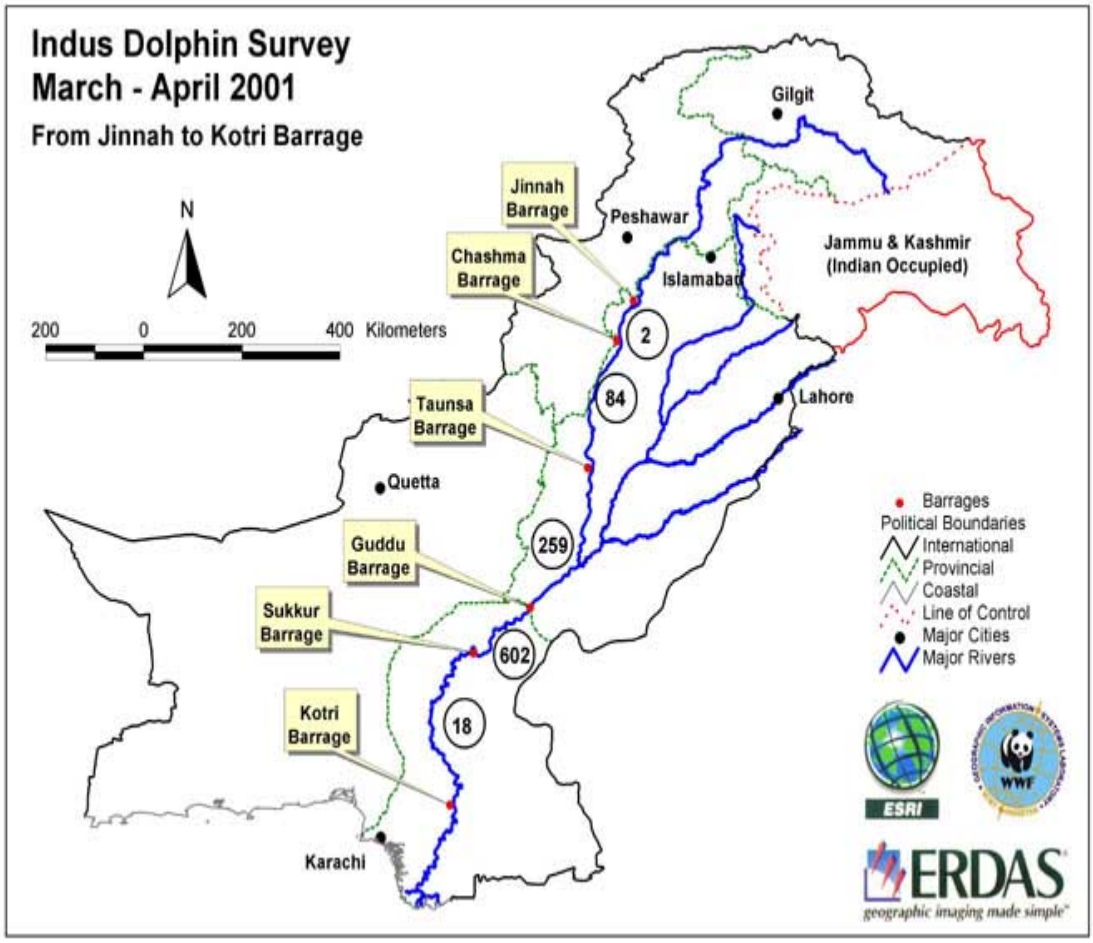
Forest cover has increased in the vicinity of the dams and widespread watershed management projects have been put in place. The impacts of these developments however have limited influence on the sedimentation at Tarbela **which is mostly due to high level glacier melting and weathering affects**. The forest department has claims that most of the erosion in the watersheds is responsible for the sedimentation problem in Tarbela. However, since about 70% flow is from snow and glaciers while 30% is from small rainfed catchments areas this contention of the forest department appears to be overstated. Fishing industry alongside the dam has also prospered and the local fishermen (many of Sindhi origin) are engaged in trade. Especially valuable is the species *Tor Putitora* or mahasheer that has found the dam environment highly conducive to its propagation. While there are no firm numbers the WCD survey of Tarbela reservoir noted that there were over 100 families (mostly of Sindhi descent belonging to Larkana) who were engaged in fishing activities in the reservoir through government fishing permits. Numerous other local fishermen also fish in the reservoir but only for small catch. The catch is transported to different markets in the Punjab and NWFP and has increased employment opportunities through transportation, fish vendors, and newly opened fish restaurants. If, the fisheries department were to organize this small scale industry on scientific lines the income and employment impacts could be further enhanced.

While the direct impacts to water surroundings are often stated to be mostly positive there have been serious problems of environmental degradation downstream.

Schemes like barrages, canal diversions and large dams in the Indus system have had negative impacts on the lower Indus Plains and the Indus Delta ecosystems. However, since dams only store water for release during certain peak demand periods like winter the impact is rather minimal. However, construction of barrages upstream Kotri including Kotri and Sukkur barrages have reduced environmental flows below Kotri. The degradation of the delta preceded the construction of the two dams. Much of the deforestation in the delta and destruction of mangroves has been inflicted

by over population of settlement of communities in these areas. These communities have developed heavy reliance on the riverian and mangrove forests due to loss in fishing opportunities along the coast (Qureshi, 2000). The reduced flows have impacted riverian forests, reduced grazing opportunities, fishermen have been impacted by much reduced catch and there is also loss in the wildlife and fowl habitats. The Indus River Dolphin sanctuary between Sukkur and Guddu Barrage has shown reductions in populations over the years. The reported numbers of the Indus Dolphin are less then 6000 (IUCN) and Akbar et al. 2004. The Indus Dolphin has faced problems with reduced water flows and so has the general fish population, especially the famed Palla fish. The situation in Manchar Lake is very serious with salts raised from 800ppm in 1970 to about 3000ppm. The situation with respect to Mangroves has also been attributed to the reduced flows below Kotri. While many of these environmental impacts are due to water shortages and deviations in minimum flows they should not be attributed to dams as the single factor responsible for this situation. Dams store and regulate water.

Figure 7: Dolphin Map



Source: WWF Pakistan

Following the Tsunami tidal wave phenomenon in the Indian ocean in 2004 , Scientist, feel that deforestation on mangroves is a significant cause for wide spread destruction in coastal areas. There are recommendations to take special measures for protection of mangroves to reduce negative impacts from future Tsunami.

2.1 Climate Impacts: There has been an increase in annual rainfall at Mangla from 550 to 950 mm and at Tarbela from 762 mm to 1016 mm. Average temperatures remained unchanged, while minimum temperatures have dropped by 1 degree F. Now there are fogs and cloud cover over the area. These changes are near the vicinity of the lake and around the reservoir townships (Tariq, 1993)

2.2 Flood Attenuation. High flows at Tarbela during the summer are from snow melt as noted earlier. WAPDA operating procedures link Mangla and Tarbela to mitigate flooding downstream. Most floods in the Indus occur during July and August. However, during 1992 the flood occurred during September. Filling of the reservoir during the early periods can help attenuate flood peaks. Review of the data show that peak flows in July, 1988, July 1989 and August 1997 were reduced by 2%, 26% and 43% respectively. However in case of the September 1992 floods was attenuated by only 2% as the reservoir is close to its maximum capacity at that time. Dams like Tarbela can have a positive affect on mitigating the effects of floods. Since the creation of Pakistan it is estimated that floods have caused a damage of approximately Rs 78 billion with a loss of 7530 lives. The losses to infrastructure, property, and livestock inflict considerable economic set-back (WCD, 2000).

2.3 Areas affected by Water logging and Salinity: Water logging and salinity continue to be serious environmental concerns that have negatively impacted Pakistan's agriculture. It is estimated that 37.6% of the gross command area in Pakistan is water logged of which about 15% is severely water logged. In the case of salinity out of 11.23 million acres surveyed area 1.6 mha were slightly saline, 0.44 moderately saline and 0.63 were considered strongly saline. The problem in Sindh is even worse where out of 5.3 mha, 3.38 and 1.96 were moderately or considered severely salt affected. It seems that additional supplies from dams like Tarbela along with a highly inefficient irrigation system resulted in some water logging in the Sweet ground water zone. In the late 1970's this problem was at its peak but in later years due to heavy pumping and other drainage measures the trend was arrested. Likewise recent drought like conditions and reduced water flows have also lowered water tables and in some cases reduced the water logging problem. It must be appreciated that storing water does not lead to water logging or salinity. It is the mismanagement and misuse of water at the farm level that results in the twin menace. In fact dams can help regulate water to those areas were it is needed the most and also restrict it where it could do most damage. Investments in improving better water management couple with additional storage would help achieve the desired control of the salinity problem.

Table 7: Summary of major Positive and Negative Impacts of Dams on Indus.

	Positive Impacts	Negative Impacts
Upstream & Downstream	Create hydroelectric power	Resettlement
	Acts as reservoir for drinking water	Reservoir may cause the instability of surrounding hillsides
	Source of water for irrigation canals	Dam will stir up its own controversy because of its impact on its surroundings. (water logging)
	Help to control floods and prevent areas from flooding	Reservoir may foster water borne diseases
	Recreation	Biomass removal
	Give rise to an ecosystem	Risk of failure of the dams
	Dams aid in navigation by making water deep and calm	Destroy the native ecosystem of an area
		Threat to endangered species (flora & fauna)
		Inundate archaeological sites or ancestral burial grounds
		Reservoir water can evaporate significantly
		Reservoirs can cause earthquakes

3. Ecological Flows: Much concern has been expressed by downstream inhabitants regarding the negative impacts of reduced flows to the Indus Delta, the riverian belts and the overall ecology of the Indus Basin. These concerns in most cases are genuine but at times the damages attributed are out of proportion to ground realties. The situation in the Indus Delta has been created primarily after the completion of the Kotri and Sukkur barrages where water is diverted for irrigation purposes leaving less then historical flows passing to the Indus Delta. Historical flows downstream of Kotri are given in table 8. Major reductions in flow resulted from the construction of the Kotri barrage.

Table 8: Historical Surface Flows Downstream of Kotri Barrage under Key influences
Flow Downstream of Kotri Barrage
(bln.m3)

Key-Influences	Period	Kharif	Rabi	Annual	Peak Discharge (m3/Sec
Pre- Kotri	1955-61	84.4	14.85	99.25	27787
Post-Kotri	1962-67	60.2	3.6	63.8	16639
Post-Mangla	1967-75	50.6	1.4	52	22269
Post-Tarbela	1975-80	58.1	3.4	61.5	21690
Post-Tarbela	1980-85	33.1	1.2	34.3	13441
Post-Tarbela	1985-90	28.7	2.3	31	18406
Post-Tarbela	1990-95	67.7	5.9	73.6	23174
Post-Tarbela	1995-98	50.5	2.6	53.1	10895
Post-Tarbela	1975-98	47.6	3.1	50.7	23174

Source: WCD Case Study Tarbela Dam and related aspects of the Indus River Basin Pakistan 2000

This has threatened the mangroves, disturbed the ecological balance and created extreme hardship for the fishermen and other communities residing in the delta and near the coast line (see WCD, 2000). There has been some proposal that a minimum of 10 MAF should be guaranteed as environmental flows to sustain the basin ecology. Even this figure is widely challenged, some claiming it to be on the lower side and others especially the upper **riparian** feeling that high value water is being wasted and not put to productive agriculture use. While 10 MAF minimum flows became the working rule however in years of extreme drought these flows fell even below 1 MAF which resulted in major degradation in the delta and consequently complaints from the Indus delta dwellers that "dam construction" has resulted in less water to the Delta. Guaranteeing minimum flows for all times along with judicious distributional patterns would partly solve the problem. These mandated flows would have to be agreed upon and transparent mechanisms established to monitor and ensure that these minimum targets are achieved. This would be akin to the minimum consumptive use requirements of Punjab and Sindh.

A recently GOP financed study is underway to address these concerns and to provide estimates on the minimum ecological flows in the Indus and other major rivers to firmly establish the system requirements. While there is less likelihood of a definitive agreed upon figure, dams can actually play a useful role in regulating the minimum flow requirements. What must be understood and appreciated is that dams are water stores that can be filled and emptied at the management's choice. Dams can in fact improve the management capability of macro water managers. The social choices have to be made through consensus. The values attached to those choices must build on trust and transparency. While, it is difficult to assume that minimum flows would be relevant for all times to come as social choices could change over time, what is important is that all parties realize that building dams in no ways restricts adhering to or modification of reservoir operational rules keeping in mind the needs for ecological balance Even when a dam is in place it is often possible to adjust the operational regime to better meet a variety of needs. So-called 'environmental flows' provide

critical contributions to river health, economic development and poverty alleviation (IUCN, 2003b). Environmental flows (or, more accurately, managed flows) are not natural flows but are aimed to find a balance to meet a variety of water needs, including those of ecosystems and downstream communities

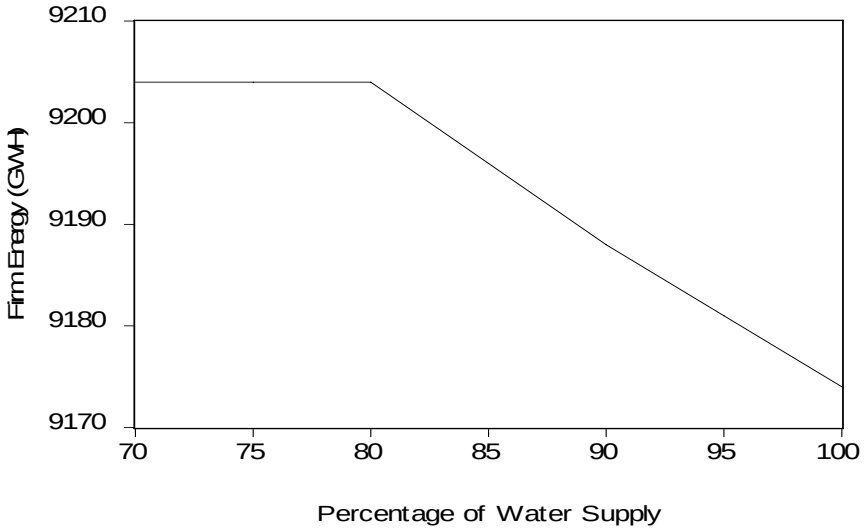
4. Operating Rules: Dams are operated under a set of Standard Operating Procedures that ensure their most efficient and safe operation. These set of rules are in the best operational and public interest and for the following reasons as identified by WCD (2000):

- Support day-to day operations like reservoir operations and releases
- Change operations in response to new regulations be they economic, technical, social, and or related to dam safety
- Change operations of existing dams when a new dam is introduced in the basin
- Adopt operations to changing needs of services i.e. power vs. irrigation
- Renovation, upgrading or expansion of existing facilities in countries that require re-licensing processes

Pakistan has established rules of operation for both its major dams Tarbela and Mangla. These operating rules were established for all stages of the dam operation (initial fill, seasonal variations, day-to-day operation, emergency procedures etc).
In the case of **Tarbela TAMS (1984**) provide written guidelines for reservoir operation criteria, annual reservoir operation procedures. Reservoir draw-down calculations are also formulated and the storage capacity of Tarbela is estimated annually. The maximum gross capacity level of 473 m is achieved around 20 August every year. Operational criteria are based on safety principle and the dam is filled at an average rate of 3m/day to the elevation of 460 m.
For seasonal operation criteria, the operation is evaluated over 10 –day period taking into account: estimated flows of Tarbela and Kabul at Nowshera; provincial water allocations at the canal head, system gain and losses and other criteria. During the operation an important aspect is to ensure compliance of apportionment accord.
Thus it is clear that there are well laid down operational rules that are followed by each dam manager with clearly monitorable indictors that help apprise senior management on the operation of the large dams. Dams are still operated on the basis of 1984 rules.

There have been attempts to analyze the tradeoffs between water supply and Hydro-power reduction (Alam and Tariq, 1997).Based on Tarbela reservoir data the authors have developed a tradeoff curve for the Tarbela reservoir. The curve shows that for 100 percent water utilization 9174 GWH and 47663 MCM can be produced. Likewise with 70% water 9204 GWH power and 33364 MCM water supplies (essentially for irrigation) can be achieved. Similar models can be used to obtain optimal benefits of limited available water resources (during periods of drought stress) for irrigation supplies and hydropower production. Analysis of such trade-offs can also be helpful in the policy analysis of tube wells- to supplement surface irrigation.

Figure 8: Tarbela Reservoir Tradeoff between Energy Production and Water Supply



Source: (Alam M.M and Ata ur Rehman Tariq, 1997: Developing Trade-of Between water supply and hydropower production: International Symposium: Water for the 21st Century 7-19, 1997 Lahore

Table 9 shows the amount of possible additional power that could be achieved and the required additional storage releases. For instance take the case of January 1990 the benefits forgone from additional contribution of power would have been Rs 113 million. This would have required 0.33 MAF of water releases. The estimated gain for storage retention was Rs 47 million. There is obviously a much higher value to be achieved by producing electricity during critical shortage periods.

Table 9: Trade-Off between Storage and Power
(Benefits of Tarbela Dam Project during maximum Load-Shedding)

Month	Year	Possible Additional Power Contribution			Correspondingly Required Additional Storage Release			Net Estimated Gain for Storage Retention (Rs. Million)
		Energy At Consumer End1 (Gwh)	Estimated Benefit Per kWh (Rs.)2	Benefit Foregone (Rs. Million)	MAF3	Estimated Benefit/AP (Rs.)4	Retained Benefit (Rs. Million)	
January	1983	37	1.06	39	0.19	310	59	20
March	1985	28	1.06	30	0.18	338	61	31
January	1986	68	1.15	78	0.32	377	121	43
December	1988	68	1.20	82	0.26	422	110	28
January	1990	75	1.50	113	0.33	485	160	47
February	1991	48	1.64	79	0.14	563	79	0
January	1993	150	1.74	261	0.44	725	319	58
April	1994	45	1.68	76	0.18	813	146	70
January	1995	173	1.72	298	0.47	956	449	151
January	1996	90	1.80	162	0.27	1079	291	129

1. Net after deduction of 25% System losses.
2. For scarcity period economic value of power, average sale price excluding surcharges etc. doubled (Table 3.25, page 98, Power System Statistics, 23 Issue, WAPDA, March 1999).
3. Corresponding to possible additional power generation.
4. From Annex - 5.

Source: Tarbela Dam Case Study

The above analysis shows that estimates can be derived for cases where all priority is given to produce maximum power with irrigation water as residual. These would obviously vary from year to year depending on available flows, dam safety consideration and so forth. There is lack of a dynamic model that clearly shows the scenarios of aggregating monthly benefits if hydropower generation was the prime concern and irrigation a residual[5] table 10.

Table 10: Benefits of Irrigation and Power Generation from Tarbela (Qty/value) 2000

	Power Production (Million Kilowatt Hours)	Irrigation Production (MAF)	Power Value Million Rs.	Irrigation Value (Million Rs.)
Current Operation (Primacy to irrigation with power as a byproduct)	12811.24	8.69 MAF	3843.37	7820.10
Operating for Power with Irrigation as a Byproduct	Data gap here			

Source: WAPDA, 2002

5. Resettlement: Dams displace people who fall in the direct zone of impact. In the case of Tarbela the original design estimated that 80,000 people would be displaced and 100 villages would be submerged. However at the completion of the project 96000 people had been displaced and 120 villages submerged. Most of the increase is due to population growth, some opportunists also tried to get registered to become project beneficiaries. In the case of Mangla 80,000 people were displaced. Showing a tendency for project designers to under estimate the direct damage to people and villages that occurs due to dams. GOP had envisaged several types of compensation mechanisms to cater to the displaced population. They were given alternative land, plots and some received cash compensation. Majority received the promised compensation but most felt they were losers. While provincial government initially agreed to provide the necessary land for resettlement later they reduced the allocation of Promised Land creating extreme hardship for people. However, no loss of life occurred and level of stress acceptable under such mass re-location was placed on the population of area. In the Tarbela resettlement schemes both Sindh and Punjab government's Promised Land once the dam was in its advanced stages many pending cases remain where land was not allocated to the rightful owners. (WCD, 2000) By the same token many fraudulent claims surfaced that are still being fought out after almost 30 years of construction of the dam.

The cost of Tarbela resettlement was around US$100 million in 1998 prices. While the resettlement of people involves large scale movement the major cost is social cost. People leave their abode and perhaps the most significant and painful aspect is the submergence of graveyards and other historical and archaeologically important sites. As a remainder the Indus has a history sprawling over 3000 years and there are historical sites all along the river (Fahlbusch, Shultz and Thatte, 2004)

Dams are not the only projects that require large scale resettlement—new airports, large motorways, new townships etc all require involuntary resettlement. Are all resettlements bad? Based on a rather elaborate review of extensive Bank experience (1986-1993) with large scale projects involving involuntary resettlement the study found that where good practices were adopted for resettlement they had positive impact on poverty reduction. In majority of cases people found themselves better off. Challenges of resettlement include focus on income restoration, re-employing acquired skills within new environments or learning new skills, asset formulation elsewhere with minimal loss in growth in opportunities etc. While future projects will continue to involve resettlement especially in the case of dams, when attractive and fair practices are adopted those giving up their abodes could be

[5] An attempt has been made to fill this data gap, but this information is lacking-especially the technical data.

made better of when they share the long tem gains of their immediate losses. Compensation packages must be reviewed by external sources and in the light of international experience to term them "fair and reasonable".

In almost all cases, right from the start, the planning and implementation of resettlement and rehabilitation was, till recently, carried out by the government through its own agencies with no participation by the people, especially the affected people. These agencies were also not multi-disciplinary but manned mostly by engineers. The identification of areas to be submerged or otherwise affected, the determination of who would qualify for compensation, of the nature and quantum of compensation, and of the time frame and process by which relocation, resettlement and rehabilitation would take place, were all done by the project authorities along with other government agencies. In some cases, the district authority or the State government was made responsible to carry out relocation, resettlement and rehabilitation and in others it was done by the project authorities themselves.

Even during the implementation of the resettlement process, lack of transparency affects the process. The manner in which resettlement and rehabilitation is handled becomes susceptible to patronage and corruption and it becomes difficult to ensure that every affected person is treated fairly and receives his or her due share.

Depending on the size of land holding and type of irrigation practiced, two-thirds of the affectees were provided replacement land and the rest were given cash compensation. However, according to a survey conducted in 1996, there were 1953 families still waiting for possession of allotted land the case of Tarbela.

During the construction of the Mangla dam, 65,100 acres of land was submerged. This led to the resettlement of the residents of old Mirpur town and the affected people were provided accommodation in the newly designed and developed town of Mirpur. Most people were accommodated however, some grudges remained after resettlement.

An important concern on the raising of Mangla dam is the resettlement of an estimated 40,000 people living in 7,000 houses. Some of them may be the same people or their descendants who would be forced to leave their hometown for the second time. Rs. 20 billion has been allocated for population resettlement in the Rs. 53 billion project. This change has primarily come about after realization within WAPDA that it was only fair to provide higher compensation rates given the much higher then predicted benefits realized by Tarbela. WAPDA is developing a policy and compensation package for resettlement of the affectees.

Minimizing corrupt practice in the resettlement game opens up a whole new set of issues and Pakistan has well established corrupt practices in the revenue departments that hurt the interests of those who are resettled- illiteracy is perhaps the number one culprit that puts the resettles in a disadvantaged and poor negotiation position. The touts that surface to watch such interest play out and serve as facilitators themselves emerge as a powerful interest group. Thus key summary points for good practice can be summarized as:

- Adversely affected people must be the first beneficiaries
- Resettlement must be seen as an opportunity for development of poor people, not a cost they must bear.
- Large social processes like resettlement seldom work perfectly no matter how well they are planned, thus demanding long-term mechanisms for good performance.
- The costs of poor resettlement are very high for all – the people affected and the investor.

6. Trust: Large dams in Pakistan have been symbols of pride and prosperity amongst the general populace. The benefits of power and irrigation have touched a wide section of the society as producers, consumers or indirect affectees. However, in recent years as the debate on large dams has widened worldwide, a whole array of concerns have been expressed against dams and Pakistan is no exception. A vibrant anti dam lobby exists (mostly of some NGO's, international organizations

lobbying against dam construction; media campaigns and political parties taking sides etc). These forums have been able to bring out issues and plead the various de-merits of existing and future dams- some even calling for decommissioning the presently operating dams. Much of this effort has been targeted at the construction of Kalabagh that was proposed in the original Lieftinck, 1968 study
Internationally there has been considerable opposition to the rigid guidelines proposed by organization like the WCD that favor more long term and widespread consultation in the decisions pertaining to dams. Many countries aspiring to develop and need the irrigation, hydro-power or flood control benefits of dams have vividly objected to the "stalling tactics" that can lead to inordinate delays in the evaluation of on-going and future projects. While general guidelines are noteworthy they should not become the over-riding factor in deciding about dams (WSSD, Bonn conference on renewable resources, ICOLD and other rejected the general guidelines for appraising dams by WCD). Individual nations will set their own priorities. Likewise international donors supporting such projects will also adhere to their institutional policies that generally include more rigorous criteria for evaluation of new dams fund worthiness. For example the World Bank has decided to re-engage in funding large scale infrastructure after almost two decades of reduced emphasis on these types of projects. The rules of engagement have been clearly documented in the Water Resources Sector Strategy of the Bank (World Bank, 2004).
There is considerable polarity on the question of dams in Pakistan, while arguments are put forth about Sindh being he lower riparian and the need to protect its historical rights, the situation has largely been created by reduced trust and apprehensions about the benefits of dams and how they will be assured (see earlier section where . The Indus River has flowed smoothly over centuries and never has any provinces one-sidedly taken charge of the waters. Behind dams are hidden issues of historical inequalities, economic disparity, interest groups, feudalism, power play, regional development imbalances and the sort. The common man seems almost unaware of the noise created in favor or against dams where he/she is made the scapegoat to promote vested interests. The lack of transparency in information sharing and hiding data that should be in the public domain has created an environment of distrust and despair. While these issues are important in expressing opposition to certain social choices like dams, it is important to address the underlying causes of water mismanagement at 4 levels National- Provincial- Canal and the farm.
Unless the grievances in relation to water entitlements, distribution, and governance are addressed in a comprehensive manner, dams or even other large scale water infrastructure projects will be blamed for all the shortcomings in water sector. To move forward requires that infrastructure development be viewed with joint national ownership. Its costs and benefits are shared by all the provinces. The processes and mechanisms for transparent distribution and attribution of benefits and costs are clearly identified and institutions that are to be engaged in their administration be upgraded. Consequently when trust and ownership is restored resolution of conflicts around the other economic and regional disparities becomes possible. Under some circumstances as the Kalabagh or Basha dams it may be desirable to ensure support for regional development initiatives (i.e. lower Indus Delta) as part of the project and a proportion of the dam benefits from the overall benefits pool could be assigned to high priority projects. The negative connotations attached to even the most fundamental and analytically sound arguments are held and perpetuated as a "belief" system by many. This lack of trust is expressed at many forums and each political entity exploits the situation according to its own interests.
The fact remains that little concerted effort has been put forth to develop consensus amongst those who matter—the 75% of population that eventually face the consequences of water shortages, higher power tariffs, food price hikes, load shedding etc. The media has been unable to engage the experts and analysts into direct dialogue with the public. In particular it has failed to bring out the trade-offs, choices and likely impacts of timely and delayed decisions. Nor has there been any education of the masses of the potential multiplier affects and backward/forward linkages of these choices. There is

less sustained effort i.e. public channel covering the water and environment issues in local languages with local participation. In-door workshops and discussion groups all try to address the issue from a particular perspective with less regard to the national interest or long term consequences of water development. Suspicions are not limited to domestic concerns but the international community is viewed equally with mistrust. Many interest groups feel that International donors including the World Bank are pushing large scale infrastructure projects as good business with little concern for the direct and indirect social costs inflicted on the people i.e. resettlement, environment, etc. In other cases a large segment of people in Pakistan, including WAPDA and in the international arena have felt that the bank abandoned them in their pursuit of dam development. The re-engagement strategy currently put in place has received strong international support worldwide in those countries where Water Country Assistance Strategy has been developed (i.e. India, Mexico, and Philippines etc.) Some political parties in Pakistan voice that if projects are trusted upon them, they will campaign against re-payment of loans as they view this against ethical loaning. The lack of political will and inability on parts of elected governments to take decisions of national importance have been marred with delay tactics and brushing aside the fundamentals-water will be scarce, increasing in cost/value and in limited supplies has further complicated matters.

Management of Water the Missing Link!

Water management at all levels is perhaps the most critical dilemma in the sector today. Regardless of how the nation precedes with large scale infrastructure it can only build trust and transparency by sorting out its management and governance problems at the Federal-Provincial-Canal and Farm Level. This requires a fresh look at the institutions and instruments that are in place to manage water. Without the long term intellectual base, analytical capacity and needed investment in establishing new institutions (Water Basin Authorities or other organizations that specialize in a integrated and comprehensive approach to water management) or giving greater attention to the water rights and entitlement aspects water will continue to be debated and its shortages widened. Pakistan can benefit greatly by taking a forward looking posture and set its house in order through a "Management led Philosophy"

7: An Analysis of Options

There is discussion on options other then dams. The political arguments tend to favor dams upstream of Tarbela i.e. Basha on grounds that such a dam would increase the life of Tarbela, would be less controversial to NWFP and Sindh provinces and there would be limited control of Punjab which some provinces as noted earlier fear will undermine the interests of smaller provinces. Other arguments include better sediment management demand management, pricing, improvements in agriculture water conservation and the sort. As these options are reviewed one thing stands out clearly-regardless of whatever decisions are taken with respect to new storages there is general agreement across all stakeholders that water needs to be better managed at all levels, water rights and entitlements need to be made much more clear with strict adherence to their implementation and finally there will be scarcity in the future that will require a comprehensive strategy to better mange, conserve and allocate water amongst different users. With this caveat in mind this section covers the various options and also comments on their pragmatic suitability in addressing the storage needs.

7.1. Declining Storage and options: The average canal water from the 3 storages Mangla, Tarbela and Chasma will decline from an estimated 15.7 MAF live storage to about 11.7 MAF by 2010 and by 2023 to an aggregate loss of 6 MAF.

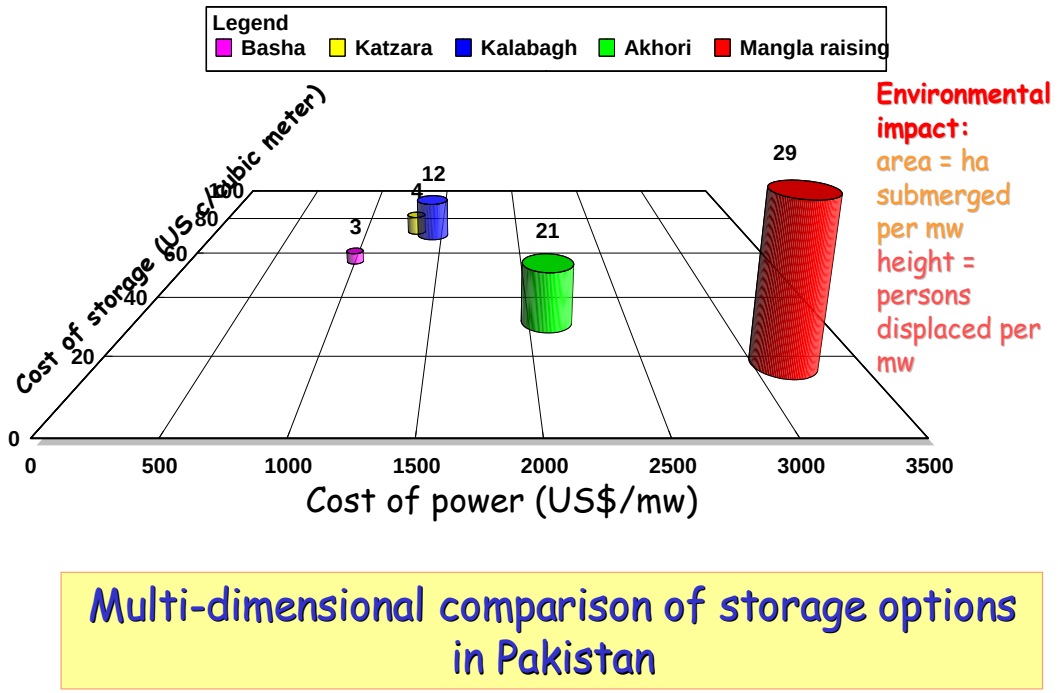
- There is little scope to develop new resources surface or groundwater
- Existing volume of storage is declining with negative implications for irrigation and power
- Pakistan will be unable to meet demand over next two decades with present storage.

Pakistan even under the most conservative scenarios as pointed out by the ADB study on Water Sector Strategy calls for a minimum of 18 MAF of storage to be developed over the next 20 years. Developing such a large infrastructure will involve billions of dollars and attracting such financing will require a long term comprehensive strategy with participation of different international agencies i.e. IFC, World Bank, ADB, Islamic Development etc.

There are some smaller projects like Gomal Zam and Mirani that are on-going. But such small efforts only add about 1.46 MAF that is rather insignificant when viewed in macro terms. Regardless of what decisions the make it is absolutely essentially to address the water management question at different levels. A brief synopsis of key technical parameters of the two large reservoirs under consideration Kalabagh and Basha are provided in Annex II.

A simple comparison of the three contending dams along with Mangla raising (already approved) project show the different trade-off in terms of cost of persons displaced and storage capacity is provided in figure 9. The trade-offs allow choices in the long run. For the time being only Kalabagh's feasibility are ready and the others will take 3-5 years to become serious contenders.

Figure 9: Multi-dimensional comparison of storage options in Pakistan.



Source and Chart Credit: Briscoe, J. Pakistan Road Show- multi media presentations to GOP and provinces, 2004

7.2 Storage and its implications:

The ADB Pakistan Water Sector Strategy study in line with the Water Vision 2025 states that minimum storage requirements replacement and to maintain agriculture productivity at low scenario level requires 18 MAF (22.2BCM) live storage by 2025. This includes 6 MAF to replace existing capacity due to sedimentation and 12 MAF to bring the average diversions to meet the projects requirements for low demand scenario of 134.07 MAF

7.3 Assumption 1 No additional storage:

Here it is assumed that no storage is built on the Indus and the present "uncertain state of affairs continues" Water conservation will then become the key thrust to improve crop productivity. This could be done through water management, lining of distributaries, land leveling, adoption of drip and sprinkler techniques and an array of improved water saving options like zero tillage, direct rice seeding, raised furrow/cotton-wheat[6]. The manual canal diversions will be stagnant at about 103.81 MAF. Keeping in mind that there is little scope to increase ground water extraction presently at 41.6 MAF not much promise exists in this arena. Under this analysis the current shortfall of about 11% in 2001 will increase to 23.5% by 2010. There will be serious food shortages that can greatly undermine the national economic growth rate. The net result would be expansion on costly thermal power and import of key food commodities. Put simply this would create immense hardship for the general populace and perhaps even challenge the sovereignty of the Pakistani nation.

7.4 Assumption II Additional Storage:

Under this scenario there will be a replacement dam for the lost capacity from Tarbela and Mangla just to maintain present level of storage (6 MAF) an additional 12 MAF will be built to bring the total to about 18 MAF. The estimated average canal diversion needs would be 134.07 MAF as in the scenario # 1. There will still be a shortfall but in years of good inflow much higher diversion will be possible. However, even if decisions were put in place right now large scale storage would only be available after 2010 because studies, design and construction would require 10-12 years or even more. Replacement storage will not work the miracles; however additional storage would help increase the average canal diversions beyond 103.81 MAF.

Dams will provide the needed security but will not be an outright solution. There will still be need for rapid investment in water saving technologies and additional expansions in the power sector. However by saving the dwindling water resources that translate into high value water it would be judicious to save each drop that can be put to productive pursuits. In earlier times of excess flows water wastages were less critical however, under a scenario of postulated climate changes and each and every country trying to conserve water it would be essential that Pakistan makes effort to store its water and make it available on equitable basis for the betterment of its people and environment.

It is important also to note that during drought periods there has been increase in productivity of crops like wheat particularly in areas that were prone to water logging. While such short term gains should not be translated into long term potential, the point is noteworthy that even droughts can lead to increase in production of certain crops. Likewise the recent heavy February, 2005 rains are a temporary phenomenon. While all predictions suggest that wheat production will be drastically reduced due to canal water shortages (less 47%), timely rains in February and a favorable low temperature is likely to have positive impact on yields, allowing the government to meet its target of 20.8 MT of wheat. Even the late planted wheat due to non availability of canal water could help compensate the losses and achieve higher production due to long grain filling period and low cold temperatures. The proper management of ground water resources can help address such temporary situations and act as a long term buffer that promotes stability and sustainability of the system.

8. Cost estimates of Kalabagh and Basha

There has been lot of attention given to the possibility of Basha dam with its feasibility completed in August 2004. The recently released feasibility report (WAPDA, 2004) for Basha points to relatively high cost of construction due to remoteness of site, the need to transport materials and power plants over hostile and difficult terrain. Besides the long distances present civil infrastructure may not be

[6] Details of these various options have been covered in the compendium paper on "Agriculture Modernization through water management.

able to support such heavy vehicle movement. Developing large scale and long distance grid stations and power line will also involve considerable cost and has been budgeted into the feasibility. Table 10 shows the breakdown of these costs. The power transmission facilities alone are US 994.2 million

Table 11: Summary of Capital cost estimate. Basha Diamer Dam

	(Million US $)		
Description	**Local**	**Foreign**	**Total**
1. Direct Costs			
A. Reservoir and Dam Including Diversion	573.9	708.3	1282.2
B. Power Generation Facilities	389.9	718.1	1108
C. Power Transmission Facilities	454	540.2	994.2
2. Indirect Costs Including Relocation/			
Rehabilitation of road ,EIA and Resettlement			
A. Permanent Facilities	156.8	30.9	187.7
B. Temporary Facilities	341.8	42.8	384.6
Sub Total	1916.4	2040.3	3956.7
3. Engineering & Project Management	154.9	78.7	233.6
4. Physical Contingencies @ 10%	207.1	211.9	419
Total Base Cost of the project	2278.4	2330.8	4609.2
5. Duties & Taxes	243.5		243.5
6. Escalation during Construction(Estimated)	428.1	279.2	707.3
7. Interest During Construction	568.5	329.5	898
Total financial Cost	**3,518.50**	**2,939.50**	**6,458.00**

Source: Feasibility Study, WAPDA August, 2004

Similarly breakdown of the cost of Kalabagh is provided in table 12. The Kalabagh costs are in 1987 prices. As pointed out earlier in table 4 current estimates would be in the tune of US $ 5 billion.

Table 12: Kalabagh Dam Summary of project costs based on June 1987 Prices (US$ 1.00=17.50) Estimated cost Description

Initial 8x300 MW Installation	**Local currency Component**	**Foreign Currency component**	**Total**	**Local currency Component**	**Foreign Currency component**	**Total**
Relocation and resettlement	204532	21145	225677	3579310	370034	3949344
Jinnaah barrage modification	3627	14965	18592	63475	261888	325363
Preparatory works	18085	2297	20382	316500	40189	356689
WAPDA & Engineering's Colony	37684	1310	38994	659460	22934	682394
Camp & mobilization	84674	127011	211685	1481794	2222691	3704485
Division works	26611	36689	63300	465682	642062	1107744
Embankment dames and Earthworks	157551	333254	490805	2757160	5831936	8589096
Power intakes & conduits	68001	98411	166412	1190010	1722196	2912206
Power station	103214	110634	213848	1806244	1936095	3742339
Convertible conduits	75310	97806	173116	1317919	1711612	3029531
Orifice spillway	81522	82813	164335	1426644	1449225	2875869
Overflow spillway	71987	67429	139416	1259782	1180000	2439782
Mechanical & Electrical equipment		304408			5327140	5327140
Sub- Total	**932798**	**1298172**	**2230970**	16323980	2.3E+07	39041982
Physical contingencies @10%	93280	129817	223097	1632398	2271800	3904198
Sub- Total	1026078	1427989	2454067	17956378	2.5E+07	42946180
Engineering & Administration @ 8%	82086	114239	196325	1436510	1999184	3435694
Total project cost at june1987 prices	**1108164**	**1542228**	**2650392**	**19392888**	**2.7E+07**	**46381874**

Source: WAPDA Kalabagh Dam Project Executive Summary 1988.

Beside the above direct costs there are costs associated with resettlement and in terms of areas that would be inundated. If, for assumption sake Kalabagh were to be started in 2006 it would displace about 132000 people from Punjab (76600) and NWFP (54,500). Majority would be from Punjab. In either case of Kalabagh or Basha no direct displacement or social cost is generated for the other two provinces (Sindh and Baluchistan).

Also noteworthy is that Kalabagh will cover 164 sq miles or 425 sq kilometers. In terms of land 134500 acres (54450 HA) are affected. In terms of type of land, culturable land (35000 acres) and unculturable 99,500 acres are affected. At an elevation of 915, the culturable land acquired permanently would be 27500 acres (24,500 acres in Punjab and 3000 acres in NWFP). It is also worth noteing that only 3000 acres of irrigated land is affected (2900 in Punjab and 100 in NWFP), the remainder is essentially low (cost and productivity) barani lands. According to WAPDA plans, 27 new villages will be required, 20 extended villages and proposed number of 16700 new plots will be needed. Thus, much of the aggregated costs occur in Punjab and NWFP. The direct impacts of the project are also on Punjab while seepage will benefit some of barani areas in Punjab and NWFP by raising the water table as has been the case in Tarbela.

Implications of Waiting on Resettlement-Raising the future stakes!

An added consideration is the re-settlement of the population. At present the population is much higher in Kalabagh areas (83000 at inception in 1983/84 and 125777 in 2005) then in Basha 24000 in 2004. Assuming same growth rates of 2.1 % the population in Kalabagh areas(2025 estimated at 194590) would expand in higher quantum compared with Basha (2025 estimated at 37132). This aspect would mean that over next 20 years implementation horizon it would be better to focus on Kalabagh first and follow this up with Basha where population is relatively low. Ideally if the resources were in place both dams could be started simultaneously-which would obviously be taxing in capital and human resources.

Table 13: Arguments for and Against Kalabagh Dam

Arguments of those favoring	Argument of those Against
Serve as Reservoir, would store surplus water in flood season	Drainage of surrounding area of Mardan, Pabbi and Swabi will be adversely affected.
Generate a large chunk of hydropower to meet growing needs (2400 MW)	Fertile cultivable land would be submerged
Replace storage lost from existing dams i.e. Mangla, Tarbela and Chashma	Large number of people would be displaced
Provide additional storage to meet existing water shortages	Sindh will be rendered into desert
Provide effective regulation of Indus river to meet additional Kharif allocations	Lack of surplus water to fill Kalabagh
Regulation and control of high flood peaks in Indus	High level outlets would be used to divert water
Create employment for 30,000 persons during construction and operation	Cultivation in riverian areas would be adversely effected
	Sea water intrusion in Indus estuary would accentuate
	Mangrove forest would be destroyed
	Fish production and water supply below kotri would be adversely affected

* Based on review of several papers see Bengali, 2000; Khan et al 2000 and others

9. Benefits and tradeoffs of Kalabagh and Basha Dam

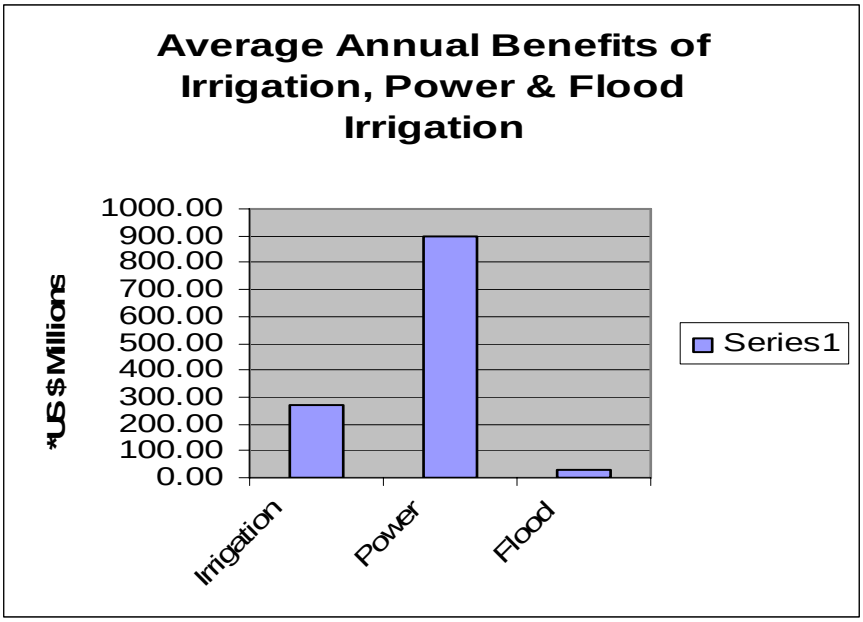
The financial costs of the two dam have been presented above in this section. Besides the direct costs these dams will displace Kalabagh (125,000) and Basha 24,000. In both cases there are no known significant environmental costs that make either of these dams infeasible.

The more important aspects that need a closer look are the benefits of these dams that have been well analyzed in the feasibility reports of Kalabagh and Basha. The analysis for Basha appears to be analytically more rigorous.

9.1 Benefits:

The average annual benefits from Kalabagh are given in figure 10. While the predominant reason to build Kalabagh is stated as irrigation the annual irrigation benefits are almost 1/3 of the estimated power benefits. The annual benefits from irrigation were estimated at Rs. 12.53 billion in 1998 price level or US $ 268.31 million. In terms of 2005 prices this would translate into US $ 482.94 million. Likewise the estimated annual benefits in 1998 prices for power are Rs. 42 billion or US $ 899.36 million at nominal exchange rate 46.7 (1998). In 2005 US dollar terms the power benefits are calculated at US $1618.83 million. Average yearly benefits from all sources are estimated to be Rs. 33.20 billion per annum. The benefits from flood are estimated to be Rs 1.44 billion per annum in 1988 prices equal to 30.84 million dollars. In 2005 prices this would be US $ 55.94 million dollars. While the flood benefits are low their overall impact on the economy is multifold in terms of their indirect consequences avoidance of loss to life and property. The estimated Economic Rate of Return (ERR) for Kalabagh according to the feasibility report using 1987 prices is 16.8%. The report entitled Project Costs and Economics does not provide estimates on aggregate values for the three types of benefits- for comparison with other long term investments this would be useful information. The average annual benefits can be aggregated be aggregated over the life of the project (say 50 years). At an average of Rs. 33.20[7] billion per annum this would amount to Rs. 1660.0 billion over the life of the project based on 1987 prices. Converting Rs. 1660 billion into 2005 level would translate into (Rs. US $ 63.98 billion)

Figure 10: Benefits of Kalabagh Dam in 1988 prices



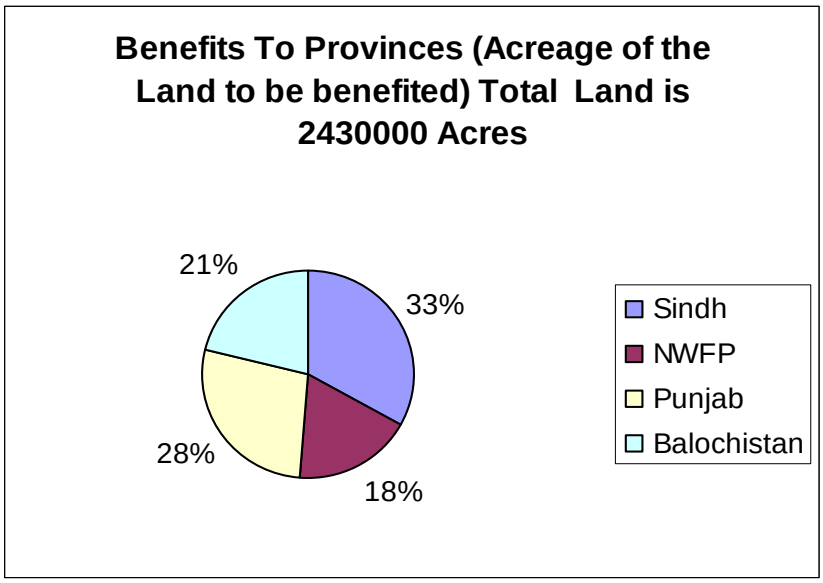
Source: Kalabagh Dam Project, Pakistan Water and Power Development Authority. Public Relation Division, WAPDA, Lahore Pakistan (July 1998)

- Rs. converted into US$ at 1/46.7 (1998)

[7] By construction of Kalabagh additional Rs. 3.5 billion revenues are attributed to come from Tarbela. If this aspect is excluded average annual benefits are reduced to Rs. 29.70 billion

In terms of sharing of the irrigations benefits, the report estimates that 243, 0000 acres of land will benefit from the waters of Kalabagh. The distribution of these benefits amongst the provinces is shown in fig 11. Sindh followed by Punjab are the highest beneficiaries. Kalabagh will provide the necessary storage capacity to maintain continuity of agriculture. In the absence of another reservoir Kalabagh will increase the storage volume available in Pakistan by 48%. The maximum annual demand in the irrigated area below Kalabagh is about 67 MAF that exceeded 79 MAF by mid nineties according to the project feasibility.

Figure 11: Kalabagh Dam Benefits to Provinces

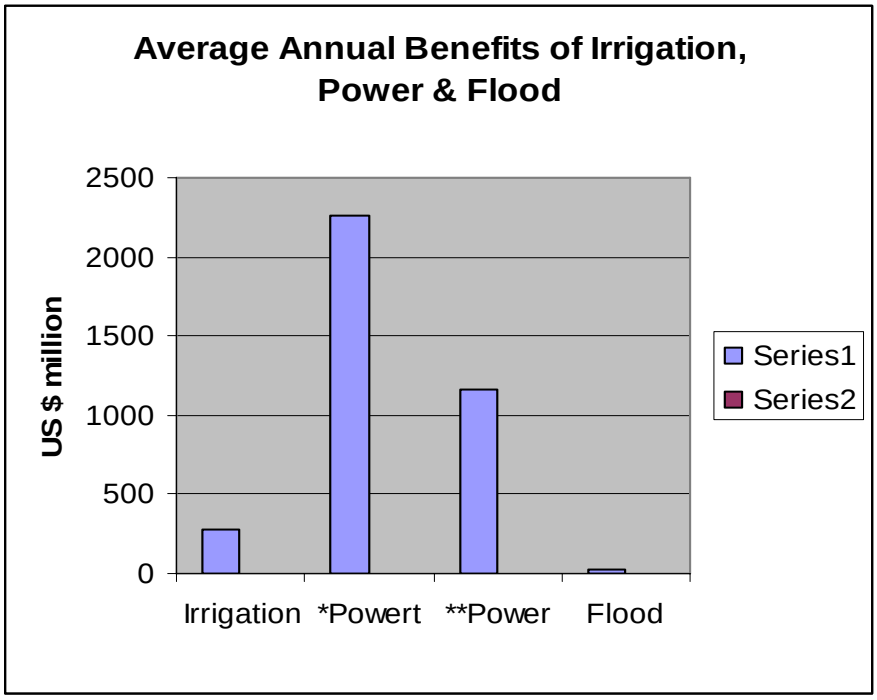


Source: Kalabagh Dam Project, Pakistan Water and Power Development Authority. Public Relation Division, WAPDA, Lahore Pakistan (July 1998)

9.2 Benefits of Bhasha Dam.

The Basha feasibility has just been finished and the estimated time of completion of the project if it is to go ahead is scheduled in 2015. The average annual irrigation benefits are estimated at US $ 273 million (US $ 197.5 million in Rabi and US $75.52 million Kharif); average power benefits at project tariff are U$ 2259.28; at constant Tariff plus consumer surplus US $ 1744.08 million while flood benefits are estimated at an average value of US $ 25.61 million. While the flood benefits are almost similar to Kalabagh, the power benefits (tariff plus consumer surplus) are about six times higher than irrigation benefits for Basha. The FIRR=14.92% and EIRR is 17.35 % at 12% Discount (WAPDA, 2004). As noted earlier Basha would displace 25000 people if it were started in 2005/6. All these displacements would be from district Diamer in the Northern Mountainous region of Pakistan.

Figure 12: Average Annual Benefits of Irrigation, Power & Flood.



Source: Feasibility Report of Basha Dam
*Average Annual power benefits on the basis of Energy delivered at consumer end at projected tariff
**Annual Power Benefits on the basis of energy delivered at Consumer end at constant tariff. (including Consumer Surplus).

Basha generates more power of the two dams, stores similar amounts of water and the flood benefits are likewise almost identical. The economic efficiency measured by the FIRR is not too different. Basha also extends the useful life of Tarbela (thus continuation of its storage and power benefit). Since, Basha as noted earlier requires a full design, vetting and tendering it is pre-mature to speculate on the decision with respect to this dam in the short/medium run 3-4 years. The technical design, its placement at high elevation, possible delays speculated on the Karakorum Highway (about 140 km of this Highway would be submerged), the high maintenance cost of the transmission lines, height 920 feet with its associated risks (sesmic) were noted as points that need further consideration when looking at details of Basha (Dawn, 2004). There is also reservation amongst some technical experts about the completion of this dam by 2015 indicting that 2018 would be a more realistic estimate**.**

Feasibility of Kalabagh is complete in all respects and tendering can take place on short notice, in contrast Basha feasibility has just been released and will require detailed design and other support studies- with possibility of another 3-4 years for this process. Thus, realistically at the moment Kalabagh is the only fund worthy project. Since both dams are technically and economically feasible from the present documentation the politics will decide whether one or the other and even both are to be undertaken in a long term scenario. As noted earlier dams do generate social and political resistance but seldom do changing sites allow a neutral playing field? In the case of water one conflict leads to another—only judicious decision making that takes into account all interests and allows for a practical participatory assessment of the needs and wants can resolve such complex problems. Debate, advocacy, analysis and widespread consultation may help but the final decision has to be taken on technical, social and economic merit.

The nation will have to define its own interests in the light of time frames, cost, socio-economic aspirations and the resolution of hidden political agendas. Kalabagh dam has faced considerable resistance due to the resettlement aspects and above all the fears of Sindh province (lower riparian)

over possible hegemony over the waters of Kalabagh once it is built. To enter into political consensus through negotiations is a wise option given the fact that the design for this dam is ready; several donors have vetted this feasibility. The case for and against Kalabagh has been documented extensively (Bengali, 2000, Khan 200; and several others). There are almost over 200 articles in the press "for and against" Kalabagh and it seem that as Basha and others develop many more will be added to this list. If, Pakistan wishes to weigh its options it can wait a few more years till similar resistance develops for Basha—the only aspect that will rise is the cost- both financial and social. Highlighting the benefits and costs to the general public and explaining them the implication is one aspect missing from the overall campaign to accelerate the decision making process[8]

When viewed over a 50 years long term perspective with growing population, higher demands for agriculture, expanded industrial requirements for power most likely both Kalabagh and Basha will be needed and perhaps even an additional dam of 6-8 MAF on the Indus. Within this timeframe it is then just a matter of sequencing the choices and not debating one over the other. Since, the analysis and documentation for Kalabagh is in place and as recommended by Lieftinck and noted earlier Kalabagh may be a more reasoned choice.

10. Exploitation of Ground Water Resources: While most experts agree that potential ground water resources are already being over-exploited there is an opportunity to still utilize approximately 1 MAF of ground water through further mining. The balanced and sustainable use of this reserve through conjunctive application with canal water can be better managed. However, over use in certain areas where there is already pressure on the aquifer and the absolute lack of any form of regulation creates problems, especially in those areas that grow high delta crops requiring much more water i.e. rice, sugarcane.

The government and public media lament about water shortages especially for drinking water but no reforms have been put in place to manage this scarcity through better demand management. No effective metering systems exist and multiple uses **and** users still feel that cheap and unlimited supply is a civic right. There is a challenge to clearly establish and mange the water rights amongst different users. Two papers in this series on Ground Water and the other on Water rights address some of these issues in greater detail.

B. Other Options

1. Sediment Management: This option explores increasing the life of Tarbela through better sediment management. Most arguments are based on the TAMS study of 1998. The study findings provide for simulation of various alternatives to

a) find out whether flushing was technically feasible and could be used to estimate storage capacity that could be sustained in the long run
b) analyze reservoir survey results and predict future sedimentation rates

This study put forth a three phase action plan

1.1. Reservoir Operating Strategy. They suggest that raise the minimum reservoir level to 1365 feet and by 4 feet each year afterwards, limit the draw down period to a maximum of 15 days. This

[8] *GOP and highest level of decision making at President and Prime Minister Level are still grappling to make a final decision about storage. In January, 2005, General Musharaf announced that a final decision would be made within 3 months. The president has further intensified is public campaign on dams with addresses in Sindh and Nowshera (NWFP) explaining the public pros and cons of the two dams and their necessity.*

approach would ensure security of power tunnel intakes for the next ten years to complete construction of underwater rock-fill dike and minimize reduction in live storage

1.2. Underwater Dike: There was an also a suggestion that construct a rock-fill underwater dike to protect the intakes of tunnels 1-4. Technically the dike would require about 8 Mcm of rock fill; have a crest of 1380 feet and an overspill section at1340.

1.3. Flushing By-pass: This proposal requires a high capacity by pass to flush sediments on the left abutment between the main and auxiliary spillways where flushing would be carried out on a 30 days period.

The consultants felt that by following this plan the long term sustainability of Tarbela's capacity can be ensured.

This approach outlined by TAMs has generally been put forth as an alternative to constructing a dam of a capacity of 6 MAF (i.e. Kalabagh) see Bengali, 2003.By utilizing the approach proposed by TAMS and following a reservoir operating strategy by raising the minimum reservoir level to 1365 feet and by 4 feet each year thereafter, limit draw down period to a maximum of 15 days those against the Kalabagh dam feel that the problem of siltation and the need to build another dam can be avoided (Khan, 2000).

The WCD Pakistan Tarbela dam study conducted by Asianics in 2000) and of which the author of this paper was heavily involved with looked at these alternatives and provided the following comments.

i. The report states that while TAMS originally looked into the sluicing option. However since almost 50% of the annual sediment passed during the months of June and July sluicing could be a major breakthrough in enhancing the life of Tarbela. However it was concluded after deliberations that effective sluicing of Tarbela was precluded by the nature of the site due to broad valley, great dept of alluvium beneath the dam thus enough outlet could not be provided.
ii. Sluicing through the tunnels was not possible because of the likelihood of damage that could be caused by high tunnel velocities. The technical limitations do not support such sluicing.

With these limitations the proposal put forth by TAMS were considered infeasible. Another consideration was that by following these proposals power generation capabilities would be restricted for about 60 days making this scheme impracticable. With these facts TAMS also concluded that sluicing would not be practicable. There is general agreement amongst dam experts in Pakistan that TAMS proposals are no longer a pragmatic solution to Tarbela's problems.

2. Demand Management: Demand management is closely tied to the manner in which the overall water resource is managed. Thus the theme of development and management go together and is an integral part of the whole strategy to improve delivery of the benefits through more efficient management. This is perhaps a weak link in the existing system that requires new investment. Investment in infrastructure be it for rehabilitation of the existing assets or creation of new assets has to evaluated in a holistic perspective with a clear appreciation that returns to development are contingent upon how well it will be managed. The paper has stressed the need for addressing the water storage needs given the highly stochastic nature of the river system, climate change patterns, and changing demands of the population. A new dam in Pakistan would essentially provide replacement storage, allow continuity of Pakistan's agriculture and would generate low cost hydropower. Without this facility and depleted storage due to sedimentation, Pakistan's agriculture would be seriously jeopardized. In the event of new dam (s) it would be most critical to establish a

well laid out management plan that demonstrates the trade-offs of these benefits (irrigation and power); how demand is managed during periods of stress for both these products and what will be economic (differential pricing) and institutional measures (clear water rights, tradable water markets) that could make demand management more effective. An alternative to restrict storage to current levels has also been discussed by better demand management of the irrigation and power generation of existing dams. Demand and supply are essentially controlled by some regulatory mechanism i.e. quotas, tariffs, prices, historical trends etc. In the case of irrigation water there could have been a major crisis in the making with 2004 releases for Rabi almost 47 % less than the previous year. As noted earlier dams are likely to fill only about 75% of the time and even less. There will be wet and dry years and a stochastic curve that governs these patterns. Given this stochastic nature this aspect be built into the future management plans (operation rules) and all parties concerned with sharing of the benefits clearly apprised of these facts. Secondly, while the present rains have greatly helped in salvaging the Rabi crop, in the absence of these rains there would be much reduced flow for the irrigated wheat crop.

With a growing population 2.10%, the demand for water and power will increase at a higher rate. Projections for food and food security require that the irrigation needs of the nation be met. Likewise hydropower is a cheap source of energy with minimal environmental impacts. There is a significant trade-off between storing water for agriculture and using it for hydropower whereby the later provides a much higher value. Growing levels of income place higher demand on power needs and fulfilling such public and commercial needs are vital to achieve long terms sustained growth.

Present demand management for irrigation water is based on payment of abiana in addition to other land revenue taxes. It is doubtful that merely increasing the dismally low abiana, even two or three times would greatly increase efficiencies in usage or help cover the mounting cost of O&M of the irrigation system. It is only a high price for water often in absence of an alternative like (tubewell pumped ground water) that farmers start changing water usage. The best yields reported are often on the middle reaches in irrigated areas and lowest amongst tail enders. Greater attention to water demand management at different levels and more clear water right/entitlements that are enforced through user participation are likely to be a better solution. While the warabandi provides clear water rights—such rights are of no use if there are no flows in the canal or mismanagement occurs at the reservoir level. The abiana fails to reflect the true opportunity cost of water or even comes close to its shadow price under different use regimes.

Table-14: Abiana Rates for Major Crops in Pakistan (Rs/acre)

Crops	Punjab*	Sindh	NWFP	B' tan	Range
Wheat	59	53	63	70	53-70
Rice	83	89	148	124	83-148
Cotton	83	93	148	126	83-148
Sugarcane	178	182	328	242	178-328
Oilseeds	65	75/53	118	70/56	53-118
Fodders	36	53	87	56/70	36-87
Fruits (K)	113	142	155	99	99-155
Fruits (R)	42	142	155	99	42-155
Vegetables (K)	113	142	130	99	99-142
Vegetables (R)	42	142	130	99	42-142

Source: PIDAs

*In Punjab, the water charges per acre are Rs. 50 for Rabi and Rs. 85 for Kharif crops under flat rate system

Differential rates are employed i.e. orchards rate is higher; the abiana rates are very low to cover even fraction of the O&M costs.

There is a strong need appreciated by the farmers but vehemently opposed by the irrigation departments that demand management of water at the canal level is assigned to farmer organizations. The Farmer organizations or "Nehri Panchyats "are community based principles that use a participatory framework allowing them to

- Manage, operate, maintain and improve the irrigation and drainage infrastructure
- Supply the water equitably and efficiently to all users
- Assess and collect the water and drainage cess and pay an agreed amount to the irrigation authority
- Settle member disputes.

While the communities strongly support this system, there are vested interests to see that this system does not see the light of day—there are hidden benefits of cheap water, corrupt add-on to existing supplies by large farmers etc. certain quarters wish to ensure continuation.

While the communities strongly support this system, there are all out efforts by vested interests to see that this system does not see the light of the day—there are hidden benefits of cheap water, corrupt add-on to existing supplies by large farmers etc. While this option is available there will be considerable resistant to widespread reform. Thus solely concentrating on the farm level water management issue and expecting it to serve as the panacea of all water problems may not help realize the desired results. Current estimates place the needs over next 25 years between 20-25 MAF and a minimum storage requirement of 18 MAF—this includes 6 MAF of reduced capacity from Tarbela and Mangla and an additional 12 MAF to barely sustain the agriculture of the country. The cost roughly 22.5 MAF of storage is estimated to be US 14 billion; however the cost of expanding irrigation in its absence would be US $ 32 billion according to Water Sector Strategy, 2002. As a two pronged strategy if agriculture could be developed fully and water conservation techniques were widespread there would a hypothetical situation where the additional 6 MAF capacity could be covered by conservation measures. Still about US $ 10 billion would be needed to build the needed 18 MAF.

3. Pricing: Water prices both for irrigation and drinking are dismally low as noted above. Even one sided increase or cross subsidization (output price increase) will not automatically solve the water supply/demand problem. The question of mismanagement, water right/entitlements and governance is most fundamental. There is also potential to introduce market based pricing systems with tradable water rights for irrigation users on pilot basis. Successful models have been demonstrated in Australia, Egypt and Israel. Tradable water rights and differential pricing through segmented market based on demand and value options are a way to control demand and put scare water to its best use-where it gives the highest return after meeting basic drinking water needs. Making people pay price close to the marginal value product is not easy. Without a regulatory mechanism and knowing how many users are to fall under this pricing scheme, its implementation would be difficult. What happens cross borders (India) where Pakistan competes for its agriculture trade is absolutely a different matter. The almost negligible price farmers pay for electricity partly explains the higher productivity and profitability of farming in parts of India. A clear understanding of demand elasticities for different groups and markets is necessary before pragmatically implementing new price regimes.

11. Reduce Storage Requirements by Water Saving in Agriculture: It has been estimated by the ADB Pakistan Water Sector Strategy that possible 4.7 MAF water could be saved through conservation in current irrigation efficiency of 40-45%. Such savings in usage imply that the same water saved will probably improve the state of the aquifer. If, others do not follow suit, those not participating in efficiency improvements just gain access to more water through the aquifer that ones being efficiently helped improve. What are the linkages and related interactions is a complex question. Without a basin level dynamic model the true relationships, magnitudes, simulations are merely hypothetical and best avoided. Likewise in areas where a recharge is a necessity measures have to be put in place to ensure that a monitoring systems warns against overuse and incentives are built in to maintain the health of the aquifer. Much of this would come through intensification of on-

farm water conservation efforts. In addition to canal lining new agriculture techniques like lazer leveling can help conserve water. Besides being wasteful, excess application leads to water logging and salinity. To save about 4.7 MAF will cost the public exchequer roughly US $ 1.66 billion. This is quite attractive against a dam that will cost around 4.5 billion for the same saving and storage capacity. The main difference would be that the saving through agriculture does not generate any power benefits nor will it provide the necessary regulatory storage so essential for growing Rabi crops like wheat, sugarcane. Implementing widespread agriculture will require a 20-25 years planning and implementation

C. Needed Preconditions for Development of New Storage:

The analysis presented in earlier sections suggests that there are several preconditions that if met would make the participation of the World Bank less risky and help enhance its reputation. Amongst others these could include:

1. Ensure much more clarity of the Rights and Entitlements at different levels and strategies that would ensure the compliance of these rights
2. Resolution of the apprehensions on dams to satisfaction of parties concerned. The World Bank could facilitate such a dialogue and eventual agreement on the lines of the IBT. Developing such a consensus should be considered a necessary condition for Bank financing of dams.
3. Settlement of the minimum flow issue in the light of upcoming studies.
4. Development of a dynamic model while not necessary a pre-condition must be considered of high priority to make realistic evaluation of the various emerging scenarios within a basin framework
5. A demonstrated commitment on part of the government that it intends to address the management issues regardless of the decisions it takes on dams
6. While both Kalabagh and Basha feasibilities confirm that there will be sufficient flows to undertake water development in the future. The Bank should ask for a more rigorous analysis even if it is rather modest in nature to ensure itself that sufficient water will be available for storage given the best available information. In particular it would make it a pre-condition that climate change scenarios, glacier related aspects are adequately addressed.
7. The Bank in its final analysis is an investor and would have to be assured that the investment it undertakes provides an acceptable return within defined risks associated with it and attractive in relation to other options in the country.

1. The National Water Accord on Apportionment of Waters

Apportionment of Water of the Indus River needs to be followed in letter and spirit. There have been complaints-especially by the lower riparian Sindh that at times its allocations are not strictly adhered to. One reason for this complaint relates to the overall reduced nature of flows like in 2004 when for reasons beyond anyone's control overall flows were reduced by almost 50% during the Rabi season. At other times complaints from Sindh have focused on reduced flows to Indus delta which during drought were almost 1 MAF as opposed to the expected 10 MAF. The accord is appended as **ANNEX-** There is a need to develop more clarity on "principles and procedures" to be followed under different scenarios and these must be made public and transparent. As a Bank pre-condition for engagement, a comprehensive set of operating rules and regulations must be in place fully vetted by the competent authorities. A viable and functioning Indus Basin Authority revamped on modern lines with the necessary powers would greatly meet this pre-condition. There must be clear national guarantees issued by the legislative bodies that these guidelines will be adhered to and any deviations will not be made one sided but must be done with the written consent of the provincial

governments. Tying these conditions for payment of *royalties and distribution of other revenue receipts especially from power revenues* would be a step in the right direction.

11. Resettlement Issues:

Resettlement issues have received high profile protests with expressed dissatisfaction on the compensation rates, possession of land permit. Tarbela affectees have lodged serious complaints that they have not been adequately addressed. While the government has clearly established rules of compensation these need to be updated and revised according to current economic conditions and societal norms. Such compensation must be "fair and reasonable" and must encompass both the direct and indirect settlers that are affected by large involuntarily settlements. There is considerable knowledge on the resettlement procedures that are currently being adopted world wide-Pakistan needs to familiarize itself with these procedures and also develop a framework that is widely debated and has acceptance amongst the majority. The grievances of the minority must be addressed under prevailing law of the land.

For upcoming schemes that are likely to cause large scale involuntary settlement e.g. Kalabagh 125,000 people to be displaced, the government would be required to propose transparent and widely consulted resettlement packages both for direct and indirect settlers. In the case of land compensation guarantees would needed on the location, local acceptability, value and unencumbered availability of such land. Since, there has been a marked preference for most dislocated people to resettle in nearby vicinities priority should be given to seek assurance that people are resettled in the nearby areas. The cost and social implications of such resettlements needs to be looked through very carefully. A draft resettlement policy is in place and will require both national and international vetting for it to be pronounced "fair and just".

12. Questions and Concerns of Royalty and Benefit Sharing:

Diverging views have been expressed about the sharing of royalties from Dams in Pakistan. For example NWFP received a gross royalty of roughly Rs144 billion for the period 1975-98 (equivalent to US$ 17.46 billion in 1998 dollars terms) from Tarbela Dam. For instance annual budget of NWFP was Rs. 28.52 billion in 2005. A separate 6 billion rupees is provided as a special royalty grant over and above the budget made available to NWFP[9]. While the dam has been constructed upstream and most benefits accrue to the upstream population significant social costs are generated downstream (other than initial cost of resettlement and environmental damages near the lake- that are considered minimal). With the lions shares of royalties going to the NWFP province there is considerable uneasiness amongst other provinces. An innovative approach to share these large royalties may make the issue of controversial projects like Kalabagh more negotiable and potentially in the domain of being settled after 35 years of bickering and half hearted attempts at conflict resolution. Developing a more equitable formula for sharing of the royalties in light of where costs and benefits are generated in a broader sense could be built into the design aspects of the proposal for any future dams. The constitutional basis (National Awards Commission) could establish an equitable formula through more transparent and debated process for future dams. This may be a pre-condition to resolve the present debate. Those that are hurt need to be compensated both from the initial outlays and in the form of proportional royalties over time. In addition there must be clear schemes of regional development initiatives along the Indus Basin that are likely affected by the construction of water infrastructure. Commitments to such concerns need to be demonstrated in terms of regional development initiatives. Such programs are likely to be viewed positively by the donor community and especially by those solicited for financial support for dam projects on the Indus. In certain cases progress in this direction could appear as a pre-condition for investment in dams.

[9] I would like to thank Dr. Sarfraz Qureshi (consultant) for clarifying this point to me.

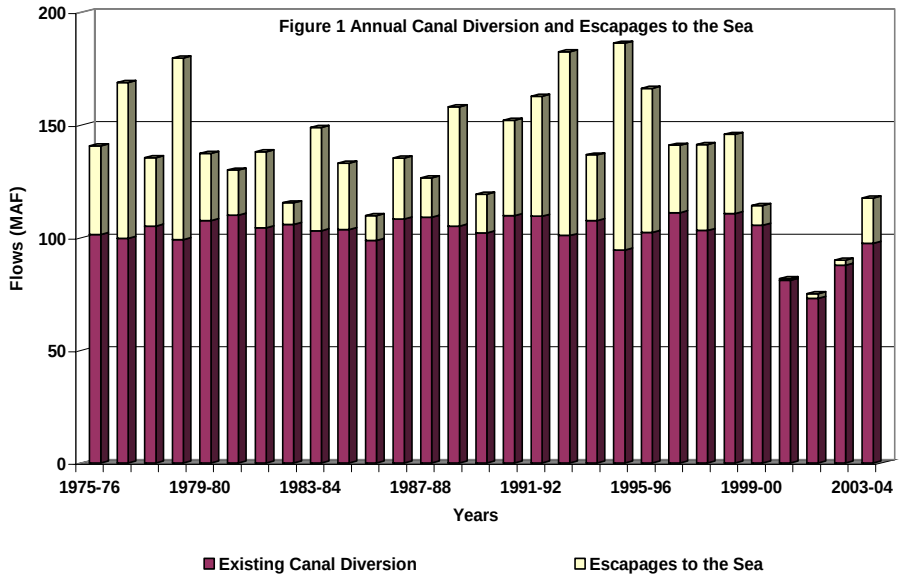
13. Environmental Flows.

The need for certain minimum escapage to sea below Kotri the last Barrage on River Indus was recognized in Para-7 of the 1991 Water Accord, which reads as follows:

- The need for certain minimum escapage to sea below Kotri to check sea intrusion was recognized. Sindh held the view that the optimum level was 10 MAF, which was discussed at length while other studies indicated lower/higher figures. It was therefore decided that further studies would be undertaken to establish the minimal escapages needs downstream Kotri.
- As a follow up of Para-7 of the 1991 Water Accord the Government of Pakistan through Ministry of Water & Power and Indus River System Authority (IRSA) made several attempts from 1991 to December 2003 to undertake studies to establish minimum escapages needs downstream Kotri Barrage in line with above Para. These efforts were made through Council of Common Interests (CCI), UNDP, World Bank ECC. In 1995, the ECC considered decided inter-alia that "the Ministry of Water & Power in consultation with Provinces / concerned Ministry and in accordance with the provisions of the Water Apportionment Accord should undertake further studies to establish the minimal fresh water escapages needs downstream Kotri. However these efforts which were made during the periods of past Governments did not materialize on account of differences of opinion of provinces on the Terms of Reference (TORs) of the proposed study especially by Punjab and Sindh.
- On December 16, 2003, The Parliamentary Committee succeeded in developing consensus among the four Provinces and getting their agreement on earlier TORs for the two studies prepared by the office of the Chief Engineering Adviser & Chairman Federal Flood Commission M/O Water & Power and IRSA for the two studies namely i) *Study on water escapages below Kotri Barrage to check sea water intrusion and ii) Study on water escapages below Kotri Barrage to address environmental concerns*. The committee also decided to undertake third study *to address environmental concerns of all the four provinces (Excluding Areas Covered In Study-I&II)* through Government of Pakistan financing (WAPDA, 2003).

These studies will try to address the different ecological and environmental requirements in the basin on the Eastern Rivers and on Indus especially below Kotri. The latter has attracted some debate with reports claiming about 40 MAF as the minimum required flow, while Sindh has been claiming that at least 10 MAF flows are required to sustain the mangrove and delta areas below Kotri. Regardless of what figures and management practices the forthcoming studies recommend one thing is clear that these recommendations will be debated and the Sindh province asking for "more is better then less". While there is agreement that minimum flows are essential for the environmental health of the basin—one must also be clear what are the critical times (during Kharif no problem) for water releases in order to balance these flows in an economically and socially rational manner. A vibrant water market (foreseeable down the line) may allow certain users to trade over these minimum flows and even enhance or supplement these flows during lean periods and allow for different usage of water during less critical periods. Such tradable surpluses will have to be looked at carefully and require much more thinking and analysis to determine there workability on a Basin wide basis.

Figure 13: Already environmental flows in to the delta ("escapages to the sea") are Often less than the estimated environmental flow requirement of 10 MAF/yr.



Source: J Briscoe. 2004. World Presentation to Provinces (updated to 2004)

14. Political Economy of Decision Making

Large dam are considered Mega Projects that attract the attention of a wide array of interest groups. Such attention often takes the form of national debates whereby political and social groups try to assert their peculiar viewpoints. These debates help bring out conflicts often unrecognized at the time of inception or not given serious enough consideration (i.e. social costs, environmental impact). The debate on dams in Pakistan is on-going for a considerable time—for example Kalabagh is on the cards for now over 35 years. New proposals and feasibilities are being undertaken i.e. Basha etc. These are all parts of the 12 dam sites that were identified by Lieftinck (1968). There have been several past governments like those of Nawaz Sharif and Benazir Bhutto that were sworn-in with huge mandate and overwhelming majorities. Each of these governments shied away from taking bold decisions on these large reservoir projects. However, once a decision was taken on the rather controversial Motorway Project by the Nawaz Sharif government the Benazir government that was elected into power did not intervene and the project was successfully completed. So what is so special about large dams that even strong governments shy away from these projects? Even the half hearted effort to built Kalabagh by Prime Minister Nawaz Sharif was marred by uncertainty. Governments that followed used a "wait and see approach". This type of uncertainty has further aggravated the conflict and with nation wide water shortages even the political apparatus is being taxed. Only the intensity of noise increases, issues remain the same and often unattended with bureaucracy sharing the helplessness of those in power and those over-powered.

In recent years the NGO's often with international funding and networking have raised the issues of large dams. These anti-dam lobbies try to create doubts about newly planed projects often without a clear technical, social and economic understanding. What they overwhelmingly and rightly question is the social costs these dams generate (people, resettlement, and environment) and worry that these concerns are not sufficiently addressed in the existing proposal. The views of such quarters are well documented but seldom help decision makers and politicians to evaluate the options where a decision can be arrived at. The political economy has pitched itself against upstream vs. down streams interests. Loud noises are made about the costs of new infrastructure i.e. Kalabagh US$ 5.6 billion; Basha US $ 6.7 When down streamers want to talk about cost they want to turn a deaf ear

to benefits. The mistrust with WAPDA continues — partly because it is unwilling to address the issue of transparency.

In political economy power brokers often wish to present the dams issue as the most fundamental and the only unique issue specific to Pakistan. Not realizing that all countries go through such debate including India where with the Narmada the argumentation and counter argumentation has been going on for a long time and finally put to rest through a court ruling-allowing the continuation of works on the Narmada dam. The technicians and analysts clearly realize that the dam's option has to be evaluated purely on the technical, social, economic, political and administrative grounds. They tend to conduct the analysis only as far as technical and the economic domain is concerned and leave the political and administrative intricacies for open debate. Since the benefits of dams are closely tied to the power and agriculture sectors there are strong lobbies in the assemblies that wish to ensure their interests are fully incorporated into any new proposals**.** The only difference this time around is that Pakistan got Tarbela and Mangla built within a treaty framework now if it is to go ahead with replacement storage or developing future capacity much of the financing will have to be done by Pakistan, even if it is in form of external loans. Thus the question of direct costs must be evaluated with the minutest details. The uncertainties with respect to design are also raised in various circles. Society wishes to minimize the variance between predicted and actual benefits. People want to be assured of what is promised is what they will get.

The social pressure on Pakistan is immense in the light of unprecedented growth rates in India. In relative terms Pakistan would lag behind tremendously if it does not make the right choices. Right choices are perhaps those that are well reasoned with the best available information, take into account all options, engage those affected directly and make them recognized stakeholders. Proposals that help eradicate widespread poverty and lead to multidimensional and sustained multiplier effects are considered important and when explained carefully will carry support. Where large infrastructure projects utilize local expertise, materials and much of the costs are internalized and the benefits can be shared with the local populace. This aspect must be built into the design. Focusing more on labor intensive vs. capital intensive technologies that engage labor resource of all the provinces especially, the lower riparian and the traditionally neglected areas would make proposals more attractive. When large contracts are conceived to involve overly international participation in proportion to joint ventures engaging higher level of domestic resources, such proposals are more liable to face resistance (and thus indecision). The Pakistan Engineering Council has recently been lobbing for a 70:30 ratio of domestic to foreign consultant/contractor input when most of the technical services are available locally. However, the balance needs to be determined with only one consideration- the national interest, all other interests subservient. This does not mean that political economy will not respond to adverse actions to favor certain interests. However the tautology that issues break up countries is absolute nonsense—interest must be recognized to the extent legitimate accommodated within a pragmatic framework. Inordinate delays serve no ones interests especially not of the poorest of the poor who receive neither delayed benefits nor the tax payers who pile up heavier debts as the burden rises over time.

15. Who are the winners and losers in the Dams game- what they gain and lose?

Dams are often multipurpose entities that affect different people in different ways. The way people perceive gains and losses also differ and so do the means and ways these are estimated.

15.1 Winners:

The winners of dams are the general populace in the economy who has cheap and assured supply of hydropower. The second large group of direct beneficiaries is the farmers who have access to the stored water. The enhanced supplies and timely assurance (provided that occurs) ensures that this group comes out as true winners. Where dams like i.e. Kalabagh have direct flood control benefits the downstream dwellers like Sindh would benefit from built-in flood controls, since floods play havoc. Besides these direct winners the government, provincial governments who obtain royalties, construction companies and their associated interests, international financier's benefits from the profits on the contracts that are awarded for the civil works. In certain projects like the construction of large infrastructure like the I-40 interstate in USA after II World War and works on the TVA dam projects large involvement of labor from different regions had widespread multiplier affects touching the very core of communities in different parts of the country. While these impacts are immediate and help boast the economy in the short term the water supplies/irrigation and hydropower can provide long term employment benefits both upstream and downstream as a consequence of increased economic activity. Planned and well thought strategies can have widespread impacts on the reduction of rural poverty in Pakistan. Those laborers are also clear winners as large employment opportunities are opened up for them. In case of Tarbela 1600 expatriate and 17000 and in Mangla 14000 Pakistanis and 700 expatriate were employed for Mega Dam projects.

Post dam construction employment in nearby townships provided over 100,000 jobs in both Mangla and Tarbela dam cities. In the case of Tarbela some areas were of marginal value and productivity. When these areas were inundated the people who lost their land and dwellings were handsomely compensated. They may lose socially but the economic compensation often for rather unproductive land and (opportunities) results in benefits that suggest that they come out as winners in the long run. Where dams have a strong regional development component and well designed social uplift schemes in the vicinity of the dam, improved livelihoods also help place the inhabitants in the winner's category. In the Ghazi area near Tarbela and nearby vicinity of Haripur land values increased over 50-100 times and so have the lease and rental vales of the previously pre- Tarbela unproductive lands. Establishment of industrial states, universities and expanded agriculture provided job and business opportunities. Public hearing held at Haripur district the vicinity of the dam suggested that landless, non agriculture working classes saw improvements in their incomes after the construction of Tarbela dam (WCD, 2000)

15.2 Losers:

The losers from dams are similarly large. First those who are displaced and will have to be resettled in the short term are clear losers. For instance in the case of Kalabagh about 125,000 people would have to be resettled whereas in the case of Basha this number is estimated to be around 24000. These people, who leave their family abodes, lose property, land, value systems and their ancestral abodes are clear losses. Many lose the graveyards where there forefathers were buried. This leads to considerable social costs that are difficult to measure in economic terms. Loss of property is often accompanied by loss of livelihood. Past resettlement efforts suggest that people who are allocated land downstream often find themselves isolated. Many sell out (often at low prices) and resettle in the vicinity of the dams. In the short run they are obviously net losers. Besides the direct losers there are several downstream implications for those whose livelihood is curtailed by the reduction in river flows (i.e. fishermen, mat weavers, mangroves dependent communities) etc. In cases earlier people

had access to unhampered flows the reduced flows when they are curtailed without clear planning negatively impact farm communities downstream who now have less water for their agriculture.

16. Means of compensating for the losses- Steps forward:

The losers from the construction of dams have been identified above. It is crucial that those that lose land, property and livelihood are adequately compensated for their loss. While it is human nature to be seldom satisfied with any compensation package—the formulation of such package requires close stakeholder participation to arrive at what may be termed as "fair and reasonable" by a third party. The losers can not be written off with one time compensation say as a transfer payment- especially those that are direct affectees in the vicinity of the proposed dam sites. There direct compensation (agriculture land, land for homesteads, employment etc.) could be supplemented with benefits like cheaper electricity rates (or even free electricity) for a certain grace period. It is even more difficult to design regional development projects to ensure that those that are hurt downstream receive adequate compensation and long term benefits from the construction of the dam. Such compensation can be in the form of reduced hydropower costs, special loaning facilities for agriculture for those affected by reduced flows, improved technology etc. However, care must be taken to identify these losers and the associated compensation packages so the whole exercise does not become"money making game". The procedures and practices that are proposed for such loser compensation must be designed based on international best practices and what is affordable by a country like Pakistan. Simultaneously compensation schemes should not be directed towards those "who scream the loudest through NGO voices"- but be based on the "damage and hurt" principle that is viable and pragmatic**.**

17. Description of Good practice- identification, designing, operating of a new large dam- the WCD guidelines

The World Bank has clearly established guidelines for the evaluation of large infrastructure projects such as dams based on its own exhaustive experience with design, financing, supervision of dams over the last several decades. Adherence to these general guidelines can help countries like Pakistan modify, evaluate or arrive at a decision regarding dams at approval (Kalabagh) or feasibility/cum design stage (Basha) The World Commission on Dams provides a listing of 26 generic guidelines considered as helpful to assess options and plan and implements dam projects to meet the commission criteria (Page 278, World Commission on Dams). However, these guidelines have been deemed rather too extensive and cumbersome for inclusion in Project evaluation. The ICOLD in its letter to WCD found these guidelines too difficult to implement and with existing levels of expertise available in developing and even some developed countries even unrealistic (see WCD website for responses received on final WCD report). Pakistan is a member of ICOLD and consequently has also expressed its reservation on such elaborate and detailed adherence to the proposed processes that it has decided to go with the general consensus of the international community regarding evaluating dam projects as development investments with trade-offs, choices and national interests.

The World Bank has already been incorporating the social and environmental concerns (partly expressed by WCD).While this lists is rather elaborate and doubtful whether any country can realistically incorporate all these guidelines (due to time, expertise, cost constraints)-nevertheless there are some aspects that could be built into existing designs (Kalabagh) or advanced stage feasibilities (Basha) to modify, evaluate or arrive at a decision.

Table15: Winners and Losers from Construction of Dams

S#	Interested and affected parties	Losses	Winners	Major Activities
1	Residents of project area	• Decreasing public investment in area • Decreasing private investment in area • Land speculation • Psychological stress • Loss of social capital • Disruption of economic system • Political unrest Impoverishment • Loss of productive resources • Loss of access to productive resources • Increased competition for resources • Speculation in land Loss of control over local development • Loss of flows of benefits from flooded land, forest, river • Loss of property • Socio-cultural loss due to crash modernization • Stress of relocation • Loss of access (roads/paths) • Loss of business activity • Loss of floodplain agriculture • Loss of fishing • Tensions between in-migrants and local people • Poor health status of local people • Increased infant mortality from disease • Effects on downstream economic activity • (fishing, agriculture, navigation) • Effects in estuary or delta resource use fisheries • Effects on offshore fisheries	• Engineering/Consultant jobs • Financial Activity • Economic activity • Construction jobs • Firms with equipment contracts • Financial/market activity • Local business activity • Forest felling contractors • Increased accessibility • Fishing activities in the reservoir • Recreation in the reservoir • Navigation in the reservoir • Increase in power availability • Fossile fuel pollution avoided • (SO2, NOX, particulates) • Avoiding fossil fuel greenhouse gases • Export income from electricity sale • Positive aspects of irrigation • Year-round water	• Planning a Large Dam • Building a Large Dam • Building power lines/access roads/ • irrigation canals/other • infrastructure • Impounding/flood ing • Managing the reservoir • Supplying electricity • from hydropower • Supplying irrigation water from the reservoir • Supplying drinking water from the reservoir • Managing Floods • Refurbishment or Upgrading • Decommissioning
2	Land speculators			
3	Public administrators			
4	Local businessmen			
5	Public service providers			
6	Host population			
7	Indigenous people			
8	Other vulnerable people			
9	Unskilled labor			
10	NGOs			
11	Women			
12	Children/elderly			
13	Children			
14	Ethnic minorities			
15	The landless			
16	Indigenous people			
17	Those renting property or land			
18	Those without secure legal tenure to property or land			
19	People in host communities			
20	Traditional leaders			
21	Downstream farmers, fish catchers and their dependents			
22	Traders			
23	Lakeside residents			
24	Dam managers			
25	Local farmers			
26	Oil, gas nuclear industry			

27	All people in downstream communities	• Concentration of landholding • Uneven water distribution and growing inequity • High running costs (machinery and crop inputs) • Waterborne disease (Bilharzia, malaria) • Farmer debt • Pesticide poisoning • Lack of secure tenure and income for the poor • Impact of unseasonal flood flows Economic losses to floodplain resource uses • Social and cultural change forced by economic change • Decreasing public investment in area • Decreasing private investment in area • Land speculation • Disruption of economic system • Loss of productive resources	availability on irrigated land • Growth of economy in irrigated area (inputs supply, services, education, health etc.) • Health benefits • Sufficient clean water • Reduced drudgery • More time for employment or economic activity • New industrial activity • Reduced flood losses in agriculture • Reduced flood losses to • infrastructure and property • Regulated river flow for navigation	
28	Downstream industry and commerce			
29	Wealthy households in irrigation area			
30	Poorer households in irrigation area			
31	Estuarine resource users			
32	In-migrant conflict with host community			
33	Downstream flood plain pendent people			
34	Riparian communities			

1. The first strategic priority is to gain **Public acceptance:** In Pakistan as noted earlier there is controversy regarding new upcoming dams. There is much debate and discussion on the existing design of Kalabagh and less so on upcoming dam feasibilities. Basha, Bunji, Skardu as little is known about them, other then broad design parameters. Much of the debate has centered around the ***controversy*** between the two provinces of Punjab and Sindh whereby Sindh has vehemently opposed the construction of Kalabagh on grounds that have been narrated earlier. The major issue is that of trust and transparency. Sindh has repeatedly said it has no problems with Kalabagh dam or its location provided it remains a run of the rivers dam and no water diversions (canals are included in the project). The government has embarked on addressing these concerns through public awareness and making the responses more transparent and allowing for feedback.

18. Options assessment:
This strategy calls for widespread assessment of the likely impacts on environmental social, health and cultural heritage etc- it elicits various criteria and broaden the venue of analysis. Much of the proposed assessment techniques are often incorporated into the analysis of dams under standardized feasibilities.

19 . Addressing Existing Dams:
It is important that lessons of dams already in place in any given country are put to use. Pakistan has both Tarbela and Mangla to capitalize on in ascertaining what role these dams have played in its economic development and what beholds the future of new reservoirs if they are to be built. Both dams were highly successful in providing the much needed waters lost as part of the treaty and also made widespread contributions to economic development and helped ensure Pakistan met most of its agriculture needs. Future dam projects need to take into account the special emerging needs of the whole Indus basin systems with much greater attention to distribution and releases to the Indus delta. The importance of distributional aspects of the benefits (irrigation, power, flood avoidance) should be taken within a regional development perspective. Perhaps the area receiving lesser attention through the earlier dams (Tarbela and Mangla) could now be given priority in the earlier years of dams operation. These modalities need to better addressed by the government and made more clearer to the public how the large investments in future dams will take care of the inter-provincial and regional disparities.

20. Sustaining Rivers and Livelihoods:
This is an area of major concern and often the bone of contention between the lower and upper riparian. The downstream dwellers feel that upstream damming will undermine their vital interests. Government of Pakistan is currently supporting three studies in this area to help determine the minimum flows and impacts on ecology on Indus and the Eastern Rivers of Chenab, Jhelum and Sutlej to obtain a wider view on how best to sustain the flora and fauna in these riverbank systems. By the same token the interests of fishermen folk both in vicinity of the proposed dams and downstream need to be investigated carefully and impartially.

21. Recognizing Entitlements and Sharing Benefits:
Here it would be important to recognize the entitlements of each beneficiary Provincial-Canal-Farm for irrigation and the overall inclusion of different groups, especially those neglected in the past (for instance electrification of remainder villages). Likewise broadening the base of beneficiaries so the distribution helps all core groups falling in the poverty domain would make the investments in dams more attractive. Some of the proceeds from the benefits stream could be used in isolated areas in the basin that have traditionally been ignored (i.e. Southern Punjab and

Central Sindh). Similarly, Baluchistan and NWFP would share the benefits to enable it to target development efforts to its neglected areas.
Likewise how, what, when, where and by whom will the benefits be shared, under what conditions and operating rules needs to spelled out in greater detail and in a transparent manner. Much more effort and thinking needs to take place on the benefit sharing proposals and greater attention to making these known in the public. Similarly, those negatively impacted must be adequately compensated within the mainstream development through clear entitlements to such compensation program

22. Ensuring Compliance:
This is the final stages of assessment. The agreed upon covenants during negotiation of different parties at the domestic level and other technical, financial, regional and international covenants must be brought together in a compliance plan. In the case of Pakistan whatever agreements are reached between the provincial governments, Sindh and Punjab may ask for international guarantees to back up the agreements which particularly Sindh fears may not be honored in the future. This is absolutely essential in making any headway on the issues of dams in this country otherwise another 30 years can pass in debating scenarios and options; these have been revised umpteen times. The water accord is already in place. What needs to be assured is that it is implemented in a transparent and objective manner

23. Sharing Rivers for Peace, Development and Security. Pakistan has borders with India and Afghanistan with whom it has to share waters. New developments on those rivers that pass through Pakistan i.e. Kabul flowing from Afghanistan and Chenab in India require developing long term strategies for water sharing. This strategy realizes that rivers flow over space and recognized legal entities with often defined shares. When these arrangements are based on pragmatic consideration resolution of conflicts becomes easier-however when historically stated positions are taken there are potential sources of conflict. In Pakistan's case the people of Punjab and Sindh have to realize that there is history in the usage of waters that is imbibed in the pre-partition era. That history is changing based on pressure on demands for food and regional development. Solutions need to be found within this perspective and hardlines can only further the resolve of each party. Concerned stakeholders must be brought to the table for negotiated settlements. Once such settlements are agreed upon the transparent legalization of such interest needs to take place

24. World Bank comparative advantage in Large Dams in Pakistan
The World Bank has been a long term partner in the development of Pakistan's Water Sector. It rightly takes great pride in helping settle a potentially explosive water dispute on the Indus Rivers by brokering the widely acclaimed "Indus Water Treaty" in 1960. The overriding essence of the Indus Water treaty was a fair settlement with built in checks and balances and provision for international arbitration in the event of default. This treaty has generally worked well over the past 45 years. . Given the present inter-provincial conflict similar model could be followed for both conflict resolution and as a solution to the loaming water crisis that has stalled the water resource development in the country with consequently serious economic development ramifications. The treaty allowed certain infrastructure to be constructed in Pakistan as part of the agreement between India and Pakistan. The two large dams Tarbela and Mangla were constructed as part of this treaty. Thus, large dams have largely been conceived, articulated and supported by the World Bank in Pakistan at the behest of the Government of Pakistan. This clearly shows that no other donor has participated in the development of such large scale

infrastructure nor has the country experience to assist with this sector. The Bank also brings in the international technology and know-how to ascertain risk and provide guidance in all stages of infrastructure development. It has absolute comparative advantage to assist Pakistan in construction, management and post construction operations related to water development.
Besides long association with the Water sector the Bank has a strong presence, needed infrastructure, highly qualified staff with prior Pakistan experience, a deep understanding of the economic history and sensitivity to the political economy of the country. It's financial, technical and human resources allow it to fund large scale projects. The Banks Water Sector Strategy (2004) clearly establishes guidelines on how-to engage in high reward high risk activities. Amongst others it calls for closer look at.

- Relevance to overall national development strategies as reflected in the CAS.
- Relevance to poverty reduction.
- Relevance to the Development of World Bank's comparative advantage

Perhaps another dimension to the Banks comparative advantage is its water program in India that provides it the necessary experience to address cross boundary conflicts, highly relevant I the Pakistani context. The Banks Water Sector Strategy provides ample documentation of its experience in handling sensitive issues in at the regional level.
A new and emerging dimension of large scale reservoirs is the fact that new projects bring new conflicts and requires newer approaches based on experience elsewhere for resolution. Experience with such risk assessment and mitigation needs a long term perspective of say 25 years. Such a perspective may be absent with many other development agencies.
Infrastructure development is one of the many facets of overall country assistance (World Bank Pakistan CAS, 2003). Dams feed into the overall development streams. Unless complementary investments i.e. agriculture, social development, poverty alleviation, fiscal and monetary reforms etc) are put in place, the outcomes for development may be less then desirable. When the Bank is financing along with ADB a large portfolio of investments, it has a distinct advantage to see the dams within a broader development perspective. The World Bank can better gauge the needs of sequencing, prioritization and decision making then financiers that look at dams as isolated mega projects without realizing the important backward and forward linkages they foster with economic development.

25. Associated Risks: Large scale dam projects the size of Kalabagh or Basha pose design, construction, and natural disaster risks. While such risks are well calculated nevertheless Insuring against them requires long term persistence and perseverance. The Bank is also aware of the uphill tasks associated with dam construction on the Indus. The political stalemate has essentially put the Kalabagh project in complete jeopardy despite the fact that it was considered otherwise technically feasible. Voices from parties expressing discontent must be evaluated taking a long term view. The geopolitical situation in the region must also be assessed in terms of the associated risks. Pakistan is presently a favored international partner against the war on terrorism—as tides turn will the financial commitments of other international donors continue with same enthusiasm. It is important that Pakistan better integrate itself within the international financial markets—widespread economic growth in the region could stir frustration and backlash creating a situation of social unrest. Measures that help alleviate poverty and allow the bank to focus on opportunities that are good investments and address the problems of equity, growth and poverty reduction are likely to down play the risks.

26. Major Findings of this paper

To sum up, the paper has provided information on large dams in Pakistan, how they have contributed to conflict resolution and enhanced economic security for Pakistan. After Tarbela and Mangla, Pakistan now faces unique challenges in the Water Sector due to silting up of these dams. Some important conclusions are

1. Dams have provided Pakistan immense economic benefits in the Post Green revolution that helped Pakistan achieve high growth rates and multiplier impacts. They contributed in replacing waters lost to India (3 rivers) to India under IBT, ensured continuity of its agriculture and also provided the needed energy to expand the urban and rural industrial based through cheap hydropower. These dams continue to generate benefits that are vital for sustaining economic growth in Pakistan.
2. Dams directly and indirectly created jobs and continue to do so by expanding employment multiplier impacts and have also helped reduce poverty. At present agriculture productivity is stagnant and reduction in storage water is creating further gap between Rabi productions of wheat.
3. Dams as elsewhere generate there own social costs in terms of resettlements, upstream and downstream and Pakistan is no exception. Those resettled were adequately compensated by the norms of the day. Valuable lessons have been learned and Pakistan has designed resettlement policies based on international good practice.
4. There is a widening gap in per capita water and storage availability in international comparison. The present set of rules and regulations prevalent in the country require urgent reform. Likewise the paper stresses the need to pay greater attention to water rights and entitlements. Other instruments like demand management, tradable water markets, diversification, fiscal and monetary, better governance measures can also help in address equity and water distribution issues at the farm-canal-province and federal level
5. The present debate around additional storage centers on Kalabagh and Basha. The later still being too early for decision making. As replacement storage Kalabagh is ready and was conceived as an integral part of the 1968, World Bank study done by Peiter Lieftinck. With certain modification that have been made on the design and intensive technical, economic, social and environmental analysis the government is presently undertaking public debate and addressing apprehensions of Sindh and NWFP to arrive at a decision.
7. The strong views on future storage are largely a question of mistrust and transparency. Sindh the lower riparian views its disadvantages and feels it would lose control on Indus Water with special worries that Punjab may divert these waters for its own benefits. The need for Conflict Resolution is recognized and the potential role of an outside mediator (like the Bank) has been identified.
8. There are environmental concerns of downstreamers, fearing that upstream developments will undermine interests of the Indus Delta Dwellers. It was found that past dams had little to do with reducing flows to these areas as they had been impacted by barrages constructed prior to Independence in 1947. The paper recognizes this aspect and points to the need to highlight this in public debate. It also notes that considerable political energy is misdirected and issues about further storage development can be resolved through dialogue in a trust creating and transparent environment. Weaknesses in the institutional aspects have also been noted-particularly in the lack of a Basin Authority and a dynamic model, the later would facilitate answering the “what if”questions.

9. Minimum flow requirements to safeguard the ecological health of the river systems have been noted, and become major issues during periods of stress like recent droughts. Ongoing studies will help identify some of the needed flows-however the paper notes that conflict resolution strategies will be needed because chances of complete agreement on the true requirements are liable to take the form of an open ended debate.
10. The paper made a comparison of the potential new dams along with their pros and cons. It appears that in the short to medium run the realistically viable option is Kalabagh. While Pakistan needs almost 18 MAF storage by 2025 other designs like Basha could also come up for serious consideration. If resources were in place even both could be started but this would put excessive strain on the economy.
11. Dams are generally justified in Pakistan on grounds of irrigation benefits. The analysis pointed out that both Kalabagh and Basha would generate much higher power benefits, while the irrigation benefits are important they are a smaller portion of the overall benefits. Likewise the trade off analysis between irrigation and power in the case of Tarbela also suggests that optimization models when properly applied could further enhance the benefits of dams by following different decision rules.
12. A major data gap has been identified related to the environmental and ecological quantitative information. Investments will be needed in the future to rectify this situation to enable monitoring of river ecological health over time.
13. Finally, it became clear that the core issue underlying Pakistan's water problems is its "Management". There are significant returns to be realized in correcting this deficiency at all levels. Regardless, of what decisions are taken with respect to dams one thing is certain that Pakistan will have to address its water management problem at all levels while paying special attention to issue pertain to water rights/entitlements, equitable distribution.

27. Suggestions for Productive Bank Engagement

The Bank has sufficient experience with Pakistan' irrigation system and water resource development needs that it must ensure that it engages in infrastructure development cautiously. While it will work within the prevailing geo-political situation in the region it must be clear that dams are sensitive and the people of Pakistan alone can make the important decision regarding where, when and in what numbers will future dams be constructed. At best The Bank can serve as a guide and partner but the painful process of arriving at a decision must be shouldered by Pakistan alone. The following suggestions are made in line with the broader assessment presented in this paper

1. Engage in conceptually supporting the reservoir infrastructure as outlined in the Water Resources Strategy with a broader objective of water resources conservation and new storage development.
2. Evaluate the quality of debate and the processes that are adopted to arrive at decisions pertaining to new infrastructure development with cautious positioning on which dam to support.
3. The Bank could initially commit to one dam and set out the necessary pre-conditions outlined earlier in this paper.
4. At present the only realistic option amongst large dams is Kalabagh, the others are either under feasibility or still far from serious consideration. It is unlikely that detailed design and construction feasibility of Basha will be available within the next - 2 years and again it will require international vetting putting it up for serious consideration after 4-5 years.

Thus, the only real immediate fund worthy proposal is that of Kalabagh. The Bank should look at the design modifications that have taken place, further appraise the future impact of climate change on water resources and engage in serious dialogue with the government on how it wishes to proceed with its immediate problem of replacement storage and what path will it take regarding the development of at least 18MAF of capacity over next 10-15 years. This will include evaluation of its proposals for financing such huge outlays.

5. The Bank could greatly contribute to Pakistan's development through re-engagement in storage infrastructure provided it paid greater attention to the water management issues at all levels. Thereby supporting hardware development along with focus on the core water management issues that impact overall economic development.
6. Regardless of the decision on new dams there are clear opportunities for Bank engagement in the agriculture water conservation arena. There is already heavy investment going into on-farm water management, a major push in the area of facilitating the use of modern irrigation systems i.e. lazer leveling, drip, sprinkler and widespread promotion of new agriculture agronomic interventions would be a step in the right direction. While the Bank should after careful assessment engage in financing new dam opportunities, it must ensure that it sets a clear priority for water saving techniques and makes this pre-condition for future Bank support in replacement storage investment. Other instruments like demand management, water pricing (less effective in initial stages), enhancing trust and governance must be linked. Much more attention is warranted on the Water Rights and Entitlements issues that will determine acceptability of any long term.
7. The bank has to stress the need for institutional reform and establishment of modern and vibrant structure that serves as the Basin Authority with a functional management system that caters to all the basin related issues. This must be made a pre-requisite without which chances of long term success are rather limited. The Bank can bring the experience to bear on both the infrastructure and management needs of Pakistan.
8. Bank must come up with its own assessment of true social costs and encourage the government to develop short to medium term regional investment plans for the "hot spot" areas where most of the resistance for new dam projects is focused i.e. delta area of Sindh, southern Punjab and Sindh agriculturists etc.
9. Lastly without help in resolving the conflict between Punjab and Sindh little headway is possible on the issue of dams—the Bank could provide the needed facilitation (as it did for IBT) in achieving "conflict resolution".

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Source: The Social Impact of Large Dams: Equity and Distributional Issues
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Groundwater Development and Management in Pakistan

By

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Country Water Resources Assistance Strategy
Background Paper # 11
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Summary

Intensified groundwater use has been the single most important contributor to agricultural growth in Pakistan in the last thirty years. Groundwater is also the source of drinking water for over 70% of the population of Pakistan and a considerable number of industries use groundwater for their process requirements. Even so groundwater by and large remains an unknown quantity. It is unmanaged and measured fragmentarily. This is in spite of serious threats to the national resource base, livelihoods and even national security, associated with intense groundwater exploitation. The threats concern declining groundwater in barani areas, saline water ingression in canal commands, point pollution, deterioration of urban aquifers and concerns on sodification and arsenic contamination.

There are several meaningful programs and policies that can be pursued to counter these threats:

- Promotion of local groundwater management in barani areas, supported by enabling rule-setting laws. Examples of such laws exists and they should be activated and enforced
- Reconsidering water allowances in the different canal commands, taking into account groundwater use and groundwater quality, in order to come to conjunctive planning and management of surface and groundwater
- Avoid groundwater disasters at hot spots – using a range a regulatory and investment measures
- Initiate institutional coordination and particular strengthen provincial and local institutions in groundwater monitoring and regulation
- Stop financing overuse, as now occurs through reduced electricity tariffs for agricultural use, flat rates, non-collection of charges as well as the continued and non-essential operation of public sector wells in fresh groundwater zones
- Reroute financial resources to institutional strengthening and recharge. In case of groundwater recharge a broad range of recharge options – from water harvesting to spate irrigation – should be developed and used. At present funds for recharge are spent on delay action dams only, but evaluations have shown that a large number of these do not contribute to artificial recharge
- Investigate and reverse groundwater contamination

In promoting groundwater management in Pakistan the World Bank can play an important role. The focus should be on developing and up scaling new approaches with the emphasis on workable institutional arrangements. There is less scope for a priori developing a large investment portfolio. Intervention areas for the World Bank would be:

- Crash programs in worst-hit areas combining a range of measures to reverse serious overuse or water quality deterioration
- Combine investments in rural water supply programs with promoting local groundwater management
- Investment in a broad range in recharge measures and spate irrigation – again combined with promoting local water resources management
- Promotion of efficient irrigation – through various measures such as changed cropping patterns, moisture conservation measures and micro-irrigation, preferably through the local private sector
- Support the transition of the remaining public wells in fresh groundwater zones, in particular in Sindh and NWFP
- Work on arsenic mitigation, yet after validation of the magnitude of the problem
- Support relevant studies and monitoring and dissemination of knowledge.
- Last but not least - institutional strengthening in provincial and local ground water management, with clear tasks and capacities in monitoring, data dissemination, rule setting and enforcement.

1. INTRODUCTION

1.1 Groundwater in Pakistan

The total abstraction of groundwater in Pakistan is estimated at 50 BCM out of a potential of 63 BCM (Kahlown and Majeed 2004). Most of this is used for agriculture. Yet also more than 70% of the population of Pakistan depends on groundwater for drinking water and domestic use.

Considering the importance of groundwater in Pakistan, it continues to surprise that the resource is still for all practical purposes considered 'a given' and is neither systematically monitored nor managed. Much of the economy in Pakistan depends on groundwater. Agriculture employs 47 % of the workforce and contributes 25 % of GDP and 60 % of export. With the restraints on large-scale surface water development since 1976, agricultural expansion in the country has been driven to a very large extent by the development of more than 600,000 private tube wells (PTWs) in the country. It is estimated that 75% of the increase in water supplies in the last twenty-five years is to be attributed to public and private groundwater exploitation. The investment on these private tube wells is of the order of Rs. 30-40 billion whereas the annual benefits in the form of agricultural production are estimated at Rs. 200 billion, roughly equivalent to 5% of GDP. In addition many industries rely for their water supply on relatively 'clean' groundwater.

This spectacular success story has however in many areas gone too far. Overuse of groundwater is dramatic in some of the barani areas of Pakistan, underlined for instance by orchards in Balochistan being dismantled and by out-migration, destabilizing a region that is already volatile by nature and location. It is fair to say that the constant overuse of groundwater in the last decades has made the barani areas of Pakistan less resilient to drought.

In the large alluvial aquifer systems of the Indus water shortage is less acute, but also here groundwater use in several areas is larger than recharge. Intrusion of saline groundwater from the central doabs into fresh groundwater zones is observed in a number of locations. In other areas water tables have declined forcing farmers to install pump sets in sumps. The water productivity of groundwater is higher than that of surface water. Its application by nature is timely and it does not suffer from the high conveyance losses, common in the canal networks. This is brought out for instance in a study on the different canal commands in Punjab (Tahir and Habib 2000). This study observes that the gross value of production of water in the kharif ranges between Rs. 0.21 per cubic meter to Rs. 1.47 per cubic meter). In rabi – when there is a far larger reliance on groundwater supplies - the productivity is between Rs. 0.39 per cubic meter to Rs. 2.41 per cubic meter).

In drinking water the major concern is groundwater quality. There are several problem spots – mainly in urban areas and around rural industries – where groundwater quality is compromised with sewerage effluents, oil residuals, chromium or other contaminants. This holds true for major cities, such as Karachi and Lahore, where a large number of households still depends on individual wells for water supply (Rahman 1996, Mashhadi and Anwar 2000). In addition, in recent years a number of surveys have recorded the extent of arsenic in ground water, with results from Sindh being particularly worrisome. Finally for some urban areas the absolute shortage of drinking water is posing questions on the future. The prime example is Quetta (Birch et al, 1998).

This contribution to the Country Water Resource Assessment Strategy discuss the current status of groundwater use in the different parts of Pakistan (section 2), describes the major challenges (section 3) and policies required (section 4) and the contribution that the World Bank can make (section 5). The main thrust of this paper is that little has happened but that much is required in terms of groundwater management in Pakistan. The remainder of this introduction section briefly discusses past policies and institutional arrangements.

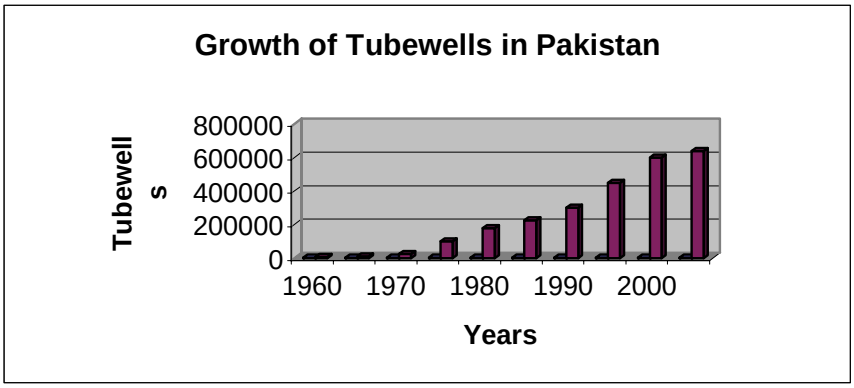
1.2 The Changed Scenario

For a long time the groundwater agenda in Pakistan was exclusively dominated by two themes. The first theme was the 'twin menace of water logging and salinity'. After independence seepage from canals, the irrigation of low-lying areas and the obstruction of natural drainage paths increased water tables in the Indus Basin over a massive area – 4 million ha –, causing soil salinization and severely reducing agricultural productivity. The response consisted of the Salinity Control And Reclamation Projects (SCARP), the crash deep tube well program starting in 1960s after piloting from 1954 onwards. In many of the worst affected areas the SCARP formula worked wonders – converting a saline wasteland back into a productive area. In fresh groundwater areas the SCARP drainage tube wells doubled up as an additional source of irrigation. Over the years 16,700 high capacity tube wells (56 to 140 l/s) were installed in the Punjab, Sindh and NWFP, mainly in fresh groundwater areas. In saline groundwater areas the problem of disposing the highly saline effluent made the deep tube well program for more complicated and only 3400 deep tube wells were installed.

The second theme used to be the promotion of agriculture through the development of private tube wells. At the time of independence, groundwater use in the country was very limited - mainly through Persian wheels in the riveraine areas and karezes in Balochistan. This changed dramatically from the mid-sixties onwards and accelerated in the mid-eighties. The government in several ways supported private groundwater exploitation. Foremost was he provision of power supply to tube well owners. The electric charges, moreover were subsidized. For tube well owners in Punjab and Sindh they were 40% less than the normal rate and in Balochistan and NWFP the subsidy even amounted to 60%. Tube well development was further promoted through a series of government programs, that provided free pump sets and wells and tube well loans under soft conditions (Johnson, 1989).

Soon this was no more necessary. Particularly when cheap locally manufactured diesel pump sets came on the market in the second part of the eighties, the number of private tube wells started to rise dramatically, especially in the fresh groundwater zones of Punjab province. In 1960 groundwater accounted for only 8% of the farm gate water supplies in Pakistan's most populous Province. As a result of the spectacular makeover of the water system 25 years later this had gone up to 40%. At present the groundwater use for agriculture accounts for more than 60 % of the water at the farm gate in Punjab. The number of tube wells rose faster than abstraction in Punjab. The density of tube well points increased, which made it easier for non-tube well owners to have access to groundwater. In the process the market for hiring diesel pump sets changed from a supplier to a buyers market. Another Province that witnesses a rapid increase in groundwater exploitation was Balochistan. As water tables fell rapidly in some areas, the traditional kareze was replaced by dug wells, which were then replaced by electrically operated submersible pumps operating at depths of 25 meter and more.

Figure 1: Growth of tube wells in Pakistan



Source: Qureshi, Shah and Akhtar (2003)

The most recent estimate puts the number of tube wells at some 630,000 (Qureshi, Shah and Akhtar 2003). The large majority of these wells are in Punjab. Tube well density is Sindh is markedly lower. In comparison to its population and groundwater potential the number of tube wells in Balochistan is very high.

Table 1 Breakdown of tube wells per province and type of prime mover

Province	Total	Diesel	Electric	Electric As %
Punjab	566,446	501,092	65,354	11.5
Sindh	28,079	25,086	2,993	10.6
NWFP	11,077	5,539	5,538	50.0
Balochistan	24,000	13,871	10,129	42.2
Total	629,602	545,588	84,014	13.3

Source: Qureshi, Shah and Akhtar (2003)

The intense use of groundwater has changed the water management scenario. Intense shallow tube well development in the Indus Plain resulted in the spectacular increase in productivity and made up for many of the deficiencies in water supplies in the world's largest contiguous surface irrigation system. This is illustrated by the stabilization of grain production during the drought years 2000-2002, with shortfalls to a large part made up by the use of groundwater. The intense use of groundwater however also requires more intense management – to address problems of a declining water tables, saline water ingression and groundwater quality.

1.3 Legislation and regulation

Over the years a number of laws and acts have been issued to support the management of groundwater, but the common thread is that on the ground they have not been implemented.

The first act that was promulgated in this field was the 1952 the Punjab Soil Reclamation Act. This act created the basis for the Soil Reclamation Board to control water logging and salinity through the development and operation of drainage tube wells. For the designated land reclamation areas, the board was in control of groundwater management and could also instigate a licensing procedure, permitting landowners to install private tube wells. Later on the Board was suspended and its executive powers were eventually transferred to the Provincial Irrigation and Power Department. At one stage in 1965 licensing rules were framed, yet they were never enacted. Another act, announced in 1958, covers the same ground. This act, the Pakistan Water and Power Development Authority Act, is the legal basis for the establishment of the Water and Power Development Authority (WAPDA). It also mentions that WAPDA would issue area-specific rules on groundwater use. Such rules were never announced however. Further, in 1978 the Government of Balochistan introduced legislation to control groundwater mining. Under the so-called Groundwater Rights Administration Ordinance a procedure was spelled out to issue permits for the development of new karezes, dug wells and tube wells. The relevant authorities were the District Water Committees, composed of government officials as well as appointed local 'notables'. The Ordinance specifically mentions the estimation of safe yields and the registration and administration of all water points. Based on this information minimum distances could be specified for each region, that could serve as guidelines for the issuing of new water permits. Some use was made of this law, but mainly by litigants who started cases against neighbours with whom they were in dispute. Specific guidelines for each region, however, were never issued and the 1978 Ordinance did not make a noticeable impact on the groundwater rush that continued unabated in the next twenty-five years.

Water quality issues for the first time got a legal cover with the Environmental Protection Agency Act that was formalized in 1996. This Act provides the first beginnings of groundwater quality management. It establishes the Environmental Protection Councils at federal and provincial level that are charged among several other things with setting standards on groundwater quality. National environmental quality standards were established subsequently, dealing with industrial effluents but not with groundwater quality yet. The EPA Act resembles the other legislation in that it has a strong focus on giving permits and setting standards, but it has had difficulty in getting implemented.

Finally, the last laws with reference to groundwater management are the 1997 Provincial Irrigation and Drainage Authority Acts. In Sindh this Provincial Act was later replaced by the Sindh Water Management Ordinance in 2002. They form the basis for the establishment of Provincial Irrigation and Drainage Authorities. Alongside responsibilities for irrigation and drainage operations and cost recovery, the new authorities are to ensure that groundwater monitoring is undertaken. They moreover have a mandate to initiate policies to address groundwater management problems. So far the new Irrigation and Drainage Authorities have had difficulty coming off the ground. In Sindh the span of control of the Sindh Provincial Irrigation and Drainage Authorities extends to three out of fourteen canal commands, but there has been no attention to groundwater management either within or outside the canal commands. In Punjab and NWFP the Provincial Irrigation and Drainage Authorities are largely invisible.

1.4 **Institutional Arrangements**

The lack of decisiveness in legal arrangements is mirrored by the absence of focus in institutional arrangements. There is clearly a gap in the middle. Several government agencies undertake tasks, but a brief account of the institutions involved in the planning, management and monitoring of the groundwater resources suggests that the past emphasis on new groundwater development and control of water logging and salinity still carries over.

At federal level the Ministry of Water Resources serves as the umbrella institution. The Planning and Development Department oversees the review and approval of various projects. The Water and Power Development Authority (WAPDA) was established in 1958 to take up all the major works under the Indus Basin Development Program. WAPDA carried out the planning and investigations for SCARP projects and implemented more than 35 SCARP projects involving vertical and horizontal drainage. The emphasis was on the preparation and construction of projects, and not so much in water management as is important in the present scenario. The bias on drainage projects is also clear from the activities of the SCARP Monitoring Organization (SMO). SMO is part of WAPDA and has been responsible for the groundwater monitoring. It concentrates on water levels observations and checks on tube well water quality almost exclusively in the SCARP areas. At Federal Level the Water Resources Research Institute and the Pakistan Council of Water Resources Research (PCRWR) is involved in research on water resources. The latter organization has for instance carried out Groundwater Quality Monitoring Study, but this was a one time exercise. In summary, at federal level there is no organization that has a strong concern with ground water management.

Although groundwater management is a provincial responsibility in the end, it also appears that there is no institutional focus for groundwater management at provincial level. Before independence, all the functions of groundwater development, management and monitoring were the responsibility of provincial irrigation departments, particularly in Punjab and Sindh. In Punjab at one stage Ground Water Development Organization (GWDO) was established (1958) within the Provincial Irrigation Department. In 1960 the tasks of this GWDO were transferred to WAPDA.

As mentioned above, under the different Provincial Irrigation and Drainage Authorities Acts of 1997 the development and management of both surface and groundwater has been vested in the newly created Provincial Irrigation and Drainage Authorities. These Authorities are still in the formative stage with only Sindh having made substantial progress. The Authorities are also involved in the establishment of Farmers Organizations (FOs) for participatory irrigation management. This task may

be stretched to include the local management of water resources. Water quality – including groundwater management – is part of the mandate of the provincial Environmental Protection Departments/ Agencies. Because of resource constraints this task in practice is very narrowly interpreted to control of industrial wastes.

Several other provincial departments are involved in groundwater use, in particular the Public Health Engineering Department (water supply and O&M of the drinking water wells) and the Agriculture Departments (tube well census). Under the decentralization the Local Government Bodies have become involved in developing groundwater for domestic and industrial needs. While all these organizations have a partial mandate in groundwater development and monitoring, groundwater management and regulation is not undertaken by any one of these. Over the years several efforts were made to provide an institutional focus for groundwater management in the different Provinces. In NWFP an extensive hydro geological study was undertaken from 1979 to 1986. As part of the study a network of piezometers was set up. The Provincial Planning, Environment and Development Department and the Provincial Irrigation Department would be responsible for groundwater monitoring, but neither Department took any initiative in this field and the piezometers remained unutilised. In Balochistan a Water Resources Bureau was set up as the central point for information exchange and water management. This Bureau however vanished and suffered from little external support. Finally under the Punjab Private Sector Groundwater Development Project (PPSGDP) a Groundwater Unit was established in the Provincial Irrigation Department. Cognizant of the pressure on groundwater situation the Government of Punjab also commissioned the preparation a Groundwater Regulatory Framework under the same project. This consisted of the development of a data base on groundwater conditions, the preparation of mathematical models for simulation of groundwater conditions under present and future scenarios and support to the groundwater monitoring network of SMO. On the regulatory side critical groundwater management areas were identified and a draft law was developed. Unfortunately, as with the other attempts, also this effort was short-lived and there was no follow-up when external funding under the above-mentioned project came to an end.

2. CURRENT USE IN DIFFERENT PROVINCES

In the this section an overview is given of current use and groundwater management in the different Provinces in Pakistan as well as the major urban areas.

2.1 Punjab

In Punjab groundwater has played a central role in meeting increasing crop water requirements over the last decades. The total area of the Punjab is about 51 MA of which 24.6 MA is under the irrigation system commanded by 24 major canals. Presently, about 38 MA of land is under cultivation. Both inside and outside the irrigation command groundwater has importantly contributed to the development of agriculture. Within Punjab different hydro-geological zones may be discerned.

The first and foremost of these zones is the alluvial plain of Central Punjab, that consists of active and abandoned flood plains along the rivers and the bar uplands. The bulk of the 560,000 tube wells in Punjab (approximately 85%) are located in this area. The water-bearing stratum ranges in thickness to up to more than 500 meters and is replenished by river flows, storm water and irrigation return flows. The plains consist of six interfluviums or doabs, separated by the five rivers that define the landscape in central Punjab. Towards the centre of the doabs the groundwater is saline, whereas nearer to the river course the water has been replenished by river flows and has salinity levels less than 1500 ppm. Along the rivers the area is in many cases entirely groundwater dependent. These are the flood plains, where the inundation canals by and large ceased to function after the construction of the major reservoirs in the country. The largest number of tube wells in the central Punjab however is located within canal commands itself. In most canal commands water use is conjunctive. Tahir and Habib (2000) established that in seven out twenty-commands groundwater abstraction is more than surface

water abstraction. In the rabi season this figure is even higher. Within the separate canal command areas there is no clear-cut pattern in tube well densities. Intuitively one would expect the dependence on groundwater to be higher at the tail of the systems, where surface supplies are generally low. There is however no systematic trends and in several command areas densities are high both at the head of the canal, where they may sustain the cultivation of paddy, the centre where they make deficiencies and at the tail where groundwater is used as a substitute for the sometimes altogether missing surface supplies (Malik and Strosser 1993, van Steenbergen and Oliemans 2002).

It appears that tube well densities in areas with marginal groundwater quality do not substantially differ from those in areas with fresh groundwater. Data from the Punjab Private Groundwater Project indicated that even in saline groundwater areas as much as 19% of the on farm water supplies come from tube wells. As a corollary water table have declined, even in some saline groundwater zones, especially in the recent dry years. Figure 2 is an example from Chaj Doab, where water tables dropped 3 meters over the period 1998-2001. It is only in areas with very saline groundwater, such as the Fordwah Sadiqia area in the extreme Southwest of the Province, that tube well densities are lower. Because of the intense use of groundwater in the irrigation commands, the area that is water logged and has water tables of less than 1.5 meter is reduced drastically and is confined to a number of highly saline areas only in Punjab. Table 2 brings the data collected by the SMO for the SCARP areas:

Figure 2: Water table decline in different saline groundwater zones (SZ) of Chaj Doab

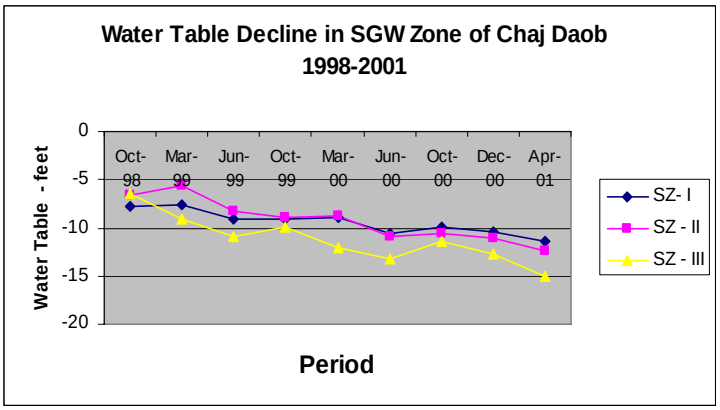


Table 2: Groundwater table depth in selected areas of Punjab (1999)

Water table depth (In meter)	Area (M ha)	Proportion (%)
Less than 1.5	0.62	6.2
1.5 to 3.0	1.89	18.9
3.0 to 4.5	2.92	29.3
4.5 to 6.0	1.47	14.8
More than 6.0	3.06	30.8
Total Area covered	9.96	100

Source: SMO

In other parts of Punjab groundwater is equally important. Three more hydro geological zones can be my be discerned, the Pothwar Plateau and Salt Range comprising a number of inter-mountain valleys

and basins; the piedmont areas along Suleiman Range in the western part of the Province and the Cholistan Desert in the southeast. Agriculture in these (non-canal command) areas is heavily dependent on groundwater, supplemented by spate flows in the Suleiman Range area and relatively high rainfall in the Pothwar and Salt Range. Water tables are much deeper - up to 100 meters. Water quality varies. In the Pothwar and Salt Range groundwater quality is good. In the piedmont zone DG Khan and Rajanpur districts along the Suleiman Range groundwater close to the foothills is saline but improves as one comes nearer to the Indus. In the Cholistan Desert groundwater is predominantly brackish-saline.

Table 3 presents a generalized groundwater budget for Punjab under normal and drought conditions[1]. Aquifer recharge in Punjab comes from rainfall recharge, especially in the northern Punjab where rainfall is higher, seepage from the irrigation system – estimated at 38% and return flow from groundwater use, estimated at 15-20% of pumped water[2]. The budget shows that in normal years recharge and discharge are balanced with certain areas having insufficient inflow. In dry years the total sum is minus. The water table decline trends during recent dry spell supports this rather general water budget. A decline of 0.3m in the water table or storage of the aquifer over 12 m ha of cropped area indicates an over pumping of around 5-6 BCM - considering an average specific yield as 0.15. During the drought year's annual water table decline of 0.6-0.75 has been observed in several places, whereas a similar rise of water table occurred in the more than average wet years (e.g. 1996 and 1997).

Table 3: Groundwater budget Punjab

Recharge - Discharge Components in BCM	**Normal Year**	**Drought Year**
Recharge Components		
Recharge from Rainfall	7.99	5.99
Recharge from Irrigation System	25.46	19.10
Return flow from GW Abstraction	5.7	6.23
Recharge from Rivers	4.00	1.00
Total	43.15	32.32
Discharge Components		
Groundwater Abstraction (Public + Private)	38.00	41.5
Non-beneficial ET losses	2.00	1.00
Base flow to rivers	3.15	0.5
Total	43.15	43.00
Net change	0	-10.68

Source: PPSGDP

From the water balance it is apparent that that groundwater potential in Punjab Province has been largely used, even in the canal commands, as any large water table decline cannot be sustainable. The non-beneficial ET loss is around 2 BCM and comes from the shallow water table areas in the topographic depressions. Only limited part of this loss can be harvested through reclamation measures in some of the areas in the fresh groundwater zone. Water table lowering – to some extent – may still be allowed in the FGW zones up gradient of the SGW zones (for example in Gujranwala-Sheikhupura areas). Yet any decline in the fresh groundwater areas down gradient from the saline ground water zones will accelerate salt-water intrusion.

2.2 Sindh Province

[1] Drought defined here as rainfall and canal flows being 75% of normal. In the water balance it is also assumed that during drought water-use is more judicious, resulting in less seepage losses and return flows.
[2] Ahmad (2002) suggests this may even be more

Sindh Province can be divided in three hydro-geological zones i.e. the Indus Valley plains, the Eastern (Thar) Desert and the Western Mountains. These three zones resemble very much the central alluvial plain, the Cholistan desert and piedmont zone of the Suleiman range respectively in Punjab. The groundwater scenario in Sindh however is remarkably different from Punjab. This is related to the more extensive zone with saline groundwater in the Province and the higher canal allowances in Sindh.

The most important groundwater area in Sindh is the Indus Plains, which is recharged from the meandering river and from the irrigation network. The Indus River in Sindh Province generally flows on a ridge and is hence mainly influent. Some of the flow drains towards the desert in the east and towards the Khirthar Hills. In the rabi season, when the flow in the river below Sukkur Barrage is almost nil the river receives groundwater, especially the left bank. Along the Indus groundwater quality in Sindh is generally fresh and useable (within 1500 PPM), but it deteriorates away from the river. The native groundwater of the Lower Indus Plain is highly saline. The entire deltaic area south of Hyderabad is a saline water area, except in some shallow pockets in the abandoned riverbeds of the Gaja.

In comparison to Punjab private tube well development has not taken a big flight in Sindh. In normal years the relatively generous surface irrigation supplies, especially on the right bank of the Indus reduce the need for additional groundwater supplies (Ahmad and Kutcher 1993). In addition, groundwater is saline in close to 70% of the Province. Some have argued has argued that even so in many areas of particular Northern Sindh a layer of fresh water floats on the more saline layers that could be exploited more extensively by skimming wells than is done so far (Ahmad 1993). Hand tube wells already use these thin lenses along canals and distributaries in several parts of Sindh. A careful approach is required, however, because in some areas (for instance Badin and Thatta) the layer of fresh groundwater is so thin that it does even not suffice to provide domestic water needs throughout the entire rabi period, particular in the areas served by non-perennial canals. In those areas drinking water problems are as severe as one can get.

Private tube well densities in Sindh are far below those in Punjab. The estimated number of tube wells in Sindh is slightly over 28,000 (Qureshi et al 2003). Tube well densities in different canal commands are in the order of 2 to 3 private tube wells per 100 ha (Lashari and Memon 2000, van Steenbergen 2002). A shape of things to come is the groundwater exploitation in the Kunner-2 Minor (near Hyderabad), where tube well density is 6.6/100 hectares – related to relatively better groundwater qualities and the proximity to a major market.

For the time being salinity and water logging persist in most part of Sindh, even in some fresh groundwater areas. In 1999 38.5 % of the irrigated area was water logged (table 4), causing a range of problems – lower farm yield, but also impediments to rural sanitation facilities and a large prevalence of human and animal diseases. The problems appear to be most persistent in the areas, served by non-perennial canals. These canals receive copious supplies in the kharif season, causing the water table to rise significantly, but to fall again in the winter season, when the canals are not functioning. This annual cycle of rise and fall of water table has brought the salts to the upper soil strata (Mukarram 1994). The problems in the perennial channels in Sindh are different from the non-perennial channels. In the perennial channels the water duties are generally lower. Here salinity is concentrated on areas with deficient surface water supplies, where there is not enough water for leaching accumulated salts. This often concerns the tail reaches of the channels.

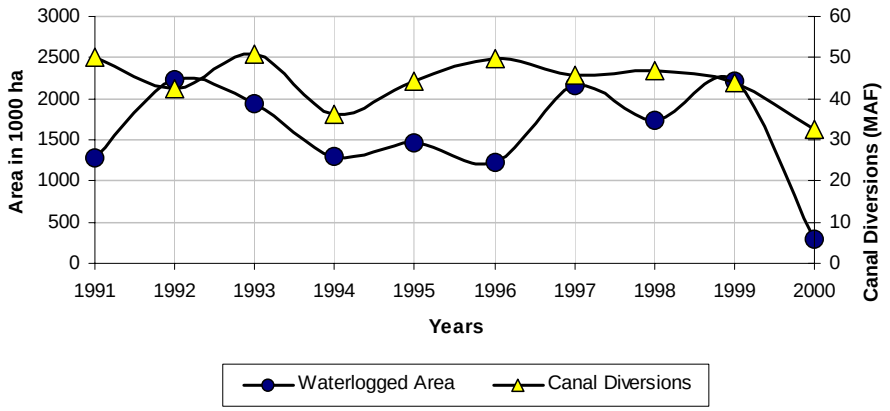
Table 4: Groundwater table depth in selected areas of Sindh (1999)

Water table depth (In meter)	Area (M ha)	Proportion (%)
Less than 1.5	2.21	38.5
1.5 to 3.0	2.87	50.0
3.0 to 4.5	0.35	6.1
4.5 to 6.0	0.17	2.9
More than 6.0	0.14	2.5
Total Area covered	5.74	100

Source: SMO

The waterlogged area however fluctuates enormously from year to year. The main factor appears to be the canal diversions in the years previously. The waterlogged area increased from 1.272 Mha in 1991 to 2.26 Mha in 1992 responding to canal diversions of 50.30 MAF in 1991-92 and dropped to 1.30 Mha in 1994 as the availability reduced to 36.1 MAF. The waterlogged area fell from 2.22 Mha in 1992 to 1.22 Mha in 1996. In 1999-2000 due to drastic reduction in available supplies the waterlogged area even reduced to 285,000 ha. There is hence a very strong case to re-evaluate the surface water allocation in Sindh in normal years, because at present normal years bring huge increases in water logging and reduced crop production[3].

Figure 2 Water logging and canal supplies in Sindh (1991-2000)



Source: Rasheed (2002)

Outside the Indus Plains there is scope to improve groundwater management. The Thar Desert is one of the most densely populated deserts in the world. As one moves towards the South of the desert

[3] Monitoring under the SCARP Transition Project shows no indication of groundwater-induced secondary salinization in Moro and Sakrand, but instead suggests that in recent years soil salinity has improved, due to increased tubewell development and the leaching this made possible (SSTNRPP 1997). This suggest that it is worthwhile to look into option of draining saline water to create more storage for fresh water recharge.

annual rainfall increases considerably, reaching 350 mm/year. The rainfall pattern however is highly variable and characterized by spells of dry years, causing outmigration as even drinking water sources fail. The groundwater recharge in Thar are mainly saline with 86% ranging between 2000 and 10000 µS/cm. Generally this is unfit for consumption, but under duress water quality up to 5000 µS/cm can be considered (Zaigham 2001). It has been argued that there is scope to develop groundwater resources in the Thar in a more systematic manner, as particular the dune zone, coal bearing sedimentary units and basement formation have remarkable potential. Moreover, recharge of the aquifers is immediate and the quality of deep groundwater can improve after long pumping.

A summary groundwater budget, considering average rainfall and canal flows is given in table 5. Groundwater discharge is mainly through the non-beneficial evapo-transpiration and return flow to the river as groundwater use is limited[4]. The main challenge in Sindh appears to be revisiting the management of canal supplies and promote groundwater abstraction. There appears to be scope to develop groundwater resources more carefully by introducing skimming wells and other appropriate technologies.

Table 5: Groundwater budget Sindh

Recharge/Discharge Components in BCM	**Normal Year**
Recharge Components	
Recharge from Rainfall	2.42
Recharge from Canal System @ 15 % of 56 BCM	8.34
Return flow from Irrigation system @ 22.5 % of net flow	10.58
Return flow from GW Abstraction @ 22.5 %	0.97
Recharge from Rivers	0.37
Total	**22.68**
Discharge Components	
Groundwater Abstraction (Public + Private)	4.30
Non-beneficial ET losses	16.96
Base flow to rivers	1.42
Total	**22.68**

Source: ACE 2001a

Another important issue in Sindh is groundwater quality. This has surfaced only recently. An extensive survey was undertaken in four districts of Sindh, in which 67,556 samples were tested (Abro et al. 2004). In all four districts – Dadu, Khairpur, Nawabshah and Tharparkar – a significant portion of the samples showed arsenic values above the ideal norm of 10 ppb. Further investigation is required but these results warrant serious attention.

2.3 North West Frontier Province

Groundwater in NWFP occurs both under water table conditions in the alluvial deposits in the valley fills and under confined conditions in the piedmont areas and hard rocks. Groundwater use in the Province is moderately intensive. A detailed, but now-outdated assessment of groundwater use estimated that groundwater accounted for 11% of agricultural water supplies in 1988 (Kruseman and Naqvi 1988). After that year groundwater use increased due to private initiative and development projects. Particularly in the intermontane basins in the northern and central part of North West Frontier Province where land resources are abundant, groundwater use has intensified. Overwithdrawal is reported from a number of areas: Parachinar in the Federally Administered Tribal Area, Shamozai and

[4] Assessment of groundwater use by ACE-HALCROW is about 4.3 BCM where as a recent study by IWMI has estimated the discharge through tubewells as 2.15 BCM. In this budget the higher figure is used.

Kotlai valleys in Swat and Jandool and Adinzai valleys in Dir. The Farm Machinery Census estimated that there were some 12,000 tube wells in operation in the Province in 1999. A recent survey makes an estimate of the same order of magnitude - 11,000 (Quereshi 2003). Among this number there are approximately 800 public tube wells in the Province. Approximately half of these are public irrigation wells, whereas the others are SCARP drainage-cum-irrigation wells, installed in the irrigated areas of Mardan and Peshwar valley in the 1960s in response to the water logging at that time. In spite of high irrigation duties, over time water logging has by and large disappeared in these areas. SMO estimated that in 2000 only 5% of the irrigated area has water tables within in 1.5 meter.

The quality of shallow groundwater in the valleys, which is largely derived from infiltration of rainfall and seepage from canals and fields, is generally good (less than 1500 PPM of dissolved salts). Only in Bannu and DI Khan the groundwater is saline. Modern developments in agriculture and industry present threats to groundwater quality. Notable pollutants are fertilizer, nitrate and non-bio-degradable pesticides and herbicides from agricultural activities; industrial wastes and the wastes from mining operations; and organic wastes and bacteriological contaminants from domestic activities.

A groundwater budget for the Province in broad terms is given in table 6. The figures in the budget are best guesses. They suggest that NWFP is in deficit. This may be the case, but it is also likely that the increased abstraction now reported has resulted in a reduction in ET losses, sub-surface outflow and base flow to rivers and that the water budget is, in fact, more or less in balance.

Table 6: Groundwater budget NWFP

Recharge/Discharge Components in BCM	**Normal Year**
Recharge Components	
Recharge from Rainfall (estimate for 10 M ha area)	1.08
Recharge from Canal System @ 15 % of 8.23 BCM	1.23
Return flow from Irrigation system @ 15 %	1.05
Return flow from GW Abstraction @ 15 %	0.16
Recharge from Rivers	0.16
Total	**3.84**
Discharge Components	
Groundwater Abstraction (Public + SCARP)	0.44
Groundwater Abstraction (Private)*	1.74
Non-beneficial ET losses	0.30
Sub-surface out flow	1.51
Base flow to rivers	0.30
Total	**4.29**
Net	**-0.45**

Source: Kruseman and Naqvi 1988, ACE 2001a - * Estimation by IWMI as 1.03 BCM

2.4 Balochistan Province

In Balochistan the groundwater situation, especially in the intermontane valleys and plateaus, is best described as the classical 'race to the bottom'. In some basins, especially the Pishin-Lora, the race has already reached its logical conclusion. Some of the deep tube wells have run dry now too – precipitated by the drought that has affected Balochistan as it has done other parts of the Pakistan.

Five hydro-geological zones can be recognized in the Province, i.e. the mountain ranges, the valley floor and basin plains, the piedmont plains, playas and the rolling sand plains. Groundwater in substantial quantity occurs in unconsolidated aquifers in almost all basins and sub-basins. The depth of the water table varies from less than 1 meter to over 100 meters but typically ranges from 5 to 50

meters. The alluvial sediments form the best productive aquifers. Fractured/karstified limestones are also providing significant amounts of groundwater.
Of the total water resources in the province groundwater is a mere 5%, but it is the most crucial 5%. Drinking and domestic water supply depends entirely on groundwater (IUCN 2000). Tube well irrigation moreover supports the high value cultivation of deciduous fruits. The number of wells in the province is estimated at 24,000. Overwithdrawal is reported from three important basins the Pishin-Lora (where Quetta is located – see section 2.5) as mentioned, the Nari Basin and part of the Zhob Basin. The other eleven basins in Balochistan still have small surpluses that one may expect to come under more pressure in the years to come.

The most significant response to the groundwater crisis in the uplands by the Government of Balochistan has been the construction of 150 delay action dams. The primary objective of these dams was to collect water after the sporadic rainstorms, in order for it to infiltrate and contribute to the groundwater stock. The cost effectiveness of the dams that have been constructed has been criticized. The first point of criticism is that their life span as a recharge structure is limited by the deposition of fine sediment in the reservoir, severely reducing groundwater recharge within a period of 2-3 floods. The second point is that even with the best efforts the total contribution that artificial recharge can make is limited. An extensive study on an experimental delay action dam in Quetta Valley concluded that the dam could provide additional water capable of supporting less than 1.5% of the existing orchards in the project area (Halcrow 1990). A third point is that much of the rainwater collected by through delay action dams would otherwise be recharged in a natural manner.

The situation in the canal areas of Balochistan is a complete contrast to that of the highlands. Canal irrigated irrigated areas make up approximately one percent of the area of the Province. Water logging is common here and affected twenty percent of the area in 2000. Since then the situation has further worsened. Due to water allocation problems in the newly improved Pat Feeder canal there was very little development of secondary and tertiary networks. Different from what was designed, the area has been converted into a rice growing area following a wasteful field-to-field system.

Groundwater quality in Balochistan varies. In the northern region of Balochistan, comprising Zhob and Pishin-Lora, the quality of groundwater is good. In the western and southwestern parts groundwater is saline to highly saline at all depths. In coastal area of Balochistan, quality of groundwater is particularly poor due to seawater intrusion.

The groundwater-recharge/balance for the Province in broad terms is given in table 8.

Table 6: Groundwater budget Balochistan

Recharge/Discharge Components in BCM	**Normal Year**
Recharge Components	
Recharge from Rainfall (estimate)	1.49
Recharge from Canal System @ 15 % of 2.39 BCM	0.36
Return flow from Irrigation system @ 22.5 % of 2.0 BCM	0.46
Other Return flow / GW Abstraction @ 20 %	0.10
Recharge from Rivers	0.22
Total	**2.63**
Discharge Components	
Groundwater Abstraction (Public + Private)	0.56
Non-beneficial ET losses	1.39
Sub-surface out flow	0.41
Base flow to rivers	0.17
Total	**2.53**
Net	**0.10**

Source: WAPDA 1984, Halcrow 1996, ACE 2001a;

2.5 **Urban areas**

Urban areas present a special case. Most of Pakistan's major cities rely on private pumping for domestic water supply. The piped supply from the Water and Sanitation Agencies is generally far too limited and unreliable. Shallow private wells are sunk in large numbers to augment supplies. The large scale exploitation of the aquifer underneath the cities and in urban periphery has however led to falling water tables and to contamination of water supplies by leaking sewerage systems and septic tanks, as Rahman (1996) has documented for Karachi. In Quetta the overexploitation of the confined aquifer by agricultural users around the city has already led to a number of doomsday projections, predicting that in a foreseeable future even the supply from deep groundwater to the capital of Balochistan province will dry up. Birch et al (1998) estimate that the remaining groundwater may be exhausted by 2016. Another problem is the disturbance of the riverbeds near big cities, which are often used for the excavation of building material. In the Malir River near Karachi the disturbance of the riverbed resulted in a limited recharge of water flows and reduced water levels in wells in the adjacent area. Similarly the catchment of Lei Basin, feeding the twin cities of Islamabad and Rawalpindi is disturbed by quarrying and deforestation. In addition, the rapid expansion of the built-up area, the increased and unregulated private exploitation of groundwater for domestic consumption and the disposal of untreated or semi-treated sewerage in Islamabad and Rawalpindi has led to a decline in the water table of 1.4 meter annually and an estimated 90% of the drinking water wells being contaminated with coliform bacteria (Malik 1998). Similarly water tables in Lahore have fallen at a rate of 0.55-0.65 meter annually over the last thirty years (Mashadi and Anwar 2000). As in other major cities the decline in Lahore is attributed to a lowered recharge capacity due to development of built-up area and loss of flow in the Ravi River as well as the increased abstraction, tripling over the last twenty years. So far these urban groundwater quality and quantity problems go unaddressed.

3. CHALLENGES

The management and use of groundwater is faced with a number of challenges. The common denominator in all these challenges is that a start has to be made in addressing them. In groundwater management lethargy has prevailed. In spite of substantial financial resources dedicated to the water sector overall, not many initiatives have been taken to address the opportunities and threats in groundwater management. The main challenges in groundwater management in Pakistan are: (i) address groundwater quality deterioration; (ii) protect groundwater from pollution; (iii) reverse the continuous lowering of groundwater tables, especially in the barani areas and the canal commands in Punjab; (iv) address remaining water logging, particularly in Sindh and (v) set the finances and institutions right. These challenges are discussed below.

3.1 **Addressing Groundwater Quality Deterioration**

Due to the changed water management scenario concerns on groundwater quality in Pakistan have taken a new dimension. In groundwater quality increased salinity and sodicity and arsenic and fluoride levels are the main concerns. In addition there is point pollution near municipal and industrial areas. Point pollution is discussed in section 3.2.

3.1.1 Salinity and sodicity

There is concern that the heavy use of groundwater is affecting the salinity and sodicity of groundwater, especially in the very crucial central alluvial aquifer, in the areas where fresh and saline groundwater zones border. The heavy pumping in fresh groundwater areas invites saline groundwater from adjacent saline zones or causes up-coning from deeper and more saline layers. These phenomena for instance caused more than 250 drainage cum irrigation tube wells installed in the fresh groundwater zone of SCARP-II to be abandoned. The salinity of pumped water in the tube wells increased due to the lateral movement of saline groundwater from the central part of the doab. Similarly hydro geological studies for the SCARP Transition Project in North Rohri Pilot Project established that the wells installed at the fringes of the fresh water areas showed a continuous increase in salinity of groundwater (NESPAK 1997). The areas most prone to this salinization are fresh water zones hydrogeologically downstream of the saline areas.

Another development that has been suggested that could cause increased groundwater salinization is the heavy reliance on groundwater in selected spots, in particular tail-end areas of canal commands. Groundwater after being pumped recharges back in the shallow aquifer from where it is reused again. This recycling has been suggested to increase salinity levels (Murray-Rust and vander Velde 1992). The extent of this type of 'secondary salinization' however is not supported by substantive evidence and it may well be limited to certain areas. Probably more threatening than secondary salinization is secondary sodicization. Data from the draft Drainage Atlas (WAPDA 2004) suggest that in several parts of the country sodicity is increasing. The issue is not investigated in detail, but require more attention.

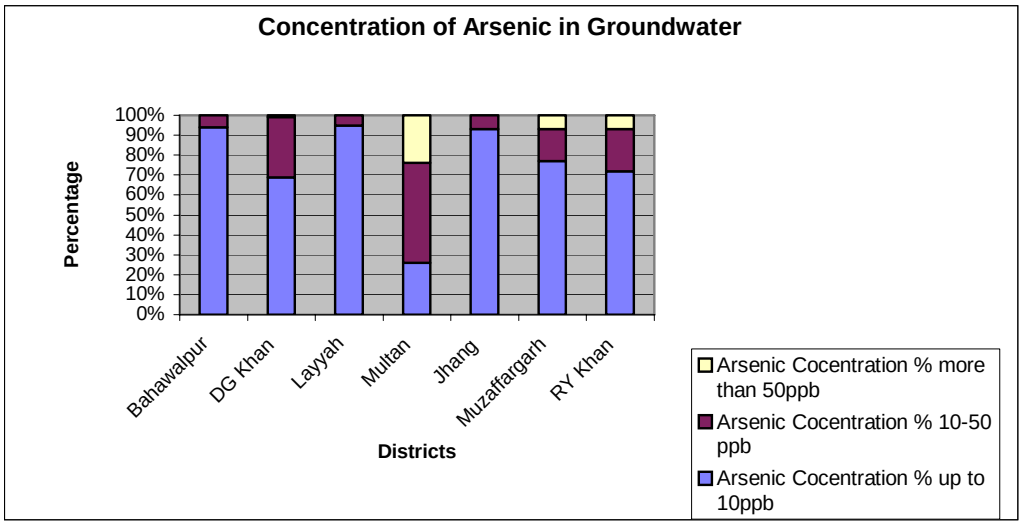
3.1.2 Arsenic and fluoride contamination

In chemical groundwater composition arsenic and fluoride contamination are most relevant. The extent of arsenic contamination of groundwater has recently has been documented for the first time. Some of the results of these studies caution concern. Preliminary findings of the National Water Quality Monitoring Programme indicate that arsenic found its way in large number of water samples from cities such as Bawalpur, Multan and Sheikhupura and Lahore (PCRWR 2004). Further, in seven districts in Punjab (i.e. Bahawalpur, Layyah, DG Khan, Multan, Muzaffargarh, Rahim Yar Khan and Jhang) a total of 5594 samples were collected by UNICEF and Pakistan Council for Water Resources Research (PCRWR 2003). Besides households were interviewed and members of the households were

examined for clinical manifestations of arsenic contamination. The results from the survey are given in figure 3a. In 19% of the samples values exceeded safety norms (10 ppb), but were still below the maximum permissible levels of 50 ppb (0.05 mg/litre). However, toxic level concentrations (> 50 ppb) were encountered in 5 % of the samples, with the lion share from Multan District, but also Muzaffargarh and Rahim Yar Khan. Initial inferences of the study found a higher concentration in shallow sources (50-100 feet) and relatively older water points. These results need to be validated, if only because the 'Mereck' field kit that was used shows high levels of error.

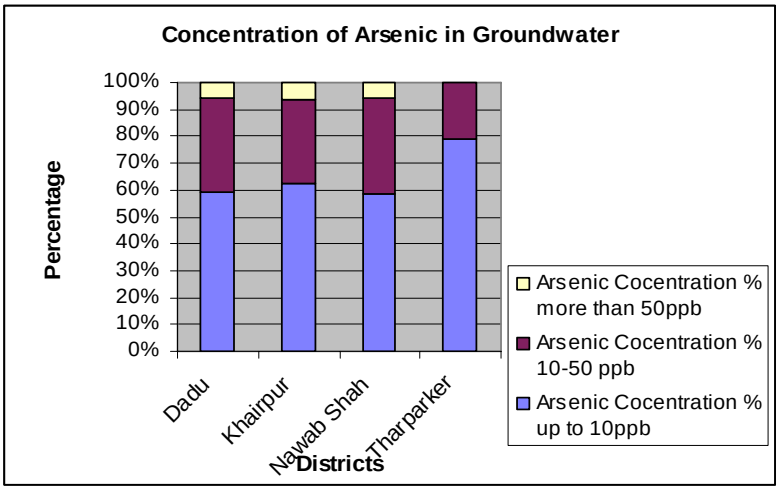
A more extensive survey was undertaken in Sindh. Here the results are even more alarming (Abro et al, 2004). The 67,556 samples covered four districts, i.e. Dadu, Khairpur, Nawab Shah and Tharparker. The samples were taken from hand pumps (94%), open wells (4 %) and water supply schemes – tube wells - (2 %). Contamination level in various districts is shown in Fig 3b. In all 4 districts combined 22% of the samples have values exceeding the minimum norm of 10ppb. 6% of the samples exceed the maximum permissible level, all from Dadu, Khairpur and Nawabshah. The study also looked at the possible reasons and sources and/or causes of high concentration of arsenic. As in Punjab it was observed that the highest concentration was in the hand pumps installed at 51-100 feet depth. It is notoriously difficult to identify the causes of the arsenic. In the study it was noted that the highest level occurred in the vicinity of agricultural fields. Several explanations are offered.

Figure 3a: Arsenic levels Punjab (2003)



Source: PCRWR (2003)

Figure 3b: Arsenic levels Sindh (2004)



Source: Abro et al (2004)

No large-scale survey into fluoride contamination has been undertaken. There are several reports (among others PCRWR 2004) of areas with high fluoride content, such as Loralai, Quetta, Mastung, Kharan, coastal Makran (Balochistan), Salt Range, Bawalpur, Manga Mandi – Kalalanwala (Punjab) and Tharparkar (Sindh). The most comprehensive study, a survey of 987 samples from sources of domestic water supply, showed however that they are predominantly low in fluoride, with 84% containing less than 0.7ppm of fluoride (Ajjaz et al. 2002). This suggests that fluoride and fluorosis – including the dental and bone deformation are not uniform but can be serious at specific places.

In both arsenic and in fluoride contamination alertness is required without being alarmist. The result of the recent studies needs to be substantiated, before initiating programs to deal with these issues. It is important at the same time to keep things in perspective and not loose track of the fact that bacteriological contamination remains the major contamination and cause of morbidity in drinking water.

3.2 Protecting the groundwater from pollution

A second important challenge concerning groundwater quality is to protect groundwater from pollution. The uncontrolled discharge of industrial effluent and municipal sewerage poses a threat to the availability of potable water, especially in major urban centres (see also section 2.5). Several studies are underway, but there is not yet adequate information to catalogue the specific 'hot spots' and undertake remedial and mitigation measures in a systematic manner.

A recent study, conducted by the Environmental Protection Department in Punjab (EPD 2003) took 280 samples, distributed evenly over all districts in the Province. It found the concentration of the different heavy toxic metals (cyanide, cadmium, chromium, mercury, lead, boron, nickel, selenium, zinc) to be in excess of WHO standards for 1 to 25% of the samples. Bacterial contamination was the largest concern, affecting 64% of the samples.

Similarly, under the Punjab Private Sector Groundwater Development Project (PPSGDP) groundwater quality checks were undertaken. Samples - mainly from the hand pumps and private tube wells - were collected from Sheikhupura, Sargodha, Jhang, Muzaffargarh and Toba Tek Singh district. These studies indicate that pesticides residues have found their way to the shallow groundwater aquifer

especially in the cotton belt. In the areas downstream of the various industrial units the concentration of heavy/toxic metals was generally beyond permissible WHO limits. Near the industrial clusters along Gujranwala and Sheikhupura roads arsenic, lead and selenium were prevalent.

3.3 Reverse the lowering of water table

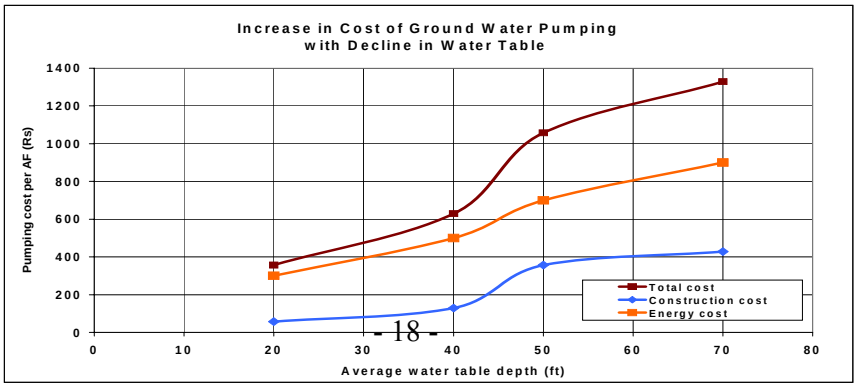
Though the intense use of groundwater has boosted the economy for years, the lowering of the water table in barani areas has at the same time caused considerable hardship. It has undermined livelihoods and affected the availability of drinking water and generally increased vulnerability to droughts. It has also changed access to groundwater in the barani areas. In the canal commands the overuse and lowering of the water table increases pumping costs and induces ingression of saline water into fresh groundwater areas (section 3.1).

The drought of 1997-2002 has brought home the effects of groundwater overuse over the decades. Worst hit areas were the parts of Quetta –Pishin in Balochistan, Tharparker in Sindh and Pothwar Plateau and Cholistan Desert in the Punjab where large numbers of wells went dry or saline. In many areas groundwater exploitation had exceeded sustainable yields for a long time. In the Pishin-Lora and the upper Nari basin in Balochistan groundwater levels declined at a rate of 0.25 to 1.10 metre for decades (WAPDA 1992). During the dry years this trend accelerated, causing considerable hardship. According to Qureshi and Makhtar (2004) the drought triggered outmigration of 9% of all people in the barani areas in Sindh and Balochistan. In Balochistan 75% of the orchards were affected; animal mortality increased (16 goats or sheep per household respectively in Balochistan); animal stock reduced further because of distress sales and it took longer on average to collect drinking water for household purposes. It may be argued that the sheer presence of tube wells relieved the effects of the drought, but the issue is double-edged, because overall the falling water table reduced resilience and made it more difficult to find alternative sources of water.

The decline in water tables has also caused changes in access to groundwater. In the past the most common form of groundwater exploitation in Balochistan was the vertical well, which was usually owned by a group of shareholders. Not everyone had access to a kareze and when dug wells came in vogue, they were often financed by farmers that did not have a share in the kareze. Over time both karezes and dug wells fell dry and deep tube well became the most viable option. The cost of these deep tube wells is high (Rs 1,000,000 and more) and can only be afforded by a privileged few with access to financial resources of their own or of banks. It is estimated that the total number of tube well owners in Balochistan is close to only 7000, or one-third of the total tube well population.

This increase in pumping cost with the decline in water tables is a general trend. In the unconfined shallow aquifer of the Indus valley for instance centrifugal pumps are most common. These pumps have a maximum suction depth of 20 feet. Beyond this depth farmers have to construct a sump. With gradual increase in water table depth, the farmers have to deepen their sumps and this is not only uneconomical but also hazardous at depths more than 50-60 feet. Below that depth, deep well turbine pump may have to be used as prime mover. This more than doubles the cost - from Rs 60,000 to around Rs. 300,000, taking groundwater use out of the reach of small farmer. Similarly the pumping cost increase from around Rs. 300 to more than Rs. 600 per acre-foot of water as shown in figure 4.

Figure 4: Increase in cost of ground water pumping with decline in water table



3.4 Address Water Logging

Paradoxically some areas are still suffering from water logging, mainly in Sindh and some parts of the Punjab. These areas are located in the topographic depressions and/or along main canals – feeders. They are found especially in areas with high irrigation duties and/or saline groundwater. The National Water Policy Study by ACE-HALCROW (2002) indicates that in a normal year 18 % of the irrigated land is still water logged and about 5 % suffers from severe salinity. Improved irrigation efficiency and better drainage facilities are proposed to mitigate this (see separate CWRAS paper on this).

3.5 Setting the finances right

A final challenge is to address the continued financial support to the overuse of groundwater through subsidies on pumping, both in the private and the public sector. Tariffs for agricultural tube wells are approximately 35 % below rates for the domestic or industrial uses. The electricity charges for tube wells in NWFP and Balochistan are relatively less compared to Punjab and Sindh, even though the cost of producing and transporting power in the first two Provinces is higher. In Balochistan for instance the average cost per kWh at the power plant gate is 6-dollar cents or Rs 3.6/ kWh. If one adds a conservative 25% distribution costs – including technical losses – the value would come to Rs 4.5 / kWh. This is well above the 3 Rs/kWh charged to the agricultural consumer. In the current scenario such financial incentives are an anomaly, yet they continue to be used with considerable political opportunism. In response to the drought in Pakistan politicians for instance called for free electricity for agricultural wells, not for tightening up groundwater regulation.

As a corollary there has been substantial discussion on energy pricing for agricultural usage. An argument, that is made frequently, is that the electricity subsidies for agricultural use should be phased out, in order to encourage farmers to use groundwater more judiciously. This demand management argument, however, has only limited validity. Reduced subsidies would probably only marginally promote efficient water use. For one reason the majority of tube wells in Pakistan (86%) operates on diesel and is not be affected by electricity prices (table 1). Moreover, in general energy prices are low. Even to a farmer entirely dependent on groundwater the expenditures on diesel or power are less than those on fertilizer or pesticide. Water is a crucial but relatively cheap input and this will not change considerably. It is unlikely that in the foreseeable future the price of pumping will greatly affect the use of groundwater.

In addition, many electric tube wells – particularly in Balochistan - are charged on flat rate basis. Obviously flat rates give no incentive to economize on consumption. The background of the flat rates was the complexity of doing meter readings in an area as vast as Balochistan. The additional attraction of flat rates for electricity distributors is that it allows them to mask unaccounted losses under the guise of high consumption by flat rate consumers. The largest 'subsidy' in groundwater exploitation is the non-payment of energy bills. In NWFP and Balochistan recovery rate does not exceed 50 %. By 1999 the total arrears for electricity tube wells in Balochistan for instance had reached Rs. 4.15 Billion (van Steenbergen, 2002). There are hence many strong arguments to reform electricity pricing in agriculture, but the most important ones deal with public expenditure management and releasing resources for more meaningful public activities.

4. PRIORITY AREAS FOR ACTION

The recurrent theme is that most of the groundwater issues in Pakistan need more management. At present the groundwater sector is a predominantly private affair, requiring regulation rather than financial support. Regulation needs to be seen in a broad context – depending on the location either stimulating private groundwater exploitation or restricting it. We want to advocate that regulation is not the behold of the government and top-down only but that local regulation needs to be stimulated in equal measure. There is a need to revisit the current institutional and financial arrangements in groundwater. Public funds in the groundwater sector in particular should not be directed at subsidizing overexploitation, but at augmenting supplies. This supply augmentation should be complemented by improving local groundwater governance. A final priority is to tackle groundwater contamination and overuse, particularly in those locations where the problems are largest.

The priority areas for action first and foremost concern:

- Re-examine irrigation duties in canal command
- Promote and support local groundwater management
- Avoid groundwater disasters at hot spots
- Initiate institutional coordination
- Stop financing overuse
- Invest in recharge
- Tackle groundwater pollution in selected places

4.1 Re-examine irrigation duties

In canal commands the most important strategy in balancing supplies and demand in groundwater is to re-examine surface water supplies. With close to 600,000 tube wells in the Indus system, conjunctive water use in fact presents itself as the most powerful mechanism for water management. In canal commands with fresh as well as saline groundwater alike, farmer use a mix of surface and groundwater supplies. A systematic integrated strategy at system level, however, is missing. The history of the 2000-2002 droughts, when - in spite of 35% reduced canal supplies - grain production went up, though slightly (from the level of 20 M ton) provides a very strong pointer to the expediency of rethinking surface water allocations.

During this drought period the shortfall in water delivery was compensated by intense groundwater use and by more efficient irrigation. As the figures from Sindh show there was a concomitant dramatic reduction in the area under water logging – indicating that drainage conditions would benefit as well from reconsidering irrigation duties. At present water allowances in the perennial canals range from 2.8 cusecs/ 1000 acres (LCC, LJC in the Punjab and Eastern Nara and Rohri canals in Sindh) to 7.7 cusecs per thousand acres in Kalri – Bhaggar Feeder in Sindh. For non-perennial canals the water allowance varies from 3.5 cusecs in the command of UCC (in Punjab) to 17.6 cusecs/ 1000 acres (Rice Canal, Sindh). There is no reasonable justification for these differences, particularly because they trigger wasteful water use in the top-end commands.

A re-examination would need to be done for each Province separately for the canals within the Province. Undertaking the re-examination in this manner should avoid the stalemates usually associated with interprovincial water distribution. There is a case to reduce the wide variance that now exists between canal commands within the same Province. Water budgets could be developed, looking at the prevailing agricultural production systems as they have developed over the years, the expected production systems in the future, groundwater quality and current groundwater use, and the scope to improve water management, i.e. reduce water logging, control ingression from saline groundwater zones into fresh water zones or create flood water buffers for later conjunctive use. In selected canal commands scheme modernization would be required too. A case in this point is the Pat Feeder canal,

where no command area development has taken place for several reasons, nudging the area into relatively wasteful paddy cultivation.

So far the issue of re-examining canal supplies has been a political no-go area. However, there has never been a systematic discussion on the merits, including the considerable possible impact of releasing water for other areas and the considerable benefits of reduced water logging for health and property. A strategy for re-examining canal supplies would need to incorporate a systematic information campaign to avoid dysfunctional polarization.

Action Required

- Re-examining water allocation for the different canal commands, keeping in mind official irrigation duties, actual deliveries, cropping patterns, groundwater quality, current groundwater use and over- or under-exploitation.
- This needs to be complemented by an extensive information campaign to opinion makers to avoid the discussion becoming captive to politicization.
- Promote skimming wells in areas with saline groundwater to exploit the fresh water lens on top of the saline layers

4.2 Promoting and supporting local groundwater management

To regulate groundwater outside the canal commands the promotion of local groundwater management is the most promising avenue. In a few valleys in Balochistan, i.e. Panjgur, Kech and Mastung, kareze shareholders in the past took spontaneous initiatives to control groundwater exploitation and prevent overdraft (van Steenbergen 1995). In other areas the response to declining water tables was to activate the traditional harim (border) rule. These spontaneous arrangements – though few and far between - are so far the only examples of groundwater regulation in Pakistan. In areas with relatively small confined groundwater systems, there is scope to promote such local regulation systematically and on a large-scale.

On paper, the 1978 Balochistan Groundwater Rights Administration Ordinance had the making for an enabling framework for local resource management. It involved the local administration as well as tribal elders and allowed flexibility in determining usage rules. This strategy made much sense in the tribal society of Balochistan. Unfortunately the legislation was not complemented by an effort in establishing such local rules. In fact very few people knew the law existed at all. It was not realistic to expect such rules to evolve spontaneously, barring a few isolated places, and therefore the legislation failed.

There is a need, however, to revive the effort. A broad-based awareness campaign on the limits to groundwater utilization and on effective actions to reverse overuse should be part of this. Such a campaign should break the grounds for local regulation and familiarize a large number of people with the legal provisions, as they exist. The net should be cast wide, hoping to find local champions to promote groundwater regulation. In the social environment such as exists in Balochistan but also in other arid tribal areas in Pakistan, where it is extremely difficult to enforce any regulation which individuals or tribal groups judge not in their immediate best interest, the only way to ensure that policies and laws are implementable is through consensus building and intense education and communication programmes. Participatory hydrological monitoring and local micro planning should follow up from the campaign. In participatory hydrological monitoring groundwater users are being facilitated to measure groundwater fluctuations and prepare local groundwater budgets. In micro planning a series of PRA tools – resource mapping, transect walks, time lines and local water audits – are used to identify common measures in demand management, social regulation and improved local recharge. Both approaches are implemented to scale in Andhra Pradesh in India, which is equally

faced with groundwater overuse. The awareness and micro-planning programs should be complemented by the active promotion of alternatives to current intense and often wasteful groundwater use – such as alternative crops, soil water retention measures, affordable micro irrigation and local water harvesting techniques. An enabling legislation, along the lines of the Balochistan Groundwater Rights Administration Ordinance, should provide the regulatory underpinning. Similar laws may be initiated in other barani areas such as the Pachad in DI Khan and DG Khan, the Thar and Cholistan Desert and the tribal parts of NWFP. The important point however is to engage a social mobilization campaign that will set the local regulation going. In this regard there is also a need to activate the role of local government in this field. Under the devolution plan Tehsil Administration Authorities are responsible for the provision of basic services such as water supply and sanitation and much needs to be done to build capacities in this field and in water resource management in general.

Local water management can also be strengthened in canal commands. This would need to build on the development of Farmer Organizations. In Kamalia local water budgets were prepared and piezometers installed under the PPGSD, which was received enthusiastically and could form the basis for local water resource planning. So far the support to the development of Farmer Organizations in Pakistan is best described as half-hearted – with more lip service than resources devoted to it. The importance of the Farmer Organizations however in the end depends very much on the extent to which they are able to improve local water management – not so much whether they are able to bring together the finances for system management. This requires considerable more support to the Farmer Organizations than has been given so far.

It has been suggested that the promotion of local groundwater management should be complemented by the definition of rights, entitlements or concessions. The priority however in the short term is the formulation of local usage rules, endorsed by legislation. This would create the larger impact. It is not difficult to see that at this junction defining quantified entitlements and rights would take the entire effort in promoting groundwater management off on a tangent. The effort involved would be enormous and would most probably be rife with controversy: the number of groundwater users is enormous and the data base on abstraction, safe yield or even number of wells is inadequate. Moreover, assigning abstraction rights would either be open to corruption or expected to be so, which would undermine the basis for enforcement. Moreover, in a country where there is a large default on agricultural electricity bills and there is no systems in place for the rights to canal water supplies, defining groundwater rights is not opportune. Instead formulating rules of the game and getting them endorsed by the local administration is much more promising.

Action Required

- Reactivate the Balochistan Groundwater Rights Administration Ordinance and introduce similar legislation in other non-canal command areas
- Initiate an awareness campaign that familiarize groundwater user on the local aquifer conditions, risk of overexploitation, legal provisions, water conservation measures and importance of local management
- Initiate a social mobilization programme to develop local groundwater regulation, focused on participatory hydrological monitoring and micro-planning. Engage teshil administration in these efforts
- Strengthen capacity of Farmer Organizations to manage water resources through training programmes and local water budgeting

4.3 Avoid groundwater disasters at critical areas

There is also a need at certain hotspots – groundwater quantity or quality wise – to initiate crash programs that combines regulatory and physical measures. Birch et al. (1998) have suggested this for Quetta for instance. Such crash programs could consist of strengthening regulatory and coordinating capacity, updating data sheets, survey and monitoring of abstraction points, alignment of energy policies, awareness building and extension on wise-water use, buy-out agricultural groundwater consumers, balanced investment in recharge and promoting catchment management.

4.4 Institutional Measures

Institutionally groundwater is nowhere and everywhere at present. More than a dozen agencies have been involved in groundwater development and monitoring, but there is no coordination, proper staff availability and adequate logistics. None of these agencies has complete knowledge of the issues and none has operational responsibilities in groundwater management. What is required is to develop a focal point within each provincial administration that will promote and enforce regulation, coordinate the activities by various agencies and gradually develop a database. Ideally, one provincial agency would be overall responsible for groundwater monitoring, management and regulation. According to current legislation the Provincial Irrigation and Drainage Authorities have this task. The PIDAs are to ensure that groundwater monitoring is undertaken and have a mandate to initiate policies to address groundwater management problems. So far, nothing has happened on this front. In other comparable countries in the region, special full-fledged units have been created in the main irrigation or water resource departments (for instance Egypt) or special departments, closely attached to water use departments have come into force (West Bengal, Andhra Pradesh). This is very much the need of the day, particularly in Balochistan and Punjab Province, where the dependence on groundwater is large. It is proposed that where Provincial Irrigation and Drainage Authorities are in place and capable such Groundwater Cells are set up in the PIDA. Where this is not feasible the alternative and temporary arrangement is the Planning and Development Department. It is important to consider these Groundwater Cells as 'principal agencies' and not as sole bodies. The Groundwater Cells should coordinate the data collection by the most competent parties, not necessarily undertake it itself. The Cells should also be the mechanism to assess the requirements by different users (agricultural, industrial, domestic and environmental) – that may be diagonally opposite - and should facilitate finding pragmatic solutions. For example the lining of canals in SGW areas may be useful to control seepage in irrigation and agriculture but may not suite PHED as they install water supply wells along the canals and distributaries to tap potable water for communities located in the saline zones. The establishment of the Groundwater Cells needs to be supported by a package of measures – legislative, in institutional development and in data collection. Without such programs, initiatives will not go very far, as experience with earlier efforts show (see 1.4).

Presently, data on aquifer characteristics, groundwater levels and groundwater quality, in as far as they exist, are scattered over various organizations. The most comprehensive data sets are those with SMO, but their coverage is limited as they were mainly collected to assess the performance of the SCARP wells in controlling water logging. A study on groundwater potential from 1988 (WAPDA 1988) established that the water table was declining during the last 10 years (1978-87) in 23 out of 44 canal commands surveyed. This did not trigger a change in the monitoring system of SMO. There has also not been systematic data collection for the non-SCARP areas. Particularly, for areas exclusively dependent on groundwater, basic time series are missing. Another shortcoming has been that data have generally been non-available to the public at large and to groundwater users in particular. Data are hard to get and often presented in formats that make them complicated to understand to non-experts. This has made it difficult for any one to act upon these. What is required is to start groundwater monitoring programs in a number of hotspots, i.e. areas where groundwater use is intense and essential for domestic water supply, agriculture or other uses. Information sharing should be part of such monitoring programs, communicating results to local media, decision makers and key stakeholders.

What is required is to assess the most pressing data needs, initiate monitoring programs and to make the information that is available easily accessible and packaged in formats that non-expert users can benefit from. Another priority action in this field is the capacity of laboratories. There are few, if any, laboratories, which are able to perform on a routine basis all the 37 tests required for drinking water under WHO standards – for determining the level of physical, chemical, toxic/heavy metals and organic/bacterial parameters. There is a need to upgrade the services in this field, preferably through private sector laboratories with government organizations (such as PCRWR) doing sample checks and quality control.

In section 1.3 an overview was given of the various laws and acts of relevance to groundwater management, promulgated over the years, but the common denominator is that none of it has been put in practice. With the exception of the Balochistan Groundwater Management Ordinance referred to above (which is also largely dormant), no clear-cut legal framework for groundwater management exists. It is recommended that the Balochistan legislation is updated and reactivated and also introduced in other barani areas. Legislation as it exists now for most of the country 'implies' that for the installation of a private tube well in canal commands a person will need the permission from the Superintending Engineer Irrigation in canal commands areas and from the Managing Director WASA in the towns. Yet for none of the tube wells in the country permission has been sought. Efforts in recent past to put in place appropriate legal measures concern the development of a 'Groundwater Regulatory Framework' for the Punjab Province under PPSGDP. There has however not been any follow-up to these and other proposals. Given the importance of groundwater, the government should see to it that a Framework for Groundwater Management and Regulation comes into existence in each province taking into account the hydrologic, social, political and economy aspects. Such legislation would at minimum need to define mandates and procedures for regulation and coordination. It is proposed to avoid at this stage legislation that is overly detailed or only concerned with licensing procedures only. These legal framework need to be complemented by program of implementation, allocating resources for enforcement, legal awareness building and training.

Action Required

- Establish Groundwater Cells in each Province, preferably in the Provincial Irrigation and Drainage Authorities, or else in the Planning and Development Departments
- Support the Groundwater Cells by a program of implementation, consisting of building the capacity for enforcement and coordination and awareness building
- Activate the Balochistan Groundwater Management Ordinance in Balochistan and introduce similar regulation in other barani area. Introduce provincial Framework for Groundwater Management and Regulation to be complemented by a program of legal awareness building
- Reassess the monitoring of the groundwater - less but sensible. Ensure availability of the funds to the skeleton staff of the monitoring agency on long-term basis under the principles of less and qualified staff, least number of monitoring points and data management on MIS format.
- Package and popularize existing groundwater information
- Assess the capacity of laboratories to provide basic services. – reviewing current workload and screen these as per requirements, support and equip a selected core group properly.

4.5 Realign financing mechanisms

In spite of the overuse of groundwater in several areas, exploitation of groundwater continues to be subsidized and still draws heavily on public budgets (see section 2). Agricultural electricity tariffs are below cost, recovery is low and in an anomaly deep tube wells, developed under the SCARP program

in Sindh and NWFP province, are still operated by the public sector. This gives the wrong signals and incentives, and primarily it is not necessary. As discussed in section 3, the major drawback is that public budget is spent on the wrong priorities. To put things in perspective: more funds are being spent on subsidizing electricity for tube wells than for teacher training or the running of primary health clinics. In changing the financing strategies electricity prices need to be revisited and the remaining public deep tube wells in fresh groundwater zones would best be closed. The main argument for setting the house in order, i.e. phasing out energy subsidies and enforcing payment, is that it would release funds for more relevant activities in groundwater management. This could be recharge measures, water harvesting or flood buffering or improved governance.

Another area where considerably public money is spent on groundwater extraction is the running of public deep tube wells. The number of public tube wells installed over the years under the SCARP program and some irrigation development programs (in NWFP and Balochistan) is nearly 15,000. Most of these public tube wells (12,000) have been installed in fresh ground water areas and they served both drainage and additional irrigation. Over the years deep tube wells became gradually redundant in the fresh groundwater areas, because private shallow tube well development took off in a large manner, as described in section 2. The performance of the SCARP wells moreover left much to be desired. Of the deep tube wells 67% was assessed to be running at less than 50% original capacity. In spite of this energy bills remained high. They were estimated at close to 50% of the entire operational budget for irrigation and drainage in Punjab for instance, prior to closure of most fresh groundwater zone public tube wells in this Province. So far Punjab is the only Province that has systematically transitioned these tube wells. Under the SCARP Transition Projects and the PPGWSP financial and technical assistance was given to farmer groups for the installation of community tube wells in lieu of the public deep tube wells. This helped giving small farmers access to groundwater. It also resulted in an important saving for the provincial exchequer – estimated at Rs 2 Billion annually, on account of the closure of the 7800 public tube wells. In Sindh the transition program started but then stagnated. Only 450 SCARP tube wells were transitioned under the Rohri North Project. After that the program did not continue. In NWFP the transition never started. The closure of the remaining SCARP and other public tube wells in fresh groundwater areas in these two Provinces is a priority action, which would relief the provincial government of a liability for which there is no longer serves a purpose. In Sindh there are still 3500 SCARP tube wells on the government record in fresh groundwater zones. For Punjab the number is 2100 and for NWFP 400.

Action Required

- Simplify electricity tariffs all over the country and phase out subsidies so as to release funds for meaningful investments;
- Improve the recovery rate, by strengthening the collection of revenues and initiate strict action by the government on default
- **Transition remaining public deep tube wells in the fresh groundwater areas of Sindh and NWFP**

4.6 Re-route investment to Groundwater Recharge

It appears more useful to invest in groundwater recharge than groundwater exploitation. The priority action is to develop appropriate and cost-effective water harvesting packages. Site selection is equally important in groundwater recharge. The locations should be chosen so that they concentrate recharge in areas with fresh groundwater and high value uses (drinking water or high value agriculture) and avoid floodwater being lost otherwise to saline playas, such as the Hamune Mashkhel or Dasht in Balochistan) or damage the roads and perennial canals at the periphery of the Indus system. In site selection care is required to prevent interrupting existing sub surface flows and natural recharge and a basin approach should be followed, as far as practical.

The major investments in groundwater recharge so far have been the so-called delay action dams in Balochistan, of which 150 were constructed with 300 more potential sites identified. In addition there are around 100 small dams in the rain fed areas of the Pothwar. These small dams are used for localized irrigation for cash crops, but also indirectly serve local community water supply schemes along the periphery of these dams by laying infiltration galleries.

However, there is large scope to improve the effectiveness of the delay action dams. A survey, that investigated 110 delays action dams in Balochistan, established that some had a noticeable impact on groundwater availability, yet most did not (Nippon Giken Inc. 1997). The average area served by the delay action dams was small (85 ha) and the success of the delay action dams depends very much on their location. A recurrent problem with the delay action dams is that the bottom of the reservoirs is rapidly sealed with fine sediment, impeding the downward movement of water. Majeed (2002) has recommended the use of siphons to gradually transport water out of the reservoirs and infiltrate through the downstream wadi beds. Majeed also recommended that the repertoire of water harvesting and recharge measures in Balochistan is enlarged and that permeable riprap gabions, infiltration ditches, inverted wells, loose stone check dams and deep dug wells are used. There is also much scope to introduce some of the floodwater spreading techniques, used in similar climatic conditions in Iran (Kowsar and Pakparvar 2004). The flood spreading techniques, first introduced in Gareh-Bygone, seek to divert floodwater to high infiltration areas. They have served to revive dry wells, create new grazing area and facilitate spate irrigation. Recharge during the ephemeral flows depends upon the discharge of the stream, physical properties of the sub-soil below the streambed and the duration of the flow. Under the normal hydro-geologic set-up in the mountainous basins the groundwater recharge mainly occurs at the foot of the mountains (fanglomerates and the piedmont slopes) whereas very little recharge occurs in the central part of the valley or basin. In these types of areas the conservation measures involve increasing the duration of the flow as other parameters are fixed by nature. What is important is to link investment in groundwater recharge with support to building up local water management, as described above (4.2). It is important to avoid that watershed management programmes deal exclusively with increased recharge of groundwater, while ignoring the way that water is used. If recharge is not combined with demand management, imbalance will persist.

To improve groundwater recharge in arid areas spate irrigation systems, as are common in Balochistan, Dera Ghazi Khan, Dera Ismail Khan and Dadu, should be revived as well. The spate or rod kohi systems divert floods from ephemeral rivers to sustain the cultivation of crops such as sorghum, millet, wheat and guar. In recent years the spate systems have been in decline for a number of reasons: under investment, out migration following a series of drought years, new infrastructure works disturbing local surface hydrology. The spate systems however still provide livelihood to a large number of relatively poor farmers and the area under spate irrigation is estimated at 1.4 million hectares. In general experience with heavy civil investments in these systems has not been good. A review of 47 spate systems in Balochistan for instance found that only 16 of the modernized systems were still functioning (van Steenbergen 1997). In reviving spate irrigation systems the better options are to make bulldozers available for the substantial earthworks involved in the system (Qazi and Nawaz 2002), to improve governance and water distribution, to ensure there is adequate capacity to store soil moisture and to improve cropping practices. From a groundwater management point of view priority should be given to spate areas with fresh groundwater as they can come to sustain highly productive conjunctive water management systems.

In recent years there have been a few experiments in groundwater recharge in canal commands in India. In the Madhya Ganga Canal in Uttar Pradesh (Shaktivadivel and Chawala 2002) surplus river flows in the monsoon period were diverted to unlined irrigation channels in order to recharge the shallow water table. During the dry season the stored water was pumped up and the draw down of the shallow aquifer in this period made it possible to maximize water storage potential during the next monsoon. As described in section 4.1 there is much scope to develop conjunctive water management strategies at command area level. So far these types of interventions are not on the agenda in Pakistan, but it is an important area for research.

Action Required

- Invest in recharge structures in carefully selected locations using a basin-management approach – combined with improving local groundwater management
- Increase the repertoire of water harvesting structures, meanstreamed in Pakistan
- Revive spate irrigation system through bulldozer programmes, agronomic innovation, improved local governance.
- Research option of groundwater recharge in canal commands as part of conjunctive water management strategy

4.7 Combating Groundwater Contamination

More than 70% of the population of Pakistan depends on groundwater as the source of drinking water. This may be individual wells, tankers, community systems or municipal water supply. It is here that groundwater quality issues become very pressing. In urban areas – such as Karachi, Lahore and Quetta, the greatest threat is the pollution due to the unchecked sewage and industrial discharges and leaking septic tanks. This sometimes aggravated by the use of untreated wastewater in peri-urban areas. Industrial pollution is not limited to urban areas. Where there is intense rural industrialization, groundwater is often heavily polluted too. The most notorious case is probably Kasur, where groundwater has been polluted with chromium and other toxic chemicals due to the seepage of tannery effluents discharged without any treatment. Ground water is the only source of drinking in Kasur and hand pumps, domestic motor pumps and tube wells are the major source to fetch groundwater for drinking.

The priority action here is point control. The Environmental Protection Departments are trying to enforce national environmental quality standards for industrial effluents and encouraging industries to treat wastewater before discharge into water bodies. So far the results are not spectacular. This is not unusual – it is common in many countries. In controlling water pollution by industries in countries with relatively weak formal enforcement mechanisms good results have been obtained through public disclosure, the PROPER program in Indonesia being often quoted in this regard (World Bank 2000). There is scope to introduce similar activities in Pakistan and raise awareness and introduce local water quality monitoring and training on effluent standards to those most affected by it. At the same time special credit lines and common treatment facilities may be developed for industries investing in effluent treatment, particular in areas with fresh groundwater.

The final issue with respect to groundwater quality is the arsenic contamination that was recently established in the survey in Sindh. A priority action is to corrobate these findings, particular because clinical cases are still few. The arsenic problem should also be put in perspective because even in those areas in South Asia where arsenic contamination occurs on a large scale the health risk from dirty water is much larger.

5. THE WAY FORWARD – PRIORITIES FOR WORLD BANK SUPPORT

Need for Bank's Participation

During the last decades, the assistance of the World Bank to the water sector in Pakistan has been extensive. Loans have typically covered packages of infrastructure investments and water management support measures, such as studies and research, the preparation of models, capacity building and institutional strengthening. A number of projects aimed specifically at groundwater development and management. Most of these have their roots in drainage. Table 9 gives a short overview and annex 1 a more detailed list.

The World Bank could make a meaningful contribution to addressing the various challenges in groundwater management, described in section 4. The focus should be on developing and up scaling new approaches with the emphasis on workable institutional arrangements. The pilot approach, as was followed in the SCARP Transition Projects, is appropriate in this regard. Most of the challenges in groundwater management at this stage do not need bulky investments and packages need to be carefully composed in order to avoid that managing expenditures will start to prevail over managing impact. World Bank should assist in introducing novel activities – such as re-examining water management in canal systems, promoting local water management and surveillance and control of groundwater quality. It is important to not a priori settle on untested and mechanical solutions to groundwater management, as do float around in international literature, such as registration of abstraction points, issuing permits, defining groundwater rights or aquifer associations. While some of these may have merit, some do not and it is important not to force-feed. An important asset is that the World Bank has access to a wide array of practical and professional knowledge – from groundwater programmes in other countries and from knowledge centres such as the GW-MATE program. This hands-on knowledge should be mobilized to introduce learning experiences in Pakistan. What is particularly important is to develop and share new approaches among the large community of engineers, farmer leaders, and hydrologists in the country.

Table 8: Recent World Bank Projects in Groundwater Management in Pakistan

Project	Activity
Private Tube well Development Project	Rural electricity grid to encourage private tube wells in order to reverse drainage problems
SCARP Transition Pilot Project	Pilot disinvestments of SCARP tube well by promoting private shallow tube wells
Second SCARP Transition Project	Disinvestments of SCARP tube well by promoting private and community shallow tube wells in Punjab and Sindh
Punjab Private Sector Groundwater Development Project	Disinvestments of SCARP tube well by promoting community shallow tube wells in Punjab Development of regulatory framework for groundwater management
National Drainage Program	a.o. Augmentation of network for groundwater monitoring Assessment of groundwater conditions and groundwater regulatory framework

The remainder of this section makes suggestions for a number of activities in groundwater management that may be supported by the World Bank.

5.2 Crash programs in critical areas

In a number of locations groundwater overuse or contamination have taken very serious proportions. A first category of projects would be in the nature of crash programs in such critical areas – introducing integrated packages of supply and demand management measures. Such critical areas have been identified as part of the Punjab Private Groundwater Development Project and various studies in other Provinces. The crash programs should start with diagnosing groundwater issues both scientifically and through information sharing and stakeholder consultation. Central to the crash programs would be the preparation of local water management plans. These should be supported by participatory monitoring of groundwater levels and quality. Following this package of measures as appropriate can be introduced – be it local recharge measures, promoting more efficient water use, groundwater zoning, waste water and sewerage treatment.

5.3 Rural water supply programs combined with groundwater protection

To ensure safe drinking water to the increasing population in the face of the pressure on the quality and quantity of resource is one of the greatest challenges. What is required is to link drinking water programs with groundwater protection. At present the rural water supply coverage in the provinces ranges between 10 % (Sindh) to 55 % (Balochistan), whereas sanitation coverage is much less. To attain the targets in the Millennium Development Goals much more needs to be done. The Punjab Rural Water Supply and Sanitation Project, now in its second phase, can serve as an example. In this project community based organizations play a central role in the development, cost sharing and O&M of rural water and sanitation schemes. Health and hygiene education is an integral part of the project. Training on groundwater protection should be added to this package, consisting of local water quality monitoring and micro planning, including the preparation of simple water balances and the identification of sources of pollution and groundwater quality deterioration. In such programs should play a central role, if only because they are the ones most affected by the poor water availability and management.

5.4 Invest in recharge and spate irrigation

There is a case to invest more in artificial recharge and water harvesting, but a wide range of options should be considered, including the cost-effective promotion of spate irrigation, flood spreading and innovative designs of groundwater recharge dams. In general the knowledge base in water harvesting in Pakistan is weak and the number of professionals limited. It is understood that there is interest from both ADB and World Bank to invest in delay action dams. More than 400 sites were identified only in Balochistan for groundwater recharge dams, but what should be avoided is that the shortcomings of the past programs in this area are perpetuated – in particular the lack of sensitivity in site selection, problems of sedimentation reducing downward seepage and interference with national recharge. In planning recharge structures a basin approach should be followed. Equally important is to combine the development of delay action dams with measures to promote local demand management through self-regulation – including the establishment of local groundwater organizations.

5.5 Promote efficient irrigation in groundwater scarce areas through local private sector

In groundwater scarce areas the introduction of efficient irrigation methods should be developed – such as drip irrigation, sprinkler irrigation or lay-flat hoses. This promotion should include low cost versions of these methods as have been developed for instance in India. What is important is to develop a promotion strategy that gives ample opportunity to the local private sector to develop this service – in manufacturing as well as retail. Ultimately micro-irrigation products need to be purchased as any other farming input. To prime this line of business ‘smart subsidies’ may be required – whereby

farmers obtain the novel products at reduced prices from local suppliers rather than through special governmental delivery channels.

Along the same lines the well point technology (*nalka bores*) should be popularised in Sindh, both in canal command and in riveraine areas. The technology is relatively common in Punjab. Farmers sink skimming wells in saline areas with a shallow lens of fresh groundwater (formed due to the seepage from the irrigation system) – for water supply and irrigation. At times they encounter saline water up coning. More farmer-field research is needed to educate users to develop groundwater is such areas.

5.6 Support SCARP transition in Sindh and NWFP

In policy dialogues the World Bank can make useful contribution to the incentives and disincentives in groundwater management and in particular the current imbalance in priorities in public financing. A very tangible contribution would be the support to SCARP transition projects in Sindh and NWFP, where this program has stalled in spite of the positive experience in Punjab.

5.7 Support relevant studies and monitoring – including dissemination of knowledge.

A number of important studies are required, in particular the re-examination water duties, exploring the possibility of recharge in canal commands and the validation of arsenic/ fluoride pollution. In groundwater monitoring the current program should be revisited, with larger attention to monitoring groundwater quality and water levels in critical areas. It is also important to consider the way such studies and monitoring activities are conducted. Much of the work in groundwater hydrology has remained very esoteric, hard to access by outsiders and often even more difficult to understand. In some sensitive fields however it is important to draw in a large number of persons and particularly inform decision makers and political leaders. Communication and dissemination strategies should be part of the studies, because what matters are the response they draw. The end product of such studies should not be a report or data set that is difficult to get but understanding of the issue that is widely shared and easy to get. The important thing of the monitoring and studies is to get groundwater management on the agenda.

5.8 Arsenic mitigation – after validation

The reports on arsenic contamination of groundwater in Sindh and Multan are a course of concern, and as mentioned above the results need to be substantiated. Arsenic contamination is widespread in several parts of the world, such as Bangladesh, West Bengal and Cambodia, and has attained 'cause celebre' status. If results remain alarming after validation, arsenic mitigation measures, as are ongoing for instance in Bangladesh for instance, need to be promoted. These consist of awareness building, marking of wells, use of arsenic filters and transport of safe water. It is strongly suggested to widen such programs to include the improvement of overall domestic water quality, which is equally important health issue. Bacteriologic contamination can be reduced through low-cost household treatment systems, such as solar disinfection and ceramic silver filters.

5.9 Institutional strengthening in provincial and local ground water management

Finally and very important the institutional blank in groundwater management needs to be resolved. The various arrangements as they exist need to activated, coordinated and strengthened. The World Bank could play a useful role in supporting institutional and regulatory development at Provincial level and in supporting capacity building and social mobilization in support of local groundwater management.

At Provincial level the legal coverage in groundwater management would need to extend. The Groundwater Rights Administration Ordinance is a useful model for barani areas, whereas the Groundwater Regulatory Framework developed but not yet endorsed in Punjab can serve as an

example for the alluvial aquifer systems in the Indus valley. At the same time – preferably within the Provincial Irrigation and Drainage Authorities – Groundwater Management Units need to established and activated in each Province. Past history showed that such efforts quickly went in dormancy, for instance in Balochistan and Punjab (section 1.4). By giving the Units a central role in the enforcement of groundwater legislation and in the implementation of programmes, as suggested in the other sections of this chapter, they can become vibrant organizations in their own right however.

There is also a large need and potential to strengthen local groundwater management. In the above section it is already suggested to make this an integral component of crash programs in critical areas and support to rural drinking water supply and artificial groundwater recharge. This should go further by incorporating water management planning systematically in capacity building support to the Farmer Organizations that are being established in the canal commands. The Farmer Organizations can be trained and made responsible for participatory groundwater monitoring, evaluation of water budgets for individual distributaries and minors or parts there of and estimation of groundwater availability – or the safe draft – under wet and dry years. Accordingly, the selection of crops and crop area can be discussed. This approach worked well in the Kamalia Distributory that takes off from Burala Branch Canal of LCC. Th initial response of farmers and local agencies was lukewarm, but after a first awareness building stage the ice was broken. During the course of the pilot participatory piezometers were installed at farmers land and local water management was discussed in plenary. The results were a shift of paddy cultivation to other crops and water releases to the tail ends of the distributory for the first time in three years. Promoting local groundwater management is also highly relevant in the barani areas. Particular in tribal areas this may well be the only way forward. In these areas promoting local ground water management should involve traditional leadership and local government, encouraging them to broaden their roles from development to management.

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Agricultural Modernization Through Better Water Management

By

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Country Water Resources Assistance Strategy
Background Paper # 12
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AGRICULTURAL MODERNIZATION- THROUGH BETTER WATER MANAGEMENT

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1. Economic, issues and resources

Pakistan is predominantly an agriculture country where agriculture is the major income, contributing 24.5 per cent to the GDP. It employs more than 45 per cent of the country's total labor force and supports directly or indirectly about 68 per cent of its population's livelihood. The country's overall economic growth rate is dependant on agriculture. Any changes in its performance can have widespread impacts on the overall economic growth rate. This fragile nature of agriculture can be understood by the fact that it contributes about 65 per cent to total export earnings derived from raw and processed agricultural commodities. Other sectors that contribute to export include petroleum and products, synthetic textile, surgical instruments, leather, sport goods and woolen carpets (Pakistan Economic Survey, 2004).

Despite the importance of the agriculture sectors performance has lagged in the last decade. During the past few years, Pakistan has witnessed a major drought that negatively impacted its agriculture and continues to do so. The Pakistan Water Sector Strategy 2002 suggests that because of deficient water for irrigation, agriculture grew only by 4.2 % and similar reduction in agriculture was recorded in 2004. Overall impacts of the last drought have been negative, especially due to reduced wheat and sugarcane production. Based on planned investments in agriculture, productivity scenarios till 2010 estimate that the average growth rate would be around 5%. (FAO, 2000). However, maintaining the 3-4 % growth without fundamental reforms in irrigated agriculture has been considered difficult (Faruqee, 1995 and 2000). Postulation of such growth rates is closely linked to favorable weather, that creates a degree of uncertainty in formulation of long term trends.

There continue major disparities in the distribution of land and water resources. It is noteworthy that 2% of the households own almost 45% of the land and consequently have control over almost 50% of the water resources. The large land owner section of the society has been the major beneficiary of past subsidies in water, credit and government

Schemes. Even the credit mostly benefited the large farmers who capitalized on the implicit subsidies through higher land prices and cheaper access to mechanization. In cases like the relatively progressive cotton belt such a trend has been healthy to help develop the necessary processing and marketing infrastructure with backward and forward linkages centered in the main production areas. The gains from cotton were ploughed back into the system to improve its efficiency in line with international demands.

The Bank in its Public Expenditure Review (2004) review noted that support for agriculture Research and Development had declined after the green revolution. Livestock productivity has been lagging behind despite its potential and presence on almost every farm in the country. There are opportunities that can be availed through forums like WTO to help improve agriculture growth through diversification strategy that focuses on market opportunities, competitiveness, farmer's organizations and more attention to norms and standards that help make the irrigation services reliable. Decentralization of such services to the lowest tiers of the agriculture production chain has also been a constraint. (National Commission on Agriculture, 1987)

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[1] *Economist Asianics International. I would like to thank Drs. Amir Muhmamed and M Ashraf (Director General NARC, Islamabad for suggestions and comments on an earlier draft.

The rural non agriculture sector is also an important section of the economy, engaged in non-agriculture related activities that draw on the farm economy's produce. However, because many poor rural households lack access to land, agricultural growth alone is insufficient to significantly raise incomes of large fraction of the rural non-farm poor, even with substantial multiplier effects on the non agricultural economy. Poorest households can be made more productive by including expansion of micro-credit, enforcement of laws on bonded labor (particularly in brick making industry) and training in marketable skills (Dorosh, 2004) .This study highlights the need to address the important linkages the non agriculture sector can have on accelerating growth in the agriculture sector through increased demand for high value agriculture products and broadened multiplier impacts on the overall economy. More investment to enhance productive capacity of labor in the non farm sector could directly impact agriculture—by making the labor force more productive, specialized and responsive to emerging demands.

There are several outstanding issues that hamper growth in the agriculture sector. Little breakthrough has been witnessed in major crops yields in the last decade and a stagnation is noted. There continues a widespread gap between potentially achievable yields and those obtained on average farm conditions for most major and minor crops. Yields obtained on progressive farmer's field are almost twice as high as those obtained under average farm conditions. See table 1

Table 1:- Yield Gap of Major Crops in Pakistan (tones/ha)

	Potential Yield	**National Yield**	**Gap**
Wheat	6.4	2.2	4.2
Rice	9.5	2.0	7.5
Maize	6.9	1.5	5.4
Sugarcane	160	46	114

Source: PARC annual reports and WAPDA publications

Institutional constraints in research, management of services, policy analysis grass root institutions tend to foster stalemate in the agriculture sector. General lack of vibrant institutional setups that link farmers with remaining agriculture system (technology, knowledge, market) are limiting factors in transforming Pakistan from a low tech to a modern high tech efficiency based.

Given the world wide "knowledge pool" those facilities high input-high output agriculture under different scientifically proven systems-agriculture in Pakistan continues at best as an archaic art form (highly variable across districts and agro-ecological zones) with limited injections of knowledge, technology, institutional linkages and global exposure.

At the farm level high price of fertilizer, pesticides, low availability of new and improved HYV's of crop, vegetable and fruit seeds, farm implements, and costly fuel serve as disincentive for modern way agriculture. Even when inputs of fertilizer and pesticide are well introduced at the farm level adulteration in pesticides and non availability of fertilizer (particularly potash) and pesticide at the needed time also hampers crop productivity[2]. Thus, differential usage amongst farm sizes and agro ecological zones can be attributed to several constraints including credit, uncertain prices, and delivery of inputs in far flung areas. Water shortages in canals and underground resource depletion have an overall negative impact on the agriculture in irrigated areas (PER, 2004).

[2] Also see P.Amir "Pesticide Use and its impact-farm level survey", 2002 and P. Amir "National Fertilizer Use Survey-micro level assessment of situation in Pakistan, 2004" both supported by NFDC, the Planning Commission Islamabad Pakistan.

Even within this environment the government has taken some credible positive steps to encourage this sector and better recognize agriculture's pivotal role in economic development. Amongst others, significant steps taken include reduction in interest rates from 14% to about 9% and introducing on pilot basis crop insurance schemes.

Announcement of a whole package of incentives with special attention to improvement of the on-farm water management situation (investments exceeding Rs. 66 billion) could help uplift this sector in the future. The National Program for Improvement of water courses Pakistan (Punjab component) suggests that out of 58,110 water courses in Punjab 22971 (39.5%) have been improved and the balance of 60.5% still needs improvement. Those remaining to be improved fall in the fresh 15,479 (44.1%) and 19660 (55.9%) in the saline groundwater zones. There are 449 schemes under the OFWM component of the NDP, district governments 440, government of the Punjab financed accelerated improvement watercourses in the Punjab (250) and the Forthcoming World Bank Project OFWM-IV 6000 water courses. A new project has been formulated by the Federal Government to improve remaining water courses (28,000 in the Punjab).

The overall objectives of the new ON-FARM WATER MANGMENT water course improvement schemes are:

1. Increasing agricultural production by effective utilization of irrigation water through improvement of the water courses
2. Enhancing agricultural production in barani/non commanded area through improved of irrigation faculties in these tracts
3. Strengthening farmers participation to improve their capabilities in better management of water at the farm level
4. Promoting increased employment opportunities in the rural sector utilizing local resources.

The government project envisages 87,000 WUA's. Remodeling of 87,000 canal irrigated water including 28,000 in the Punjab in fresh ground water and 15,800 in saline ground water zones. It involves partial lining of critical reaches. The project in irrigated areas will also train 1863 fresh recruits in surveying and designing of water courses.

In the dryland areas about 2000 WUA's will be organized, lining of 500 water courses of water storage to irrigate by gravity flow. About 500 lift irrigation schemes around catchments small dams/water storage tanks where irrigation by gravity flow is possible. In addition about 1000 watercourses of tube wells in barani regions and non-canal commanded areas will be renovated,

The project covers the entire irrigated and barani areas of Pakistan. It is coordinated at the Federal Level by Water Management wing of the Ministry of Food, Agriculture and Livestock (MINFAL) project is designed to provide intensive coverage and water course lining over a period of 4 years (2004-2008). The staff from NDP project will be inducted into this project.

The recently concluded Agribusiness conference in Lahore in December 2004 and a similar one to be organized in Karachi in January 2005 show keenness on part of the government and private sector to enhance international participation in this sector. International co-operation from several countries including China, USA, UK, Holland, Australia and Italy lends further confidence to see major changes in agriculture by application of modern technology and in specialized areas by encouraging corporate farming. Prime Minister Shaukat Aziz has been rather vocal in expressing his desire to modernize this sector-but there appears to be general sense of "indirection" on the main drivers and instruments that can help accelerate the growth rate and put agriculture on a fast track focused on high value enterprises. While the environment favors actions and there is some agreement on focus areas -no comprehensive strategy exists to put agriculture on modern lines and ensure sustained economic growth in

view of the projected water shortages. Many stakeholders continue to cite examples of India, Egypt, Israel and China and the exemplary growth rates achieved by them in overall and particularly agriculture growth. Mimicking this growth requires an intimate understanding of the issues that face majority of the farm population. Since almost 60% farms fall in the smallholder category, it is this sector that requires uplift with the new available technology.

2. Progressive Farming in Pakistan

The already modernized farms with some type of formal corporate set-ups that scantily appear in areas like Okara and Multan in the Punjab and near Hyderabad Sindh are examples of how management can be organized around modern technology to develop efficient production and market systems.

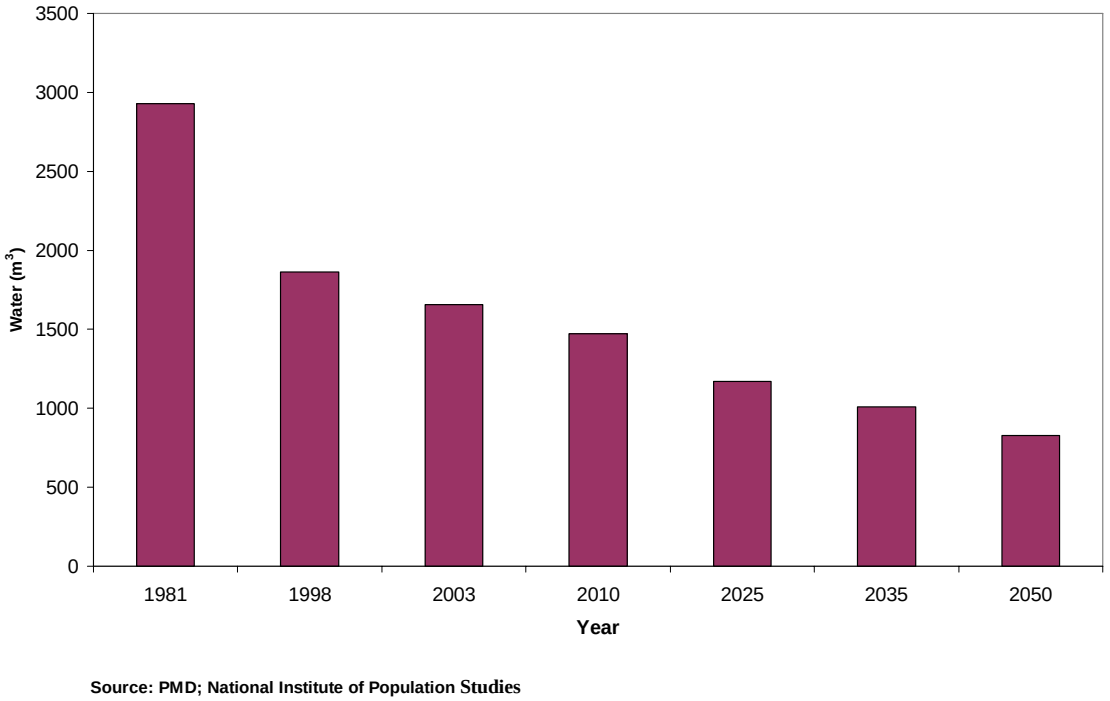
In Okara, Pakpattan and Sahiwals districts progressive farms are owned by large owners and are professionally managed. The dominant production systems are cotton, sugarcane and wheat. Orchards are widespread with special attention to mango and other high value enterprises like vegetables and dairying. The large landowners have a certain political clout and are able to obtain credit on relatively easier terms. Many owners live in Punjab's capital Lahore and commute to their farms. All farms are highly mechanized resulting in intensive agriculture. Land leveling is undertaken both by conventional and high tech lazer levelers. These farms have access to canal water and are able to ensure its regular supply. Practice conjuncture use of wall (canal + tubewell) Farms are well linked with the research system and also obtain technology directly from the intersectional cool abroad. As an example a large dairy farm developed at Shah Jewena (Jhang) gets its technical assistance in dairying directly from Holland with on site staff. Likewise in the case of Mango production, entrepreneurs from Multan's private sector have started to invest & develop this sub-sector on modern lines with special attention to production technology, storage; international marketing linkages and transportation. There have been direct spillover affects to neighboring farms where both technology adoptions (drills, harvesters, combines) have positively impacted productivity. On such progressive farms additional water requirements are supplemented with installation of tubewells. Access to canal water is much better with often perennial supplies covering both Kharif (the spring-summer crop season from May-October) and Rabi (autumn-spring season November-April) season with quantity and quality assurances. However, tail enders on these canals show marked differences in productivity. Such modern progressive farms can be compared with highly productive farms abroad. The same comments would apply to farms in the Tandojam, Halla areas of Sindh, Mango and Citrus in Multan and Sargodha, apple and grape growers in Baluchistan and progressive farmers in the Mardan (sugarcane, tobacco, livestock) and Charsadda (fruits and sugarcane) districts of NWFP. Important **lessons** that can be drawn from such modern & progressive farms are: (1) land must be consolidated and not fragmented into small parcels with sufficient collateral value to avail loans (2) Marketing systems be well developed with provisions for forward production contracts and buy-back guarantees i.e. cotton and sugarcane (3) HYV'S pesticide, fertilizer, machinery, through credit provided at the farmers door-(4) modern technology options and improved HYV's along with imported seed of vegetables and fruits are known to the farmers through private extension (5) Water availability is assured and made certain and modern means to access meteorological information are available (6) farmers have a holding capability to sell produce in domestic and foreign markets without being exploited at the time of harvest (7) farms employ principles of scientific farm management at times by hired professional managers.

There are also other well known examples of specialized production areas i.e. citrus near Khushab, flowers near Pattoki, maize near Chiniot (Faislabad); Mangoes near Multan and Bahawalpur, Guava in Kasur, citrus near (Khanpur in vicinity of Haripur) dairying in

Hyderabad Sindh, sugarcane in Badin Sindh etc. Despite these encouraging illustrations the wider success stories are still rather limited - perhaps it has something to do with what the government perceives as a modern agriculture. These centers of agriculture excellence have several common ingredients as enumerated above. If, such agriculture is to become widespread it will require well laid out policy options giving clear economic signals of comparative advantage within each region, locating the champions of change and entrepreneurial skills and above all an established strong marketing and processing system that encourages investment in agriculture. Such a system would be neutral to landownership and also engage those farmers who do not own land but have the necessary farming and entrepreneurial skills. The well known cotton, sugarcane and fruit production belts have one string in common- all production systems are closely linked to an established market and functions of the market are competitive.

In future, perhaps the single most constraint and opportunity to modernize agriculture will be the way **water is managed** and how new agronomic practices are **organized and managed around it**, to help improve the efficiency of ET on crops, jobs and capital investment. The old maxim of profit maximization and cost minimization will probably be re-looked in terms of getting the best out of a given unit of water-which obviously may not be the highest yield or least cost. The population of Pakistan is increasing at the rate 2.10% (many challenge that the figure is much higher 2.8%) and the difference between the supply and demand of agricultural goods is widening. The current population of Pakistan is above 145 million but, it may be 180 million by year 2010 and 344.2 million in 2050. Increasing population pressure on quantity and quality in food supply and dwindling land and water resources forces the farming sector to increase land productivity through higher yields and crop intensity. The per capita availability of water will decline on per capita basis -see figure.

Figure 1: Per capital water availability in Pakistan (cubic meters)

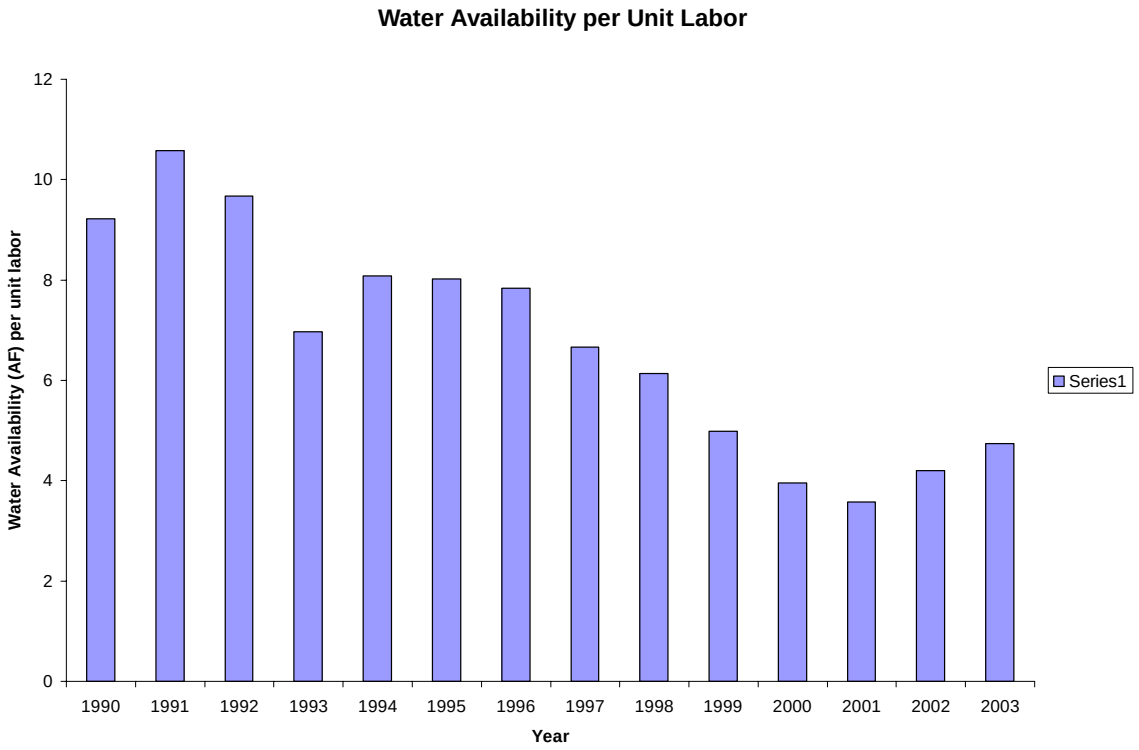


Source: NIPS and WAPDA, 2003

3. Water and Labor productivity:

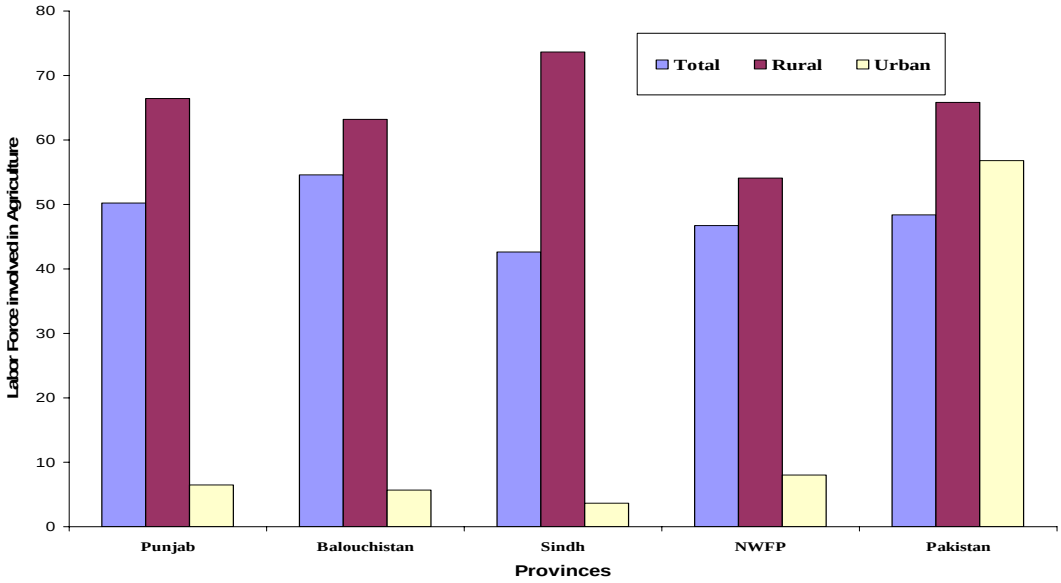
It is important to get some idea of engagement of the agriculture labor force in relation to water. Majid. et al (2000) in an ILO study showed that during 1970-80 the productivity effect was .063 while employment effect was 0.918 and the multiple effects 0.18. In the 90-95 period the productivity effect was .361; employment effect .623 and the multiple .04. Thus the effects in the 1990's tend to show a slowing down of growth. Still there was a contribution of labor productivity. If aggregate irrigation water is divided by the rural population we get a rough idea about how many cubic meter of water is available to the total rural labor force. Total labor force employed in agriculture is 18.91 million. As water resources decline and population increases the per unit of water will also decline leaving more labor to work with much less water thereby either reducing their productivity or making them surplus for use elsewhere -possible rural to urban migration. The later is healthy trend and well known transition path followed by many other developed countries, provided the nation has an expanding industrial base.

Figure 2: Water Availability per Unit Labor.



Source: Calculated from GOP statistics on water availability and labor force, 2003.

Figure 3:- Labor force employed in agriculture sector

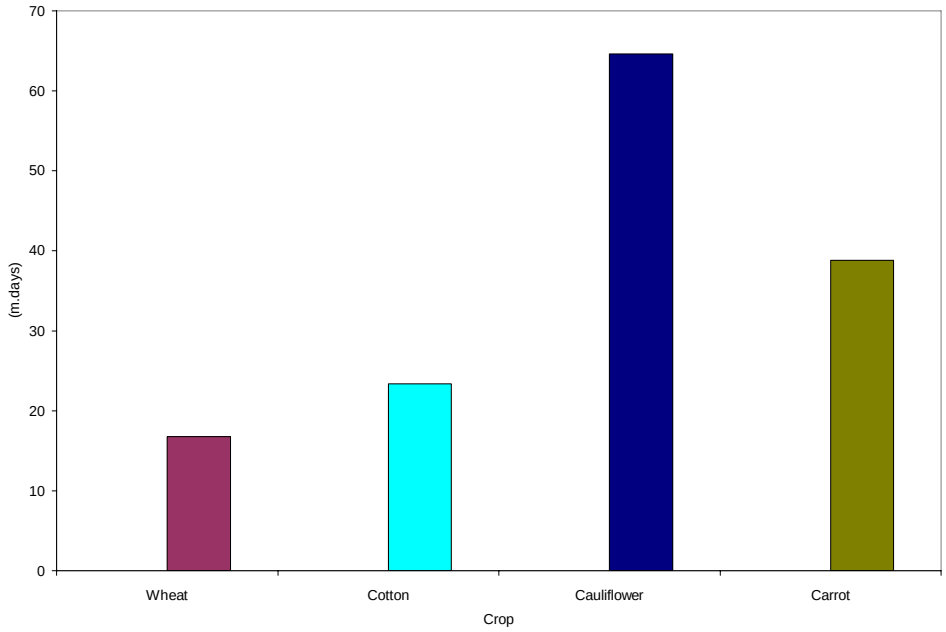


Source: Agriculture statistics of Pakistan 2003

With almost 50% of the industrial units inactive for one reason or the other reviving these sick units is just a different matter beyond the scope of this paper. However, it is important that transition is planned for the re-deployment of such surplus labor in agriculture related processing industries. Otherwise this phenomenon can further aggravate the already rampant poverty situation in the rural areas. Programming this into macro development perspective plans is an urgent challenge.

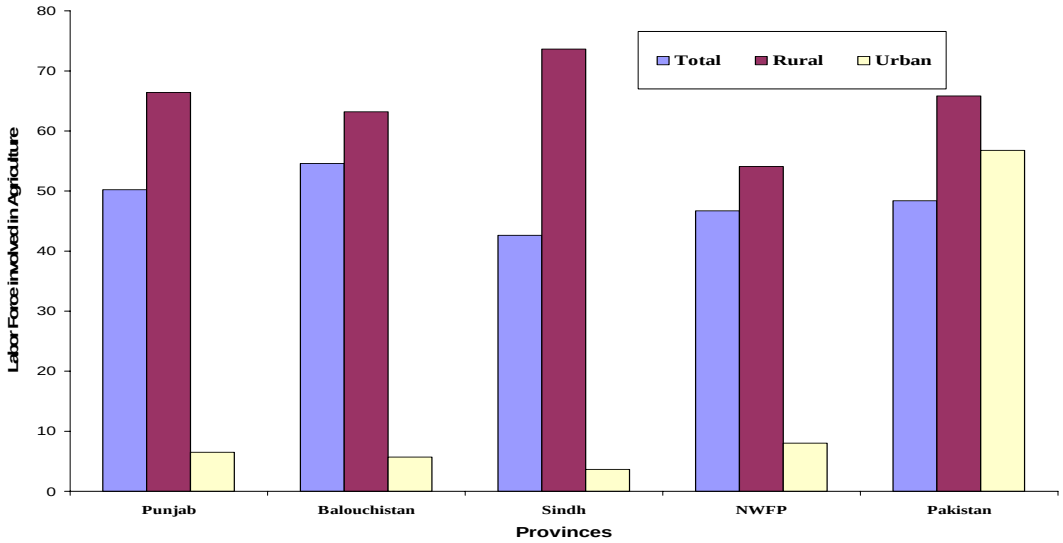
A related corollary is that when water is applied to high value systems the total productivity of labor increases and so does its demand. For instance total labor requirements for wheat and other crops can vary significantly. See figure. Thus as more intensive and high value agriculture is practiced the overall labor absorption on per acre basis increases significantly. Actually, employment generation increases as agriculture intensifies and moves away from a cereals to more horticulture, floriculture, oilseeds and other high value enterprises. In the care of carrot and cauliflower the labor requirements when compared for cauliflower are 4 times that for wheat and almost 3 times that of cotton (Baksh and Ashfaq, 2003). Vegetable and fruit enterprises can be a great source of increasing unemployment-especially of unskilled labor

Figure 4: Use of Labor in wheat and cotton in comparison to vegetables in Pakistan



Source: Data taken from Baksh and Ashfaq, 2003.
Note: The labor estimates provided by Agriculture Prices Commission, Islamabad tend to give low estimates for labor in cotton, wheat and sugarcane and appear unrealistic.

Figure 5: Rural and Urban Distribution of Labor



Source: Pakistan Agriculture Statistics, 2004

The remainder of the paper is concerned with the changing role of public and private sector in stimulating agricultural modernization, an analysis of the options for introduction and adoption of new water and agriculture technologies that improve the efficient use of water. It will also give attention to the needed steps to move towards best practice and finally provides

an assessment of World Bank's comparative advantage to assist Pakistan in this sector and suggestions for productive engagement.

4. Current Agriculture Practices for Water:

Agriculture practiced in Pakistan is based on flood or surface irrigation in the irrigated areas. This is open surface irrigation where water is freely spread over land with little regard to its leveling. Little innovation has taken place in this method which is common in the Indus basin. Surface irrigation is the oldest and most widely used method of irrigation. Also called gravity irrigation or field flooding it relies on the natural slope of a field to distribute water. Water is released at the head of a sloping field and is allowed to flow to the other end. The efficiency of a surface irrigation system is dependent on the type of soil and the slope of the field. The soil serves two roles: the first is distribution, to convey the water to other parts of the field, and the second is infiltration, the delivery of the water to the plant roots. Variations in the soil's infiltration capacity lead to non-uniform water distribution, making it necessary to over-irrigate some parts of a field to give adequate coverage to the whole field.

Surface irrigation systems have low energy requirements, since most work by gravity. The energy required for surface irrigation is the energy needed to pump water to the distribution unit. Initial setup costs for surface irrigation are generally low. Through terracing, surface irrigation can be applied to sloping land as well, though the construction and maintenance of terraces requires added labor expense.

The flood irrigation method has been used since time immemorial and perhaps served the purpose well when water was not a binding constraint. However, in the face of dwindling water resources such practice poses extreme hardship on all types of farmers (owner, tenants and owner cum tenants). The rising cost of electricity and diesel fuel have hit even the most profitable farms, that seek at alternatives to this rather archaic and inefficient method of watering Recently there is an emerging trend of land leveling and application of techniques that allows to faster movement of water i.e. in ridges. While most research and development agencies like PARC and Ministry of Agriculture agree that widespread adoption could lead to substantial saving in water, this message has not been registered at the farm level (especially amongst small farmers).Lack of utilization of modern means of communication specific to the farm level are further hampering accelerated change in this important water saving technology.

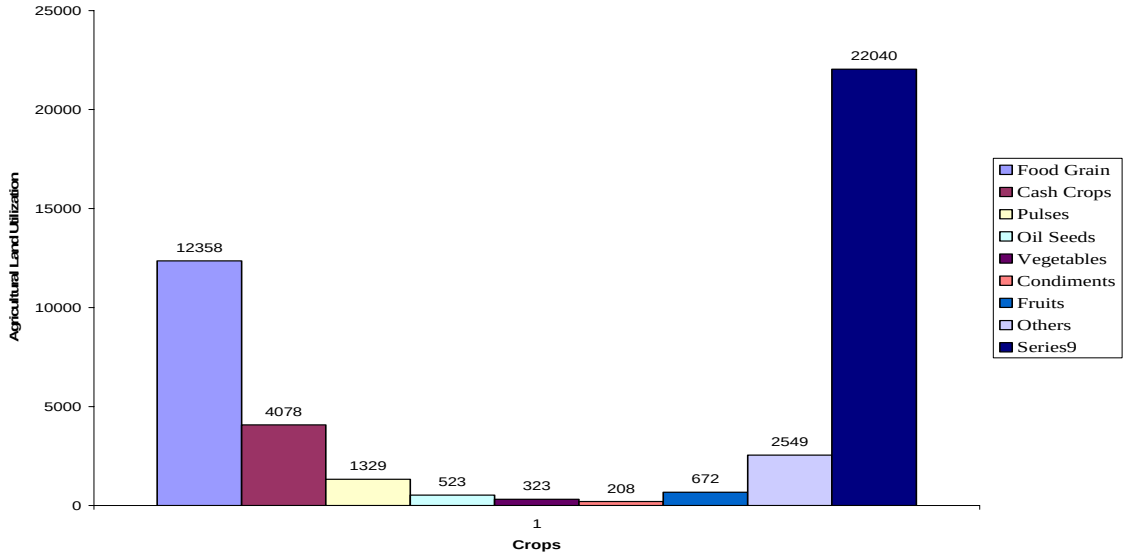
In the Barani (rainfed or dryland agriculture) areas deep drilled tubewells are used on limited scale and most agriculture on small plots/terraces is based on rain. There are opportunities for rain water harvesting and building of small dams in areas prone to torrential rains thus enhancing possibilities of agriculture in these areas recent studies however show that patterns both for rainfall and temperature are changing. Temperatures appear to be rising (as high as 1.5-2 degrees) over past two decades while rainfall seems to have been generally on the lower side especially during winter. Long term modeling results also indicate that these trends are likely to continue with significant negative impacts on agriculture unless mitigation measures are started almost immediately (APN, 2003). Recent surges in tidal waves in the coastal belt brought havoc to Badin's agriculture in Sindh with widespread flooding due to typhoons. While nothing as hazardous as the Tsunami tidal ways that ravaged the Indian Ocean coastline in December 2004, future occurrences need to be planned for diverse and at times unpredictable climate change phenomenon that makes agriculture even riskier and consequently costlier. An example of such trends suggest that for instance China could lose almost 15% of its rice crop to adverse whether leading to major water shortages (IRRI, 2004).

5. Land Utilization

The overall land utilization in the country shows that about 22.04 million acres are under cropped agriculture covering major grain crops, cotton, sugarcane etc; minor crops like pulses, oilseeds (table 1 a, b). Water requirements for these different crops are discussed later. But it is important to note that with decreased water resources and higher water costs two things need to happen:

(i) Drastic changes in the crop mix within current rotations
(ii) Introduction of new technologies that help conserve water through agronomic practices and water saving techniques like sprinkler, drip, laser leveling etc.

Figure 6:- Agriculture Land Utilization – Crop Wise (000 Hectares)



Source: Agriculture statistics of Pakistan. 2002-03

Table:-2 Agriculture Land Utilization in Pakistan (Million Hectares)

Province	Forest Area	Not available for cultivation	Culturable Waste	Cultivated area	Total Cropped Area
Punjab	0.54	2.97	1.66	12.35	16.06
Sindh	0.80	6.13	1.28	5.88	3.10
NWFP	1.32	3.91	1.25	1.86	2.04
Balochistan	1.13	11.33	4.84	2.07	0.84
Total	3.79	24.34	9.03	22.16	22.04

Source: Agriculture statistics of Pakistan. 2002-03

Expecting short to medium run changes in the cropping mix seems far fetched and will have to be introduced based on realistic assumptions of moderate technology adoption and change. There are however opportunities to reduce the acreage under crops like sugarcane where yields have been almost stagnant during the past 35 years (changed only by 23 % over a period. (1966 to 2000). Other crops like wheat, rice and cotton reported a yield increase of 228%,118% and 146% respectively during the same period. Even in canal command areas where water availability is not an immediate constraint, there needs to be a clear realization amongst the farm communities that the "good old days" of excessive and cheap water are about to end and achieving water use efficiency is the norm of the day. To further illustrate the gains of diverting area from wheat and its implications consider the following: Pakistan has an average yield of about 3 tones per HA in the irrigated areas. If it were to increase wheat productivity through better input management, timely sowing (possible with present technology) and removal of various constraints like fertilizer availability, certified seed, planting method (drill vs. broad cast),earlier planting of wheat (through better water management at micro and macro level) it can achieve a 25% increase in yield. If area was reduced by 20% or about 3.46 million acres and yield increased by 25% the aggregate production from irrigated areas would remain the same. There would also be simultaneous decrease in water demand of about 5.7 MAF (assuming 1.6 ac ft water requirements) for wheat that could be saved or used elsewhere for high value crop production i.e. oilseeds.

Mass media campaigns that widely communicate the future perspective of water shortages and strategies that farmers can adopt in both water saving (discussed later) and crop substitution could be communicated on a priority basis. A good start would be to further this information through radio, TV and even on internet with its expanding web resources specific to Pakistan[3]. Artificial incentives especially those of higher support prices for wheat and sugarcane (see Niaz, 1995) and cross subsidization (abiana) tend to create distortions where irrigated farms are forced into producing low value grains and high water consuming delta crops. Switching to more productive rotations that incorporate oilseeds, vegetables, floriculture, herbs and medicinal plants need technology and marketing investments with clear price and quantity demand signals. Mexico with similar conditions has shown the way. Whether may be done by more efficient use of water on the farms, based on the ***principle of allocating water to the enterprise with highest return*** per unit. Attention to clearly defined water rights at all levels along with tradable markets (informal trading already takes place at farm water course level) will allow farmers to better plan crop rotations and include higher value enterprises into their farm systems. It will also facilitate an exit strategy from wasteful water use on saline and water logged lands that can be traded upwards to higher productivity farms. An important driver for higher water efficiency and farm productivity will be establishment of hi-tech modern farms with international cooperation that show the modern way. Exposing industry leaders to opportunities of joint partnership can help bring new biotechnology, efficiency based systems thinking and international marketing perspective to a larger segment of the farm community.

Furthermore including measures like lined channels, better measurement of water flows and basing watering on volumetric as opposed to time applications etc. is a matter of strategy. Water pricing in the short run will have less impact compared with other instruments like water rights /entitlements as noted by Blackmore and Pearce (September, 2004), However, market segmenting according to "farm systems, soil types, technology level and entrepreneurial skills" could be undertaken and attention to water entitlements are some instruments that can introduced on pilot basis. A good starting place would be the Thal Canal Project command areas in Bhakkar and Jhang that is currently being developed. Establishing centers of high value enterprise production like dairying, fruits, vegetables, medicinal plants, floriculture through international agribusiness linkages can help motivate farmers to diversify the existing cereal dominated systems.

The government could also take serious note of the potential of rainfed areas (presently less then 20% wheat comes from drylands) to enhance wheat production and to release some of the highly fertile irrigated areas for high value enterprise production. The government also needs to realize that to modernize agriculture, essentially means a gradual shift in cereal production from high value irrigated areas to less productivity dryland areas. This would be a major shift in policy emphasis. Filling this gap by oilseeds (2004 imports valued at Rs. 37917 million) needs updated domestic resource cost analysis. Even other marginal soils that are not suitable for high value crop production can be developed for wheat production (areas with tolerable salinity and periphery of drylands) likewise there will have to be a diametrical change in thinking regarding the true crop water requirements.

Balancing food security needs with long term sustainability & growth of farm systems will need more analysis of rather rigid policy goals. Pakistan still falls way short of meeting its goal of wheat self sufficiency, despite allocating its best land & precious water. Changing the mindset needs concerted and sustained efforts by both public and private sector technology transfer agencies, advocacy and nationwide campaigns on crop water requirements for different soil and agro-climatic conditions. Widespread media campaigns and judicious

[3] Excellent websites have appeared over the past 3-4 years that are well linked with the national and international data bases. For example see www. Pakissan.com, www.IndusFarming.com

"carrot stick" policy instruments i.e. revised abiana rates (presently dismally low), tax breaks etc. Different farming areas will respond differently. In high production area (where most of the political clout is centered) there will be sharp resistance to higher water charges. In the low productivity areas increasing prices would not have consequently large impacts on productivity in the short run. Change needs to come at the highest level of leadership and institutions, with recognition that this is the underlying factor to sustain future agriculture. Those who participate in the reform process must be rewarded while those showing resistance brought to task through negative penalties. The end result can be a "win-win "situation for all in terms of higher agriculture productivity and reduced cost of production which is of grave concern in the present scenario.

6. Water and Kharif crops:

The total water situation during the Kharif is generally good allowing for the two major crop producing provinces Punjab and Sindh to utilize the resources for rice and cotton. In certain areas of the Punjab double rice cropping system is recently being introduced. The monsoon further facilitates these crops. However both rice and cotton despite being the prime export crops of Pakistan are heavily taxing on water. Just as an example, to produce one kilogram of rice in Pakistan requires 5.10 cubic meters of net water and like wise cotton needs 10.45 cubic meters with existing technology (PARC, Water Resources Institute-personal communication).

Table: - 3 Water Requirements Equivalent of Crop Production

Crop	Net Water Requirements per hectare (m^3)	Yield Per Hectare (Kg)	Water Requirements (m^3) for Producing 1 kg	Farm gate price of 1 kg of the product	Water (m^3) per rupee of product produced
Wheat	4050	2388	1.70	9.33	0.18
Rice	10260	2013	5.10	9.54	0.53
Sugarcane	11810	47300	0.25	1.01	0.25
Cotton	6500	622	10.45	20.79	0.50
Fodder	4660	22719	0.21	1.25	0.17

Source: Agriculture statistics of Pakistan. 2002-03 and PARC (1984)
Note: price for sugar is for cane at the farm gate (I kilogram of mill sugar valued at Rs 26 kilo)

Such comparisons are educating, and help to re-look at the national strategy within water shortage scenario, how much, where, when, with what inputs can the country produce a certain commodity and within a general water constraint environment by asking how Pakistan wishes to continue with the high water consuming crops? At the macro level policy direction for area allocation to cereal crops is essentially controlled by a support price and a public procurement system. This system generally provides the needed signals for farmers to grow wheat in relation to other rabi crops. If, alternative agriculture enterprises were promoted with the same support system farmers would have a choice to allocate area to other enterprises. The marketing and processing infrastructure is weak and in want of major investment if a pragmatic sift in the right direction is to be achieved. What is the potential "off the shelf" substitutions and is there sufficient know-how, government support to look at these alternatives. The technical, economic and macro management skills and resources

warrant a fresh look if Pakistan is to make a transition into the "new era of modernized agriculture".

Agriculture products are now being viewed as virtual water outputs that result in net transfer of water when the produce is sold. Thus a water endowed country when it exports wheat, rice, meat, beef and cheese, is essentially using a large input of water that it transfers to water scarce nations. Such trade also takes place within a country or a region. In Pakistan wheat produced in Punjab and Sindh is being exported to neighboring provinces, NWFP and Balochistan. To show the magnitude of inter-provincial virtual water transfer take the case of wheat, Punjab produces roughly 78% of the wheat and has a surplus of 4.7-5 million tones after meeting its own requirements. The other provinces are deficient (Sindh 2 m/tones; NWFP 2.5 m/tones and Baluchistan 0.5 million tones. Thus in meeting the requirements of other provinces Punjab exports virtual water equivalent to (2 m/t*1200 cubic meter/t) 2400 million cubic meter (1.95 MAF) to Sindh, 3000 million cubic meters (2.43 MAF) to NWFP and 600 million cubic meters (.49 MAF) to Baluchistan. The variations in production and demand (i.e. Federal, stock, Afghan Refugees, smuggling to border areas) still force Pakistan to important 1.5-2 million tones from abroad.

Table 4 gives a clear picture of water consumption in cubic meters required to produce a tone of say potatoes or wheat etc.

Table: -4 Virtual Water Content of a Few Selected Products in M^3/Ton.

Potatoes	160
Maize	450
Milk	900
Wheat	1200
Soybean	2300
Rice	2700
Poultry	2800
Eggs	4700
Cheese	5300
Beef	16000

Source: Hoekstra, 2003

Note data for sugarcane were not available

7. Water and Crops:

The principle Rabi crop is wheat and is often grown in the irrigated areas with support from the canal system and private tube wells. About 22% of the total stored water is made available during the Rabi season. As wheat is planted after the dominant Kharif crop in the rice-wheat or cotton-wheat systems in the irrigated areas there is "is an optimal sowing data problem" partly determined by the water constraint. The crop sown after first of December shows a marked decline in yields regardless of the level of inputs that are used for wheat production (April, 2004). Managing laud preparation including heavy first watering poses severe constraint on meeting this deadline. Thus the whole wheat production system is likely to be put under extreme stress unless water supplies are guaranteed. Drought impacts are further aggravating the situation not only in the Punjab wheat production bowl, but in other major wheat producing belts regions including Australia, US and Latin America. Given the present short term situation where almost 47% less water is envisaged for the irrigated areas of Punjab and Sindh (IRSA, 2004) the impact on sowing dates and consequently on yields is not difficult to predict. December 2004 and February 2005 rains and their well timed distribution provides respite but overall wheat situation may yield less then the targeted 20.15

million tones. The present predicted estimates are in the tune of 21 million tones. These seem to be on the higher side. Continuing growing sugarcane (which happens to be highly profitable crop under current prices) will simply be impossible.

8: Provincial Distribution of Crop area and Employment Generation:

Any change in the cropping pattern is likely to impact agriculture employment. Based on area estimates from the Pakistan Agriculture Statistics (in the case of Sindh generally believed to be under reported) estimates were derived by using labor data from the Agriculture Prices Commission. At best these are crude estimates still providing insights into the level of employment tied with each crop and where it is located.

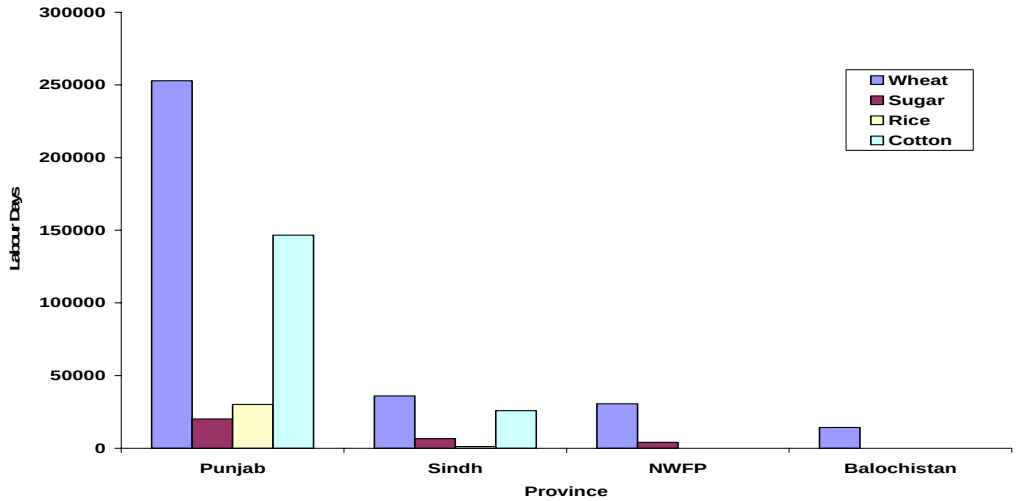
The estimated employment based on provincial statistics for wheat shows that 252855 thousand days are generated in Punjab and almost 1/6th of this is Sindh and in NWFP (see table 5). The table shows that most of the employment generated in the dominant cropping systems of Rice-wheat and cotton wheat and is predominated by the Punjab province. Given the aggregated data and somewhat lower labor estimates provided by APCOM, 2005 (personal communication) the magnitudes of employment generation estimates provided here would be on the lower side-still these clearly show the distribution of the employment generation.

Table 5:- Estimated Employment by Crops & Province and area under crop (Labor Days in, 000)

	Punjab	Punjab	Sindh	Sindh	NWFP	NWFP	Balochistan	Balochistan
	Area	Employment	Area	Employment	Area	Employment	Area	Employment
Wheat	6097.3	252855	863.7	36016.3	732.1	30528.57	340.8	14211.36
Sugar	668	20146.88	235	6584.7	95	3988.1		
Rice	1475	30060.5	461.1	1121.45	60.7			
Cotton	2540.7	146595.5	448.35	25869.8				

Note; Area in 000 hectare

Figure 7:- Employment by crops and province.



Source: Labor estimates based on APC Survey 2003, and Bakhsh, Khuda and M. Ashfaq 'Model Farming' 2003 (Area figure derived from Pakistan Statistical Bureau)

Whether it is economically wise to use 16 Cubic meter of water to produce 1 kilogram of cane also needs to be thought through at the national level. The political economy is closely

tied with stakeholder interests (many are elected into office) that own most of the sugar mills, have strong capacity to influence output prices and input tariffs there is pressure to resist rational reform agenda at the provincial and national level. Consequently leading to over investment (facilitated through cheap and politically motivated loans) in this sector with continuing installation of new sugar mills. These mills need the raw sugarcane and target areas in their surrounding reaches regardless of the consequences on water resources or the road infrastructure that is destroyed in the process of sugarcane transport from farm to mill. There is large social cost and implicit subsidy to rehabilitate these roads.

9. Policy Environment of Institutions:

Pakistan has long history of established agriculture institutions both in the support, research, extension, agricultural prices etc system[4]. This large public infrastructure has been in place and engaged in agriculture in different forms-policy, procurement, technology, processing and export. The present state of these organizations requires new investment to align then with needs of modern agriculture. Many institutions have outlived their usefulness and are in search of new mandates or mergers or an outright exit strategy. Their mandates, structures, environment and performance need a critical look and reform. Some seem to be redundant when one views the future modern agriculture establishments-present extension set would be an example[5]. The role of private sector also needs re-definition of purpose, objectives/goals, resources, opportunities and finally performance

A strategic plan to package the present institutions in the light of modern know how will require considerable human capital investment. In particular developing a joint partnership and bringing "world best practices" in water and agriculture needs a well thought out plan, prepared by the best available national and international talent. There is also a need to seek clarification of terms like "world best practice, appropriate technology and modernization relevant to Pakistan. The intellectual leadership in this sector might also be better exposed to what is possible under Pakistani situations. Isolated and commodity focused efforts have failed to meet the challenge.

An important dimension to the whole institutional reform in agriculture is that agriculture by law is a provincial subject thereby it is crucial that support to these institutions be comprehensive and relevant starting from the National-Provincial- District- Farm Level. The grass root infrastructure including extension, markets, processing facilities is dismally weak and can be singled out as the key missing link in the development process. There are however local bodies and institutions like the village headman, union councils and the recently installed district "Nazim" governments that can be more effectively organized to help bridge the yield gap. Recently the mobilization of village community by the National Rural Support Program and other NGO's lends further support to channeling grass root level initiatives. Unless there is clear chain of command established that links technology-credit-research-extension and farmer training little programmed change can be expected.

Green revolution technologies were adopted in a step-wise fashion over a period of almost 25 years. First came the varieties, then the fertilizer, later pesticides followed by post harvesting and mechanical means. Much of the success however focused on wheat and rice. Facing challenges of the 21st century requires a vision and commitment from some of the best minds in the business. The more recent brain drain out of the key research organizations has created a vacuum that is hurting the country in making this transition (PARC is just one example). However post 9/11 events like the Iraq War and their impacts on Pakistan suggest that more and more international donors and bi-lateral programs are keen to assist Pakistan in moving to stage II development scenario. Just as an example, Pakistan was awarded a special waiver by which it will annually receive US $ 700 million over the next several years.

In terms of future investments, water innovations and the related institutions three categories of farm types need to be given special attention, namely:

1. Smallholder agriculture covering almost 60% of the agriculture
2. Privately owned farming on large farms

The number of large farms from 1980 to 2000 increased by 40.54 %. In contrast the small farm class rose by 290% for the same period (table 6)

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[4] A good description of the institution in the agriculture by Khan and Chaudhri "Organization and Management of Agriculture Production in Pakistan". See Institutional Reforms to accelerate irrigated Agriculture-

[5] A good coverage of Bank's analysis of the extension issue is provided in "Government Role in Pakistan Agriculture- Major Reforms are Needed. Rashid Faruqee. Policy Research Working Paper 1468. World Bank, Washington.

Table 6:- Number and Area of Farms by Size of Farm

Size of Farm (HA)	Number in 2000	Farms Number in 1980	% change In Farms Number	Farm Area in 2000	Farm Area in 1980	% change in Farms Area
Under 0.5	1290098	330000	290.94	362544	100000	262.54
0.5 to under 1.0	1099330	370000	197.12	821245	280000	193.30
1.0 to under 2.0	1425370	690000	106.58	1981277	970000	104.26
2.0 to under 3.0	966411	680000	42.12	2256772	1630000	38.45
3.0 to Under 5.0	890755	920000	-3.18	3442507	3570000	-3.57
5.0 to under 10.0	580200	710000	-18.28	3891228	4700000	-17.21
10.0 to under 20.0	260791	260000	0.30	3324310	3390000	-1.94
20.0 to under 60.0	93050	100000	-6.95	2644400	2800000	-5.56
60.0 and above	14054	10000	40.54	1682491	1620000	3.86

*Source; Census of Agricultural -2000
**Source Agricultural Statistics of Pakistan 1990-91

3. Corporate farming where large tracts of land are brought under hi-tech agriculture-there is scope in the areas of beef, mutton, fruits, vegetables, medicinal plants etc. This is a potential area that has to be ventured carefully. Corporate farming in Pakistan has been viewed with suspicion and a land grabbing exercise by politically powerful interest groups. This need not be so provided the necessary checks and balances are built into well defined lease arrangements and local- international collaboration agreements are transparent and protected by law. Business opportunities available are that can benefit from international partnership (some through multi-national companies) like production, marketing, processing and managerial expertise. In certain areas especially in fruits there is excess capacity in processing with lower fruits intake. This investment can be utilized for expansion of areas for these fruits based on supply and demand considerations (domestic and foreign). See table 7.

Table 7: Installed Capacity for Different Types Fruit and Vegetable processing industries.

Fruit	Installed Capacity	Utilized Capacity	% of Utilized
Citrus	190,000	60,000	31.6
Mango	190,000	28,000	14.7
Banana	5,400	600	11.1
Apple	4,200	200	4.8

Source: Rural – Based Food processing Industry.
Note: Report of the APO Multi – country study mission on Rural – Based Food Processing Industry Japan, 6 – 13 March, 2001 by Sohail Younas Moghal.

Lack of technical assistance to understand the international experience and guide the process is partially responsible for the slow progress. In areas where to illustrate when a multinational company Nestle entered the milk and juice industry the impacts that followed were positive and generated healthy competition. The concept of contact growing was promoted by the large scale \maize oil company-Refhan and small farmers alike also benefited from the production technology and efficient market systems that came along with modernized agribusiness. As more valuable crop systems and improved technology is put into practice people also become more cautious in the way water is used, giving greater attention to the crop water requirements and quality of water to produce a standardized marketable surplus.

Pakistan has witnessed the role multinational companies can play in serving as catalyst to enhance agriculture in the country. On the input side there have been several interventions that have improved the performance of the sector i.e. seed (Monsanto, Cargill, pioneer, Nawab Seeds (Pvt.) and many other entrants; in the case of fertilizers besides N:P:K sales there are now composite and balanced fertilizer being introduced in the market. Some modern fertigation technology is also being made available though less widespread. Modernization of rice mills in Pakistan is also a recent phenomenon triggered by multinational investments like Roberts International Rice. Majority of the multinationals entering the agriculture sector have integrated with backward and forward linkages. They have established the essential distribution; produce collection, storage function by engaging local entrepreneurs. The results have been highly positive.

A somewhat related example in Pakistan has been the absolute revamping of the Pumping Stations by induction of Shell International. The standards set by this company have totally changed the way fuel and associated services are offered to the consumer. When high efficiency systems focus on improving quality, quantity and integrated consumer services, besides benefit to the society there is an automatic up gradation of facilities by other companies just to stay in business. Likewise introduction of quality service by Daewoo Corporation in the transport sector has directly improved the service of local transport industry. There is reason to expect that similar trends can be achieved in agriculture by introduction of similar integrated service delivery systems such as food chains, supermarkets etc.

To bring change through such examples it is essential that a large cadre of "Agriculture Champions" who are well trained, professional managers are exposed to modern technology pools and are knowledgeable about proven drivers get inducted into the system. To be pragmatically effective in modernizing agriculture, present thinking of the government will have to change from a regulatory to a participatory mode that serves as catalyst to the introduction, testing and implementation of modern water conservation technology. Much of the planning and interventions proposed tend to support systems (institutions, personalities, organizations) that have little contact with ground realties and are in weak position to serve as agents of change.

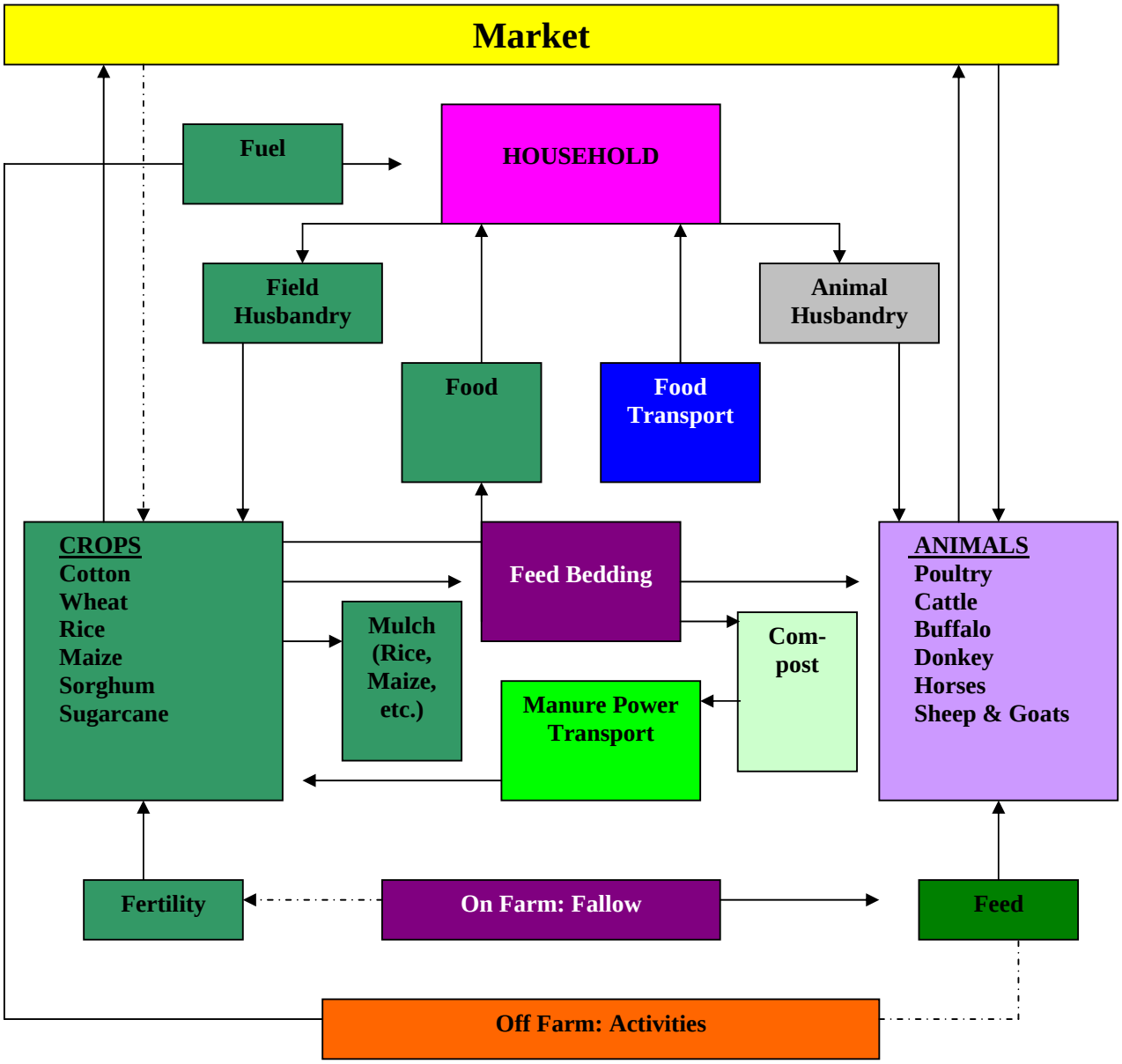
In relation to the water institutions the irrigation department is under WAPDA while the provincial irrigation departments (PIDs) operate the irrigation infrastructure and canal water supplies. These departments are however not under the Ministry of Agriculture. Irrigation operates independently of agriculture requirements (or bases its own calculations with little professional or research input). This poor coordination is also a limiting factor in the optimal placement and allocation of water based on macro agriculture considerations as described earlier.

A disturbing feature of Pakistan's agriculture institutions is that limited partnership has emerged in modernizing the water efficiency at the grass root level. Pakistan has housed a large number of international institutions i.e. IMMI, IWASRI and others but failed to attract pragmatic advice and technology relevant to its smallholder situation to overhaul its on-farm infrastructure. Even national level coordinated programs with input from ICARDA, ICRISAT and others brought little change. Recent efforts of On-farm water management though delayed are in the right direction. However, these interventions require a strong technology backing that ensure higher levels of production efficiency especially when water resources are shrinking. Simply improving water efficiency does not lead to aggregate increase in productivity. It requires a whole new set of investments that are aimed at productivity increase- with special attention to long term development of sustainable grass root institutions.

Higher returns to investment in agriculture research are likely from quantification and improved understanding of integrative role of various farm components, their constraints, performance and potential in all the major 8 agro-ecological zones (Byerlee and Husain, 1992). Farm systems analysis by PARC has identified major production constraints in the irrigated and barani areas (both technical and economic/social) Without understanding constraints, resources, objective function, linkage and opportunities proposing radical changes can create distortions leading to overall decline in farm productivity. For instance drastic reduction in wheat acreage in the irrigated areas would reduce wheat straw availability that would negatively impact livestock productivity. To illustrate a 12.5 acre farm produces roughly 9 acres of wheat resulting in 240 mds of wheat or roughly 300 mds of dry straw fodder. This is sufficient to maintain 3 animals units for one year. When making changes in the cropping pattern the overall system linkages and requirements need be taken into account. Figure-1 helps understand the important linkages between different enterprise components on the typical smallholder farm. The system inflows and outflows show how various components interact to determine overall farm productivity. Modifying one components impacts overall resource allocation, income and productivity.

- Agro ecological zone specific recommendations are needed, broad based nation-wide recommendations and policy reforms will generate lesser returns in terms of increased productivity under a water stress environment.
- Agriculture system has been introduced to favor such systems thinning-with water now as a limiting factor the research and extension institutions must come out and define what will be the new profitable systems in line with modern agriculture technology.
- The CG system while once vibrant in Pakistan now has almost a negligible role. Reviving such a role and bringing in the latest agriculture technology under water constrained environments i.e. Australia, India, Egypt and Israel through bi-lateral programs can help show the way.
- It is not mere exposure to the techniques but a series of joint agribusiness projects that bring in the technology, implement it and jointly reap the returns. People have to be convinced that they receive technology that has been adequately tested, modified and found feasible under diverse conditions within a given agro ecological zone. There is no one time or simple recipes given the wide diversity in the agro-ecologies.
- New organizations (public and private) that have widespread national net-work to bring the know-how, goods and services right to the farmer's doorstep will impact productivity. The vertical and horizontal agriculture linkages between market, processing, transportation will be key to ensure that agriculture gets a needed agribusiness orientation. to become an important feature of macro-economic planning and a thrust in the 5 year plans.

Figure:-8 A Farming System Model is showing crop, livestock, tree and market linkages for smallholder agriculture in Pakistan.



10. Water Costs for-hi tech irrigation systems:

It appears that the dominant Chinese petter pump technology is here to stay if the diesel prices remain in reach of the farmer. This technology can generate multiple benefits and be put to different uses i.e. sprinkler, drip systems. In designing a modern agriculture agenda this aspect of existing power source be borne in mind. New pumps to deliver drip and sprinkler irrigation can be integrated with this Chinese peter technology. Similarly other small processing units (i.e. cane crusher, corn dehusker etc.) can be operated with this power

The relative capital and establishment cost of some new types of irrigation systems are presented below and compared with the older black and electric tubewell.

Table 8: Capital and Operating Costs of Pressurized Irrigation Systems.

Type of System	Use	Capital Cost (Rs/acre)	Running Cost (Range %age of capital)
Rain Gun	Field crops	16194	55-100
Mini Travelers	Field crops	16194	70-90
Conventional Hand Move	Field crops	20243	35-55
Drip/Trickle	Tree crops	28340	20-35
Mini Sprinkler	Tree crops	24291	20-35
Petter Engine Tubewell	Field crops	60000	Rs/ 38484
Electric Tubewell	Field crops	102000	Rs/ 21845
Conventional Black tubewell (Kala Engine)	Field crops	90000	Rs/ 37384

Source: Based on review of different studies by PARC (personal communication)

Note: Annual operational cost of tubewell also includes repair and maintenance cost

Capital cost of tubewells has been worked out on an average basis. Significant difference exists in terms of assumptions used for average operation time, drilling costs etc.

A farmer's prime concern is to ensure the requirements of water for each and every crop grown in his farming system. It is closely linked to the key decision of production: what, when, where, how and with what technology to produce a particular enterprise i.e. crop, livestock, orchard, trees etc. Such scientific information is generally absent to the farmer who basis decisions on experience, input availability and cost considerations. Providing such valuable information could be the first step to save water and reduce cost of production for most commonly grown crops. For example the first watering for needs to be only 1-2 cm enough to wet the soil for drilling seed. However, in most cases a heavy "rouni watering" with standing water is given with little knowledge of the wheat root system and its nourishment mechanism in the early stages of growth.

Many feel that water will continue to be available and are little concerned with the ET losses. Savings of upto 20-25 % can simply be achieved by just this single intervention. Mass provision of leveling equipment backed by widespread demonstration trials showing the effects of water efficiency can be instrumental to motivate farmers to adopt water saving. Similarly, provision of more wheat drilling equipment through specially targeted loans focused o agriculture implements could aid in achieving this benefit. Water use efficiency of different crops grown in Pakistan is shown in table 9. This table could be further modified according to irrigated and barani zones where different system of irrigation is employed.

Table 9: Water use efficiency of different crops.

Crop	Net Water Requirements (mm)				
	Punjab	**Sindh**	**NWFP**	**Bal**	**Pak**
Wheat	400	450	420	350	405
Rice	1000	1100	900	1100	1026
Sugarcane	1200	1200	1000	1200	1181
Cotton	650	650	650	650	650
Fodder	457	533	457	457	466
	Yield (kg/ha)				
Wheat	2518	2442	1454	1921	2388
Rice	1706	2662	2159	2857	2013
Sugarcane	45100	53400	48100	50800	47300
Cotton	590	756	412	543	622
Fodder	22113	27098	20898	29616	22719
	Water Use Efficiency (kg/mm)				
Wheat	6.3	5.4	3.5	5.5	5.9
Rice	1.7	2.4	2.4	2.6	2.0
Sugarcane	37.6	44.5	48.1	42.3	40.1
Cotton	0.9	1.2	0.6	0.8	1.0
Fodder	48.4	50.8	45.7	64.8	48.8

Source: PARC, 2004 and MINFAL, 2003
Note: Data are aggregates and should be interpreted carefully given the known problems of varying capability of provinces in statistical data collection.

Table 7 shows the aggregate water requirements based on total cropped areas under major crops. Water being the major crop with almost 40% of total cropped areas requires 33cm of water per year.

Table 10: Water requirements and area under different crops

Crop	Water Requirement Per Year	Percent of Total Cropped Area
Wheat	33 cm	40 %
Cotton	65 cm	13 %
Rice	90 cm	11 %
Sugarcane	133 cm	4 %
Maize	35 cm	4 %

Other include forages, vegetables etc.

A recent study World Bank financed study in 2004 "Crop and Water Productivity in Pakistan" on differences in wheat yields between the two Punjabs suggests that Pakistan Punjab yields are almost 1000 kg/ha less then yields obtained in the Indian Punjab

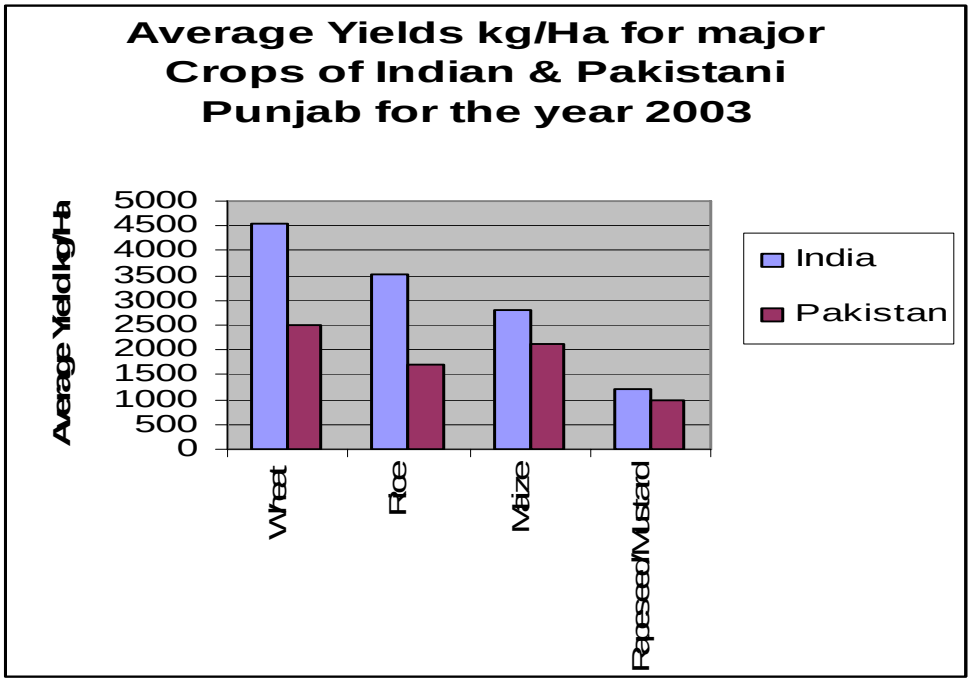
Table 11: Satellite estimates of land and water productivity for wheat

Area	Yield 1984-85 (kg/ha)	Water Productivity 2001-02	Yield 2001-02 (kg/ha)	Water Productivity 2001-02 (kg/m^3)
Pakistan-Punjab	2,663	0.96	3,462	1.10
India-Punjab	3,685	1.30	4.224	1.40

Source: Crop and water productivity of the Pakistan wheat and Rice System

Dhillon, 2004 analyzed the average yields between the two Punjab's 2003. The trends reported in this study are similar to the results of the satellite estimates reported above.

Figure 9: Average yield kg/ha for mahor crops of Indian and Pakistani Punjab for the year 2003



Source: Statistical reports for India and Pakistan, Bureau.
Note Sugarcane yields was 77 tones/ha for Indian Punjab and 45 tones/ha for Pakistani Punjab.

Reporting in the Press (Riaz, 2004) noted that Indian Punjab yields vary from 4-6 tones as compared to 2.1-3.4 tones /HA in Pakistan Punjab. With exception of Okara, Sahiwal and Pakpattan the more progressive districts none of the remaining districts reached 3 tones per ha.

While well known that wheat and rice yields are generally low in Pakistan, studies (Hobbs et al 2000, and Hobbs and Gupta.2002) show that wheat yields at the national level are low because of poor N: P: K; seed rate, incidence of phylaris minor (weed) is high, high fuel cost thus limiting watering at critical stages, broadcasting instead of drilling all contribute to the differential wheat yields. Furthermore the late showing of wheat has a dramatic impact on yield reduction. In the case of Pakistan basmati rice cultivation delays. When these constraints are removed as demonstrated on progressive farms the productivity of wheat is statistically insignificant then in the Indian Punjab.

11. OPTION ANALYSIS

Total area under irrigated agriculture is almost 45.9 million acres or about 18.06 MHA. Options for such a vast area differ both in type, intensity and effectiveness. During the post independence period agriculture grew at about 1.43% against a 3.2% growth in population. During this period the main option was to expand area under irrigated agriculture. From 1959-64 agriculture growth was accelerated due to the expansion of large number of tube wells and exploitation of the sweet round water this allowed for a growth rate of 3.7%. The most vibrant and result producing era of agriculture was the introduction and widespread adoption of green revolution technologies giving an average growth rate of 6.3% between 1965-70.

To keep pace with food needs of a growing population, develop an ability to cater for the food needs of its neighbors like Afghanistan, Tajikistan etc. Pakistan's agriculture needs to grow around 5-6 %. The option analysis pertaining to water technologies takes such a requirement into consideration.
Besides developing additional storage capacity the means to enhance the supply side of water falls under several categories including.

1 Water conservation
2 Crop substitution
3 Recycling of effluents after treatment
4 Use of saline water in agriculture
5 Rain harvesting
6 And finally de-salinization of sea water

This paper concerns itself primarily with water conservation and crop substitution options (within the farming system**)** Water Conservation and efficient use of water has two purposes. First is to reduce the use of valuable water as overuse of water can lead to water logging and salinity. Such overuse in some places has resulted in 25%-60% reduction in yields (Water Sector Strategy, 2002). .Second, as noted earlier present irrigation efficiency is about 40% and improving it to 45% within two decades could result in a saving of about 4.7 MAF.
There is considerable potential to improve the farm level water situation in agriculture in line with the needs of a modern agriculture through water management technologies that conserve water. The menu of options is rather large (see table 8) however the paper concentrates on efficient irrigation practices that could be augmented within a pragmatic implementation plan.

Table 12: Water Management Technologies in Plains under different systems

S#	Technologies For Irrigated Areas	S#	Technologies For Barani Areas
1	Watercourse Improvement	1	Small/ Mini Dams
2	Improved Farm Layout	2	Dug Wells
3	Laser Land Leveling	3	Pressurized Irrigation Systems
4	Improved Irrigation Application Methods	4	Soil And Water Conservation Practices
4.1	Bed And Furrow Irrigation	4.1	Contouring
4.2	Rain-Gun Irrigation System For Rouni	4.2	Strip Cropping
4.3	Efficient Irrigation Systems For Orchards	4.3	Terracing
4.4	Drip/Trickle Irrigation	4.4	Tillage Practices
5	Improved Cropping Pattern	4.5	Soil And Water Conservation Structures
6	Groundwater Quality Zonation	4.6	Water Harvesting Techniques
7	Skimming Wells		
8	Use Of Low Quality Groundwater For Agriculture		
9	Reuse Of Wastewater		
10	Water Quality Monitoring		
11	Irrigation Scheduling		
12	Resource Conservation Technology		
S#	**Technologies For Desert areas**	**S#**	**Technologies For Desert areas**
1	Rainwater harvesting	**Northern Areas**	
2	Reducing evaporation	1	Hydraulic ram pump
2.1	Evaporation from open water surfaces	2	Fuel-less water turbine pumps
2.2	Evaporation form soil surfaces	**Balochistan Plateau**	

3	Saline agriculture	1	Artificial recharge
4	Afforestation/drought resistant plants	2	Flooding method
5	Livestock, saline fishery and honeybee	3	Delay action dams
		4	Percolation basin
		5	Ditch or furrow method
		6	Injection wells
		7	Recharge through pits and shafts

12. Water Uses: Improving Efficiency

Improving the water efficiency in agriculture is an important objective in prevailing drought period and forecasted climate change scenarios. If the efficiency of use is increased, the magnitude of negative impact of water on agriculture can be decreased. Two technological areas where efficiency gains are possible are irrigation and bioengineering of crops.

- Irrigation
  - Surface
  - Furrow
  - Surge
  - Sprinkle
  - Drip

Table 13: Irrigation methods- some advantages and disadvantages

Irrigation Method	Advantages	Disadvantages
Surge	Simple, low setup costs, low energy	Tendency to over-irrigate, non-uniform distribution
Sprinkle	Easier to control	High initial costs
Drip	High water efficiency, high frequency, precise	High initial costs, requires expert management, prone to clogging

Source:

12.1. Practices for Efficient Irrigation Water Application: Irrigation water should be applied in a manner that ensures efficient use and distribution, minimizes runoff or deep percolation, and eliminates soil erosion. The method of irrigation employed will vary with the type of crop grown, the topography, and soils. There are several systems that, when properly designed and operated, can be used as follows:

12.1.1. Drip or Trickle Irrigation system: A planned irrigation system in which all necessary facilities are installed for efficiently applying water directly to the root zone of plants by means of applicators (orifices, emitters, porous tubing, or perforated pipe) operated under low pressure. Drip irrigation is a slower and more localized application of water. Drip heads are carefully placed precisely where plants need water. Water is always released below the infiltration rate of the soil, so the drip method is very efficient, losing little water to evaporation. Water is also released more frequently than in other irrigation methods (Crow, 2000).

Drip irrigation offers a high degree of precision and control of water application. Little energy is required because the transmission system uses low water pressures. However, drip irrigation systems are highly susceptible to clogging by suspended particles and biological agents. Surface water quality may not be significantly affected by transported substances because runoff is largely controlled by the system components (practices). Chemical applications may be applied through the system. Reduction of runoff will result in less sediment and chemical losses from the field during irrigation.

Drip irrigation systems are high initial investment and energy intensive. But, at the same time, these are labor, water and fertilizer efficient. No investment is involved in land leveling, but usually there are maintenance requirements that can be more expensive than surface irrigation systems. A major economic factor is the utility of the systems in providing a cost-effective means of fertilizer and pesticide applications. Drip irrigation systems are widely used in row crops and system cost decreases with increase in row-to-row and plant-to-plant distance.

The cost of drip irrigation system has lowered significantly. For orchards of 20 ft x 20 ft spacing, the cost is around Rest. 10000/- per acre excluding the cost of pump which is about Rest 18,000 as fixed capital cost (boring is an additional (25,000-70,000 depending on depth and drilling method used). Two companies are marketing this drip irrigation technology out of Karachi (Engro Ahi) and Lahore (Rainmakers). The demand for these systems is driven primarily by water shortages and lowering of the aquifer in some of the barani areas. Elsewhere like in Faisalabad green house vegetable production is being brought under this technology? Here the water is saline and farmers are mixing saline water with canal water to utilize this for vegetable production

According PARC (personal communication) approximately 500 HA are under this technology. The trickle irrigation systems have been installed in the areas where water is of high value, like, Balochistan, Northern Areas, D.G. Khan, Kohat, Bahawalpur, Nowshera, Haripur and Attock. These systems have been installed for fruit trees of guava, loquat, lemon, citrus, leachi and apple.

12.1.2. <u>Sprinkler Irrigation system:</u> A planned irrigation system in which all necessary facilities are installed for efficiently applying water by means of perforated pipes or nozzles operated under pressure. Sprinkle irrigation uses a spray or jet created by expelling water from a nozzle. The spray is broken up into droplets and acts like a simulated rainfall of controlled frequency, intensity, duration, and droplet size. In sprinkle irrigation, soil application is not the method of conveying/distributing water to the field. Sprinkle systems are designed to apply water at rates that do not exceed the soil's rate of infiltration to prevent surface runoff.

Sprinkle systems are often a practical alternative for sloped or shallow soils. The uniformity of application generally depends much more on sprinkler position and placement than the soil type. These systems are affected by wind and, depending on the size of droplets and the spray trajectory, uniform distribution may be limited. Additionally, when water applied by the sprinkler evaporates on a crop leaf, it may deposit salts that cause leaf scorch (Hillel, 1987).

Sprinkle systems have high initial costs and maintenance requirements. They also use high operating pressures, which is a large energy requirement. The estimated average installation cost is around Rs. 15000 per acre for a system of at least 5 acres. The cost of portable system will be less but difficult to operate due to movement of laterals. The unit cost can also be reduced by 28% by changing the design from complete irrigation to supplemental irrigation.

The raingun sprinkler irrigation systems have been installed in various parts of the country for demonstration and introduction of the technology. In Barani areas, these systems are being used for supplemental irrigation and life saving irrigation to vegetable and field crops. Timely application of only a few mm of water at critical growth stage has doubled the crop yields. The pre-sowing irrigation (*Rouni*) is also being applied with this system to sow the crop. The fodders, wheat, sunflower, groundnut, chickpeas have been successfully irrigated with raingun sprinkler irrigation system. In the Khanpur dam area, the raingun sprinkler irrigation system is being used to establish young citrus orchard, efficient irrigation to orchard and vegetables, washing of leachee and citrus, fertigation of fruit trees, cooling and frost control in orchards. In the irrigated areas, it is being used to irrigate the un-commanded

areas within canal commands for supplemental irrigation and salinity control. However, their ability to work on most types of soil makes them desirable in a number of situations.

Proper irrigation management controls runoff and prevents downstream surface water deterioration from sediment and sediment attached substances. Over irrigation through poor management can produce impaired water quality in runoff as well as ground water through increased percolation. Chemigation with this system allows the operator the opportunity to mange nutrients, wastewater and pesticides. For example, nutrients applied in several incremental applications based on the plant needs may reduce ground water contamination considerably, compared to one application during planting. Poor management may cause pollution of surface and ground water.

Drip/trickle irrigation is a method of water supply to plants efficiently according to the requirement of plants and has a relatively low initial cost. Water trickles from small tubes and directly feeds the roots of the plants. Thus on the average the water required by drip irrigation is only 20-30 % of that required by conventional methods like flooding and furrow methods. There are high evaporation losses due to flood irrigation especially during the summer. While considerable leaching takes place much of these loses are noted as improving the recharge of the aquifer. Moreover drip irrigation avoids over irrigation that is applied in other methods. In California the Hawaiian sugar industry converted 34,800 ha of sugarcane into drip irrigation out of 45000 ha (77% of total irrigated area) from 1979-1984. Drip irrigated fields produced 22% higher yield and 26% higher production rates with less cost than fields irrigated by other methods. Drip irrigation promotes faster establishment of young trees, aids sound germination of seeds increasing the population per unit area and prevents thicker growth of seeds reducing the nutrient and moisture sharing problem of soil.

Sivanappan studied a drip irrigation system for coconut fully grown trees in a farm of 4 hectares that had been irrigated by gravity from a well. The area could not be irrigated regularly since the entire well dried within a short period. The yield was about 30 to 40 nuts per tree per year. However after adopting drip irrigation system, the entire area was irrigated daily and more area was brought under cultivation. The yield increased to 60-75 nuts per tree within a year of installation of the drip system. Saudi Arabia has shown citrus production on large tract 5,000 HA using this technique. Using brackish water is also possible under scientific management.

The overall experience with lager scale drip/trickle irrigation systems is rather limited. These systems can be expected to become widespread as water shortages are experienced and the technology becomes readily available in the major production centers. Since, drip and trickle irrigation is mostly used for high value production systems like those mentioned in the specialized production areas the value of outputs both of vegetables and fruits will have to be integrated into lucrative export markets (i.e. Middle East)). As the marketing systems are developed intensification will automatically occur making these systems more economically feasible and worthy of investment. There is also a tendency to congregate some of the high value floriculture (i.e. Pattoki on Lahore-Multan road, and near Peshawar) where high quality canal water is amply available. Higher efficiency is possible through drip and sprinkler systems as demonstrated in the Thai Orchid flower industry (estimated annual turn over US $ 4 billion), when artificially low cost water commands an economic price and the government starts differential pricing based on types of high value production systems.

12.1.3 <u>Surface and subsurface Irrigation system</u>: A planned irrigation system in which all necessary water control structures have been installed for efficient distribution of irrigation water by surface means, such as furrows, borders, contour levees, or contour ditches, or by subsurface means.

Operation and management of the irrigation system in a manner that allows little or no runoff may allow small yields of sediment or sediment-attached substances to downstream waters. Pollutants may increase if irrigation water management is not adequate. Ground water quality from mobile, dissolved chemicals may also be a hazard if irrigation water management does not prevent deep percolation. Subsurface irrigation that requires the drainage and removal of

excess water from the field may discharge increased amounts of dissolved substances such as nutrients or other salts to surface water.

12.1.4 <u>Field Ditch Irrigation</u>: A permanent irrigation ditch constructed to convey water from the source of supply to a field or fields in a farm distribution system. The standard for this practice applies to open channels and elevated ditches of 25 ft^3/second or less capacity formed in and with earth materials.
Irrigation field ditches typically carry irrigation water from the source of supplying to a field or fields. Salinity changes may occur in both the soil and water. This will depend on the irrigation water quality, the level of water management, and the geologic materials of the area. The quality of ground and surface water may be altered depending on environmental conditions. Water lost from the irrigation system to downstream runoff may contain dissolved substances, sediment, and sediment-attached substances that may degrade water quality and increase water temperature.

12.1.5 <u>Land leveling Irrigation</u>: Reshaping the surface of land to be irrigated to planned grades. The effects of this practice depend on the level of irrigation water management. If plant root zone soil water is properly managed, then quality effects of surface and ground water may be avoided. Under poor management, ground and surface water quality may deteriorate. Deep percolation and recharge with poor quality water may lower aquifer quality. Land leveling may minimize erosion and when runoff occurs it results in concurrent sediment yield reduction. It has been reported that this technology can increase land use intensity form 8-63% and cropping intensity from 6-70%. Therefore leveled fields help reduce the amount of irrigation water required and labor requirements. Poor management may cause an increase in salinity of soil, ground and surface waters. High efficiency surface irrigation is more probable when earth moving elevations are laser controlled. The high cost of lazer levelers has been a major reason for low use of this technology. Only recently has there been realization that land leveling can have economic payoffs and result in saving valuable energy (On-farm Water Management, Punjab). Farmer education and reduced price of farm implements as noted earlier would help promote widespread land leveling especially where the returns are high (areas of water shortage and amongst tail enders) . Developing a machinery pool in key districts on pilot basis including levelers, heavy machinery and agriculture implements with financial support from banks and placed in the hands of private sector operators can increase accessibility to the farm community. The model of combined harvester machinery is a good example for wheat and rice harvesting that operated on the hire basis throughout Pakistan. Often starting from Sindh and moving into Punjab based on the different ripening dates of wheat and rice crop.

12.1.6 <u>Land leveling can be done at different levels of precision</u>. Present practices in Pakistan vary from the traditional wooden plank (sohaga) applied after sowing of the crop. It provides a crude method of minor degree of leveling. Then there is tractor driven levelers that are more efficient and faster to use. But general dearth of farm machinery and especially limited availability of levelers restricts this technology to only a minority of farmers. More advanced implements like laser levelers provide highly precise land leveling. The present cost is about Rs. 5, 50,000 and less then 500 are in use nation wide (personal communication with Farm Machinery Institute at NARC Islamabad). There are some reports that the cost will come down to as low as Rs. 250,000 and new models are being introduced. There is no precise data on availability of simple levelers in the country. It appears there is less then one leveller for every 10,000 acres of land.

12.1.7 Furrow: In furrow irrigation, the surface of the soil is shaped into rows of ``furrows," U or V-shaped banks in the soil. Furrows are separated with ridges, upon which crops are planted. Depending on the size of ridges, only about half of the surface is covered with water, resulting in less loss due to evaporation. Furrows are generally sloped to promote gravity-driven water distribution.

The application and distribution of water for furrow systems is similar to surface irrigation. Water partially flows downward, under the furrows themselves, and sideways, into the ridges. However, because there is no water flowing over the ridges themselves, evaporation of the water leads to saline deposits on the ridges. Salination can hinder seed germination and reduce crop growth. For this reason, furrow irrigation is often rotated with other forms to facilitate leaching and removal of salt accumulations (Hillel, 1987). Pakistan has shown success with this system in its Cotton-Wheat Zone. Its wide scale adoption has yet to take place. Furrow bed technology can also be effectively applied to maize.

12.1.8 Surge: Surge irrigation is a modification to surface and furrow irrigation systems. Instead of flooding a field continuously, the water is released in surges, as the name implies. This method requires the addition of microprocessor-controlled surge valves. The first pulse of water creates a layer of mud that ``seals" the soil, allowing subsequent pulses to continue down the field more quickly and uniformly. Adding surge valves to existing systems has the potential to increase efficiency by about 20% (Postel, 1999, 187).

13. Practices for Efficient Irrigation Water Transport

Irrigation water transportation systems that move water from the source of supply to the irrigation system could be designed and managed in a manner that minimizes evaporation, seepage, and flow-through water losses from canals and ditches. Delivery and timing need to be flexible enough to meet varying plant water needs throughout the growing season.

Transporting irrigation water from the source of supply to the field irrigation system can be a significant source of water loss and cause of degradation of both surface water and ground water. Losses during transmission include seepage from canals and ditches, evaporation from canals and ditches, and flow-through water. The primary water quality concern is the development of saline seeps below the canals and ditches and the discharge of saline waters.

14. Practices for Utilization of Runoff Water or Tailwater

Increased improvements in productivity at the tail enders can have widespread economic benefits with multiplier effects on the rural economy. According to a recent World Bank study yields differ widely between head and tail. In the case of wheat the ratio between the two is 1.4 basmati rice 1.3 and sugarcane 1.9 (Darosh, 2004) the utilization of runoff water to provide additional irrigation or to reduce the amount of water diverted increases the irrigation water use efficiency. For surface irrigation systems that require runoff or tail water as part of the design and operation, a tail water management practice needs to be installed and used the practice is described as follows:

14.1 Tail water recovery Irrigation system: A facility to collect, store, and transport irrigation tail water for reuse in the farm irrigation distribution system. The reservoir will trap sediment and sediment attached substances from runoff waters. Sediment and chemicals will accumulate in the collection facility by entrapping which would decrease downstream yields of these substances.

Salts, soluble nutrients, and soluble pesticides will be collected with the runoff and will not be released to surface waters. Recovered irrigation water with high salt and/or metal content

will ultimately have to be disposed of in an environmentally safe manner and location. Disposal of these waters should be part of the overall management plan. Although some ground water recharge may occur, little if any pollution hazard is usually expected.

15. Agronomic Steps to Improve Agriculture through Water Conservation

15.1. **Increasing water use efficiency in rice fields:** Irrigated rice production systems will continue to undergo change in the coming years as a consequence of rising labor costs and increasing scarcity of water. Both events are fueling a shift from labor transplanting to direct seeding methods of rice establishment. In India, Dhillon and Sidhu (2004) have shown that direct seeding can give almost equivalent yields as obtained through traditional nursery transfer systems. The weed problem is greatly reduced and so is the cost of pesticide and transplanting. There is also possibility of two crops during the Kharif season thus doubling the productivity of land for Kharif. Double cropping is now seen in some areas of Hafizabad and Daska in the Pakistan Punjab. This technology can have revolutionary impacts on the rice productivity, water saving and cost reduction in the Punjab and Sindh. At present there is some debate amongst the extension departments and the on-farm water management project on the utility of this technology. Widespread adoption of this system would require all out demonstration of this technology. The direct rice seeding drill needs further refinements that are underway. Since, rice transplanting is a highly labor intensive operation introduction of this technology on mass scale will have major impact on labor employment in the rice growing areas.

To adjust water requirements to two rice crops will require different water management practices. An important instrument to improve the agronomic practices will be to introduce forward pricing and production buy back agreements so farmers can invest in the new needs of the modified system. A commodity market establishment that protects the interests of both buyers and sellers must be recognized and built on the infrastructure and experience prevailing in the local agriculture marketing system. One successful agriculture commodity trading model is the Chicago Mercantile Exchange that allows for forward purchase of internationally traded commodities. The government can play a similar role to set the rules of the game and introduce a large segment of the agribusiness and stock exchange community to these facilities.

15.2 Resource conservation technology: If the soil is ploughed as is the conventional practice, it wastes the moisture present in the soil and also causes extra financial burden on farmers in term costs incurred for ploughing, planking and pre-sowing irrigation. It also unnecessarily delays wheat sowing by a couple of weeks, which adversely affects the crop yield. Nevertheless these fields can be sown with zero tillage technology well in time with minimum labor and without pre-sowing irrigation.

15.3 Zero Tillage: In zero tillage or direct planting seed is placed in the uncultivated field with the help of a seed drill. This technique was first developed in Brazil in early 1970's to check massive soil erosion. Currently in America the technology is being used on 17.3 million hectares. While in Brazil 5mha are being cultivated with this technique. Similarly in Argentina 3 mha of land is sown under zero tillage. In Africa zero tillage is applied mainly in South Africa and Zimbabwe and to lesser extent in Kenya and Tanzania. The technology was first introduced in Pakistan during 1997 by the on farm water management directorate of the Punjab.

Several kinds of seed drills have been developed for the purpose. Direct planting increases the soil fertility and organic matter in the soil, improves infiltration and moisture retention

characteristics of the soil. Because of lesser tractor wheel traffic, soil compaction is also lessened thus reducing the intensity of pan formation that eventually impacts water percolation and consequently lowers crop yields. In contrast plowing and turning the soil reduces the organic matter in the soil. Besides tillage and hoeing are extremely labor and energy intensive, therefore the availability of labor and machinery are the deciding factors in the adsorption of zero tillage technology. In certain soil types like hard clay problems have been reported in operating the drill. Design modification may be required to promote use of this technology under all soil types.

Kahlown (2002) evaluated various resource conservation technologies and found that this technology resulted in increased water and fertilizer use efficiencies. Recent research has suggested that water demands in rice fields can be substantially reduced using so-called water saving irrigation (WSI) techniques (saturated soil conditions instead of standing water, or intermittent irrigation). Dry direct seeding offers scope to advance crop establishment and to increase the effective use of early wet-season rainfall. Promising options for improving water-use efficiency could be be integrated and evaluated in major rice irrigation schemes. Little is known about the relationship between improved water-use efficiency at the field level and at the irrigation scheme or catchments level. Additionally, weed, fertilizer, and land management systems that conserve water are attractive to farmers and that are environmentally sound be developed. Pakistan will benefit by follow-up of these techniques and limited scale testing to further adopt this to bold conditions.

Table 14: Water Use Efficiency of Wheat.

Description	Zero Tillage	Laser Leveling	Conventional
Water Applied (m^3/acre)	1268	1281	1552
Yield (Kg/acre)	1754	1785	1456
Water use efficiency (Kg/ m^3)	1.38	1.39	0.94

Source: MREP, 2001

The implication of adopting these technologies for gross national level water saving can be seen in table 15. This suggests that just in wheat -rice system a water use efficiency of 1.38 (kg/m3) can be realized if zero tillage practices are adopted. This could lead to gross water saving of 1.39 MAF. The zero tillage drill is now being adopted for different soil conditions. Promoting its widespread use trough media campaigns, targeted loans for zero drills as special loans (with perhaps initial 5 year reduced interest rates for this implement) will help its widespread adoption.

Table 15: Water Saving with Adoption of Resources Conservation Technologies.

Description	Cropping Zone/Crops		
	Rice-Wheat	Cotton	Rice
Area (million acres)	5.22	7.7	5.22
Water Requirements (mm)	405	650	1022
Water Requirements (MAF)	6.94	16.42	17.50
Water Use (MAF)	8.67	20.53	21.88
Resource Conservation Technology	Zero tillage drill	Bed and Furrow	Direct seeding
Water Saved by RCTs (%)	20	40-45	25
Water Saving (MAF) through RCTs by Minimizing Application Losses	0.35	1.64	1.09

Source: OFWM, 1999-2000

16. Agronomic Measures

Agronomic measures include land leveling, non- tillage in the dry season, deep plowing in the rainy season, soil fertility improvements, organic and plastic mulching, seeds improvements and development of drought resistant varieties, balanced fertilization, improvements to planting and cultivation techniques, etc. Experiments and practice have shown in China and elsewhere that significant improvements in the amount of agricultural yield per unit of evapo-transpiration can be achieved through these types of measures. This is "real" water savings.

16.1 Watercourse improvement:

The total potential of water from the Indus River and its tributaries is about 146 MAF, how ever the crops hardly use 31 MAF and the rest is lost as conveyance and application losses. Much of these losses end up as potential recharge of the ground water aquifers that can be used later. This involves a substantial energy cost to again pump it for crop use. The main causes of these operational losses are: seepage, overflow, thin distorted, silt-loaded banks, vegetation, convoluted sections rodent holes etc. a considerable amount of water wastage also occurs in the form of application losses due to undulations in the fields and because of adoption of obsolete agricultural and irrigation practices at farm level. About 21,000 water courses have been improved so far. It has been estimated that improving the remaining watercourses in the Indus basin could save about 20 MAF of water.

16.2 Improved farm layout. The layout of most fields is based on traditional flood basin comprising a number of unwanted dikes and ditches, which cover a length of over two kilometers in each square (25 acres of land). These fields are not properly leveled which results in wastage of land and low irrigation efficiencies. Removing unnecessary field dikes and ditches, trees etc. and designing farm layout and irrigation system based on the infiltration characteristics of soil and stream size coupled with proper irrigation scheduling would greatly increase the land use intensity and water application/water use efficiency.

16.3 Bed and furrow irrigation. Basin irrigation is the conventional method commonly used in Pakistan. However application efficiency of basin irrigation is very low. Surface irrigation techniques can be improved by developing crop specific field layouts. Efficient surface irrigation methods such as bed and furrow irrigation system help save water. Kahlown et al compared the results of cotton and wheat sowing on flat basin with bed and furrow. They concluded that cotton showed maximum water use efficiency for bed and furrow irrigation method of irrigation whereas the flat basin method of irrigation had the lowest yield and highest water consumption. Water saved in the bed and furrow irrigation can be used to increase the cropping intensity and also for leaching the salts in salt affected soils. In the bed and furrow method water is applied only in furrows. With the passage of time the furrows become cemented due to silt deposition. Water then moves laterally and vertical seepage of the water reduces considerably. Since water is applied in furrows, the effect of water borne and water transmitted diseases on the crop health is minimal. The weeds is transported through the canal water is trapped in the furrows from which these can be removed or controlled easily. Moreover the same field may be used for inter cropping e.g. sugarcane in furrows and wheat on beds etc.

As noted earlier in the cotton system a saving of 7 MAF can be expected if this technology is adopted on large scale. Even if 50% farmers were to adopt this technique a saving of 3.5 MAF could realized.

16.4 Rain-gun irrigation system for Rouni: after seedbed preparation significant amount of water is applied as pre sowing irrigation for most crops. Though proper moisture is

required only in the upper few centimeters of soil profile where the seeds are to be placed, it is not possible to irrigate just a few centimeters of soil with the conventional irrigation methods. Therefore farmer either has to leave his lands fallow due to non availability pre sowing irrigation or wait until water becomes available. The crop sowing is delayed that finally affects the crop yield. This however could be used to apply desired shallow depth of water during pre sowing and first irrigation. In this way more area could be sown with same available water. Portable rain-gun system is being locally manufactured now. Typical field application efficiencies of different methods are shown below.

Table:-16 Field application efficiencies of different methods

Methods	Field application efficiency (%)
Surface Methods	
• Basin	50
• Furrow	55
• Border	55
Overhead Methods	
• Sprinkler	60-65
• Drip/trickle	Up to 90

Source:

17. Efficient irrigation system for orchards

Pakistan is known for citrus and mango orchards. Farmers normally flood irrigate their orchards; this results in the wastage of water and fertilizers. The moisture and fertilizer in the fallow area also encourages germination of weeds. Farmers cultivate the land between the plants to control the weeds and to increase profitability. The movement of machinery in the orchard damages the plants as well as roots. Introducing ditch irrigation system can save significant amount of water. The fallow area between plants may be covered with crop residues mulches, oil seed, fodder multiple, MPTS. Mulches conserve moisture in the soil and discourage weed germination. Mulches conserve moisture in the soil and discourage weed germination. Mulches also reduce the evaporation and hence the Stalinization of the soils. Moreover these mulches after some time decompose and add organic matter in the soil.

18. Improved cropping patterns:

High delta crops such as sugarcane and rice not only consume a major portion of the available water but also contribute to water logging. At present sugarcane is sown on about 1.0 million hectares and consumes about 6.0 MAF of water in addition to huge deep percolation losses. The high delta crops can be substituted with low delta crops of high market value. A strategy can be adopted to introduce the low delta crops in the cropping pattern when there is water shortage. This would help generate some income rather than complete failure of high delta crops. Detailed analysis of both micro feasibility and national/provincial level macro impacts needs to be undertaken. Farmers resistance to high give up a certain level of profitability (artificially introduced through price and cheaper abiana charges) needs rectification if water saving is the main concern. An important area requiring attention is utilizing both field survey data and available GIS technology to better ascertain areas, yield and production statistics. Investment here would help plan agriculture on modern lines and also enable both public and private sector to devise new crop-rotations on land use and economic performance.

If simple interventions are so good why not widely adopted!

1. Awareness and knowledge-not publicized or brought to grass root focus.
2. Availability of equipment, operator training, layouts.
3. No widespread trials demonstrating economic impact and benefits
4. Recommendation based on agro ecological zones lacking-where would these practices be most feasible.
5. Few vendor and Farm Machinery shops introduced to manufacturing of new water saving implements.
6. Govt. support though credit provision, technical backup, and packaging of technology absent.
7. Private sector firms not educated on large scale to make impact.
8. No major thrust from International donors in provision of technology and regional program (CIMMYT making effort to highlight the potential).
9. High cost of certain system i.e. sprinkler, drip,
10. Water rates low and entitlements poorly implemented (i.e. tail enders) – encourages wastefulness amongst canal water users.
11. Less incentives for the tenurial classes to invest in leased or share cropped land
12. Techniques being adopted but rate of progress is slow and could be accelerated at low cost if this policy thrust was given greater attention

19. Implications for Development of an Agriculture Strategy

Sections I and II help derive some broad assessment of the situation

1. Agriculture growth in Pakistan is stagnant with yields of major cash crops showing little change. Consequently, the multiplier effects of agriculture on the economy show lower impacts. The linkages of agriculture with the non-farm rural sector can be strengthened and made stronger by promoting enterprise diversification with greater attention to high value systems that increase involvement of skilled and unskilled labor. Investing in the productivity of this labor pool can have direct impacts on poverty reduction.
2. Water stands out as a key element in strategizing the future of agriculture. Its proper management can become the focal point for setting agriculture on a rapid growth curve with widespread benefits.
3. Pakistan will have to make strategic choices regarding the future of its small farmer population. The number of small farms is increasing at an alarming rate due to existing inheritance laws. At some point the farm size becomes a critical constraint. Decisions will have to be made on the long term perspective and potential/liabilities of such a sector and how this would fit into overall development strategy.
4. There are options in the form of water conservation that can greatly relieve the present water constraint. Additional water (be it from more storage) however will not imply greater productivity, if high value water is applied to low value output systems (i.e. cereals)
5. Possible substitutions for cereals between irrigated and dry land areas exist and Pakistan can seek ways to diversify its overall emphasis of wheat production in the irrigated areas at the expense of expansion of high value enterprises such as horticulture, oilseeds and dairying

6. Developing a realizing that further expansion of area and uses for the limited water supplies can have far reaching consequences on productivity, income, inter regional disparities and equity elsewhere. Conserving what is available and putting it to good use may be a more sensible option.
7. Agriculture development could make valuable contribution to Pakistan's economy provided the country invests in well chosen multinational partnerships with technology, processing and international marketing expertise, The potential of corporate farming with backward and forward linkages like those in the dairy and juice industries can help bring in the necessary managerial and entrepreneurial skills much needed in Pakistan. In some cases like the mango industry prominent in Sindh and Punjab local leaders are showing the way by establishing international networking to help establish agribusiness.
8. There is a widening gap in the generation and technology transfer to the agriculture community. Water related conservation techniques can be packaged with suitable agronomic components (seed, fertilizer, pesticide, credit, market contracts). A strategic change is needed to re-orient the present agriculture credit programs to be geared more towards a water constrained environment. Consequently investment in farm machinery (i.e. levelers, farm implements, farm to market roads etc) must feature high in the transition period and become nationally widespread.
9. Water entitlements, laws, tradable markets become more meaningful when the state sets in motion the processes and mechanisms by which these are implemented and honored. Future water storage projects so essential to ensure the continuity of agriculture (through irrigation and power) will require that operating rules for water distribution incorporate means for transparent distribution of the resource with safeguards for balanced and equitable regional development.
10. Provide support through match grant for the introduction and demonstration of modern agriculture implements appropriate under local situations. This "Water Conservation and leveling Equipment can help engage a whole array of agriculture/irrigation engineers and junior level technicians. Such investment will also have widespread impacts on rural economies by reducing unemployment amongst the youth.
11. Without sustained investment in agriculture education and related (R and D) at all levels long term agriculture growth would be unlikely. Thus expand investment in the agricultural education both formal (school, college and university) and informal like vocational and farmer training based on needs of different agro-ecological zones in a sequenced and prioritized manner.
12. Input and output markets need to be better integrated with the farm community needs. Further decentralizing the access and better availability of technical and price information in different markets can help reduce farmer exploitation. Opportunities exist to bring web based technology at the farm level due to its declining technology costs (computers and communication). Low levels of illiteracy can be overcome by developing multi-media based interactive Knowledge systems (i.e. video clips with training content on water conservation techniques i.e. minimum tillage, raised furrow plantation, lazer leveling etc.)
13. This paper has highlighted the potential role of progressive farmers to provide a model for application of modern farm management (theory and practice) to obtain higher yields and enterprise diversification/and specialization. Encouraging large scale demonstration of such systems and highlighting the key elements of their technology and resource requirement at the grass roots level can help bridge yield

gaps nationwide. Relieving constraints of physical inputs and credit can start with further strengthening of grass root institutions through a pragmatic process of reform.

14. Enhancing farmer holding capacity to market produce at time of harvest at favorable price can reduce exploitation within the prevalent marketing system. To move into a high value enterprise production system it is important that investments in the necessary storage and processing of perishables be undertaken. In fruit juices sufficient capacity already exists and stress be on production. This approach will help farmers obtain a high price for their fresh produce and a reserve price for the surplus. Exposure and demonstration of international export marketing practices and requirements can greatly facilitate participation in international commodity trade in high value produce (fruits, vegetables, flower etc).

Changes in incentive system!

- Policy decision needed at Federal & Provincial level
- Subsidized loaning for purchase of implements and Lazer levelers.
- Incentives to new industry entrants for manufacturing of equipment.
- Develop leadership in agriculture and educate the youth to participate in this change
- Sharing success stories over media under different farm systems
- Implement strategic taxation and regulatory policies focused on high value enterprises like orchards to adopt hi-tech water saving devices. Present low valued water is a disincentive for improving efficiency
- Linkages with processing and marketing systems and introduction of standards and grading system that would command a premium price for quality- consequently encourage water saving
- Providing special grants to community organizations (i.e. under devolution plan, NRSP) to participate in water savings.
- Create a sense of competition amongst districts in terms of agriculture ranking and water efficiency
- Joint venture program and corporate farms in each a district to show what can be achieved.
- Greater attention to clear water rights, formal tradable markets, rules and regulations and public-private partnership

20. Priorities and Sequencing

The analysis of priorities helps to identify a pattern of establishing sequential engagement in the agriculture sector with specialized focus on water. The following phase-wise engagement is proposed for the next 10 years:

20.1 Phase 1: Bank engages in a rigorous technical and socio-economic analysis of the dominant agro-ecological zones to appraise itself and GOP of the potential areas of engagement. It would identify the “hot spots” and establish high value opportunity areas. A review of past studies and investment in new areas (with data gaps) will help establish the most promising areas where involvement would be at different levels based on farm size, types of farms and long term commodity demand/supply scenarios. For instance drip irrigation is most suited to commercial orchards and vegetable production systems. Analysis will show how orchard and vegetable farmers can be induced to adopt these technologies

(perhaps by raising the price of water on these farms to a level where there is incentive to invest in the new water conservation techniques, providing loans for initial investment etc.) A **dynamic agriculture sector model** could be one outcome of such analysis. Government needs to engage public private partnership as a pre-requisite for long term bank involvement to modernize agriculture. The country's plans must show the set of conditions that will prevail under a modern agriculture scenario and the resources, along with time frame it wishes to undertake to achieve these goals. Measures that are needed to establish the necessary institutional link at the grass roots level need to be opened up for public debate The participation of specialized international arrangements that place "world best technology and good practice" in the reach of Pakistan with long term project i.e. olive with Spain; horticulture with Italy; dry land agriculture with Australia, Egypt for dry land crops be spelled out. During the first 1-2 years develop a clear strategic plan with clear opportunities in the production; processing and marketing sector could be prepared. Agriculture during this phase will change its focus from a low-input low-output system into a modern agribusiness industry in line with the broader development objectives of the country. While most constraints for low productivity are well documented efforts will be needed to narrow the yield difference amongst different categories of farms. This should receive the highest priority in the short run. Systems distortions that have lower yields on certain reaches (like tail enders) be reviewed and likewise wider "Green Revolution" needs be addressed to improve average yields in all districts still lagging behind in basic agriculture infrastructure.
This phase will include a nationwide- mass media campaign to highlight the water issues and available strategies. In particular it would emphasize water wastage through "flood irrigation" and future need to share agriculture water with other uses. It will engage all the stakeholders and help define practical approaches that can be followed within each of the 8 agro-ecological zones.

20.2 **Phase II**. The phase would allow development of projects with a large portfolio to continue over a period of 12-15 years covering entire planned infrastructure investment era (Kalabagh, Basha , others). The government will commit to a policy framework and reforms that are in the best interest of the farm community who are key stakeholders in accelerating agricultural development. Government will show that it is willing to undertake investment in developing large scale human resources exposed to modernized agriculture worldwide and will take steps to reorient or create institutions in line with the needs of a modern agriculture establishment. This will require a critical appraisal of existing agriculture institutions with possible replacement by absolutely new institutions. The mandates of such organizations will be developed based on successful experience elsewhere. GOP must commit to certain basic reform processes that could be made pre-conditions for investment in large scale infrastructure. All conditions for a modern agriculture production-marketing-processing must be in place during this phase. There **is little use of** investing in large infrastructure (irrigation and power) if it is to feed a low input-low output system. GOP must show its commitment to invest most heavily in the following aspects

1 Provision of large scale farm machinery with special attention to mechanization needs pertaining to land leveling, furrow preparation, zero tillage seed drills etc. It will formulate policies and plans that encourage the use of this equipment and back this with loans specially targeted to the owned and rental markets for equipment. This investment could be in the tune of 1-2 billions dollars.
2 Decentralized public-private information systems at several sub-district level that can serve as training grounds for all types of new water related technology interventions along with a well established net work of technology centers i.e. sprinkler, drip, furrow, volumetric measurement devices, laser levelers etc. Centers will also include agriculture

technologies and trained manpower to demonstrate them. Special up gradation of this new generation of techniques will require mass production of agricultural graduates with sufficient hands on experience. The later requires a re-look at the universities/colleges/institutes that train such graduates.

3 A vibrant industry that is promoted and supported by the government to develop low cost versions of water related technologies with sufficient inventory.

4 An efficient marketing and processing infrastructure in line with a modernized agribusiness orientation, this will include clear investment in storage, transportation and processing of various foods to meet domestic and international demands. All of this will be developed within prevalent WTO and GATT guidelines to ensure Pakistan engages in those products where it has comparative advantage.

5 Finally a clear realization that by saving water there are opportunities for its economic allocation through pricing, establishing water entitlements/rights and potential trading through both formal and informal markets. The water savings can help establish the necessary water markets that will enable the government to undertake projects to bring new areas under command. The core value that needs to be developed in the water sector strategizing is that of "Water Management". Without better management of water at all levels it makes little sense to support costly infrastructure development.

20.3 **Phase III.** This stage would link a modern agriculture sector into the overall Water Sector Strategy. It will involve fine tuning and readjustments from the 10 years experience Pakistan will have in place while infrastructure developments are completed and water savings from conservation are rationalized and allocated to most economic and equitable use. To ensure that development takes place in an equitable manner in all areas based on regional planning models, clear plans will be developed so all priority areas benefit from the chain of investments. An evaluation of what is required up till 2025 will be undertaken at this stage which should have accomplished most of the goals established as per phase I-II.

21. Banks Comparative Advantage

The Bank has a long history of engagement in the agriculture sector with diverse types of investments i.e. crops, livestock, agriculture research, extension etc. It is well versed with the sector issues. The Bank has also been carefully addressing the structural adjustment issues in this sector placing greater reliance on the reform process. Since, the bank has had an absolute advantage in helping harness the water resources in the country it appreciates the important linkages with the farm sector. The banks know-how about agriculture institutions in the irrigated agriculture was further strengthened by financing a study on irrigated agriculture (see Mellor and Asianics, 1994) and its past country sector reviews (1994).

To be effective in future water resource development and strategy implementation the bank will need to engage directly with agriculture improvements at the farm level through projects that carry a clear "water conservation and efficiency bias". The Bank's wide experience and staff resources allow it to draw upon diverse cutting edge know-how that is relevant to help Pakistan modernize its agriculture. As a lead financier of development projects it has the vision to address problems of long run concern with associated risks and payoffs. Its present portfolio in Pakistan is also aimed to improve the surface water efficiency. By combining these efforts with greater stress on agriculture it can expect to take a two pronged approach through integral backward and forward linkages that result in the direct uplift of the rural sector. Infrastructure investments would become meaningful only when systems are put in place to help alleviate poverty, increase agriculture productivity and help Pakistan realize the medium to long term growth objectives. Social development investment without congruent investment in agriculture is meaningless-social change must go hand in hand within an

equitable and sustainable manner. The Bank's financial resources in Pakistan can be put to best use when it addresses the root causes of lower agricultural productivity. It has helped several other countries overcome the large yield gaps. Pakistan will benefit from the World Banks intellectual leadership in guiding this process.

Asian Development Bank is another major lender to Pakistan for agriculture. A joint strategy for agriculture could be developed whereby certain investments can be undertaken by ADB. Pakistan views World Bank advice with reverence-a joint approach to resource mobilization in the agriculture sector prior to realizing outcomes of other infrastructure investments (like dams) would further the banks advantage in addressing this sector long term prospects .

The Bank's main advantage lies in setting priorities jointly with GOP on agriculture where there could be beneficial engagement i.e. rice-wheat or wheat-cotton systems. A strategic plan that gives attention to step wise introduction of water management techniques on large scale keeping in view requirements at national, provincial, regional, canal and farm level according to different agro-ecological considerations would be mutually beneficial and help achieve the desired results.

22. Suggestions for Bank Engagement-Way Forward

Suggestions for productive engagement can be summarized as:

- Develop a medium to long term engagement strategy in collaboration with GOP and the provincial governments for development of institutions (through public private sector partnership) that are suitable for grass-root level development.
- Review the needs of a modern agriculture establishment and establish priority area for engagement according to agro-ecological zones, categories of farms (small, medium, large, corporate etc) along with clear enterprise focus crops, livestock, on-farm forestry, on –farm agriculture employment etc.
- Guide the development of a dynamic agriculture simulation model that can help establish comparative advantage, plan agriculture production under different scenarios, identify and quantity impacts of water scarcity and new technologies on different farm systems. The agriculture component could be a sub- model for a larger Indus Basin level dynamic Model.
- Develop clarity amongst various stakeholders that without investment in a modern agribusiness oriented agriculture the benefits from investment in high cost infrastructure are likely to be modest. For the Bank to realistically participate in such infrastructure development—a precondition would be a well planned and sustained investment into agriculture with a clear short to medium term agriculture development plan.
- Educate the farm community and provincial departments on the need to invest and devise strategies for recovery of O&M if existing and new infrastructure is to continue to play their role in irrigated agriculture. The community at large must see visible gains in payment for the services. By the same token guide the government to address the menace of "flood irrigation" and its associated ills of water wastage, water logging and salinity. Refining crop water requirements and making this information available through mass media can be a short term solution with little capital investment
- There are opportunities in the area of water conservation technology that if properly and widely adapted could help Pakistan save considerable amount of water. This additional water could be re-allocated to other competing needs including developing new areas for agriculture. Establishing clear targets for the cotton, wheat and rice

based systems would be a step forward that can be taken with little financial investment. Efforts on the awareness campaigns can help highlight the new water strategy to be adopted at the farm level.

- Systematically engage the private sector to help widespread adoption of scientific available know-how on water conservation i.e. sprinkler, drip, land leveling, farm machinery and implements etc. on high value production systems like orchards and vegetable. As starters these innovations could be introduced in the peri-urban centers and later move down to the prime production areas. Pilot projects in the major fruit production zones would help introduce this technology. Adoption will require getting the prices right for water and loans for making this transition.
- Engage the government to better understand the implications of supporting, promoting and engaging in production of high water consuming crops i.e sugarcane and the long term consequences of the "over production/investment trap" leading to uneconomical industrial units that may be unsustainable in the wake of water shortages.
- Help foster institutional linkages between agriculture and allied water related agencies. Ideally such development would take place within a basin and micro-basin framework where regional level planners can interact on how to achieve broader macro objectives i.e social equity, poverty reduction, economic growth and farm development amongst a wide array of classes.

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Policies and Prospective Plans for Development and Management of Water Resources By The Federal and Provincial Governments

By

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Policies and Prospective Plans for Development and Management of Water Resources By The Federal and Provincial Governments

Sardar Muhammad Tariq and Shams ul Mulk

1. FOREWORD

Presently Pakistan's irrigated area accounts for only 22.5% i.e. 18 Mha out of 79.6 Mha total land mass of Pakistan. This 22.5% irrigated area supports Pakistan's agriculture which is its single largest sector of economy. Agriculture accounts for 25% or more of GWP, although its share in the GDP has been decreasing over the years as other sectors expanded, still 68% of the rural population depends on agriculture, which employs 46% of the labour force and accounts for 60% of foreign exchange earnings. Water resources, therefore, are the mainstay of Pakistan's agro-based economy.

Pakistan's Constitution clearly demarcates the responsibilities in managing and developing water resources at the National and at the Provincial levels. At the National level, Pakistan shares its basin with India, which under the Indus Water Treaty of 1960 clearly defines the shares of Indus Waters between India and Pakistan – within Pakistan, the inter-provincial water apportionment accord of 1991, sets aside the share of each Province out of the existing storages, storages to be developed in future and out of the flood flows. The inter-states and inter-provincial water accords have provided Pakistan a clear road map for its future water resources development at the National Level as well as at the provincial level.

2. WATER MANAGEMENT IN PAKISTAN

The water resources development and management closely followed the growth in agriculture more or less on fragmented pattern. With the looming grain shortages due to rapid population growth, the Government realized the critical importance of the agriculture sector and the need to achieve food self-sufficiency. Special efforts were therefore, made to increase irrigation resources to enable expansion of the cropped area and increase productivity. Massive investments at the Federal and Provincial levels went into the construction of infra-structures for storing and carrying surface water to the expanded areas and installing a large number of tubewells in the sweet water zones.

The Indus River and its tributaries on average bring almost 152.4 Million Acre Feet (MAF) of water annually including that part of flow which India has not

been able to capture on eastern rivers downstream of its diversion structures due to topographic constraints. This includes 143 MAF from the Western Rivers and 8.4 MAF from the Eastern Rivers. Most of the inflows, about 104 MAF, is diverted for irrigation with 35 MAF flow to the sea and almost 15 MAF is consumed by system losses.

Pakistan, largest contiguous irrigation system in the world, which irrigates 18 Mha, consists of three major storage reservoirs, 16 barrages, two head-works, two siphons across major rivers, 12 inter-river link canals, 44 canal commands and more than 107,000 water courses. The system also utilizes 41.6 MAF of ground water to supplement canal supplies. In addition, there are over 200 civil canals in NWFP, which irrigate about 0.33 Mha and are managed by local population.

The overall uses of available surface and ground water is 96% in agriculture sector, 2.2% for domestic purposes and only 0.6% consumed in industry (mostly groundwater).

3. DESCRIPTION OF THE ISSUES AND THE CURRENT POLICY ENVIRONMENT

3.1. Changing Responsibilities in water sector

3.1.1. National

The waters of the Indus River basin are allocated to the provinces through the accord which is implemented by the Indus River System Authority (IRSA), a constitutional body comprising five members, one from each province and a Federal member. It is supposed to act in the national interest, but there are frequent disputes over water allocation, especially during dry periods. This has led to serious controversy and mistrust between the provinces resulting in slow growth in water resources development in the past decades.

At national level there are several Federal agencies with responsibility for various areas or sub-sectors of water, there is no inter-ministerial, inter-provincial body to oversee integrated water sector planning, development and management. While WAPDA does play an important role of development of water resources, hydro power, combating waterlogging and salinity, and operation and maintenance of inter-provincial infrastructures and storage dams at the national level, its role within the Provinces is minimal.

3.1.2. Provincial

Much of water sector planning, development and management has been mainly a provincial responsibility. Irrigation, domestic water supply and sanitation and environment have been managed through respective provincial departments. This is now changing with the programme of devolution in all the water sub-sectors.

The devolution plan decentralizes most Public Sector activities from the Federal and Provincial levels to the districts level, including Public Sector Water Supply and Sanitation. There is grave concern that the district authorities will lack the technical and managerial skills needed to support development of rural water supply and sanitation. Capacity building at district level would be essentially required to make elected district authority as the main driving force in future water management in the rural, urban areas including mega cities and smaller cities and towns where much of urban growth will take place.

In irrigation, legislation has been passed to convert Irrigation Departments into financially self-sustainable autonomous Provincial Irrigation and Drainage Authorities (PIDAs). Under the PIDAs, the operation and maintenance of individual Canal Systems is to be entrusted to autonomous self accounting Area Water Boards (AWBs), which would entrust the operation and maintenance of the distributaries and minor canals to Farmer Organizations (FOs). This is currently an issue as irrigation and agricultural reforms are not fully accepted. It is feared that future donors' investments would largely depend on acceptance of these basic institutional reforms.

3.2 Current Issues

3.2.1. Lack of Coordination with in Water Sector

To bring about much needed reforms and changes there is dire need to boost the level of coordination within the water sector. It is high time that Pakistan's Water resources should be developed and managed in an integrated and holistic manner based on the Principles of Integrated Water Resources Management (IWRM), which creates strong coordination links, equity, transparency and establishes clear water rights at the lowest level for efficient management and promotes the development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital eco-systems. The increasing water demands and frequent dry spells have the potential to lead to serious conflicts between the Provinces and within the Province among the upper and lower riparian within the canal commands.
Inter-Provincial insecurities and mistrust in water sharing particularly during period of shortages has led to controversy and has been responsible for slow

development of water sector particularly at the National level. Unfortunately IRSA's decisions have been challenged time and again. Provinces do not enjoy a level of comfort with IRSA's decisions and major two provinces i.e. Punjab and Sindh interpret clause 14 (a) and (b) of the Accord to their own advantage. IRSA needs to resolve this issue once and for all since controversies only arise when sharing shortages, additional storages and linking Indus with Jhelum through additional link canal would help IRSA in better distribution and management. The enhancement in technical capabilities of IRSA would also be required.

3.2.2 Financial Sustainability

Financial sustainability in all water sub-sectors needs improvement. In the urban water supply and sanitation sub-sector, this is mainly due to low level of income generated through water tariffs and their collection. In the irrigation sub-sector, it is again the extremely low water charges and often failure in timely collection of revenues, makes the system financially unsustainable.

3.2.3. Social Issues

The growing population is converting Pakistan into a land rich water short country. High level of poverty, inequity in water distribution, limited stakeholders participation particularly women, inadequate public awareness and understanding of water issues are some of the major issues in all sub-sectors of water.

3.2.4. Institutional Issues

Inadequate coordination between organizations of the various sub-sectors, absence of dispute resolution mechanism, changing administration under the devolution plan, inadequate water information and water measurements are some of the major institutional issues. In addition, absence of clear water rights and accountable institutions are two factors which compound the social issues.

3.2.5. Technical Issues

The main technical issue which Pakistan is going to face is the insufficient water resources to meet the rapidly growing population. Pakistan with its arid to semi arid climate will face many technical issues to resolve its water scarcity problems. Water planners therefore, need to address the following urgently:

i) to meet increasing demand for drinking, food and power;
ii) address inefficacies in use of water in all sub sectors with greatest potential for improvement in irrigation sub sector;

iii) address low crop yields;
iv) arrest deteriorating water quality;
v) provide adequate domestic water supply and sanitation coverage and to enhance quality of services;
vi) improve infrastructure in domestic and irrigation, and drainage sub sectors;
vii) stop over use of water in many irrigated areas;
viii) address water logging and salinity and disposal of saline drainage effluents;
ix) create additional storages for better management and regulation;
x) address sedimentation problems and watershed management; and
xi) ground water balancing and quality.

3.3 Warabandi (Water Schedules) System

The traditional system of water use and management for small scale irrigation channels was rather simple and had evolved rules for distribution of both water and new land. Historically, traditional institutions at the grass root level had developed mechanisms and procedures to operate and maintain indigenous irrigation systems. The development of the civil canals, the main irrigation channels is an indication of the capacity of local farmers to develop and maintain the irrigation infrastructure at the local level. Similarly, the underground irrigation Karez developed by the farming communities in Balochistan is marvel of local engineering technology. The vernacular was extremely rich and sophisticated in terms of the vocabulary devised for water. Along the irrigation channels, a traditional system of water distribution schedule or Warabandi has been in force to distribute the water from the canals. This informal or Kacha Warabandi System was a very flexible method of water distribution below the outlet structure. This Warabandi ensured water for all the stakeholders along the water course. When the water flow was temporarily disrupted due to canal closure, or for any other reason of water shortage, the irrigation cycle would start from the last irrigated farm upon restoration of the flow. It was possible for any two farmers to exchange irrigation turns through mutual agreement. As long as the groups of relevant shareholders could manage the distribution of canal water agreeably and collectively, the informal or Kacha Warabandi was functional. As a result there was no need to invite the interference of government agencies. Disputes related to water distribution were settled locally, a big landlord always managed to arrange some sort of consensus without involving the state. Therefore, from administrative point of view, the problems of water distribution within the water course presented little or no difficulty to the state. However, with the development of modern technologies and infrastructures and complex nature of problems and issues, the local communities were unable to maintain

the Kacha Warabandi system started looking towards the government machinery as an effective arbitrator of some of these local disputes. The public sector institutions did not develop the capacity of community based traditional institutions in handling these new problems but instead centralized the decision-making. Thus the informal system of water distribution was replaced by a formal or Pucca Warabandi system i.e. formal water schedules. Thus there has been a gradual shift from local level management to state regulation. However, in the early 1990's there was a realization that state system had failed on several accounts. The indications of social sector development pointed to the failure of the public sector to deliver access to basic services.

3.4 Ground Water

The Indus basin was formed by alluvial deposits carried by the Indus and its tributaries. It is underlain by an unconfined aquifer covering about 16 Mha in surface area. Ground water has been a major resource in raising the agriculture production in addition to meeting drinking water and industrial water requirements over the past 30 years. In agriculture sector ground water not only supply additional water, but provide flexibility to match surface water supplies with crop water requirements. Due to extensive development of ground water by the private sector there has been excessive lowering of water tables and intrusion of saline water into fresh water with the result that 10 Mha of surface area now has saline ground water and only 6 Mha has fresh water. Lack of knowledge and absence of regulatory frame work has rendered this vital ground water basin to more or less irreversible degree of deterioration. The safe ground water yield is estimated to about 68 BCM while total extraction for all purposes is closed to 59 BCM. The remaining ground water potential of 9 BCM even though it exists, has reached to such a depth that its potential for harnessing has already touched the economic limits. Indiscriminate pumping in the absence of any effective regulatory frame work has resulted in the contamination of aquifer to various degrees in all the four provinces both in the rural and urban areas of Pakistan. The over exploration and ground water quality has therefore, became one of the major resource issues.

3.5 Existing Water Laws

The birth of water laws first took place when water was diverted for irrigation through traditional canals in the sub-continent through public sector investment. The first law which laid down the governing pattern between the state and the water users was the famous "Canal and Drainage Act of 1873". This act laid down the working principles and included:

- Governing Guidelines for the Institutions e.g. the Canal Heads
- Instructions for the canal officers in the preparation and modifications of Warabandis, Water Rates, Navigation, appeals and references, inspection of records of Warabandi cases, offences and penalties, etc.

After independence in 1947, the water management and development within a province became the responsibility of the Provincial Government. Almost all the Provincial Governments adopted Canal and Drainage Act 1873 as the basis for governance, development and management of irrigation water. Since then numerous amendments in the original act were incorporated by the Provincial Governments with the enunciated objective of enlarging the scope of the Act to include legislation for ground water, environment, fisheries, etc.

At the National level, the overall water resources development, hydropower generation, drainage and combating twin menace of water logging and salinity was assigned to WAPDA under Water and Power Development Act of 1958. Similarly at the National level to distribute water among provinces and to resolve water disputes, IRSA was formed under Indus River System Authority Act of 1992.

3.6 Current Practices in Water Resource Development and Management

Driven by the necessity of Indus Waters Treaty of 1960, Pakistan's approach at the National level for water resources development has been based on a "Basin Wise" concept. The Indus Waters Treaty of 1960 between India and Pakistan per force required Pakistan to invest heavily in the infrastructure developments to distribute the water of three western rivers equitably within the Indus Basin with particular emphasis on the areas which prior to the Treaty was served by the three eastern rivers. With heavy assistance coming from donor agencies including the World Bank, Pakistan reinforced the single largest contiguous irrigation network in the world. Pakistan did develop an integrated water resources management plan for whole of the Indus Basin with strong concept of integration including hydropower development, food sufficiency, flood mitigation, drainage and development of ground water with the exception of some other equally important sub sectors such as water supply and sanitation, environment, industrial water supply that were developed on sectoral approaches. At National level, Pakistan's future strategies and policies are based on integrated water resources development plan.

At the National level, the Government has addressed the issue of developing the water sector through several initiatives, including the Ten Year Perspective Plan (Planning Commission 2001), the National Water Policy (Ministry of Water and

Power, Draft 2002) and the latest of October 2002, the Pakistan Water Sector Strategy Study by the Ministry of Water and Power. The end product of this study comprises three main documents which are referred to in total as the Pakistan Water Sector Strategy. These are:

- The National Water Sector Profile (NWSP), which summarizes and details all aspects of the water availability and utilization as they exist today. It has therefore, become a standard source document for future water sector work.
- The National Water Sector Strategy (NWSS), which identifies the key issues and objective for the water sector and proposals for planning, development and management of water resources and their use in all water sub sectors.
- The Medium Term Investment Plan (MTIP), which identifies the key programmes and projects which should be undertaken upto 2011 which will make the initial contribution to achieve the objectives of the strategy.

The National Water Sector Strategy document covers almost all of the water sub sectors including: resource development, urban water supply and sanitation, rural water supply and sanitation, industrial water supply and pollution control, irrigation and drainage, hydropower, the environmental and flood protection. The strategy and the Mid Term Investment Plan (MTIP) emphasize institutional, management and financial matters as well as infrastructure. It prioritizes equity in water allocation, improving and maintaining the quality of water, the conservation of the country's water resources and the need for efficiency and financial sustainability in water service delivery. It promotes an integrated approach to water sector development and participation of all stakeholders in decision-making.

For the first time the water sector strategy and Mid Term Investment Plan are not limited to the irrigation and drainage sub sectors, as has been the traditional emphasis in water sector plans in the past. Rather all the competing sub sectors of water are addressed, along with the cross-cutting issues and objectives, as they should be to ensure provision of water for all in the future.

Strategy document provides an excellent road map for future development and management at the National level and outlines a comprehensive list of issues but is silent on the important issue of political economy of reforms – the greatest of all challenges in the water sector is the articulation of prioritized, sequenced and sellable program for getting from here to there. The strategy document though talks about change from fragmented water sector development and management to more holistic integrated water resources management, but lacks clear direction on how to make a series of important transitions particularly at the provincial

levels and who is going to be in the drivers seat or main actor, how poverty issues will be addressed in the water utility reform process. Realizing also that strong sociological barriers which exit against reforms, the potentials of creating hindrances in achieving water sector strategy objectives and the medium term investment plan could be a meager commitment against tall strategy targets.

In general surface water development and management inspite of its shortcomings followed some focused objectives and economic targets, both at the National and Provincial levels, the development of ground water for agriculture purposes particularly in the private sector followed a demand based pattern. Surface water scarcity, inequity in its distribution together with subsidies in energy were the factors in mushroom development of private tubewells resulting in over extraction and destruction of ground water quality. With its own political sensitivity, it has been the most difficult area to manage the water sub sector.

3.7 Existing Dispute Resolution Mechanisms

Pakistan faces water sharing issues broadly at four different levels:

- Transboundary issues
- Issues at the National level
- Inter-Provincial water issues
- Intra-Provincial water issues

The mechanism available to resolve water issues/disputes at the four levels are briefly discussed:

3.7.1. Transboundary Disputes Resolution Mechanism

The transboundary water disputes arose immediately after the partition of the British India into two sovereign states of India and Pakistan. The partition line between India and Pakistan cut across the historic irrigation network established during the British Colonial Rule. This created a serious water dispute between India and Pakistan, when India tried to stop the waters of three eastern rivers irrigating large tract of land (estimated at 8.00 million acres) in Punjab Province of Pakistan. India could do so as the control structures on the eastern rivers were located in the Indian territory. This was the first serious issue between India and Pakistan and both the countries were at the verge of war. With the timely intervention of the World Bank and prolonged and concerted efforts an amicable water sharing solution was found and the famous Indus Waters Treaty of 1960 was signed between India and Pakistan with World Bank also signatory to it. This treaty is a comprehensive document and is widely quoted in the

International forums as a success story in addressing transboundary water issues. The treaty has been mostly honoured by both India and Pakistan inspite of persistent hostilities between the two countries. The Treaty gives a detailed mechanism of "Settlement of Differences and Disputes" under Article IX.

3.7.2. Issues at the National Level

Most of the water resources development works with the active participation of donor agencies including World Bank, were undertaken immediately after the signing of the Indus Waters Treaty by the Ministry of Water and Power through the Water and Power Development Authority (WAPDA). WAPDA was created under an act of the Parliament in 1958 and has been mostly responsible for undertaking construction, maintenance and operation of mega projects. WAPDA has been operating under the umbrella of Land Acquisition Act of 1894. As little emphasis were given to environmental issues, the main disputes and legal proceedings were faced by WAPDA and Land Acquisition Collectors in the award of compensation packages during compulsory acquisition of private land and property. Such lengthy court cases often resulted in cost over-runs and time over-runs for some important foreign aided projects. However, over the last decade, Government at the National level revisited these issues together with issues resulting from environmental degradation which were hectically pursued by the Environmentalists. Issues brought to the notice of the Federal Government sensitized the policy makers that to attract future investment in infrastructure development, changes in policy framework would be inevitable. The new policies and acts which have been initiated mainly address the compulsory Land Acquisition Act of 1894, Environmental Pollution Act (EPA) and Resettlement Policy.

In land acquisition, the stakeholders participation has been made mandatory. The formulae for land acquisition based on average price to prevailing market price determined by the committee consisting of stakeholders representative, Revenue Collectors from public sector and developing agency such as WAPDA. Similarly for built up property instead of prevailing worth of the property, the replacement cost of the property was given as compensation. Over and above the prevailing market and replacement cost of land and built up property, a 15% compulsory acquisition cost was also paid to the affectees. This has to great extent reduced the number of dissatisfied affectees and court cases but unfortunately the process is still not transparent due to powers of the Revenue Collector which he still enjoys under the Land Acquisition Act.

On issue of environment, the Planning Commission at the Federal as well as at the Provincial level has made it compulsory for all development projects

including water sector projects to have environmental impact assessment (EIA) studies carried out prior to the project submitted for its approval.

The most important aspect which remained neglected for a long time was the dispute resolution mechanism between public sector i.e. the developer and the stakeholders, which were directly affected by the development of water sector infrastructures. The LAA 1894 gave extraordinary powers to the acquisition authority and little or no interest of affectees were protected. Government of Pakistan, through Ministry of Environment, local Government and Rural Development prepared "Resettlement Policy of Pakistan" January 2002, which still remains in a draft form. Many good points have been included in this draft, the fundamental being the resettlement and rehabilitation of persons taking into consideration the changed social, cultural, economic, political and environmental landscape. The policy addresses those areas which were not looked after in LAA 1894 like the recognition of adverse effects on project affected persons; processing of informed/preferred compensation choices to affectees, compensation for livelihood losses sustained by affected persons especially vulnerable population (landless, tenants, artisans, laborers, small traders/businessmen, etc.); besides sustainable rehabilitation of indigenous tribal people, refugees, women-headed households and the poorest. The draft Resettlement Policy also aims to compensate for the loss of income to those who suffer due to the loss of commercial property including common assets, productive assets, structures, other fixed assets, income and employment, loss of community networks and services, pasture land, water rights, public infrastructures like water tanks, common wells, mosques, shrines, schools, graveyards etc. The policy also has provisions for efficient and transparent dispute resolution mechanism through "Grievance Redress Committee" and further appeal avenues. To enable effective implementation of this policy, the Government would table "Project Implementation and Resettlement of the Affected Persons Ordinance".

3.7.3. Inter-Provincial Water Issues

The distribution of water among the Provinces was based on historic uses on 10-daily basis since the system carries large capacity canals and canal commands are huge, ten daily system was adopted for convenience of operation and management and the same was adopted in the inter-provincial water apportionment accord. With the construction of regulatory reservoirs such as Mangla, Tarbela and Chashma, there has been transfer of water from Kharif Season (summer season) to Rabbi Season (winter months). In Pre-Accord 1991 period there was no national institution to regulate the supply so that the Provinces could get their allocated/agreed share of water; WAPDA filled in the vacuum and preformed this function. This system worked smoothly as long as

there was enough water available in the system, but became a persistent, contentious issue when Provinces had to share shortages. Bringing the Provinces to the common table by the Federal Government along with the involvement of WAPDA frequently failed to work out an acceptable water sharing formula among the Provinces particularly during dry periods. The system was, however, formalized when the Water Accord 1991 became effective under which a Governing Body representing all the four provinces and the Federal Government was formed under an Act of the Parliament to be known as Indus River System Authority (IRSA). IRSA therefore, became responsible for the water distribution, regulation and provided a platform for dispute resolution between the Provinces. In case such disputes could not be resolved by IRSA, then a Constitutional body known as Council of Common Interests (CCI) would take up the issue for its final decision. Unfortunately, IRSA in is present form lacks minimum requirement of an institution and is highly handicapped to handle the sophisticated multidimensional regulations. On the other hand, CCI remained out of existence for a long time with the result severe controversies have surfaced which have adversely impacted the supply side management and development of water sector in Pakistan.

3.7.4. Intra-Provincial Water Issues

The main causes of intra-provincial water disputes are two: resource scarcity and inequity in its distribution. In urban areas, there are growing incidences of disputes over domestic water supply; water thefts and disposal of drainage. In rural areas the inequity has many dimensions: there is geographic inequity, seasonal inequity, cropping-pattern inequity, head and tail user inequity, the rich and poor inequity and the landowner and the landless inequity. Though complete removal of such inequities is seldom possible, these inequities in water distribution compound the problem of poverty. In Pakistan, research points to the fact that 70% of the water is appropriated by around 30% of the head end users. Both the public sector institutions and the traditional institutions at the local level are increasingly unable to handle these disputes. Under the devolution plan, the local governments have been assigned the management role, but they do not feel empowered to adjudicate their disputes and possess technical expertise to address complex water management and issues.

4. FUTURE WATER RESOURCES DEVELOPMENT & MANAGEMENT

4.1. Transition Challenges:

Pakistan faces enormous transition challenges in moving forward for better resource management. The major challenges are:

- Financial sustainability.
- Defining clearly the water rights and entitlements both for surface and ground water.
- Creating trust and transparency in equitable water distribution and improving services.
- Rationalizing water charges and increasing productivity.
- Clearing huge back log of maintenance and modernizing the existing infrastructure.
- Development of additional infrastructures for storage, distribution and delivery.
- Financial Constraints.

All these challenges are more or less generic and need to be tackled in each sub sector of water. Though the challenges do exist in all sub sectors, they also provide options for overcoming and moving forward. The challenges therefore, for each sub sectors are discussed below in more details:

4.1.1. Country's Overall Water Resources Development

Challenges are to ensure there is sufficient water of good quality available for all competing requirements both to meet the present and future needs. Water for future needs will come from both conservation and additional storages. Conservation will mainly come from agriculture/irrigation sector through various interventions. Alongside conservation, additional storage is also urgently needed. The main challenge in constructing additional storage is to obtain consensus on the location of additional storage given the urgency of the need for storage, achieving consensus must be a top priority. In the present environment, consultation would be best option rather than asking for consensus.

4.1.2. Irrigation and Drainage Sub Sector

While there are water shortages, there is also extensive over use of irrigation water and insufficient drainage infrastructure resulting in water logging and salinity. Experience has indicated higher crop production when there is drought and shortages of water in the system. Water allowances, especially for irrigation need to be assessed and rationalized based on crop requirements. Agro-climatic

zoning and rationalizing between and within canals through local management and information support to great extent would improve and curtail over use of water. Providing an effective drainage solution is necessary to alleviate the loss of productive farm land to salinity. Disposal of drainage effluent in an environmentally sound way is also essential to reduce pollution of rivers and of land. In addition, salt tolerant variety of crops also need to be introduced to reduce drainage effluent. Low cost recovery and insufficient maintenance of infrastructure, management problems within the irrigation system and inadequate stakeholders' participation, are all the transitional challenges for moving forward for efficient management of water resources.

4.1.3. Ground Water

The importance of ground water in supplementing surface water in irrigation and meeting domestic and industrial water supply cannot be ignored in the overall water management. Presently over-mining of ground water and its rapidly deteriorating quality and absence of managing and governing mechanism is a serious challenge for reversing the present trends. There are numerous challenges which would require serious and immediate attention.

- Limited water resources, poorly developed services, high population density: Persistent ground water stress can be generally traced back to three factors – low rain water run off, high population density and poorly developed surface water supply services.
- Sheer numbers: the most difficult part of managing ground water resources is the large number of small scale users involved. In the absence of accurate data it is assessed that there are more than 600,000 tube wells in the private sector, in addition to unknown number of tube wells installed to overcome uncertainty in supply of domestic water supply by the public departments.
- Secondary Salinization: A phenomenon associated with declining water table and deep pumping which is bringing salts close to the surface and adversely affecting the soil texture.
- Imbalance between extraction and recharge: The safe ground water yield is estimated to about 68 BCM while 59 BCM is the estimated extraction for all purposes. The remaining ground water potential of 9 BCM even though it exists, is difficult to exploit because ground water table in most of the fresh water areas is falling and therefore, it limits the extent to which this potential can be harnessed
- Ground water quality: The extensive unconfined aquifer of the Indus basin extends over 16 Mha of surface area, of which 6 Mha is fresh and remaining is saline. In some parts of Punjab, there are also reports of high

fluoride contents and high concentration of arsenic in ground water. In NWFP and Balochistan excessive pumpage has drastically lowered the ground water table. The ground water quality in Pakistan has become one of the major and serious issues.

Though factors responsible for ground water degradation largely remain, the general awareness at the Federal level and at the Provincial level has risen. People have started seriously talking about the issues and want the National Water Policy to address this issue with urgency so that an effective regulatory framework can emerge out of it.

4.1.4. Urban Water Supply and Sanitation

The challenges being faced by the urban water supply and sanitation sub sector are:

- The lack of capacity in the institutional framework for formulating and evaluating strategic options.
- The lack of consistent approach to funding and regulation.
- Low tariffs for water and lack of a sustainable policy and capacity for setting and collecting water charges.
- Limited private sector involvement in the sub sector.
- Growing slums and environmental degradation.

Developing strategic medium and long term plans for urban water supply and sanitation, including tariff levels, improved collection methods, demand management measures and participation by the private sector, as well as infrastructure improvement and expansion and above all capacity building are challenges to be faced in this sub sector.

4.1.5. Rural Water Supply and Sanitation

There is a significant variation between provinces in their current coverage of rural water supply and sanitation facilities. This would require different degree of interventions in each Province. However, the generic issues and challenges are not much different and are:

- Poor and deteriorating water quality at source and within systems.
- Variable history of successful community involvement.
- Changing administration under devolution plan and uncertainty in technical ability during the transition, especially in the domestic water supply and sanitation sub sectors.
- Inadequate financial resources to meet administrative and maintenance cost.

4.1.6. Industrial Water Supply and Pollution Control

The main challenges are to control industrial pollution rather than water supply. Public sector capability in monitoring industrial effluent discharges is very limited, in addition stakeholders interest and awareness is also insufficient to curb pollution. This is evident from the fact that there has been no anti-pollution legal proceedings worth the name where public tried to protect the environment from untreated industrial waste. On the other hand, many industries would at present be unable to afford the capital outlay for on-site waste water treatment. Similarly measures have to be taken to allocate sufficient fresh water for future industrial requirement under integrated water resources management plan. The transitional challenges therefore, in industrial water supply and pollution control are:

- Inadequate monitoring of industrial effluent and surface and ground water quality.
- Inability to enforce existing effluent quality regulations.
- Inability of industries to finance on-site effluent treatment to comply with regulations.
- Inability to cater for future requirement of fresh water for industries.

4.1.7. Hydropower

It has been generally recognized that hydropower projects offer guarantied answer for improving social and environmental performance in addition to having linkages with poverty reduction. Hydropower has been recognized as a renewable source of energy and sense of urgency is being felt to increase the global share of renewable energy resource. Under Vision 2025, Pakistan has embarked on undertaking large hydropower development projects in the public sector with enunciated objective of reversing present thermal : hydropower ratio of 80 : 20. So for private sector involvement in the hydropower development has been negligible. The main constraints in development of hydropower sub sector are:

- The need for formulation of a policy attractive to private investors particularly in the small to medium hydro power plants. The large hydro power would remain in the domain of Public Sector, but a best Public/Private Sector investment in the medium hydro would give more confidence to the investor and at the same time the Public Sector would be able to attract financing from the Private Sector to develop country's large untapped potentials on fast track.

- The longer development time for hydropower especially large multipurpose storages, as compared with thermal power plants making the thermal sub sector more attractive to private investors.
- High cost of development.
- Inadequate private sector investment.
- Remote location.
- Geological and hydrological complexities.

These challenges and constraints need to be addressed for future development of renewable source of energy for which large untapped potential is available.

4.1.8. Environment

The overall water related environmental goal is to help mitigate and reverse the current environmental degradation process resulting from the deterioration of water quality and overuse of water in some areas. To overcome these problems, the major challenges which have been identified are:

- Historically, lower priority had been accorded in Pakistan to water quality than water quantity.
- Inadequate institutional capacity to implement effective pollution control and insufficient funding to finance pollution control.
- The existing environmental legislation is punitive rather than cooperative in nature.
- Low levels of stakeholders and private sector participation in water and environmental activity.
- Low priority to ensure environmental flows in the water channels.

4.2. Short and Medium Term Options – a road map for efficient development and management of water resources

It is evident that to move forward for efficient water resources management, basic paradigm shift would be required from fragmented to integrated ways of developing, managing and using country's water resources. To achieve this important objective, concerted efforts would be needed in addressing transition challenges and constraints as identified in section 4.1 for all water sub sectors. A road map providing guidelines have been recommended as detailed below for each sub sector.

4.2.1. Water Resources Development

Objectives:

- Increased availability of water to meet the needs of all water sub sectors based on principles of integrated water resources management.
- Provide conservations in all sub sectors particularly irrigation water use through increase in irrigation efficiency.
- Regulate ground water abstraction where appropriate and feasible.
- Improve water quality with links to environment, municipal, industrial and agricultural sub sectors.
- Develop an information base to affect good management of water resources.
- Develop public awareness and understanding of the issues in water resources.
- Establish an institutional capacity.

To achieve these objectives and move forward, the following guidelines are recommended:

- Revisit the role of existing institutions such as WAPDA, IRSA etc and carry out capacity building for national and provincial institutions dealing with water with strong inter institutional coordination links.
- Promote and oversee initiatives in water conservation and improvement of water quality.
- Develop sufficient additional storages to meet the equitable needs of all water sub sectors in future.
- Implement a public awareness programme on water resources and conservation issues.
- Develop a Management Information System (MIS) for water and related information.
- Develop and implement a comprehensive water quality improvement programme.
- Put in place effective dispute resolution mechanism at the national and sub-national levels.
- Obtain strong political commitment and involvement.
- Design an enabling institutional architecture and initiate its stage-wise establishment.

4.2.2. Ground water

Realizing that ground water plays vital role in supplementing surface irrigation water and to large extent meeting domestic and industrial needs and also realizing that this vital resource is fast depleting and degrading in its quality, it is a matter of great urgency that effective check and balances need to be introduced immediately to protect ground water from further over-mining and degradation. The guidelines suggested below need to be incorporated in the National Water Policy so that an effective regulatory framework can be put in place in achieving environmentally and socially sustainable ground water resource management:

- Detailed Inventory: Prepare detailed inventory of all extraction points.
- Strategic Planning: To include well defined services required from ground water resources and providing an effective institutional framework to facilitate management at national as well as provincial levels.
- Hydro-geological Diagnosis and Decision Support: With emphasis on key linkages with land-use, aquifer recharge and discharge processes and aquifer monitoring.
- Establishment or Consolidation of Water Abstraction Rights: To provide a sound basis for water-user participation and contribution to the introduction of effective regulatory approaches based on participatory governance.
- Demand Management and/or Recharge Enhancement: To achieve sustainability of ground water resource development.
- Promotion of aquifer-user Associations: and raising stakeholder and public awareness more generally.
- Damage Control in Aquifer Deterioration: Identification of resources contributing to aquifer development.
- Measurement and monitoring: Install measurement devices on all extraction points and carry out quality analysis.

4.2.3. Irrigation and Drainage

Irrigation being the single largest user of country's water resources would need myriad efforts to increase irrigation efficiency, achieve equitable distribution of water in all systems, harness unused flood water and run off from hill torrents, provide irrigation water to the cultivable waste lands for local poverty alleviation, ensure sustainability of irrigation and drainage infrastructure and financial sustainability of infrastructure by promoting stakeholder participation in irrigation management and improving management capabilities of the Local Governments, PIDAs, AWBs, and FOs.

Similarly modern technologies need to be introduced in dealing with drainage to address water logging and salinity.

The guidelines suggested are:

- Improve irrigation efficiency in close collaboration with the agriculture departments.
- Shift to low delta high value crops.
- Improve equity in irrigation distribution through participation of farmers and strong Government commitment.
- Modernize, rehabilitate and improve the old barrages and deteriorated irrigation system.
- Improve drainage over existing water logged area and adopt biological drainage technology where feasible.
- Introduce salt tolerant variety of crops in the salinity affected land.
- Minimize and recycle drainable surplus effluent for useful applications.
- Rain fed irrigation should be encouraged in the arid areas of Balochistan and other Provinces by effectively harvesting rain water.
- Establish clear water rights and entitlements. National Water Policy must address it.
- Formalize water selling and crate water markets – such move could change the whole agriculture economy to more industrialized/urbanized economy.
- Introduce independent audit to create more trust and transparency among provinces.
- Capacity at grassroots organizations needs to be built.
- Encourage corporate farming for small land owners.
- Encourage Private Sector to invest in farming.

4.2.4. Urban Water Supply and Sanitation

To overcome challenges and issues in urban water supply and sanitation, a well thought out and sequenced programme of investment will be essential to cover asset renewal, business improvement as well as development projects. The suggested measures need to cover both management enhancements along side addressing technical issues. The specific guidelines are:

- Establish a coordinating and support body in each Province/Federal territory for the urban water supply and sanitation sub sector to support long term planning and cooperation between urban services providers and to support the smaller cities and towns.

- Develop a strategic medium and long term plan for urban water supply and sanitation including tariff levels, improved collection methods, demands management measures and participation by the private sector, as well as infrastructure improvement and expansion.
- Formulate necessary regulatory, fiscal and other measures to enable private sector participation.
- Restructure urban water supply and sanitation financing arrangements, including tariff reform and improvement of cost recovery.
- Prioritize capacity building in the institutional framework for water supply and sanitation services in the smaller cities and towns particularly in those where WASAs' do not exist.
- Undertake up-gradation of existing assets of both water supply and sanitation and work out a phased programme to clear the massive maintenance backlog.
- Extend existing and develop new water supply and sanitation networks to increase service coverage with particular attention to slums.
- Develop additional surface water and ground water resources to meet the existing and future growth in consumption encouraging traditional roof water harvesting.
- Construct new sewage treatment works in line with EPA efficient disposal regulations. Cost effective biological sanitation should be introduced.

4.2.5. Rural water Supply and Sanitation

The way forward would require raising public awareness on the basic issue of hygiene and sanitation alongwith giving increased coverage of water supply and sanitation. The way forward and recommended guidelines are:

- Under the prevailing environment in the rural areas it is recommended to create Community Based Organizations (CBOs) under the Local Governments to handle water supply and sanitation at the village level. In the light of socio-economic conditions of the rural areas, the Local Governments continued support would be required.
- Develop and implement a training programme for the administration and management of rural water supply and sanitation schemes and systems, for the benefit of CBOs and Local Government under the devolution plan.
- Rehabilitate existing schemes in the rural areas and increase water supply and sanitation coverage on a phased programme.
- Develop surface and ground water resources to cover existing and future population growth.
- Cost effective biological sanitation should be extensively encouraged and the by products used directly on the farm land.

- Water quality testing laboratories need to be established which are logistically accessible to the Local Governments.

4.2.6. Industrial Water Supply and Pollution Control

As already identified the main issue is not the water supply to the industries but it is the pollution control, which requires immediate attention. Therefore, the main recommendations proposed for industrial pollution control are:

- Strengthen the existing institutions to effectively enforce the prevailing pollution control regulations.
- Develop a nation-wide awareness raising campaign to increase interest in and support for the reduction of industrial pollution as part of a programme to raise overall environmental awareness.
- Provide low cost loans to industries which cannot afford high cost of on-site treatment plants along with other financial incentives.
- A phased National Pollution Control Plan should be formulated which should cover both Industrial as well as municipal waste water along with a system of monitoring waste water disposal and quality.
- Provide technical assistance to industries to help them identify opportunities for modifying production process to reduce pollution.
- Introduce the concept of "user pays – polluter pays more" with measures such as pollution charges based on the content and strength of pollution discharges.

4.2.7. Hydropower

Pakistan is fortunate to be endowed with economically exploitable hydropower potential of 40,000 MW. This renewable resource needs to be developed to offset high tariff and to increase power electrification coverage particularly poverty threatened rural areas. Whereas for mega projects the Government investment with donor assistance would continue, Pakistan needs to create a private sector friendly investment atmosphere. Whereas in settled areas full private sector investment would be possible, it would not be an easy sail particularly in the tribal and northern areas where public : private partnership would be essential for security, accountability and land acquisition. The way forward would be to seriously consider the following guidelines:

- Develop an investor friendly hydro policy.
- Credible and saleable feasibility reports of potential sites should be prepared and made available to private investors.
- Develop model agreements.

- Strengthen and where essential reorganize the existing National Electric Power Regulatory Authority (NEPRA) and Private Power & Infrastructure Board (PPIB).
- To build investor's confidence, public sector equity in the form of credible feasibility report, security, land acquisition and accessibility should be guaranteed.

4.2.8. Environment

The overall water related environmental goal is to help mitigate and reverse the current environmental degradation process resulting from the deterioration of water quality and over use of water in some areas. To achieve the goal, the main guidelines are:

- Restore the quality of surface water and ground water to acceptable standards by elimination of source pollutants through strong regulatory framework with full participation of stakeholders. The whole programme should follow a time line.
- Rehabilitate coastal and other wetland areas in a phased programme through better management of fresh water flows. Environmental flows based on sound economic and technical grounds should be given top priority in the overall development and management of water projects including revisiting the existing water allocations.
- Introduce effective watershed management to reduce soil erosion in the catchment of all storage reservoirs.

4.3. Future Water Management:

Pakistan would need major storages in addressing water challenges and their management in much broader and holistic manner. It would require to come out of fragmented resources development to a much broader basin wise concept of comprehensive and integrated resources development and management approach addressing all issues and challenges in a participatory framework including political issues, institutional and legal issues, development and management issues, socio-economic issues and environmental issues. Pakistan would need to address all the competing sub sectors of water rather than addressing only irrigation and drainage as has been the traditional emphasis in water sector so far. The future country's management objective of the resource should be provision of water for all. Effective management has been the most important constraint to progress in the water sector development. With growing population and increasing demand for all water sub sectors, Pakistan has already entered into a new regime of water scarce country. The global warming and

climate change is further going to enhance the variability in water availability. It is therefore, imperative to prioritize a national approach to water allocation within and between the sub sectors, improve the performance in services delivery and especially financial and physical sustainability. Institutional strengthening with particular emphasis on stakeholders participation will be required as a new approach to water management. The role of existing institutions and needed changes should form important part of the process essential for future management. Clear water rights and entitlements need to be established and informal selling of water would require formalization and establishment of water markets. Rationalization of water allowances between canal commands and within canal commands would be required. Conjunctive use of surface/ground water would need to be developed within sustainable limit. Ground water regulatory framework need to be included in the National Water Policy.

4.4. Road Map of Planned Changes from Sub-optimal Agro/Subsistence Agro based Economy to Industrialized Economy:

Pakistan's agro-based economy and its share in the GDP cannot be under estimated. The country still largely depends on agro-based economy inspite of the fact that its share in the GDP has been decreasing over the years as other sectors expand. Agriculture still accounts for 25% or more of GDP, it employs 44% of the labour force, and supports 75% of the population, it also accounts for 65% of foreign earnings. However, a major paradigm shift is required in agriculture sector. The cropping pattern is based on the premise of affluent water. Pakistan continues to produce water intensive crops like sugar cane, despite water scarcity. The fragmentation of land holdings, low outputs of land, alienation of agricultural land for more profitable businesses, increasing population pressure, water logging and salinity of land, increasing water demands for other sub sectors, are all compelling factors which would be responsible for bringing about changes from agro-based economy to more industrialized economy. The increase in poverty in the rural areas and population shift and increase in the urban population is a clear indication of financial un-sustainability of small land holders.

The unplanned demographic changes and manifold increase in urban population has imposed tremendous pressure on water related resources and resulted in rapid environmental deterioration with development of large slums in almost all the cities and towns of Pakistan. Under present situation, poverty equally engulfs both rural and urban population.

The water resources of Pakistan have a limit – when consumption for human uses approaches the potential available water there would be limited scope for

further development. Efforts would then be required to increase productivity or value of every drop of water – managing demand would become increasingly critical- infrastructure construction would be limited to those that aid in control and regulation - little scope will remain for real water savings. Institutions would be mainly involved in allocation, conflict resolution and regulation. Several important management and regulatory functions would give prominence including inter sectoral alteration. National level coping strategies would include Industrialization and trade for food. Water scarcity would be the main driving force for reallocation of water to perceived higher-valued uses, such as industries and cities, leaving agriculture as residual users. Though in case of Pakistan it may not be complete shift as agriculture sector is going to play a central role in country's economy, but its share is going to reduce as water scarcity becomes more dominant and its uses are diverted to more economic returns offered by increased share of industrial economy.

5. FOCUS ON INSTRUMENTS

Major policy shift would be required for future management of water resources from fragmented approach to a more holistic, integrated basin wise approach. The pressure on water resources in Pakistan is compounded by its limited fresh water endowments. The per capita availability of water has dropped by 78% over the last 53 years and is one of the lowest in the world. This decline has mainly occurred due to rapid population growth. Large population meant increase in water consumption with attendant high level of waste. The threat of inadequate safe water is real. Water being a key development ingredient impacts on a variety of factors that sustain and enhance life. As critical natural resource, the issues connected with managing it are inherently diverse and complex. They involve questions of allocation and distribution, equity, conservation, pricing, regulation, education, participation and sustainable use. With the country's rapid population growth, rising industrialization, increasing environmental degradation and pollution, and the spectrum of dwindling resource, country's national policy document (though still in draft form), emphasis the need for integrated water resources management in a comprehensive and holistic manner. This policy needs to be put into operation after it has secured the wider political backing. Once this policy is adopted and to make it effective, it will involve many reforms because project planning and implementation are presently fragmented among many institutions. A central apex body would be required to oversee the reform process and review and revise water legislation particularly in the areas of water rights and allocation among competing uses, water quality standards, ground water use, demand management, resource conservation, private participation and institutional responsibilities for water sector functions

at national, provincial, local and community levels. The major areas which would need change of one form or another will include:

(i) Policy Instruments and Legal and Regulatory Framework:

Adopt effective national water policies, water laws, and sector coordination arrangements; improve institutional capacity and information arrangement and develop a national action agenda for water sector incorporating the needs of the poor specifically factored into legal, institutional and administrative framework.

(ii) Water Allocation:

Water demand by other sub sectors, is rapidly becoming a big challenge. This impacts most on the poor who are insufficiently empowered to claim rights. The country needs to be supported to adopt participatory and negotiated approaches for water allocation. Future scarcity of water is expected to go through a process of evolution of water allocation mostly depending on markets of transferable water rights, once the necessary policy, legal and institutional framework for IWRM in a river basin context have been put in place. Regulatory agencies need to be helped to develop water rights in a manner that are pro-poor and protect the rights of the poor to equitable water services. Until such time as transferable water rights are properly developed the systems of water entitlements, or usage rights, need to be protected under the existing legal framework.

(iii) Data Collection System and Information Dissemination:

To gain public confidence, a reliable system of data collection need to be placed on ground which should include regional country and provincial weather forecasts with sufficient lead time to enable communities to prepare an adaptation plan to meet variability in water availability. Similarly a strong institutional set up is required both at the national and provincial levels to collect real time data for all the streams, rivers and reservoirs. While disseminating information on water availability, it will be essential to provide wide-ranging public awareness and community education programmes especially among women, youth and farmer groups to convey the message that water is a finite resource that has economic value and needs prudent management. In particular, education that helps communities understands the linkages between water, sanitation, health and productivity. Similarly industry also needs to be educated on the efficient use of water and the need for high prices for both water use and effluent treatment and discharge.

(iv) Policy regarding Public Private and Tripartite Partnerships:

The demand for water services across sub sectors is increasing rapidly, measures for conservation and demand management need to be urgently introduced and strengthened. Government also need to modify its role from one of service provider to regulator. Experience has shown that irrigation and water supply services are most efficient when delegated to autonomous and accountable service providers. It is therefore, required to undertake phased programme to increase the autonomy and accountability of service providers either as new enterprises or by reorganizing existing agencies. Private sector initiatives and market-oriented behavior are expected to improve performance and efficiency, particularly in the service delivery. While Government will be primarily responsible for water resources development and management with heavy investments, several management functions will attract private investments. Global experience indicates that public responsibility and ownership are often best blended with private management. The partnership of users in irrigation and drainage system operation and maintenance at the local level has increased over recent years under PIDAs and farmers organizations. The system needs further strengthening under devolution plan. Participation of consumers in local water supply and sanitation also needs to be encouraged to improve efficiency, increase ownership and lower the ratio of non-revenue water. It is strongly recommended to encourage user's partnership to (i) make services and service provider more responsible and accountable to beneficiaries (ii) align the provisions of services with user's needs and ability to pay, thereby improving cost recovery and sustainability, and (iii) transfer institution arrangements for water service management to local practices, (iv) introduce contracting system between the users and service providers.

(v) Investment and Policy Changes:

As mentioned earlier the investment in water sector should not be based on fragmented development as practiced in the past. In view of water stressed conditions it is country's urgent need to formulate and implement integrated, cross-sectoral approaches to water management and development. The policy should promote the concept of water as a socially vital economic good that needs increasingly careful management to sustain equitable economic growth and to reduce poverty. The conservation and protection of water resources in the country through a participatory approach should be at the heart of the policy.

Based on changed policy objectives future investment can be broadly split into two categories:

- Investment in developing infrastructures – hardware
- Investment in software i.e. improve governance, institutional strengthening, creation of public-private partnerships, water conservation, public education and awareness, regulation, participation, equity, sustainability, entitlements.

Generally investment in the water sector will be catalyzed by promoting policy change, legal and institutional reforms to create an environment where enhanced levels of public-private partnership become possible and where higher private investments are leveraged.

(vi) Capacity Needs and Capacity Building:

Getting the policy changes to work, capacity building would be required at the national level, provincial level, and at the community level. Institutional capacity building is a means of enhancing performance. In the context of IWRM, capacity building is the sum of efforts to nurture, enhance and utilize the skills and capabilities of people and institutions at all levels – locally, at provincial level and nationally so that they can make better progress towards a broader goal. At the grass root level building capacity involves empowering and equipping people and organizations with appropriate tools and sustainable resources to solve their problems. The objective of capacity building is to produce more effective individuals and institutions that are better able to provide products and services on a sustainable basis. Human resources development through training, education and provision of information is a key dimension of capacity building. Institutions and individuals would need incentives to change practices and approaches in order to adopt new skills and ideas. Improved human resources are a key factor in bringing about institutional capacity building. The ability of an institution to adopt to changing demands depends to a large extent upon its ability to adopt its human potential - the knowledge, perspectives and skills of its staff. Equally important for an institution's capacity to fulfill its mandate is the proper devolution of institutional responsibilities, functions and jurisdictions. This would help solve problems of jurisdictional overlaps and competitions between institutions in addition to the creation of proper and sustainable financing mechanisms. In Pakistan's context and under the newly devolution plan, myriads efforts would be required to carry out capacity building at all the three levels i.e. National, Provincial and local.

(vii) Regulatory Authorities:

To serve the best interest of both consumers and the manager of water resources, the system of pricing, incentives, and penalties, regardless of its simplicity or sophistication, requires to be regulated. Regulatory systems need to be established to ensure that laws, standards, rules and regulation are equitably and consistently applied. Such systems are absent in Pakistan and are to a large extent left to the Government to play the role of provider and regulator. At National level, IRSA was created to regulate water according to inter-provincial water apportionment accord between the provinces. This institution, though created under the act of Parliament, lacks basic technical capabilities and secretariat support. This institution has given birth to more contentious issues than resolving them and provinces do not honour the decisions of this apex body. Similarly, under devolution plan, the local governments lack the technical skill and institutional framework to address and resolve water related issues pertaining to water management and development.

(viii) Financial Sustainability:

To achieve financial sustainability in all sub sectors needs myriad efforts and improvement. The recovery of full cost should be the goal for all water users. Treating water as an economic good, as a minimum, full supply cost should generally be recovered in order to ensure sustainability of investment. But high supply cost and social concerns may require direct subsidies to specific disadvantaged groups. While subsidies "across the board" generally distort water markets and should be discouraged, direct subsidies for targeted groups may be relevant, but they need to be transparent. It has been realized that water is an economic good, has value to be traded for goods, but in a country like Pakistan where both rural and urban poverty are on the increase, it is also a reality of life that water is social good also where poor have to be provided basic necessities of life at a cost which does not rupture their already fragile economic structure. Under such circumstances, each sub sector of water has to be considered in its realities prevalent on ground. Some recommended options for various sub sectors are :

(ix) Irrigation Water Supplies:

The present institutional reforms in irrigation sector from Irrigation Departments to PIDAs and WUAs and FOs within the provinces followed by Devolution Plan are steps towards right direction. Involvement of communities in maintenance and cost recovery for delivery services at the tertiary levels of irrigation water distribution needs to be made operational in

all the four provinces. PIDAs therefore, need to be made more autonomous – Experience has shown that irrigation and water supply services are most efficient when delegated to autonomous and accountable service providers. It is generally recognized that people are willing to pay provided the availability of water is guaranteed together with equity, transparency and accountability in the whole service delivery mechanism. It is therefore, desirable to increase the participation of users of irrigation and drainage system operation and maintenance. The user participation will need to be supported to (i) make services and service providers more responsive and accountable to beneficiaries (ii) align the provision of services with users' needs and ability to pay, thereby improving cost recovery and sustainability, and (iii) tailor institutional arrangements for water services management to local practices. Subsidies for operating and maintaining public irrigation and drainage systems should be gradually phased out- virtuous cycles of investment, user charges and operation and maintenance by autonomous and accountable service agencies, with user representation should be established to modernize irrigation and drainage systems. The phased turn over of responsibilities for distribution system operation and maintenance to farmers groups should be promoted and measures should be adopted with the involvement of Local Governments to improve system sustainability.

(x) Water Supply and Sanitation:

Crucial to managing water demand is a function of efficient pricing, effective regulation, and appropriate education and awareness. It has been found in the most poverty stricken areas of Pakistan that unlike poor farmers, poor city dwellers are willing to pay for reliable and efficient services. It is possible requiring the poor to pay for the true costs of urban and rural water supplies for sustaining the services. We need to encourage and support policies that provide for explicit participation of the poor in water-related projects. Such policies would promote phased elimination of direct subsidies to the poor for accessing basic water services in line with an increase in affordability levels. Though subsidies are controversial issue in the water sector, the public sector support will be required in the following circumstances:

- Where treated water uses have beneficial external effects in preventing health problems,
- Where the transaction costs of measuring usage are very high, and
- Where a limited quantity of treated water for poor is regarded as basic need.

Many tariff models are available which are being practiced both in the developed and developing countries which guarantee financial sustainability

of water supply services by incorporating bracket tariff system, the more you use the higher price you pay. This system guarantees the basic water needs of the poor with in a subsidized bracket and the cost is recovered from more effluent society to ensure service's sustainability.

6. PRIORITIES AND SEQUENCES

Pakistan today has the extensive and expensive hydraulic infrastructure built as a necessity after the Indus Waters Treaty of 1960 when it was essential to transfer the waters of western rivers to the eastern rivers and serve the areas which were irrigated by the eastern rivers prior to the signing of the Treaty. Since then Pakistan has made a tremendous progress in meeting the ever increasing demand for food and fiber as the population grew unprecedented. Pakistan more or less followed a fragmented approach in developing its various water sub sectors. These fragmented development efforts had positive impacts on growth, poverty reduction and sustainability. The investment to water sector also had indirect effects operating through the multitude of linkages of energy and agriculture production with the development of local commerce and industry, and even with the economic returns of investments in human capital. As long as the water was affluent the fragmented approach paid dividend though number of people who did not have access to water services kept on increasing as the population increased. Pakistan today stands on a thin divide line-on one side it had a history of affluent water situation stretching over its 57 years of history and on the other side it is entering for long journey with multiple and complex problems of water stress situation. Pakistan therefore, needs to have a more holistic view of how its going to manage its finite and scarce water resource to meet the requirement of its future generations. Pakistan's top of the agenda priority should be to adopt a National Water Policy based on Integrated Water Resources Management, which dictates better practices based on social equity, economic efficiency, transparency, accountability and participatory approach.

The policy should be linked to country operational strategy based on the recognition that water is prime development input. The strategy should establish priorities and sequence to address water sector issues and development approaches to tackle them. The three principal factors governing policy implementation: integrated packages of policy support capacity building, sector reform and investment support in a long-term framework needs to be prepared. The investment in water sector could be catalyzed by promoting policy, legal and institutional reform to create an environment where enhanced levels of public-private partnerships become possible and where higher private investments are leveraged.

The challenges of ensuring that water is conserved and managed wisely are huge and no single agency can hope to address them in isolation. Strengthening partnership would be crucial for policy implementation.

Once National Policy has been adopted, it will act as a catalyst to pick up priorities and would help sequencing implementation, strengthening existing institutions, creating new institutions where necessary and providing directions for enacting regulatory framework for better management.

The sequenced approach should be to move from development to development/management to maintenance/management. This would involve both software and hardware. The software would include management and hardware would include maintenance and infrastructure development. The future priorities would definitely require more emphasis on management and efficient use of scarce water resources. The high priority actions required to be taken in regard to both management and infrastructure at the Federal and Provincial levels are:

A) Management

(i) National Water Policy: Adopt National Water Policy and obtain political commitment.

(ii) Regulatory Framework: Adopt various water governing laws and regulatory frameworks out of the Policy for efficient, transparent, equitable management of water resources.

(iii) Financial Sustainability:

- Rationalize water charges as part of institutional reforms.
- Create clear water entitlements for both surface and ground water.
- Review functional analysis of Irrigation Departments.
- Water charges increase with better infrastructure and service delivery.
- Create institutions for irrigated agriculture – merger of irrigation and agriculture departments.
- Create Community Based Organization (CBO) in farming sector to increase productivity – financing through social collateral.
- Create water markets – delink water from land.
- Create water regulatory authority on pattern of NEPRA and OGRA.
- Continuously assess the country's capacity to undertake sustainable reforms and factors into individual water action agenda.

- Policy implementation will involve a period of transition. To ensure the reforms take place in accordance with a predetermined time line, an apex body would need to be constituted at the national level to oversee process of reform.
- Similar apex bodies need to be constituted at the Provincial levels to oversee Provincial water sector reforms agenda.

(iv) Water Entitlements:

- In water distribution the water entitlements are crucial and need to be streamlined for future management. Clear individual entitlements need to be defined.
- Ground water management needs to be vested in the state (Provincial Governments) and must address the issue of ground water entitlements.
- Free trade of water and creation of water markets should be initiated in all the Provinces. This would resolve many water issues.
- At Federal level, the inter-provincial water accord needs to be reviewed in the light of ensuring minimum flow for biodiversity.
- Establish dispute resolution mechanism at each level of water management.
- Measurement tools need to be introduced.

(v) Trust and Transparency:

- IRSA's technical and management capacities need immediate attention so that trust between the Provinces can be developed.
- Telemetry system to give real time data to Provinces.
- Carry out annually independent audit of IRSA.
- Transparency in allocation and distribution needed at all levels.
- Provincial Governments to support user's participation.
- Capacity building at both community and agency level.
- Prepare register of entitlements.
- Installation of measurement devices and data dissemination.

B) Infrastructure

(i) Infrastructures maintenance:

- Develop asset management strategy.
- Prepare 5 year asset maintenance plan assigning priorities.

- Progressively install measurement devices for both surface and ground water.
- Prepare integrated packages of rehabilitation plans – large canals to on-farm delivery including water, land and environment with emphasis on ground water balance.
- Develop specialized agencies for specific maintenance functions and modernization objectives.
- Introduce new technologies including modern equipment to reduce maintenance cost.
- Introduce institutional reforms and capacity building.

(ii) Infrastructures Investment:

- Develop a Basin Model to assess the cost effectiveness of future investment.
- Work out a plan to invest in a new generation of integrated investment packages, keeping in view what already exists and adopting an incremental approach.
- Huge backlog on infrastructure development and deteriorating standard of services would require a realistic, prioritized and sequenced locally designed reform packages and supporting appropriate infrastructure investment would be essential complement to such reforms.
- Within a Province, each Province has to prepare reforms and investment packages according to their own priorities within broader outline of IWRM. Incremental approaches would be imperative as challenges in the reforms process and backlog of deteriorated infrastructure and expansion needs of infrastructure ore all capital intensive.
- Pakistan's rapidly depleting storage capacity due to heavy sedimentation would require construction of additional storages to recupe the lost capacity to cope with future regulation for ever increasing demand together with massive conservation strategy in all the sub sectors of water.
- Create seasonal to yearly carry over storage capacity in a phased programme to combat high variability in the hydrological cycle.
- Continue simultaneously the development of storage, diversion and distribution structures. Balochistan and NWFP would require additional infrastructures to utilize their full share of water authorized under inter-Provincial water apportionment accord of 1991 and their share out of the future storages and flood water.

- Provide infrastructure to deliver water to the most deprived areas in all the four provinces.

7. BANK INVOLVEMENT

The overall investment in water sector over the last 57 years of country's history have paid dividends in addressing poverty, economic growth in all sectors of economy, industrialization, human resource development and return on investment. As mentioned earlier, the affluent water situation was a catalyst to have achieved remarkable growth rate by sectored approaches in developing water resources. International donor agencies particularly the World Bank has over fifty years of history of committed investment partner of Pakistan.

Historically Pakistan's investment strategy can be divided into two periods. The period prior to the Indus Water Treaty of 1960, when most of the investment in infrastructure development took place during the colonial period and were inherited by Pakistan after independence in 1947. Water regulation was smooth till India decided to divert the water of three eastern rivers of Indus basin.

The Treaty necessitated heavy investment in new infrastructures and up-gradation of existing structures to meet new challenges. Going back in time, Pakistan's water related infrastructural development has been unparallel. To undertake such massive development programme within a stipulated timeframe, major institutional changes were required in the existing framework by re-carving some existing Federal Ministries and creating at the National level an autonomous body i.e. Water and Power Development Authority (WAPDA) with clear objective of developing water and power resources of the country on a unified pattern to meet ever increasing demand of water for irrigated agriculture and power for domestic and industrial needs of the country. In spite of creating a single largest contiguous irrigation network in the world, the other water sub sectors developed on a fragmented pattern to meet the water and sanitation requirements of rural and urban population and the industries mostly controlled by the public sector. With rapid population increase, the problems in each sub sector have multiplied manifolds. In section 2, attempts have been made to identify issues and challenges in each water sub sector. To sum up the problems in all the water sub sectors can be grouped under four main headings:

i) Gaps in institutional arrangement and governance – the software.
ii) Shortfall in financial sustainability.
iii) Inadequate infrastructure and poor coverage of service areas.
iv) Accumulation of backlog on maintenance.

In order of priority, it is recommended that process of reforms which is taking place in Pakistan needs to be supported, as it is a fact that institutional in-capabilities will even mismanage an affluent situation whereas a good institution can manage scare situation in more equitable manner. Institutions and governance are the components of the same software. Governance includes processes of making choices, decisions and tradeoffs and basically covers a whole package of diverse content with the aim of managing the whole nexus of land, water, ecosystem and society: legislation, institutions, stakeholders participation, reallocation, water banking, policy, politics, provision of water professionals, financing, incentives etc. It includes dialogue in which three main partners will have to be involved, Government, private sector and civil society-turning the process into "trialogue" including of course in the governance, the voices of marginalized people. Under the devolution plan, the local support would be needed to strengthen the Local Governments by providing technical and management capabilities. At the National level, IRSA's role in water management and dispute resolution will need strengthening.

Pakistan's infrastructure development particularly after the replacement works under Indus Waters Treaty, move or less remained stagnant. Pakistan's total storage capacity is less than 15% and per capita storage is only 132m^3. Such figures in an arid region can only create disasters to future development. Even the storage and regulating capacity for high variable water availability created after the Treaty is fast depleting due to sedimentation in the storage reservoirs. The country therefore, needs to create additional storages. Similarly both NWFP and Balochistan are short of infrastructures to utilize their share of water allocated to them under 1991 Inter-Provincial Water Accord and to utilize their shares out of the future reservoirs and out of flood waters. These two provinces would need water diversion and water carrying infrastructures. Similarly Pakistan's largest contiguous irrigation system is not fully integrated. The upper 13 million acres of Punjab's irrigated area wholly depends on Jhelum and Chenab rivers and is not integrated with Indus. For better management on single basin concept a link between Indus and Jhelum rivers would be needed. Bank's financial support for these benefit-generating infrastructures would have marked advantage.

Similarly Bank's assistance in improving the existing infra-structure and extending the services particularly to the poor and slum areas would help to great extent in addressing poverty, health and sanitation in meeting Millennium Development Goals.

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ABBREVIATIONS

FO	Farmers Organization
IWRM	Integrated Water Resources Management
IRSA	Indus River System Authority
NEPRA	National Energy and Power Regulatory Authority
OGRA	Oil and Gas Regulatory Authority
PIDA	Provincial Irrigation and Drainage Authority
PPIB	Private Power Investment Board
WAPDA	Water and Power Development Authority
WUA	Water Users' Association

Flood Control and Management

By

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Country Water Resources Assistance Strategy
Background Paper # 14
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1 BRIEF BACKGROUND AND KEY ISSUES

1.1 INTRODUCTION

Destructive floods in Pakistan (Map at end of Report) are generally caused as a result of exceptionally heavy rainfall in the upper mountainous regions and foothills during monsoon, superimposed by snowmelt as the base flow. At times, natural landslides or rapid advance of glaciers have acted as barriers across natural river/stream flows. Upon failure of those obstructions, huge quantities of stored water got released suddenly, there by accentuating the flood peaks greatly. Fortunately, with the construction of Kara Kuram Highway (KKH) permitting better monitoring and communications, together with automatic telemetry stations, such phenomena are unlikely to happen in the future. The normal flood-causing rainfall is invariably associated with tropical depressions which originate in the Bay of Bengal and travel from the east and merge with weather system from the west. The tracks of depression recurve northward-eastwards after convergence and cause heavy rainfall which when superimposed on snowmelt base flow, results in devastating floods.

Floods have caused massive damages to infrastructure and crops, besides loss of life in Pakistan. Floods are detrimental not only in financial terms, but also in their ability in severely undermining the productive system that has to be reasonably free from uncertainties and frequent disruptions. Besides losses to life and property, floods also have a serious environmental impact with millions of acres remaining inundated some times for months. It is indeed universally accepted that complete prevention of floods is almost a physical impossibility. However, flood protection to the extent it is technically and economically feasible, is a socio-economic necessity. By proper planning, means can be devised not only to minimize flood losses but also to conserve the surplus flows for augmenting water availability for productive uses during dry periods, and to promote welfare of the community.

From strictly river engineering point of view, a river has to be prevented, in so far as is feasible, from causing:

- Inundation of area
- Erosion of useful land

Inundation of land, takes place when flood peaks exceed a certain level that causes overbank flooding or breaches take place where embankments have been constructed. On the other hand, erosion of land results due to change in river morphology, when the flow undercuts the natural banks of the river. This phenomenon can occur under all categories of flows with varying intensities. Sometimes, erosion is more pronounced during low flows when undercutting of erodible banks may be maximum. This loss is almost of permanent nature, and concerted efforts are required to reclaim the land by constructing transverse spurs projecting into the deep river channel at the site of the erosion.

1.2 DEVELOPMENT OF STRUCTURAL FLOOD PROTECTION WORKS

Floods in Pakistan are most extensive and damaging along the Indus and its four major tributary rivers. Sometimes, heavy rainfall in the catchment areas of hill torrents which cover over 50 percent of the total area of Pakistan, results in flashy floods with high peaks of short duration.

Due to varying physiographic, climatic and socio-economic conditions in various parts of Pakistan, flood problems of the areas largely differ, thus necessitating different management approaches or the construction of different types of structures. In the Punjab, flood protection embankments (bunds) and spurs have been constructed primarily along rivers to protect canal headworks, irrigation networks and to safeguard certain towns. In Sindh, almost a continuous twin lines of embankments on each side of the river, have been constructed along the Indus River. In addition, compartmentalization has also been done with cross dykes between the double embankments on each side to confine spills in case of breach in the front-line embankment. This practice is popular since the Lower Indus River runs along a somewhat higher ground (ridge) and should a breach occur in an otherwise single line embankment, and flood waters escape, the damaging overland flow would not be able to revert to the river even after traveling long distances. In NWFP and Balochistan, flood control works have been constructed for the protection of irrigation structures and to safeguard cities and agricultural areas from the onslaught of both the rivers as well as hill torrents in mountainous areas. Since the nature and severity of river flooding is entirely different as compared with flood problems posed by hill torrents, different strategies have been adopted.

In order to safeguard the areas from inundation, approximately 6,000 km of flood protection embankments have been constructed so far along major rivers and their tributaries in Pakistan as indicated below:

Punjab	=	2,800 km Long
Sindh	=	2,500 km Long
NWFP	=	400 km Long
Balochistan	=	300 km Long

Source: National Flood Protection Plan (1987)

Likewise, to protect areas from erosion nearly 800 spurs projecting well into the deep river channel to deflect the flow, have been constructed of which approximately 100 spurs are meant purely to guide flows through barrages and bridges. Thus, the number of spurs in the country for the prevention of land and embankment erosion, stands at approximately 700.

As also stated earlier, the need and the nature of flood protection facilities vary according to specific physiographic characteristics and local conditions in different parts of Pakistan. In Punjab Province, the problem of inundation and river action on banks i.e. land erosion, both are prevalent. In Sindh, generally the Indus bed is higher than the adjoining natural surface level, and as such the river is contained within man-made

network of embankments, in the absence of which the problem of inundation during breaches would be very serious. Wherever, river current is anticipated to strike these embankments, spurs or stone pitched revetment aprons, are provided to protect the embankments. In NWFP, Balochistan and certain parts of Punjab such as DG Khan, hill torrents pose a more serious threat to the areas due to their steep slopes resulting in flashy flows of high magnitudes from torrential rains. The hill torrents cause flash floods creating havocs in the denuded hilly areas. In these areas, a complex system of flood abatement/dispersion structures, detention reservoirs (dams), retaining walls, etc. have been constructed to harness some of the hill torrents.

The damages caused by floods of 1973 and 1976 generated considerable concern in Pakistan. The first serious step was taken with the preparation of Appraisal of Flood Management in Pakistan (*Harza Engineering Company*) which gave an overall perspective on flood situation, highlighted specific problems and recommended short-term measures. The International Development Agency provided financial assistance under Credit Pak-683, 1976 “Flood Damages Restoration Project”. The credit terms included a provision for the “Preparation of a National Flood Protection Plan and an Action Programme”. The Government of Pakistan established Federal Flood Commission to administer, plan, execute (through Provincial Irrigation Department) and coordinate flood management activities at the national level. Since then, the Federal Government, through the Federal Flood Commission, has also been assisting the Provinces in terms of finances for structural measures for flood protection; better operation of storage reservoirs; flood forecasting, flood warning and flood management. The actual construction and maintenance of flood protection works, however, remains the responsibility of the Provincial Governments. Flood warning, flood fighting, and rescue and relief operations are again primarily the responsibility of the Provincial Governments but Federal agencies such as Federal Flood Commission, Meteorological Department, Pakistan Army, WAPDA and Federal Disaster Relief Cell, actively participate whenever and wherever needed.

After completion of two “Flood Damages Restoration Projects” of 1976 and 1988, financed largely by the World Bank/IDA, the Asian Development Bank has financed two major Flood Projects, namely, 1st “Flood Protection Sector Project (FPSP-I)” and the 2nd “Flood Protection Sector Project II (FPSP-II)”. The primary objective of both the projects was to take up priority flood protection schemes and to strengthen the institutions involved. The first project was successfully completed at a cost of approximately Rs. 5 billion in 1996 with ADB providing 80 percent of the funds required. The second project in the sum of Rs. 8.7 billion was thereafter initiated, however, it ran into problems in terms of, inter alia, its scope of work, and only a small portion of the work is expected to be completed by the due date of termination, namely, June 30, 2005. The main reason of delay was suspension of the project over a prolonged period when the succeeding government could not be convinced that there was a sound balance between structural and non-structural components of the work. The approximately 20% provision for consultancy services and non-structural works, was considered to be on the higher side. ADB was of the categorical view that the Federal Flood Commission, with its token staff, needed consultancy services to be able to efficiently organize, coordinate and supervise the work that was supposed to be executed by half a dozen federal and provincial

organizations. After work on the reformulated project was resumed, ADB did not agree to further extensions beyond June 30, 2005.

Although the works carried out as described in the foregoing paragraphs have been of considerable help in curtailing damage and frequency, yet major flood problems still exist that need considerable more work in terms of further extension and improvements. There are a number of river reaches which have not been taken care of; many flood protection dykes do not meet the criteria of safe dimensions; revetment sizes or the needed freeboard. A lot of work is required for harnessing of hill torrents as well.

1.3 DEVELOPMENT OF NON-STRUCTURAL FLOOD MANAGEMENT

Structural measures such as protection embankments, spurs, channelization, and diversions, are necessary to control or modify floods directly. Non-structural measures are required to mitigate floods and the damages indirectly. These include permanent/temporary relocation of potential flood affectees, review of reservoir operation regulations to attenuate flood peaks, land-use regulations for hazardous areas, and an extended and reliable Flood Forecasting and Timely Warning Network. Also included is river modeling and flood routing leading to, inter alia, preparation of a comprehensive Flood Warning Mannual containing village-wise warning mechanism which the potential flood affectees can readily understand. The Warning Manual should also clearly cover the operational guidelines and decision-making under emergency and action programme at different levels of federal, provincial, district and local governments.

A weather radar of five cm wave length was installed in Sialkot. Another 10 cm radar was installed in 1996 in Lahore, under ADB financed FPSP-I; the latter being of tremendous value in estimating rainfall in the catchments of Rivers Sutlej, Ravi and Chenab. Currently, both the radars are being upgraded. A number of telemetry stations installed under FPSP-I, are providing real-time information on rainfall and stream flows through meteorburst radio-waves-reflection communication system. Another weather radar is under installation at Mangla under ADB financed FPSP-II which will be of great help in timely estimating rainfall in the Jhelum River catchment and in predicting river flood magnitudes. Real-time data obtained from this equipment, is instantly reviewed by the Flood Forecasting and Warning Centre in Lahore. Flood warnings are issued through police wireless, internet and other means of communications. As stated earlier, more work is indeed required to further extend and strengthen the existing forecasting and warning system.

1.4 HISTORIC LOSS OF LIFE AND PROPERTY FROM MAJOR FLOODS

Destructive floods, both large and small, have been taking a heavy toll of life and property in Pakistan. Monetary losses during major floods since 1950 aggregate to over $ 15 billion (at 2004 prices) including loss of land worth approximately $ 3 billion due to erosion along the banks of various Indus Basin Rivers. Over 8,000 people have lost their lives during these floods. Besides financial loss, inundation of millions of acres of land in various parts of Pakistan also constituted one of the most serious environmental hazards. Losses during major floods experienced are tabulated below:

FLOOD DAMAGES FROM MAJOR FLOOD EVENTS

Year	Direct Monetary Losses (US $ Million)	Lives Lost	Villages Affected	Area Flooded (Million Acres)
1950	386	2,910	10,000	4.48
1955	299	679	6,945	5.12
1956	252	160	11,609	18.60
1957	238	83	4,498	4.00
1959	185	88	3,902	2.61
1973	4,060	474	9,719	10.37
1975	541	126	8,628	8.73
1976	2,756	425	18,390	20.48
1977	267	848	2,185	1.64
1978	1,761	393	9,199	7.65
1981	236	82	2,071	1.05
1983	107	39	643	0.47
1984	60	42	251	0.27
1988	678	508	100	1.54
1992	2,380	1,008	13,208	9.69
1994	666	431	1,622	1.39
1995	298	591	6,852	4.17
Cumulative Since 1950	15,170	8,887	109,822	102.26

Source: National Water Policy – 2004, and Relief Commissioners' Records,, Provincial Revenue Departments.
Monetary losses updated using Statistical Bureau annual price indices, and from 1995 onwards inflation @ 6% per annum.

The foregoing losses do not include figures for Northern Areas, FATA and Azad Kashmir which are not available but where extensive damages have also been caused by hill torrents, and rivers that flow at the foothills in gorge-like narrow courses. The terraced agricultural lands developed along the banks of these rivers and streams, are often attacked by floods causing severe land erosion. The towns and villages located on the banks of these streams are also vulnerable to damage due to storm-generated landslides. Hill torrents that cause flood damages in Balochistan, NWFP and parts of Punjab, is characterized by high peaks though of short-durations. The flooding of agricultural areas sometimes also delays sowing of the next crop which heavily impacts on the already poor people and their local economy. Localized benefits due to retained soil moisture do accrue in non-irrigated areas, however, on an overall basis the flood damages to standing crop, land and private property by far outweigh the positive impact.

In the plains of Sindh and Punjab, as earlier stated the main threat of flooding arises from the overbank flooding by the main rivers. The problem becomes particularly acute when heavy monsoon storms enter the catchment areas of these rivers. In Punjab, river

flows have largely to be confined to within the river's right-of-way (several miles in width) to provide reasonable protection to high value agricultural lands and villages, to major cities and towns, irrigation structures such as barrages, the canal network itself and other infrastructure such roads, railway lines etc. Since the land generally slopes south-west towards the sea, breaching sections in the embankments are often provided on the north-east side at important barrages and river structures to permit flood water that is greater than the design capacity of the structure to bypass it. As the natural gradients direct the overbank flood spills to return ultimately to the river downstream, the damage is somewhat lesser. In Sindh, on the other hand, since the Indus River flows on a ridge the escaped flood water continues to flow overland causing damage enroute.

In the foregoing table, flood damage factors have been used to represent direct losses per unit area flooded from river spill and is expressed in rupees per acre. For rural areas, only culturable commanded area is taken into account, because in non-irrigated areas flood losses during summer (Kharif) are largely compensated by improved winter (Rabi) crops due to enhanced soil moisture. Other losses in rural areas comprise damage to standing summer crops, livestock, stored-grains, private housing, and infrastructure. Estimates of direct losses to standing crops are based on an analytical procedure that considers the depth of water, duration of flooding, drowning vulnerability of the type of standing crop, cropping pattern, and cropping intensity. The damage to crops is equal to the market value of crops damaged less farm costs not yet incurred at the time of flooding. The damage factors Rs./acre for private housing properties is calculated by considering the housing density, pattern of damage condition and the unit repair costs fixed by the Government. Direct flood damages to urban areas located in the flood plain of the major rivers, largely comprise damages to private housing and infrastructure and are based on published urban development cost.

Intangible losses, of course, cannot be expressed in monetary terms. In recent years, attempts have been made to express, for instance, the value of health deterioration in monetary terms. Despite this, however, the cost of human life and mental anxiety cannot be quantified in terms of money using a completely satisfactory basis. This deficiency is very much relevant to floods in emerging nations where there is large concentration of population residing in the flood plain.

In summary, as would be observed from the figures tabulated in this Section, floods in Pakistan have been causing tremendous loss of human life, besides damage to public and private property and indeed to the national economy. Major floods since 1950 have caused a total loss of nearly 9,000 human lives and a tangible loss of over 15 billion US$ (at 2004 prices). The floods have affected nearly 110,000 villages (cumulative) and inundated over 100 million acres (cumulative) of irrigated land over the period since 1950.

1.5 KEY ISSUES

Despite significant investments made in the flood sector, breaches in embankments and failure of ancillary structures, frequently take place causing loss of life and property. As the impact of such damages is progressively becoming more intense with higher levels of development and economic activities, there is a need to review the existing design

and maintenance standards. The latter is particularly in a deficient state and a lack of budgetary funds is frequently given as the chief reason.

One of the principal non-structural measures is flood forecasting and timely warning. Under Flood Protection Sector Project-I (FPSP-I), considerable work has been done, and as a part of FPSP-II, some work is under way including flood plain mapping of some major rivers. However, there is a lot of room for carrying the work further. Additional weather radars at critical locations are required to enable more accurate forecasting of prerecipitation in the catchment areas, and on the development of a reliable flood warning system.

Flood Warning Division should also expand its coverage to include all main urban centres likely to be affected directly by major rainfall events even if there is no threat from a river flood. Rainfall warnings should be timely issued so that cities' drainage organizations are not taken by surprise.

Total protection from floods is almost a physical impossibility. However, protection to the extent it is technically and economically feasible, is a socio-economic necessity. By proper planning, means can be devised not only to minimize flood losses but also to conserve the surplus flows for augmenting water availability for productive use of the community. **The current drought phase, prolonged as it has been, must not be misunderstood to mean that Pakistan will not be hit by severe floods again. Indeed, the progressively declining storage behind dams due to sedimentation, if not replaced, will eventually mean that flood peaks will be even higher due to loss of attenuation ability of the man-made reservoirs. Global climatic changes may only make the problem worse in terms of diminished reliability of forecasts.**

There are still many areas along the rivers that are subjected to severe inundation and erosion. Additional structural measures in the form of dykes and spurs are necessary to provide reliable flood protection. Certain gaps need to be closed while existing embankments require raising and strengthening. At several locations, stone pitching on slopes and in aprons, to prevent erosion and collapse of embankments, requires replenishment. At a few barrages, bypass floodways need to be properly demarcated, encroachments removed and channelized. There are certain bridges, such as the Alexandra Railway Bridge on River Chenab, that need to be extended to avoid excessive choking and flood ponding upstream that causes frequent inundation of towns and villages for several weeks on end.

Urban storm drainage for major cities is the responsibility of such organizations as the Water and Sewerage Agencies (WASAs). To incorporate urban storm drainage into comprehensive flood management, it is desirable that the Organizations responsible prepare urban drainage plans such as the one now under way in Karachi. Urban drainage plans need to be considered with respect to national priorities. Criteria of outfall conditions should be taken into account in the comprehensive plan.

Many of the Survey of Pakistan maps are obsolete as well as out of print. It is desirable to have the maps updated and printed in sufficient quantity, to be utilized in the

preparation and finalization of the next Comprehensive Flood Management Plan which is overdue. Also, special mapping may be required based upon satellite imageries of hill torrent problem areas. These areas need to be identified as soon as possible.

In view of the foregoing general discussion and other pertinent factors, following are considered to be the key issues that need to be appropriately addressed:

1. Developments in irrigation, drainage, and other water management activities per se interact with flood management. New problems also tend to arise with increase in population and economic development. Furthermore, government policies and goals change, requiring changes in flood management strategies. Therefore, planning for flood management must be regarded as an integrated and a continuous process which is not being done. The last National Flood Protection (NFPP) Plan was issued in year 1988.

2. Construction of additional flood protection facilities is a definite requirement, but the structural plans are not always developed/adhered to on a river reach basis; from one control point to next; rather local emergency approach is the more frequent way of construction.

3. Design standards of existing flood protection works, grossly fall short of the required levels. For instance, existing side slopes of protective embankments are rather too steep. The shanks of spurs are too long and spacing too large. Design standards require a fresh look for the needed improvements.

4. The maintenance standards of the existing flood protection infrastructure, are particularly deficient. Replenishment of eroded embankments, spurs and stone aprons, etc. is carried out inordinately late while adventurous risks are taken, with the result that breaches/damages are not uncommon. This needs an asset management plan and assessment of liabilities.

5. Appropriate actions are lacking in the land use, and therefore, growth of vulnerable developments in flood plain areas, continues unabated.

6. Old reservoir operational rules are not being upgraded to properly attenuate flood peaks despite better forecasting methodologies now available, particularly with the newly-installed telemetry and other modern communication system.

7. Post-dam records are long enough to give a fairly good indication of the effect of the reservoirs but the quality of regulation is not being improved by extending the period of record by simulating reservoir operation for the pre-dam periods.

8. The magnitude of Probable Maximum Flood (PMF) at Mangla, remains controversial among various concerned agencies which issue is not being earnestly resolved, particularly vis-à-vis, the views of Meteorological Department on the estimation of Probable Maximum Precipitation (PMP).

9. Monsoon systems causing Pakistan's high-magnitude floods, including travel mechanisms of weather systems from Bay of Bengal, and their interaction with Westerly currents from Arabian Sea and Mediterranean etc. vis-à-vis seasonal low pressure over Balochistan, Tibet Plateau pressures, wind velocities and other relevant factors, are not fully integrated and understood. There are also many gaps in the coverage provided by the existing weather radars.

10. Flood response plan lacks (1) level of awareness; (2) flood warning time and (3) reliability of warnings.

11. Implications of the vague terms currently used for Flood Warning such as "High Flood", "Very High Flood" or "Exceptionally High Flood", are not understood by even literate persons, let alone the potential village affectees.

12. Progressive deposition of sediment on the river beds, particularly in the lower reaches of the River Indus, is proceeding unchecked. Current management of the problem by correspondingly raising of the dykes to contain the river every few years, is certainly not sustainable on a long-term basis.

13. Urban storm drainage even in major cities, is not being regarded as a part of a comprehensive flood management plan.

1.5.1 Floods Vis-á-Vis Poverty and Gender Issue

Taming of rivers and hill torrents will essentially help the most deprived communities of Pakistan who are already in miserable conditions. The poorest lot is worst hit by floods because it is they who live and earn their livelihoods from the low-lying degraded and hazardous areas prone to inundation whenever there is a heavy downpour or a high flow in nearby river/stream. Therefore, investment in the flood sector would provide protection largely to the "have-nots" of the Society.

From amongst the poor, women are perhaps the most adversely affected as under any disaster situation. This is true since it is the women who have to care for the children and the latter are more vulnerable to a variety of sicknesses due to exposure and consumption of contaminated water.. Even a minimal level of domestic work including cooking, under crisis environment, without a roof or as a dislocated refugee, adds to their sufferings. Press reports frequently indicate that females are by far the more frequent victims of crime under the relatively unprotected environment created by floods.

From this perspective as well, flood protection needs to be assigned a higher priority. The deprived communities deserve a home and a subsistence-level agriculture, without too frequent dislocations, so that their lives are not put to further miseries caused by the vagaries of nature.

2 ANALYSIS OF AVAILABLE OPTIONS

2.1 GENERAL

As also stated in Section 1, both structural and non-structural measures have been provided to mitigate flood losses in Pakistan. Despite considerable investment made in this sector, flooding of agricultural land frequently takes place, together with occasional breaches in protective embankments and damage to ancillary works such as spurs, when the impact is particularly severe. Because of this and also because the consequential damages from the same intensity floods are progressively increasing with time due to higher levels of economic activity, the approach needs a thoughtful look.

2.2 PLANNING OPTIONS

Over the preceding 30 years or so, there has been a considerable improvement in flood management planning. The catastrophic flood events in the seventies and consequent heavy losses to the national economy, indicated that the then-existing facilities and planning strategies, were grossly inadequate to provide effective protective measures for the country. Lapses in planning strategies were identified some of which are:

- Flood Management is a Provincial subject, and after each catastrophe, Provinces invariably state that funds are grossly inadequate.

- Flood Sector is receiving a low priority in the National Development Programme.

- Works are normally planned on the basis of localized situations.

- There is no systematic procedure for evaluating the efficacy of protection works constructed.

- Design flood is seldom related to the level of protection.

- Modern engineering practices and techniques were not being followed. Manuals on the subject are still more than half a century old.

It was then decided in 1977 to establish Federal Flood Commission (FFC) to cope with the multifarious problems stemming from the frequent occurrence of floods. One of the functions of the Federal Flood Commission was to pursue integrated flood management planning starting from the Provincial level and finalization at the National level. Since the establishment of FFC, the flood problems have been receiving better attention and greater emphasis is being laid on flood problems in the national policies and development plans. There has also been some awareness of the need to follow continuous, rather than the traditional crisis-provoked approach. Previously, when flood management was a Provincial subject, the planning strategy followed a pattern of **short bursts of feverish activity stimulated by a flood event followed by long periods of complacency**. **Even now there are institutional deficiencies, and it is generally seen that as the memory of flood fades into the past, the motivation for action also passes away.**

It is also recognized that plans have to be revised and should remain flexible to respond to changing factors some of which are:

- Aggradation and degradation of river beds and corresponding changes in the stage of river flows for the same discharge;

- Changes caused by new embankments, spurs and other control structures along rivers;

- Construction of storage dams and increased irrigation abstractions from the rivers;

- Changes in river channels as a result of natural morphological and meandering process;

- Encroachment of active flood plain by people, thereby diminishing valley storage with consequential higher flows in the channel; and

- Major changes in land use patterns.

Recognition of the foregoing led to the preparation of the first National Flood Protection Plan in 1978 and later on the National Flood Protection Plan (Phase-II) in 1988. A third plan in the series, however, is still under preparation/finalization although 16 years have elapsed since the issuance of the second plan. Out of various options regarding updating interval, it would appear that a 10-year period is a reasonable span; not too long and not too short.

Planning options and priorities would further require that a comprehensive plan should broadly aim at:

- Reducing flood damages through a technically sound and economically viable strategy.

- Assigning highest priority to poverty-striken hazard areas and to human sufferings in low lying villages and in “Kachhi Abadis”, in addition to protection of cities and vital infrastructure.

- Making maximum use of existing flood control/protection facilities by improvement, where necessary, to bring them to the level of functional capability and reliability.

- Adopting new flood control measures which should not adversely affect either upstream or downstream reaches as far as would be feasible.

- Applying both structural and non-structural flood management measures in combination, since in most cases they are complementary rather than being mutually exclusive.

- In the case of hill torrents (almost invariably traversing more impoverished areas), making maximum efforts to utilize flood flows productively in the area where they are generated. In other words, a multi-purpose approach for management and utilization of flood flows of hill torrents for development of irrigation and other socio-economic activities, may be adopted.

- Minimizing adverse effects on natural ecosystem and environment.

As regards the level of protection, an optimal option would be to provide safety against 1 in 100 years flood event wherever question of life, vital infrastructure or cities are involved. A much lower degree of flood protection against (say) 1 in 5 years flood event may be acceptable for agricultural lands. Standing crop such as rice does not get damaged unless it gets completely drowned and remains drowned for more than 72 hours.

2.3 COMPARATIVE ANALYSIS OF VARIOUS STRUCTURAL APPROACHES

A region-wise and river-wise analysis of approaches currently being followed through various structural flood protection works, is briefly discussed in the ensuing paragraphs.

2.3.1 Upper Indus River

The Indus River upstream of Kalabagh in **Punjab and NWFP** mostly flows in a well protected gorge and, therefore, spillage is not a major problem. Further downstream, the River enters into the generally plain areas, and a number of Flood Protection Embankments with and without stone aprons and spurs, have been constructed over the decades for instance in the Chashma-Guddu reach. River Training Works, extending several miles upstream of each major river structure such as Jinnah Barrage, Chashma Barrage, Taunsa Barrage, Ghazi-Ghat and other Bridges, also provide protection to adjacent agricultural lands against river spills.

There is a reach some distance downstream of Chashma Barrage, on the right bank of the River Indus, where some 12 Spur were constructed to avoid erosion of land, but they are merely protruding into the river plain, remaining otherwise high and dry. The River has never touched these spurs and flows have been attacking the left bank instead. This is a classic example of a prediction about river behavior, that was well-intentioned, but which went wrong.

On the other hand, there are several reaches in Upper Indus where additional structural measures are urgently required to protect agricultural land and villages. The Indus River flows along the eastern borders of Dera Ismail Khan from Chashma to Ramak in a stretch of some 96 miles. The existing Indus River Training Works in D.I. Khan District need to be reviewed in the context of “lessons learnt”.

The fundamental concept to contain a river in Punjab and NWFP, would preferably be to construct spurs instead of embankments where inundation of crops for a few days can be tolerated. Another option would be to construct, instead of long-shank spurs widely spaced, short-shank structures at closer spacing. The maintenance costs would reduce while safety performance would enhance with lesser adverse effects, particularly on the

opposite river bank. However, the number of spurs would increase correspondingly. Optimum spacings and sizes need to be determined through comparative cost: benefit studies. The most effective option would be to construct properly designed stone pitched "studs" instead of conventional "spurs", however, the very large number required may prove too expensive.

2.3.2 Lower Indus River

In the Lower Indus reaches i.e. in **Sindh and Balochistan Provinces**, the combined flows of the Upper Indus as well as the aggregate of the other four rivers, viz. Jhelum, Chenab, Ravi and Sutlej, get combined and consequently the flood discharges are the highest, flood durations the longest, and the flood volumes the largest. Long-term historic records of floods show that the highest peaks occur most frequently in the month of September. The frequency of high floods is also greater than that in the upper reaches. Generally, the land slopes down laterally away from the river on either side and, as also stated earlier, when the river overspills its banks or a breach occurs, the flood waters are unable to drain back into the river, even when the river flood has subsided. Over geological ages, the Indus River has been bringing in sediment from Mountain Ranges and dumping it into the sea. The formation of the entire Indus Valley, in fact, owes its existence to the Indus and its Tributary Rivers. The Province of Sindh has virtually been the delta area for millions of years, and there is ample geological evidence that there is not a single square meter of Sindh where Indus has not been flowing. It has been filling up the lowest lying areas wherever they might have been, depositing sediment, and then moving on to next low area and so on. Changes in the course of Indus to even far away low routes, of course, took place during high floods. The process continued till an uncertain situation such as this became totally unacceptable to the inhabitants. Therefore, over the past 150 years or so dykes have been constructed progressively to a point that the Indus River has now been put in a straitjacket, thereby fixing its location. This naturally resulted in deposition of transported sediment largely on its own bed giving rise to a situation where the river is now significantly higher than the natural ground. The choice would be between dredging / excavation to lower the bed, or to continue to raise the side embankments.

Currently, when a protection bund breaches in Sindh Province, inundations are prolonged, and the floods not only damage summer crops but they also interfere with the sowing of subsequent winter crops. The potential for economic losses, and human sufferings for the poor inhabitants of relatively cheap flood-prone lands near the river, are the greatest. In addition to millions of acres of irrigated land that is subjected to flooding, country's major rail and roads are also sometimes affected by super flood events that keep the infrastructure out of service for long durations.

Notable recent floods along the Lower Indus River have occurred in the years 1973, 1976 and 1978. During the 1976 floods, 53 breaches occurred, 3,767 villages were affected while 32 human lives were lost and some 250,000 acres of standing crop got destroyed. Again, the flood of 1978, though carried somewhat lesser flow, yet it was even more critical hydrologically because concurrent rainfall and hill torrent flooding, resulted in damages over a longer duration. During 1978, one major breach occurred in FP Bund near Moro which alone took two weeks to plug.

Sindh Irrigation Department (SID), has a number of flood protection projects in hand. Their planning, feasibility and execution is at various stages of completion, but the programme is excessively behind schedule.

The Sukkur Barrage is the world's largest diversion structure through which the river level has been raised further to enable gravity command of approximately eight million acres of Sindh's most productive agricultural land. Seven large canal systems offtake from this Barrage. Currently, the Barrage is facing structural stability problems which the Sindh Irrigation Department is finding difficult to handle. However, from floods point of view, remodeling of the barrage is necessary to increase its safe flood passing capacity. Some other priority schemes include Guddu Barrage river training works, remodeling of loop bunds below Kotri Barrage, and providing stone pitching and stone aprons at a number of critical locations.

2.3.3 River Jehlum

River Jehlum contains Pakistan's second largest reservoir at Mangla which is capable of playing a very important role in controlling floods in Punjab. In view of 1992 Flood routing, however, when Mangla Reservoir was full and was unable to attenuate the flood peak that led to colossal damage all the way downstream, operational rules need a fresh look together with the possibility of revising the Probable Maximum Flood (PMF). This exercise is being conducted as a part of the raising of Mangla Dam, permitting some 30 feet rise in Reservoir Level. Yet, certain quarters in the Meteorological Department, seriously question the methodology of estimating the Probable Maximum Precipitation (PMP) that is being used in the current analysis which leads to an unrealistically high value of PMF. This is an important aspect warranting an independent review.

The Provincial schemes for additional measures to protect vulnerable areas along Jhelum River, need to be reviewed in the context of structural options discussed in Section 2.3 "Upper Indus River" and priority works selected for implementation.

2.3.4 River Chenab

The Punjab Irrigation Department (PID) has prepared several dozens of flood protection schemes for the Chenab River such as extension of Haripur Bund, a number of new spurs, remodeling of river structures and training works at Khanki, Qadirabad, Trimmu and Panjnad Barrages. The Pakistan Railway has proposed schemes for raising the railway embankments, including extension of Alexandra Bridge Spans near Wazirabad that presents a serious bottleneck, and inundates vast areas upstream on the left bank of Chenab River for incredibly long periods. All these schemes present piecemeal solutions to cater for local problems. As was also recommended in the Flood Protection Sector Project-II (FPSPII), the entire length of the River needs to be considered as one entity, and feasibility studies for increasing the discharge capacities be undertaken with due regard to effects both upstream and downstream, afflux formation, aggradation and degradation of the channel besides adequacy of freeboard, etc.

The flood problems at Khanki Barrage need immediate attention as a part of the studies currently under way to construct a new Barrage at Khanki. The existing Barrage is in the "acute danger" category and is highly vulnerable to damage.

2.3.5 River Ravi

The PID has proposed some eight (8) high-damage potential projects to be executed on priority basis of which the important ones are; strengthening of Balloki and Sidhnai Barrage marginal and guide banks, protection of Okara-Faisalabad road, protection of villages and agricultural land, and convertion of left bank of BRBD Link into flood embankment (RD 178 to 230). While these works appear necessary, alternative solutions and matters related to agricultural drainage, have not been addressed. A Master Planning study was recommended in FPSPII to be undertaken to fully identify the problems to consider broad range alternative measures for the entire River, because of interactions between the proposed remedial measures in different reaches. The attenuation now available from the completion of Thein Dam in India, also needs to be taken into account during the Master Plan Studies.

2.3.6 River Sutlej

Certain essential structural works are intended to be carried out by the PID on Sutlej River. Three major components comprise raising and strengthening of the marginal bunds of Mailsi Syphon providing crossing between Sidhnai – Mailsi – Bahawal Link Canal and the River, while protecting agricultural areas, and village abadies from the onslought of the river. Protection of Islam Headworks is also a necessary work. Again, the proposed schemes should be reviewed in the background of structural options described in Section 2.31 entitled “Upper Indus River”.

2.3.7 Hilly Areas

Floods in the hilly terrain covering large parts of NWFP, Balochistan, FATA, Northern Areas and AJK, and some smaller portions of Punjab (D.G. Khan) and Sindh (Kirther Range), occur mostly due to heavy rainfall on steep barren slopes which generates high run off velocities. Gushing rain water thus causes soil erosion and mud slides besides inundation. Most of the small towns and villages are located near the banks of hill torrents and are thus exposed to recurring devastation. Irrigation channels, communication infrastructure and cultivated areas are also exposed to frequent damages. Average annual precipitation in NWFP is higher as compared to other provinces of Pakistan, ranging from a modest five inches in the South-West (D.I. Khan) to as much as 60 inches in North-East (Abbottabad). Due to large-scale deforestation, detention of precipitation is insignificant in most areas. Heavy erosion in the upper regions ultimately causes deposition of sediment in the lower reaches with the result that gradual aggradation of stream beds takes place. The capacity of torrents thus reduces further till they are unable to accommodate even medium flood flows.

In **NWFP**, nearly all canals offtaking from Warsak Dam, Munda Headworks, Kurram Garhi Headworks and Tanda Dam, frequently breach or get damaged by hill torrents. The canal supplies are thus interrupted for prolonged periods and the agricultural output of the province is severely affected. Although flood protection schemes such as in Kohat, Karak, Bannu, Mardan and Swat have been undertaken and some work is performed each year as permitted by the funds available, the effort is not adequate. Since breaches in canals can also be attributed to inadequate cross-drainage capacity, proper drainage structures over or under the canals permitting safe passage of medium flood flows,

would be of substantial help. This option may be worth considering at least as interim measures till complete harnessing of hill torrents in the area is achieved.

Several projects are required for the protection of lands and villages along Kurram River, Kalpani Nullah, in Dir District and Panjkora Valley, etc. Feasibility Studies for protection and improvement of Rod Kohi Irrigation System in D.I. Khan is also a priority work that requires construction of a number of small dams in this area to control the situation.

In **Balochistan**, although a number of flood protection embankments have been constructed such as for Zhob Town, Chaman Town, Lahri Town, Sani and Degari in Turbat, Quetta and Pat Feeder Right Bank Bund, yet flood problems caused by hill torrents are far from under reasonable control. Aside from the need for additional flood protection facilities, the existing embankments have not been generally constructed in accordance with the engineering safety criteria and thus have not been able to provide a reliable protection. Ironically, Hydrology Division which was once responsible for hydrologic surveys and data collection in Balochistan was abolished in 1970, due to financial constraints. The hydrological activities in Balochistan are currently confined to data collection aimed solely at developing new irrigation schemes rather than for flood control.

Some of the priority schemes include construction of a number of delay action dams which approach appears to be quite promising.

The schemes prepared so far comprise the planning of most sensitive areas subjected to acute human sufferings. Eventually, overall planning of hill torrents throughout the Province is necessary to provide a foundation for an integrated and comprehensive plan for flood control and simultaneous utilization of flood water, to bring about economic prosperity in this relatively backward Province.

The Federally Administered Area (FATA) has proposed and executed a number of flood control schemes. Appraisal studies for flood protection works in **Northern Areas,** Hunza Nagar and Gilgit, have also been carried out and the Works are of particular interest because of their location and the damage potential.

The **Azad Jammu and Kashmir (AJK)** Public Works Department has prepared a number of flood protection schemes for various sub-watersheds in the region. AJK again faces problems of land cutting and erosion posed by numerous hill torrents. Massive land slides due to under-cutting, are a common phenomenon in different areas of Azad Kashmir. Comprehensive planning is absolutely vital to tame streams so as to save AJK land which is a highly precious source of their economy. The protection works would be largely in the form of dry (uncemented) stone spurs, retaining walls, stone pitching and stream training works.

In summary, there are a number of hill torrent project areas for which a phased programme of investigations and planning is required. These projects encompass flood management of hill torrents in various mountainous ranges of Pakistan, which comprise more than 50 percent of the total area of Pakistan. Various approaches to be used

depend upon a variety of factors such as physiography, climatic, socio-economic development and other considerations which vary from one hilly region to the other. In this Section, for various regions, different options have been broadly discussed including cross drainage structures, diversion structures for Rod Kohi irrigation, regular dams, delay action dams, retaining walls, stone spurs, stream training works, etc.

Aside from the foregoing, due consideration to Watershed Management Practices, has also to be concurrently given. Wherever adequate rainfall occurs and even a minimal soil cover exists on rocks, vegetation and its protection is, perhaps, the best way to reduce surface runoff. With the exception of Mangla Dam's catchment (and Tarbela to some extent) where a well-planned project approach has been successfully followed, none of the other areas have received much attention.

2.4 APPLIED RESEARCH REQUIREMENTS

Applied Research is considered essential to improve the flood control planning criteria, and management techniques in the case of main rivers.

This should also include re-evaluation of methods to determine and predict the phenomena of scouring, meandering and creek formation in relation to normal discharges and for flood flows. In order to properly channelize the rivers, it is essential that detailed river surveys be carried out, with X-sections at (say) one mile interval. This work of taking X-sections is very essential after every extraordinary high flood.

Design and maintenance standards have to be improved aimed at safe and efficient flood protection dykes, better specifications, efficient utilization of local materials, accurate and scientific estimation of free-board, and economic design of riprap.

Dredging or flushing of sediment deposits from high river beds, is another vital area requiring research and development of an appropriate technology. The option currently chosen in progressively raising the height of protection embankments to contain the river, is not only hazardous but impractical on a long-term basis.

2.5 FLOOD FIGHTING MEASURES

Urgent measures are required to ensure:

a. Sufficient and efficient transport system for mobility of staff.

b. More effective patrolling of bunds and river training works.

c. Strengthening of communication system by providing additional wireless equipment and/or use of internet in the flood affected areas.

d. Shingle roadways be provided on the bunds for quick access and flood fighting.

e. Old system of providing lanterns to patrolling staff be replaced with portable generators with poles and electric cables, if proper monitoring and timely remedial action is to be ensured to avoid breaches during floods.

2.6 NON-STRUCTURAL OPTIONS

Various non-structural options, are composed of the following:

- Watershed Management Practices;
- Land use Restrictions, Cropping Patterns, etc;
- Soil and Water Conservation Techniques;
- Reservoir Operation Regulations; and
- Flood Forecasting and Early Warning System;

These are briefly discussed in the ensuing paragraphs.

2.6.1 Watershed Management Practices

As also stated earlier, watershed management though a long-term activity, yields major flood mitigation benefits. The function of such measures is to reduce the velocity of flow and sediment generation, by providing/restoring afforestation cover in the catchment areas. In the face of scanty rainfall, the success of planting in the catchments of hill torrents, is generally possible only under strict prohibition against grazing. In other areas such as the upper parts of the Indus catchment, plantation is not possible because monsoon systems are unable to penetrate and thus there is hardly any rainfall to support vegetation. Mangla Dam watershed Management has been under way for the last 45 years, and its positive effects became apparent some years ago when the annual silt load entering the reservoir was found to have reduced by almost half, thus doubling the life span of the reservoir. Prolonging the effective life of a reservoir indirectly helps in attenuating flood flows that are routed downstream. At the time of design and construction Mangla Dam, the silt particles per million (PPM) were such that the annual sediment deposits in the reservoir were estimated as 60,000 acre feet which subsequently reduced to approximately 35,000 acre feet.

2.6.2 Land-Use Restrictions, Cropping Patterns etc.

Flood damages are reduced by adopting modified land-use practices suitable to the local conditions. Furthermore, in flood-prone areas, development of infra-structure, residential colonies and industrial states have to be discouraged through proper legislation and only flood-resistant crops be sown, especially those spanning the flood season. In practice, there is very little work achieved under this option, and the land use/cropping patterns remain virtually unregulated, and the people continue to take risks freely. Any high-asset infrastructure has of course, to be provided with adequate flood protection.

2.6.3 Soil and Water Conservation Techniques

Soil and water conservation practices are extremely useful if properly adopted in accordance with the catchment characteristics of river/hill torrent basins. This greatly helps in reducing erosion of otherwise productive soils, especially through storing flood waters for agriculture. In some hill torrent areas and in river catchments, conservation techniques including terracing, contouring, strip cropping, are being practiced very successfully. Such techniques significantly contribute in flood abatement, besides providing livelihood to the hilly area residents.

2.6.4 Reservoir Operation Regulations

Pakistan has three large reservoirs, namely Tarbela and Chashma on Indus River, and Mangla on Jhelum River. These reservoirs are primarily meant for irrigation supplies, hydropower generation being the secondary purpose. However, the reservoirs also provide an opportunity in flood management by depressing flood peaks.

In India, there exist five storage dams on rivers that eventually flow into Pakistan. On the Ravi River Thein Dam; on the Sutlej River Bhakara and Nangal Dams; and on the Beas River Pando and Pong Dams. These dams were constructed after the 1960 Indus Water Treaty. With these dams the Ravi and Sutlej Rivers in Pakistan, have become literally dry, except for occasional flood flow that enters Pakistan when the huge reservoirs in India, are already full or it is not otherwise feasible to store water.

The power generation and irrigation requirements aim at filling the reservoir to full capacity by the end of monsoon in August each year, both in Pakistan and in India. In terms of releases, optimum power generation requires maintaining the high water level during the entire period of operation, while irrigation supplies require maximum level in August and minimum water level in June next year, thereby enabling full utilization of the stored water for agricultural purposes. If some degree of priority were to be given to flood attenuation as well, space would need to be reserved at a certain level below the full capacity. Another option would be to permit flexibility in operational regulations relying upon instant information that is now possible from the newly-installed telemetry and more efficient communication system; by storing flood peaks in the event when the reservoirs are full at the end of August and a flood is experienced (say) in early September. Under the current regulations no flood mitigation is possible in such circumstances just as it happened at Mangla in the year 1992. This aspect needs to be given serious consideration.

2.6.5 Flood Forecasting And Early Warning

After the devastating floods of 1973, it was decided to modernize the existing Flood Forecasting and Warning System. World Meteorological Organization (WMO) was approached and a project known as PAK/74/027 was launched. This project consisted of the following main components:

a. A computer controlled Quantitative Precipitation Measurement (QPM) radar at Sialkot.

b. An Automatic Picture Transmission (Satellite) Ground Station at Flood Forecasting Division (FFD) in Lahore.

c. Installation of NIVA 3/12 and M-16 computers at FFD and the necessary software pertaining to rainfall/runoff and flood routing models.

d. A telemetric network composed of some 30 rainfall and river flow sensors.

This system was established in the year 1978. The acquisition of hydrometeorological data for use in the rainfall/runoff models, is largely through the telemetric network maintained by Surface Water Hydrology Directorate of WAPDA. Another weather radar of 10 cm wave length was installed at Lahore in 1996 with several additional telemetric stations and HF Radios (ADB-GOP financed) which further strengthened the system. Currently, the main steps in Flood Forecasting and Warning are:

- Measurement of upper catchment rainfall (through Radars) and discharge data (through telemetry) transmitted to Flood Forecasting Centre, Lahore.

- Refinement of quantitative precipitation using data acquired from other sources including WMO.

- Inflow estimation at the Rim Stations of Rivers.

- Verification from information made available by India on actual river flows in head reaches according to the Indus Waters Treaty provisions.

- Routing the flood waves below the Rim Stations.

- Dissemination of flood warnings through Police, District and Local Government Authorities using HF Radios and other communication means including the internet.

2.6.5.1 Shortcomings In The Existing Flood Forecasting System

Unlike the Lahore QPM radar, the one at Sialkot is of short wave length and thus suffers tremendous energy loss in monitoring heavy rainfall events that cause floods in Pakistan. The radar greatly under-reads and is unreliable in monitoring the rainfall amount. The error increases as the rainfall intensity increases. The QPM radar at Sialkot should have been selected to generate a 10cm wave length instead of 5cm wave length; the latter is suitable for (say) Europe's light rain. The monsoon rainfall in the sub-continent consists of much bigger drops as compared to the rainfall in the European regions.

Since floods of catastrophic nature have occurred in all the provinces of Pakistan, there is a need to extend the flood forecasting system to cover all flood-prone regions throughout the country. To accomplish this, it was proposed in the NFPP (1988) to establish six additional radar stations one each at Gujranwala, Multan, Quetta, Murree, Lahore (since installed) and Pasni. The proposed radars were to be of 10 cm wave length, for the remote sensing of precipitation within a radius of 230 kms from the radar site. A supplemental network of telemetric station had to go with each radar. Communication system to link the radars with the telemetric stations and with each other, was also recommended.

Apart from telemetry networks and HF radios for communications, only one radar at Lahore as referred to earlier, could be installed under ADB-financed Flood Protection Sector Project-I due to financial constraints. This radar has been very helpful in monitoring rainfall in the catchments of rivers Chenab, Ravi and Sutlej. Additional radars

are required at appropriate places which need to be re-established in view of experience since gained. One at Mangla Dam is currently under installation under ADB financed FPSP-II. Additional equipment, together with river modeling, and preparation of a comprehensive Flood Forecasting and Warning Manual would make the system more reliable.

2.6.5.2 Shortcomings in the Existing Flood Warning System

Although the Flood Warning Centre is suitably located and manned as an adjunct to the Flood Forecasting Division, yet the type of information that is released by the Forecasting set up to the Warning Centre and onwards, is grossly deficient from the point of view of the potential flood affectees. The forecasts are currently issued in the form of different categories of floods, with expected discharges, for some half a dozen locations (usually barrages) along each river. This is typical of Provincial Irrigation Departments' (PIDs) priorities, who are mainly concerned with their own infrastructure and flow measuring points.

A warning such as "800,000 cubic feet per second, category "very high flood", would be passing through such and such barrage or bridge on a river between (say) 10 am and 2 pm day after tomorrow", may be a good forecast in itself but may not mean much for a village that is half a mile off the river bank and some 30 miles downstream or upstream of the site designated in the Warning. Desirable Warnings ought to consider all villages (besides, of course, any towns and cities), which are likely to be threatened.

In order to achieve this objective, a comprehensive "Flood Forecasting and Warning Manual" would be required with inundation maps and tabulated information for various categories of river flows, so that the police, the local government and other concerned officials, including villagers, may readily understand the Warnings rather than doing the difficult and, at times, impossible task of interpreting. Suitable gauges would need to be installed at locations near each village within the 1 in 100 year flood plain, and periodic Warnings issued in terms of time and estimated gauge levels.

3. INSTITUTIONAL ASPECTS

3.1 RESPONSIBILITIES OF EXISTING INSTITUTIONAL SETUPS

Like any other natural disaster, flood damages have widespread and multiple consequences causing, apart from maximum damage to the people and the poor who are the worst hit, the public sector infrastructure as well. At present, Flood Control and Management involves many governmental organizations whose functions are summarized in the following Table:

S/No.	Organization Responsible		Main Functions and Responsibilities
1.	Federal Flood Commission,		Policy implementation, Coordination between Provinces and other involved organizations.

	Government of Pakistan		Integrated Planning, Review and Approval of New Flood Protection Schemes presented by Provinces, AJK, NA and FATA. Financial and other assistance to Provinces in the implementation of schemes.
2.	Provincial Irrigation Departments (PIDs)		Planning, design, construction and maintenance of Flood Protection Works such as embankments and spurs. Handling bund breaches, etc. River flow measurements at PID Stations including Barrages.
3.	National Flood Forecasting Division, Lahore (under Meteorological (MET) Department), Government of Pakistan. (*Centre is composed of Director, Flood Forecasting MET. DEPT., Lahore as Head with Reps of WAPDA, PCIW & PID.*)		Data collection, inter alia, from World Meteorological Organization (WMO), India through PCIW, WAPDA and PID Stations, data processing, mathematical modeling, and issuance of Forecasts to Provincial Flood Warning Centres.
4.	Flood Warning Centre, Lahore (under Punjab Flood Relief Commissioner-FRC). (*Centre is composed of Reps of FRC as Head with Met Dept, PIDs, Police Telecom, Info Dept. Reps*.)		Collection of Forecasts from National Flood Forecasting Division, Lahore, and issuance of Flood Warnings to all concerned Agencies largely through Police Wireless Network and Internet.
5.	Water and Power Development Authority (WAPDA). (*Through WAPDA Committees on Flood Routing at Tarbela & Mangla Dams*)		Data collection from WAPDA's own Stations upstream of Reservoirs, data processing, attenuation of floods through reservoirs such as Mangla and Tarbela. Also responsible for overall drainage of agricultural lands.
6.	Provincial Flood Relief Commissioners. (*Through District Admn,*		Evacuation, Rescue, Tented Accommodation, Public Health Services and other facilities Including Rehabilitation.

	Army, Civil Defence, Welfare Organizations & NGOs etc.)		
7.	Federal Disaster Cell, Cabinet Division, Government of Pakistan.		Coordination at Federal level including financial and other assistance to Provinces in respect of Relief Measures. Maintenance of a small fleet of helicopters and essential supplies. Special assistance as required.
8.	Local Governments and City WASAs		Storm drainage in Towns and Cities is the responsibility of Local Councils and Organizations such as Water and Sewage Agencies (WASAs) in major Cities.

3.2 ANALYSIS OF INSTITUTIONAL PERFORMANCE

The provincial irrigation authorities are the custodians of their respective irrigation, drainage and flood protection networks. They are supposed to carry out not only the operation and maintenance of these systems but also design and development of new works. Since 1958, however, with the transfer of major development works to WAPDA, provincial irrigation departments' (PIDs') functions were reduced mainly to the operation and maintenance of the systems. PID managers have not been finding these functions sufficiently challenging, and over the years have lost much of their initiative, innovativeness and morale. This is further compounded by their unenviable role as a target of fair as well as unfair criticism by others, including the federal government, WAPDA, the agriculture departments and the international financing agencies. The large land owners with political clout have choked the small landholders to the extent that there is no such thing left, in certain Provinces, as an equitable distribution of water. The tail ends of distributary channels remain perpetually dry.

In these circumstances, the PIDs' attention remains almost exclusively focused on the irrigation distribution network. Let alone the flood protection works, even the River Barrages have been in a state of neglect. Whenever a major problem of a catastrophic nature takes place on a Barrage or a flood protection embankment, lack of adequacy of maintenance funds is given as a standard cause which in several cases would be valid while in others not quite so. Deferred maintenance has become a routine practice with PIDs, which eventually results either in a disaster or in a major repair and restoration undertaking in the shape of an independent project. Some recent events in the form of breaches in the first line of protective embankments in Sindh and the current situation at Sukkur Barrage, are clear evidence of accumulative neglect. In Punjab as well, at present some six (6) Barrages have deteriorated to a point that deferred repairs are now being undertaken as major "Remodelling Projects".

Needless to say that unless some fundamental steps are taken, more and more Barrages and River Dykes will follow the suit. The consequences of a major breach of flood protection embankment or failure of Sukkur Barrage which feeds as many as

seven (7) huge canal systems irrigating some 8 million acres of the most productive land of Sindh, would be disastrous.

Even in the, Water Wing of WAPDA, the originally better professional skills, higher efficiencies and excellence in performance, have been gradually but continuously fading, and there now appears to be a lack of ownership and commitment leading to indifferent attitudes besides bureaucratic practices that have crept in. The failures in the implementation of National Drainage Programme (NDP) does not require any further elaboration. It appears that the Water Wing of WAPDA has to be redeemed from the privatization fallout of the much larger and dominating Power Wing which has acquired a typical consequential psyche. The top management of WAPDA has understandably to spend far more time on privatization, uninterrupted power supply and a host of other issues. The privatization of Water Wing, on the other hand, is out-of-the-question even on a long-term basis.

Aside from WAPDA's Water Wing with statutory responsibility under WAPDA Act, for carrying out flood works (WAPDA has not actually exercised this options), there is the other federal government organization, namely, the Federal Flood Commission, created through a Cabinet Resolution. The aforementioned provincial and federal set ups, lead to considerable dilution of responsibility.

Another relevant factor that needs to be pointed out is that despite the installation of telemetry network aimed at transparency in canal withdrawals from River Barrages, the historic lack of trust and inter-provincial accusations and counter-accusations of over-withdrawals or under-reporting, is not likely to disappear easily. Even though the newly-installed system of real-time flow data, will be of enormous help, grievances are already being expressed as to calibration aspects of the flow-measurement sensors.

3.3 A RECOMMENDED INSTITUTIONAL REFORM

A rational though radical solution to the aforementioned problems would lie in creating a **"River Management Authority"** that would be responsible for integrated planning, engineering design, construction, operation and maintenance of all hydraulic structures on the major Rivers. These may include Dams, Barrages, Hydropower Stations etc and, of course, all Flood Protection Works. WAPDA's entire Water Wing and the Federal Flood Commission would need to be merged together to form the proposed River Management Authority. Experts from PIDs on Barrages may also have to be arranged on temporary or permanent basis as would be considered appropriate. It stands to reason that the headquarters of this River Authority should be in Islamabad, but it should have strong presence in the four Provincial Metropolis. Funding would initially be provided by the Federal Government, while recovery arrangements through a water charge on hydropower and a storage charge on irrigation water supplied to offtaking canals, can be levied to make the Authority financially autonomous. A nominal flood protection charge may also be recovered from the City Administrations and Industrial areas to whom protection has been **specifically** provided.

3.4 BARRIERS TO CHANGE

Evidently, there would be strong resistance from the Provincial Irrigation Departments, particularly, from Punjab and Sindh PIDs and indeed from WAPDA as well. The Finance Department of Government of Pakistan may not initially like the concept either, lest they have to assume additional burden. Three of the four Provincial Governments, on the other hand, may welcome the idea of having headquarters of the proposed River Management Authority in Islamabad, while Punjab would not support it just as WAPDA would not like to shift any major part of its Water Wing staff to Islamabad. Whether or not Water Wing's experts would like to assume greater responsibility of the River including Flood Works, will be a question mark; some would cherish it while others would not. Provinces would resist transfer of their Barrages to the Federal Agency. Likewise, there would be a host of other Ministries and Organizations who will look at the proposed change (like any change) from their own perspective and would come out with ingenious arguments.

But the ultimate question is; what about the people at large who normally do not express themselves? A dynamic River Management Authority with adequate autonomy and a compatible accountability, will pay far more attention to River Works so that flood damages are minimal and river supplies to offtaking canals from well-maintained Barrages, are at all times possible in accordance with the equitably shared demands placed by the Provinces through IRSA. Furthermore, the lower riparian Provinces should have better trust in a federal agency in the matters of river diversions for irrigation. Once again as for floods, Provinces cannot forever go on demanding money from the Federal Government through the Federal Flood Commission, spend it themselves on construction of Flood Works and then not be able to maintain them to the required levels of safety standards. The scenario does not end here since they then want more financing for massive rehabilitation/replacement works arising out of deferred maintenance, and the cycle restarts again.

Finally, a river in many respects is akin to a live organism with its tail in the mountains and its mouth adjacent to the sea. If a dam, a barrage, a hydropower facility or a flood dyke, is constructed at any location, or under a new scheme water/sediment is extracted or added to it, the effect is felt by the river in many ways upstream/downstream or both. The morphology and regime of the river is thus affected and it takes years and sometimes decades, depending upon the degree of interference, before it readjusts itself to a new stable condition. Accordingly, an integrated development and maintenance by one competent organization would be the best way of managing the river effectively and efficiently. Tennesse Valley Authority's (TVA's) success is an example of a somewhat similar set up.

If such a reform is to be undertaken, a strategy would need to be evolved with proper timeframe to ensure that the high-level commitment is there, and the transition is smooth without upsetting the vast and valuable infrastructure.

4. RECOMMENDED PRIORITY ACTIONS & SEQUENCING

4.1 GENERAL CONSIDERATIONS

As would be apparent from the previous Sections, the Indus River system and many of the hill torrents of Pakistan, present a huge flood problem under highly variable and complex conditions. Funds available to deal with these problems are severely limited and, therefore, prioritization of projects and studies has to be done. At the outset, it must be recognized that prioritization of structural measures has largely to be in conformance with the level of importance and urgency assigned by the Provincial Irrigation Departments (PIDs) and others concerned including not only FATA, AJK, Northern Areas, but the infrastructure agencies such as Railways, Highways, City Administrations, etc.

Flood Protection Sector Project II (FPSP-II), that was formulated based on latest prioritization of sub-projects, was started in the year 2000. The Project, however, failed to take off and only about 15% progress has been achieved in physical terms. The detailed reasons for a lack of success, have been outlined in Section 1.2. ADB is firm on sticking to the cut off date of June 30, 2005. All outstanding works left over from FPSP-II would thus provide one of the bases for selecting future projects.

The primary emphasis in framing FPSP-II was to provide protection to urban areas, important communication facilities, agricultural land and to major irrigation infrastructure. Flood magnitudes and frequency and the direct damage potential was also kept in view. These and other updated considerations, would provide necessary input for analyzing various projects to establish priorities.

Broadly, the problem areas can be divided into three categories. Firstly, areas with obvious major problems that require immediate attention. These would also include construction of essential flood protection facilities which would be ongoing but still incomplete on the ADB's prescribed cut off date. Secondly, problem areas which are considered quite important and for which feasibility studies have been completed and approved. Thirdly, other problem areas where the poorest people are affected. These areas are recommended for expeditious feasibility studies. Needless to say that adequate flexibility has to be provided in reprioritization and upgradation of these projects.

Another consideration, would be that expenditures incurred on flood protection are always of the nature of minimizing risk rather than producing assured direct income, even though flood protection indirectly enhances economic productivity in many other sectors. Therefore, assessment of benefits from flood management has to be made after greater-level of deliberations and evaluations.

4.2 PRIORITY FLOOD WORKS ALONG RIVERS

Prior to 1976 floods, embankments and spurs were constructed by the Provinces at crisis locations as they emerged. These were not a part an integrated plan as such.

Immediately after the formation of Federal Flood Commission, a comprehensive National Flood Protection Plan (NFPP) was prepared in 1978. The plan was derived primarily from the then-existing proposals and schemes of Provincial and Federal agencies due to be undertaken in phases. In 1987, an updated National Flood Protection Plan was prepared. Generally in line with this updated plan, a Flood Protection Sector Project-I (FPSP-I) was implemented with financial assistance of ADB which was successfully completed in the year 1996.

In 1997, preparation of a Second Flood Protection Sector Project (FPSP-II) costing USD 140 million was initiated, however, due to a variety of reasons, including the need to economize and reprioritize, inordinate delays occurred and the Project work could only start in year 2000. In year 2001, both Government of Pakistan (GOP) and the ADB placed "Holds", one after the other. Although ADB cleared the suspension after three months, yet Government's "Hold" continued till reformulation and curtailment of the Project had been completed which process took more than two years. ADB were not satisfied with the pace of progress, non-clearance of Consultants paybills, and counter-rupee financing problems. As also explained earlier, the GOP's concern was that the project had contained unduly high component for consultancy and non-structural works. The revised project was reduced to about half the size and finally, in March 2003, ADB agreed to support the reframed Project subject to (1) cut off date of June 30, 2005, and (2) continued commitment of the Government in implementing the Project. The reduced cost of the Project amounted to USD 80 million with ADB's financing of USD 64 million.

Despite the culmination of the aforementioned ordeal, the performance has remained far from satisfactory. While 80% of the Project time has elapsed, the physical progress is under 15%. Currently, work is under way on some 19 flood protection schemes. In addition, nearly 40 schemes have been approved or are under final clearance by ADB, 51 schemes have been reviewed and cleared by the Project Consultants, but not yet approved. The Consultants are reportedly facing difficulties in receiving bid evaluations and contract award reports from PIDs, or in other words, procurement processes are not proceeding efficiently. It is also evident that the skeleton staff of the Federal Flood Commission is not sufficiently equipped to properly coordinate and monitor the Project, especially when a vital element of General Consultancy that was to support the Flood Commission, was altogether deleted by the Government in the reframed Project.

It is now estimated that the overall progress by June 30, 2005, would be merely 25% and even if another year's extension is agreed to by ADB, the progress is not likely to exceed 50%. In order to have abroad idea, a general grouping of the anticipated outstanding works under FPSP-II, is given hereinafter.

PUNJAB

1. **Ramak – Taunsa Reach of River Indus**
   Protection of several towns, villages and to prevent land erosion.

2. **Taunsa – Guddu Reach of River Indus**
   Remodelling of Minchin bund and construction of a number of spurs to prevent land erosion.

3. **Marala – Alexandra Bridge Reach of River Chenab**
Protection of Wazirabad City and construction of a guide wall spur.

4. **Trimmu – Panjnad Reach of Chenab River**
Construction of some protection bunds and several spurs.

5. **Ravi Syphon – Balloki Reach of River Ravi**
Construction of spurs to protect land and raising of Balloki Barrage Marginal Bunds and Guide Banks.

6. **Balloki – Sidhnai Reach of River Ravi**
Protection of Okara – Faisalabad road and right marginal bund of Sidhnai Barrage.

7. **Ferozepur – Suleimanki Reach of River Sutlej**
Several flood works for protection of irrigation infrastructure and agricultural land.

8. **Islam – Panjnad Reach of Sutlej River**
Raising of existing bund and restoration of subsidiary weir at Islam Headworks.

9. **D.G. Khan Hill Torrents**

N.W.F.P

10. **Chashma – Ramak Reach of River Indus**
Four (4) additional spurs to protect land and villages.

11. **Kabul River**
River training and protection works for a number of village and abadies, etc.

12. **Panjkora River**
Channelization of River and protection works for a number of villages and agricultural land.

13. **Siran River**
Protection of villages and agricultural land.

14. **Kunhar River**
Protection of vulnerable areas of Balakot.

15. **Swat River**
Protection of several towns, villages and agricultural land.

16. **Kurram River**
Construction of a number of spurs.

17. **Gambila River**
Protection of Lakki Town.

18. D.I. Khan Hill Torrents

Flood protection works for Panyala and Abdul Khel Towns.

SINDH

19. Guddu – Sukkur Reach of River Indus

Providing stone pitching and stone aprons besides resectioning, raising and strengthening of existing river embankments such as KK Bund, Sukkur-Begari Bund, Ghouspur Loop Bund, etc.

20. Guddu Barrage on River Indus

Stone pitching of Marginal Bund, Guide Bund, and channelization of river approach.

21. Sukkur-Kotri Hill Torrents

Remodeling of FP Bund (RD 0 to 120)

22. Kotri to Arabian Sea Reach of River Indus

Protection of Thatta-Sajawal Bridge.

BALOCHISTAN

23. Toba Achakzai and Killa Abdullah Area

Construction of several Delay Action Dams to protect lands.

24. Pat Feeder Canal

Miscellaneous flood protection works.

25. Construction of 20 Delay Action Dams

Protection of land at various locations.

26. Protection from Rivers/Streams

Protection of lands from seven (7) Rivers/streams such as Purali, Kech, Khadabadan etc, in Districts Lasbella, Kech, Ziarat, Zhob, Pishin and Panjgur Districts.

For a future flood control project, rather than picking up the leftover schemes as such, a comprehensive review of the aforementioned works and other schemes would be required, in close association with the Provinces to re-establish priorities. Traditionally, priority has been assigned to areas of important economic activity such as cities, industrial and manufacturing areas, as well as to canals, roads and railway infrastructure. Without diminishing their importance, the impoverished villagers and their lands along the rivers should, as a minimum, need to be assigned an equal weightage.

PRIORITY HILL TORRENT FLOOD WORKS

Perhaps, an even higher priority needs to be assigned to the harnessing of hill torrents in Pakistan. As also discussed in earlier Sections in detail, hill torrents are located mostly in backward areas and have hitherto not received the desired degree of attention. There is a general feeling that most of the water-related activities have remained concentrated over centuries, in the relatively prosperous Indus Valley. World Bank's

strategic concept of “political economy” or “pragmatic but principled” approach, may very much be applicable in this case as well.

Flood flows for selected hill torrents need to be simulated using digital computerized studies. Emphasis should be given to define the problems in quantitative terms, followed by hydrologic/ hydraulic analyses, technical and economic feasibility of structural and non-structural flood management measures. Sociological studies should also be conducted to more fully understand the needs of the affected population, many of whom are of tribal origin. Considerable improvements are required in the design of structures which presently consist of flexible and somewhat temporary stone gabion dams, dispersion structures and retaining walls. A practical way would be to continue with the existing concepts, while concurrent research is undertaken aimed at more effective and long lasting structures, requiring lesser annual maintenance.

4.3 NEED TO IMPROVE EXISTING BUND SYSTEMS

A cooperative programme with the Provincial Irrigation Departments should be initiated to ascertain the structural condition and reliability of major bunds, using modern geotechnical methods, and recommendations made for specific improvements.

Currently used criteria for bund design, construction and maintenance practices should be refined and tested. A pilot project demonstrating methods of improving existing bunds may be undertaken in cooperation, particularly, with the Sindh and Punjab Irrigation Departments. A better manual on design procedures, construction quality control and maintenance of embankments, would be the eventual outcome of such studies. Training sessions also need to be held to train inspection personnel in the use of portable equipment for quality control.

4.4 NEED FOR FLOOD SIMULATION MODELING

Future strategy for the construction of physical works for flood control should be based on computer flood simulation models. Simulation modeling can be used to determine effects of flood flows in the river system from actual as well as hypothetical hydrologic events, reservoir operations, while taking into account to effects of river-confining bunds. Flood simulation models need to be developed for the Indus, Jhelum, Chenab, Ravi and Sutlej Rivers. Mathematical modeling is also essential for the preparation of inundation plans for various flood intensities, for use in reliable Forecasting and Warnings as referred to in Section 2.6.5.2 and 4.10.

4.5 REFINEMENT OF RESERVOIR OPERATIONS

Studies of reservoir operation for flood control have been undertaken before, however, these studies were of a limited scope since a relatively low priority was assigned to flood management. The objectives of refinement of these studies would be to develop operational strategies, rule curves, and analytical tools for improved reservoir operation that would allow optimum use for flood space without unduly compromising essential uses for irrigation and power. The key to optimum operation of Mangla and Tarbela Reservoirs for flood control, will be the ability to simulate by using computer models, combined with flood discharge predictions at downstream locations as far ahead in time as the lag time from the reservoirs permits. This will allow reservoir withholding to be

properly timed to have maximum effect on the downstream flood peaks. Procedures for medium-term and short-term rainfall flow forecasting should also be developed as far as is feasible. Long-term rainfall forecasting is not possible at the current levels of technological development.

4.6 REQUIRED STUDY OF FLOOD CONTROL BENEFITS OF FUTURE DAMS

Using reservoir routing and flood simulation models, the flood control benefits attributable to future dams should be estimated. Statistical correlation of various River Flows could be used to determine the potential of introducing lag times for avoiding synchronization of River peaks through reservoirs. A variety of flow scenarios would need to be tried on the system, testing the effectiveness of dams for flood control. Benefits from reduced flood inundation, reduction of flood hazard to existing structures, lesser flood capacity for new structures, and reduced stress on existing bunds, should also be evaluated. A study on these aspects may prove highly useful.

4.7 AGRICULTURAL LAND DRAINAGE

Project plans for agricultural land drainage prepared by several concerned agencies, should be reviewed for consistency. This review should be limited to the project components concerned with storm drainage only and not with regard to subsoil drainage, salt balance or drainage of excess irrigation water. Information could then be provided to the project planners on river stages at outfall locations, and the component of drainage outflow during flood periods obtained from the project planners for use as input to river system flow simulation models.

4.8 URBAN STORM DRAINAGE

Currently, storm drainage in urban areas in the shape of an integrated network, is despicably lacking in all major cities. Besides inadequate extent and capacity of the man-made storm sewers, the natural streams (nullahs) traversing through the cities which provide the main storm drainage arteries, have been extensively encroached upon, and solid waste dumping has made them virtually non-functional. A proper final outlet to a major water way such as a river is also lacking because of insufficient pumping capabilities.

Guidelines for planning, and subsequent handling of urban storm drainage need to be prepared immediately. The guidelines should, inter alia, also include instructions for determining runoff rates for drain design, appropriate design frequencies, and relevant hydrologic information. It should further provide river outfall stage and duration information for use in construction of urban storm drainage systems.

The standing waters in the cities for days after each major rainfall, is a source of not only general pollution, but it leads to many water-borne diseases resulting in high infant mortality rate. Appropriate priority needs to be accorded in making adequate investment in this field. Required works in five important cities namely, Karachi, Lahore, Peshawar, Quetta and Islamabad-Rawalpindi should be undertaken on priority basis to alleviate flooding of streets and “Kachhi Abadies” against storms of design frequency.

4.9 NEED FOR MAJOR IMPROVEMENTS IN MAINTENANCE OF FLOOD WORKS

Any system which is not adequately maintained, leads eventually to failure. This is of particular concern in the case of river maintenance of embankments and dykes which when breach, are a source of colossal loss of life and property. There have been a number of instances where such breaches have occurred in the Main River Bunds, which could have been avoided, had proper maintenance and 24-hour patrolling and monitoring during very high floods been carried out. New maintenance and expenditure yardsticks, based upon a number of studies already conducted, need to be established, however, these yardsticks must also separately take into account the element of deferred maintenance during the initial years. These also is the dire need for greater transparency.

The PIDs often attribute bund breaches to inadequate maintenance funding. While this is also one of the factors, there are other reasons such as a lack of advance or timely action aimed at prevention which does not involve any significant expense. Traditionally, flood management is mostly confined to crisis situations. Since PIDs are far too busy and deeply involved in the operation and maintenance of the vast irrigation networks which they genuinely feel as their primary responsibility, some major institutional reforms are indicted. An “independent regulatory” system to monitor the state of flood protection works, would be of considerable help as stands already embodied in the National Water Policy (under Cabinet approval). One of the options is being proposed as described in detail in Section 3 entitled “Institutional Aspects”, to ensure better performance.

4.10 PRIORITY FLOOD FORECASTING AND WARNING ACTIONS

As discussed in some detail in the previous Sections, following are the recommended priority actions for improving the flood forecasting and warning aspects:

1. The quality and reliability of flood forecasting, using real-time data, needs to be further strengthened through installation of additional weather radars and telemetry equipment.

2. Better flood management / mitigation techniques are required through more specific and improved reservoir operation regulations to shave off flood peaks even when a reservoir is full to its capacity. This can be achieved with supplemental equipment already installed/under installation for monitoring the upstream weather conditions, together with reliable communications and staff training. In the case of full Tarbela, some space can be created in the reservoir for flood storage in advance of arrival of the peak. In Mangla, there is a provision of some 25 feet of flood storage space above the full reservoir level to absorb the Probable Maximum Flood (PMF) which is not allowed to be encroached upon for attenuation of (say) Maximum Design or Historic Floods. Cautious use can be made of this space, provided full information on the extent of precipitation in the catchment, is available.

3. Reliable Flood Routing Mathematical Models for estimating flows downstream of Rim Stations, need to be developed on a high-priority basis to give timely and

accurate warnings to the people. In the modeling, inflow from various man-made drains has also to be taken into consideration besides rivers and streams.

4. Flood Forecasting and Warning Manual containing, inter alia, village-wise gauge levels vis-à-vis various stages of flood flows along all major rivers, should be produced as soon as possible. Some work has been going on in this direction in the preceding years but it is apprehended that the Manual may not be fully reflective and, in any case, it is getting unduly delayed.

5. Medium-term rainfall forecasting mechanism based upon tracking of weather systems and monitoring of interactions between systems originating from Bay of Bengal, Arabian Sea and Westerlies (Mediterranean etc.), coupled with study of other meteorological parameters, needs to be developed and improved on a continuous basis.

6. Wherever the barrage width or the available river channel width is not sufficient to pass 1 in 200 years flood, properly built and, more importantly, properly maintained bypass flood channels, are required for safe diversion of otherwise damaging flows. These bypass channels should be equipped with proper gates, their right-of-way formally acquired, and no encroachments be permitted thereafter. Official breaching of flood embankments should then not be resorted to which causes tremendous loss of life and property, besides genuine protests from the affected people.

4.11 PROPOSED SEQUENCING

In the prevailing rather complex circumstances as discussed heretofore, a general sequencing order of the recommended actions, is given hereinafter.

Step 1 If the recommendation involving the creation of an autonomous **River Management Authority** is accepted, a pragmatic strategy has to be formulated to carry out the institutional reforms as indicated in Section 3 entitled “Institutional Aspects”. The proposed body would be fully responsible for integrated planning, development and maintenance of all water works on major rivers, including Dams, Hydropower, Barrages and indeed Flood Protection Works. Ideally, the entire Water Wing of WAPDA, the Federal Flood Commission and pertinent components of Provincial Irrigation Departments, would need to be appropriately amalgamated to form this Authority such that very little, if at all, new inductions would be required. The recommended new River Authority that may be headquartered in Islamabad, would indeed require strong presence in all the Provincial Metropolis.

Step 2 Emergency areas requiring immediate attention, evidently cannot be pre-identified. Problems emerge that need to be taken care of promptly as they arise. Government normally releases funds on demand in such situations. In case of need for subsequent additional measures, if a “Sector” type of Project approach is followed, it should enable the required degree of flexibility in obtaining Bank’s support for these works as well.

Step 3 Most of the works that are expected to remain incomplete by the ADB's cut off date, be picked up by the World Bank, of course, after proper review. Of some nine high priority projects embodied in the ADB's FPSP-II, only one, namely Mangla-Trimmu Reach of Jhelum River, is likely to be completed. The other eight are:

1.	Indus River:	Chashma – Ramak Reach
2.	Indus River:	Ramak – Taunsa Reach
3.	Indus River:	Guddu – Sukkur Reach Including Guddu Barrage Works
4.	Toba Achakzai: and Killa Abdullah Areas	Eight (8) Delay Action Dams on various Streams
5.	Pat Feeder and its Distributaries	Protection Works
6.	Soan River:	Protection of Dhok Andhrane Town
7.	D.I. Khan Hill Torrents:	Protection of Panyala and Abdul Khel Towns
8.	D.G. Khan Hill Torrents	Protection of Villages
9.	Sukkur – Kotri Hill Torrents:	Remodelling Gaj Nai and FP Bunds Including Protection of Thatta – Sajawal Bridge

Step 4 Facilitate construction of additional flood protection works following an integrated approach, rather than localized solutions. Feasibility reports of several priority schemes are ready, however, the approval process is proceeding at a slow pace. This work needs to be expedited.

Step 5 Pursue non-structural measures, including but not limited to, strengthening of flood forecasting and early warning system. Assuming that a weather radar at Mangla would have been installed by June 30, 2005, as a part of the ongoing FPSP-II Project, additional weather radars are required according to the following sequencing:

a. Murree
b. Quetta
c. Multan
d. Peshawar
e. Pasni

Step 6 There is dire need for preparing a comprehensive Flood Forecasting and Warning Manual, embodying a mechanism of determining village-wise gauge elevation forecasts corresponding to various flood magnitudes, rather than issuing “High Flood” and “Very High Flood” warnings at only a few river structures such as Barrages, the implications of which are not readily understood even by literate people, let alone the potential village affectees.

Step 7 Optimize reservoir operational regulations to ensure prudent and timely decisions to attenuate flood peaks.

Step 8 A special study needs to be carried out to explore dredging, flushing and/or removal of accumulating sediment from the river beds, particularly in the Lower Indus, to reverse the process of rising river levels. The current management by progressively raising the protective embankments, is certainly not sustainable.

Step 9 Undertake comprehensive storm drainage works in urban areas, namely, Karachi, Lahore, Peshawar, Quetta and Islamabad-Rawalpindi to alleviate flooding of city streets and “kachhi abadies”.

It would be appreciated that “Flood Control and Management” field is not a development process that may lend itself to strict sequencing. Many of the aforementioned steps could be, and indeed should be, undertaken concurrently rather than consecutively.

5. NEED FOR WORLD BANK’S ENGAGEMENT

5.1 PAST FINANCING OF FLOOD PROTECTION WORKS

In early 1990s, the normal annual investment in Flood Protection Works by the Government of Pakistan was limited to merely Rs. 25 million to Rs. 100 million. On the other hand, the need for additional works was so large that on top of the ADB’s Flood Protection Sector Project (FPSP-I) and the counterpart Pakistan’s own contribution of 20%, additional sums ranging from Rs. 400 million to Rs. 750 million, had to be provided in the years 1994, 1995 and 1996, as special Prime Minister’s grant (a rare source of budgetary funds) to meet the costs of vital flood protection works. As stated earlier, these amounts were on top of the ADB-financed Rs. 3.4 billion worth of flood protection project that was then concurrently under way, but inclusion of schemes in the river reaches not already-identified in the ADB Project, was not possible.

World Bank had also earlier financed two (2) major projects, namely, “Flood Damages Restoration” works, when massive flood damages to infrastructure took place in the years 1976 and 1988.

Subsequent to these works, and when the ADB’s FPSP-I package had been successfully completed, ADB and the Government of Pakistan initiated arrangements for another credit line in 1997 in the sum of US$ 140 million to finance the second Flood Sector Protection Project (FPSP-II). Under this project, besides structural and non-

structural components, master plan for flood protection projects was also to be updated. The work was initiated in year 2000, however, only a small portion of the intended work has so far been accomplished while the ADB is steadfastly holding on to the prescribed cut off date of June 30, 2005. A lack of success is mainly attributable to the following factors:

(1) The new Government was not satisfied with the rather large component of consultancy services, studies and other non-structural works. They preferred major investment to go into the flood protection infrastructure instead. The Project remained in the suspense state while reformulation was under way. The reframed project was reduced to almost half the size and it was only in March 2003, that both the Government and the ADB agreed to support the curtailed project.

(2) ADB were of the view that the skeleton staff of the Federal Flood Commission was not sufficient for Project Management, that is, to provide the necessary guidelines to the complex work containing diverse activities such as updating of master plan, river modeling (analogue as well as digital), installation of weather radars, heavy construction of new flood protection embankments, spurs, stone aprons, under-water revetment works, Digital Terrain Modeling (DTM), preparation of comprehensive Flood Forecasting and Warning Manual, training/human resource development, and a number of vital studies and some applied research work for improving the design and maintenance standards of flood protection works. They were of the view that coordination with the Provinces was also lacking. In the reframed project, the role of General Consultants aimed at assisting the Flood Commission, was altogether eliminated, to the disappointment of ADB.

(3) The paybills of foreign consultants, namely Delft of the Netherlands, were not cleared for years, and the ADB was not satisfied with the allegedly unwarranted withholdings.

(4) Notwithstanding the time taken in reformulating the project and its subsequent clearance by GOP and ADB, the pace of progress over the productive time span available, had been extremely slow.

(5) ADB's clearance of the Reformulated Project, was subject to two provisos, (a) that full commitment of the Government at higher level would be behind the project implementation and (b) that full achievement of the reframed project has to be attained by the cut off date of June 30, 2005.

(6) It is also relevant that late nineties were, perhaps, the most demanding and unmanageable years due, among other factors, to a serious rupee constraint.

5.2 WORLD BANK' INVOLVEMENT

Pakistan continues to face financial constraints. Of the limited resources, any substantial funding for Flood Control and Management is bound to correspondingly reduce

availability of funds for other vital sectors. While there does not appear to be the need for any elaborate justification of the requirement of financial assistance, the main question would be why from the World Bank or jointly from World Bank and ADB?
It is very well-recognized that the World Bank, due to its tremendous past experience vis-à-vis Pakistan, has a major comparative advantage in participating in the water sector programme. Bank's historic role in the Indus Basin Settlement Plan, was phenomenal and will remain a classic example for times to come. Furthermore, the Bank is a highly credible knowledge institution and investment in "Flood Control and Management" is perfectly in line with the goals and strategies of the Bank as published in their guidelines. Flood protection works especially aim at providing safety to low-level and thus low-value-flood-prone agricultural lands owned largely by the poor. The proposed programme would thus contribute substantially towards poverty alleviation which is a very high priority objective of both the Government of Pakistan as well as the World Bank. The Bank also emphasizes this aspect when it states in its recently-published Water Resource Sector Strategy that **"it is usually the poor people who inhabit degraded landscapes"**.

World Bank's engagement is particularly considered necessary when it comes to the proposed Institutional Reforms which are very difficult to effectively implement. Besides the Government's high-level commitment, as the Bank is aware, a well thought out strategy is required defining prioritized set of actions and an appropriate incentive system for leaders who have to assume the risks. Here again the Bank's, engagement would have a superior advantage.

Finally, since flood problems are being faced by a large number of countries the world over, the Bank's international experience in the way flood management and protection infrastructure is being developed by others, would be highly useful for Pakistan.

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Drainage and Salinity Management

By

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Country Water Resources Assistance Strategy
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1. INTRODUCTION

Essentially all critical drainage and salinity management issues in the country are confined to the Indus Basin and are related to irrigation. Some drainage and salinity problems also occur in rainfed lands and small irrigation schemes outside the Indus Basin in Balochistan and the NWFP but these problems are mostly of a a minor order and of a different nature (mostly watershed management problems). For enhanced focus and coherence, the scope of this paper will be restricted to the drainage and salinity problems encountered in the large irrigation commands of the Indus Basin.

In the arid zone and alluvial plain type of climatic and geomorphological settings as prevail in the Indus basin, drainage and salinity management are always two closely related disciplines as under the prevailing conditions, salinity control and sustainable irrigated land use depends on proper salt leaching, drainage and disposal. However, not all drainage requirements in the Indus basin are salinity-related as drainage is also needed to protect agricultural land, residential areas and civil infrastructure against harmful inundation and flooding. Many open drains also serve as recipients of polluted household and industrial water. Undesirably though this latter use of the drains may be, it occurs and for the time being it has to be dealt with.

The focus of the paper, however, shall be on the waterlogging and salinity control of the irrigated land and the role of drainage as one of the principal tools to achieve this control. Waterlogging and salinization of the irrigated land of the Indus Basin has been combated for almost a full century and although progress has been made some 10-15 % of the land is still seriously affected. The direct annual agricultural damage (not counting the lost opportunities of more profitable land use) is estimated to be in the order of PRps 20 billion per year. Waterlogging and salinity has also adversely affected public health and sanitary conditions in the villages, undermined the foundations of buildings and led to the collapse of farm-houses, deteriorated road conditions and/or materially increased road maintenance costs. Survey results have also confirmed negative impacts on rural welfare and well-being.

2. PREVAILING CONDITIONS

Irrigation in the Indus Basin has a long history, stretching back to Indus civilizations of over four thousand years. Early irrigation relied on inundation canals which watered narrow strips along the river banks during the flood season. By the construction of barrages and reservoirs, increasingly more river water was diverted and increasingly more land was irrigated. The Tarbela storage reservoir, completed in 1976, added some 50% to available river water for the Rabi season. The river diversions vary per year, depending on the rainfall in the Himalayan cachment and available storage.The present system is schematically shown in Figure 1. Opportunities for further expansion exist but these are quite limited as in future more water will be needed for other purposes.

The extensive use of groundwater for irrigation started with the installation of public tuewells in the 1960's, soon to be followed by the explosive development of tubewell installation by private farmers (some 700,000 at present and still growing at annual rate of 1-2%). The annual groundwater abstraction under the current drought conditions has estimatedly increased to 55 MAF (68 BCM) which compares to a estimated groundwater recharge of about 60-65 MAF (74-80 BCM). Only some 7 MAF of this recharge comes from direct rainfall while all the other recharge i.e. 90% is made up by the high irrigation water losses.

Based on the above mentioned figures for the CCA (41.2 Mac) and available irrigation water (111 MAF, counting only the river water and the groundwater recharge by rainfall), the applied gross irrigation delta comes to 2.76 ft (810 mm). Rainfall retained in the rootzone effectively adds an estimated 200-300 mm to the crop water availability in the North and some 50 mm in the South. In view of the high ET and severe salinity environment under which the irrigated agriculture in the Indus plains is practiced, the available water is clearly not sufficient for basin wide, year round high intensity cropping.

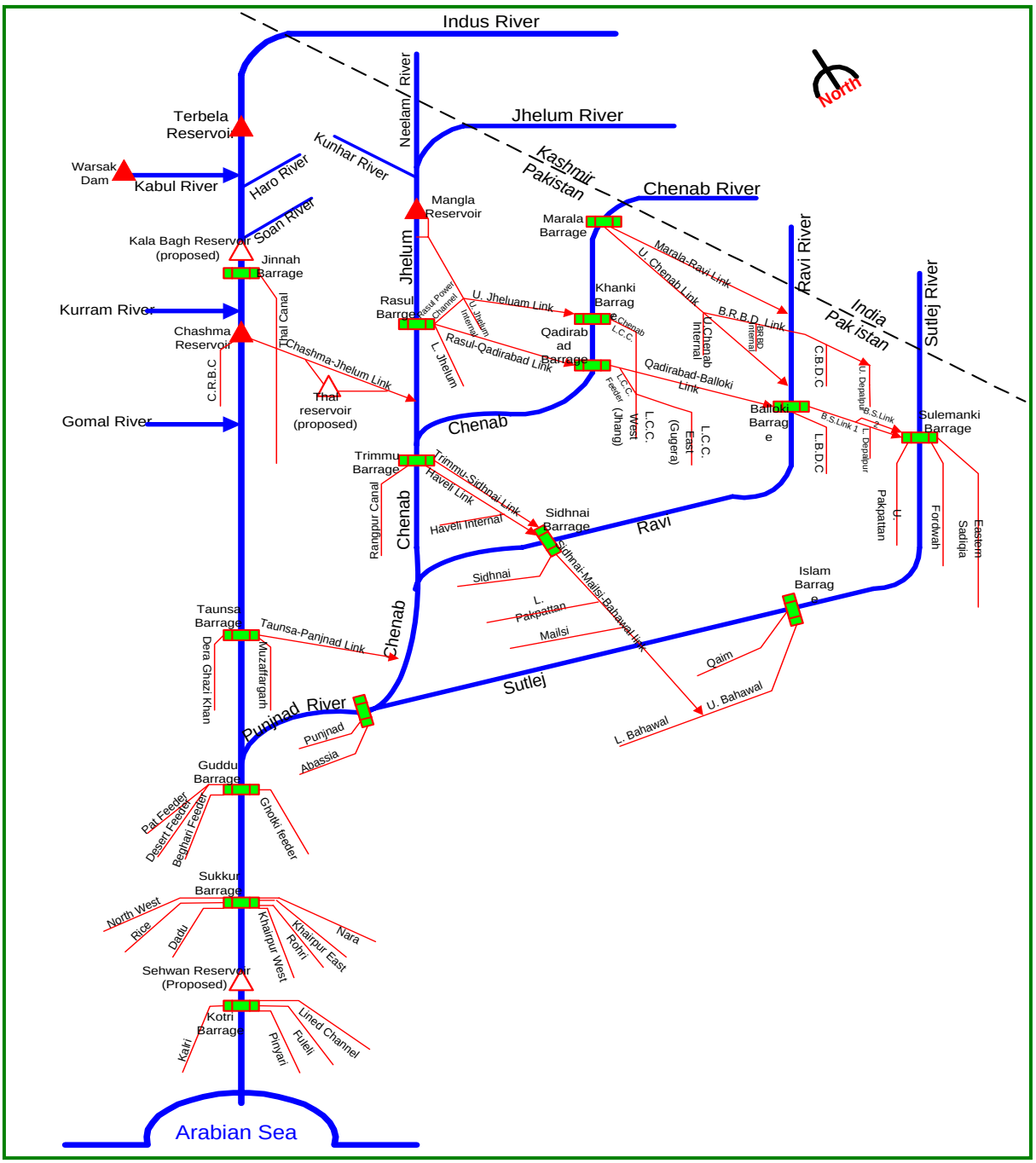

Figure 1 : Schematic diagram of the Indus Basin Irrigation System

Differences in river water allocation between the provinces as laid down in the Water Accord, regional differences in fresh groundwater availability, inequity in the water distribution within the commands account for considerable variation in irrigation water availability within the basin.

Apart from the many flagrant exceptions sustained by locally prevailing political/social power structures, farmers have generally adapted cropping patterns/intensity to the water availability expectations.

2.1 Drainage

When the Indus lands were developed for irrigation, the drainage needs were initially quite minimal. Watertables were deep and irrigation water supplies were too low to generate much groundwater recharge and surface losses. Whatever little drainage was required, could readily be accommodated by the existing natural drainage of the land (groundwater drainage to the rivers and excess rain and irrigation water migrating towards the natural depressions and few existing natural surface drains).

The drainage needs, however, increased over time as more and more irrigation water was supplied and watertable rose to harmful levels. The present drainage systems shown in Figure 2, have been mostly developed over the last 30-40 years. In total some 15,464 km of surface drainage has been constructed (a density of some 0.8 m/ha). The groundwater levels are controlled by 16,724 public TWs and the earlier mentioned 700,000 private TWs and by some 12,612 km of pipe drains (the latter serving a total GCA of 0.94 Mac (0.38 Mha). The present drainage infrastructure is, however, not sufficient to meet current drainage needs. Considerable prolonged flooding and ponding still occurs as the surface drainage system is not dense enough to connect all depressional areas to main drains. The functioning of many surface drains is also adversely affected by various types of flow blockages and poor maintenance. The provided subsurface drainage also needs to be extended to cover more of the waterlogged and salinised land.

The present reservoir capacity on the rivers is insufficient for full flood control and flooding is still a recurrent phenomenon causing considerable damage throughout the basin. During the last 20 years, 7 serious floods have occurred. The devastating flood of 1992 affected some 13,000 villages and caused the death of 1,008 people. High intense local rainfall and lack of sufficient storm drainage and outfall capacity also cause considerable local flooding and waterlogging. The latest of these local events occurred in Sindh during July 2003 when large areas of the Kotri

Command became inundated for up to several weeks, crops were lost, houses and infrastructure were damaged and public health conditions badly deteriorated (causing more than 100 deaths in Badin District).

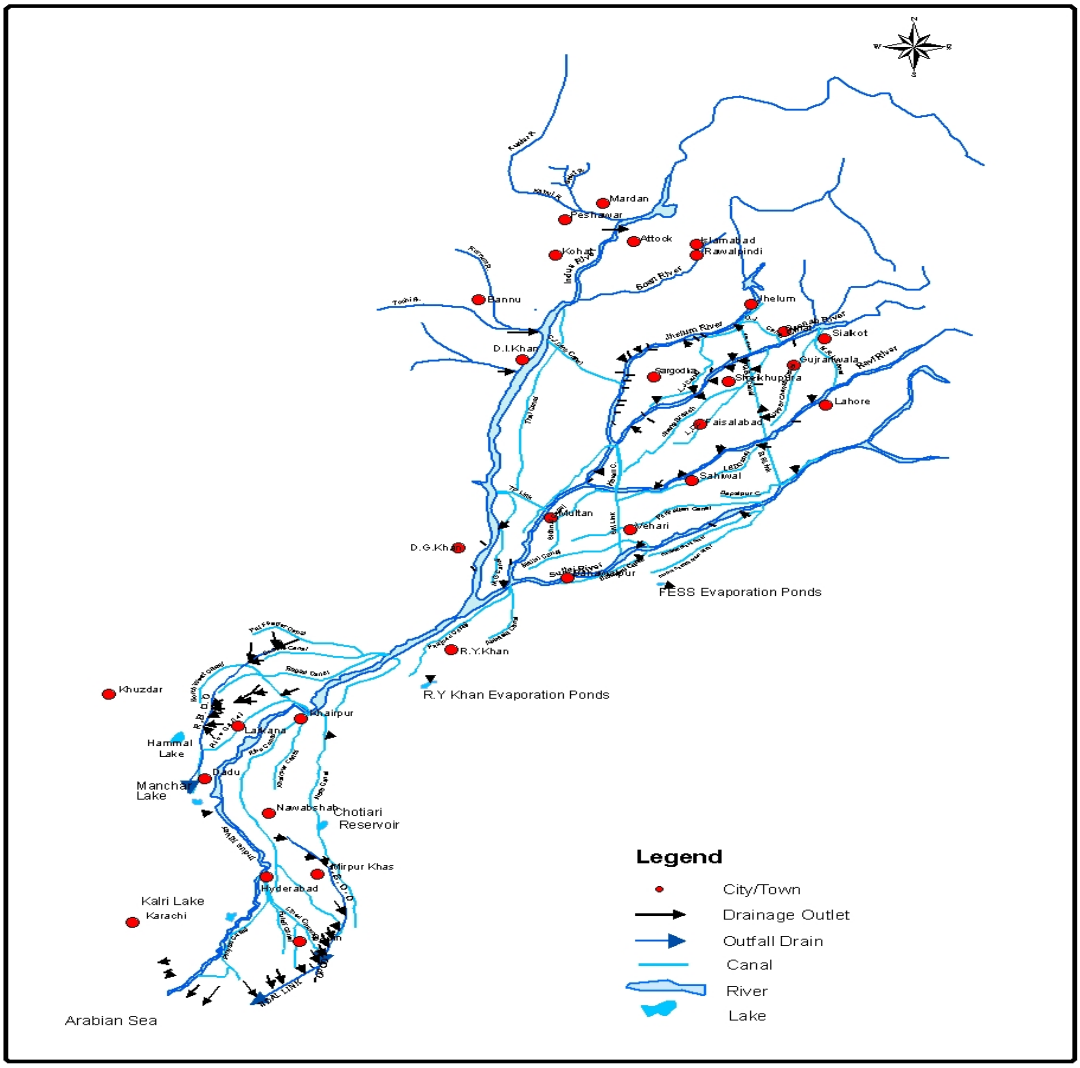

Figure 2: Indus Basin Drainage System

2.2 Salinity

The salts presently occurring in the Indus Basin are of different origin. Firstly there are the fossil salts deposited during the drier period in the geological formation of the Indus plains. These salts occur at various locations and depths in the substrata and in the groundwater. Most of the fossil salt is safely stored in the deeper substrata but some is mobilised by the ongoing TW pumping and by the deeper groundwater flows. These mobilised salts then become part of the salt dynamics of the rootzone and underlying shallow groundwater zone, mixed with the other salts.

Secondly there are the marine salts originating from the deltaic alluviation of much of the Lower Basin. While in the oldest more inland deposits, the upper soil/groundwater layers may over time have become partly desalinised, the marine salts are still strongly present at shallow depth in the younger lands of lower Sindh. Finally there are the salts imported by the Indus irrigation water. Although this water is mostly of low salinity (only some 200-300 ppm at Tarbela and other rim stations), it nevertheless adds some 1.5-2.5 tons of salt per ha per year to the irrigated land. Minor salt sources (released by mineral weathering, imported by fertilizers and rain, etc) are generally too insignificant to be considered in the salt management planning.

Most of the groundwater in the higher rainfall and naturally better drained lands of the Upper Basin is fresh (FGW). Pockets of saline groundwater (SGW) occur but these are mostly confined to the central parts of the doabs, to areas near saline rocks and to the desert fringes. The occurrence of saline groundwater becomes more prevalent towards the Middle and Lower parts of the basin while almost all groundwater in the deltaic marine zones near the sea is highly saline (with the exception of small fringes along the rivers). In some parts of the SGW zones with good drainage and heavy fresh water recharge, thin fresh water lenses may be found on top of the deeper saline groundwater which lenses under careful pump regimes may be used for irrigation and/or drink water supply.

3. IRRIGATION INDUCED WATERLOGGING AND SALINISATION

First signs of waterlogging and salinisation of the irrigated lands (soon widely dubbed as the *twin problem*) of the Indus Basin were reported in 1851 in the Western Jummu Command, soon to be followed by similar reports from other Punjab commands. To monitor the rising groundwater

tables, some 14 lines of open watertable observation wells (called *provincial well lines*) were installed across the doabs of the Punjab, some of which lines were later extended to Bahawalpur area. Some records are available since 1882, but systematic observations started in 1886. In Sindh 3600 watertable observation pipes were installed in the command of Sukkur Barrage and recording started in 1932. The Punjab lines have registered one of the historically most remarkably men-induced hydrological regimes changes (Figure 3).

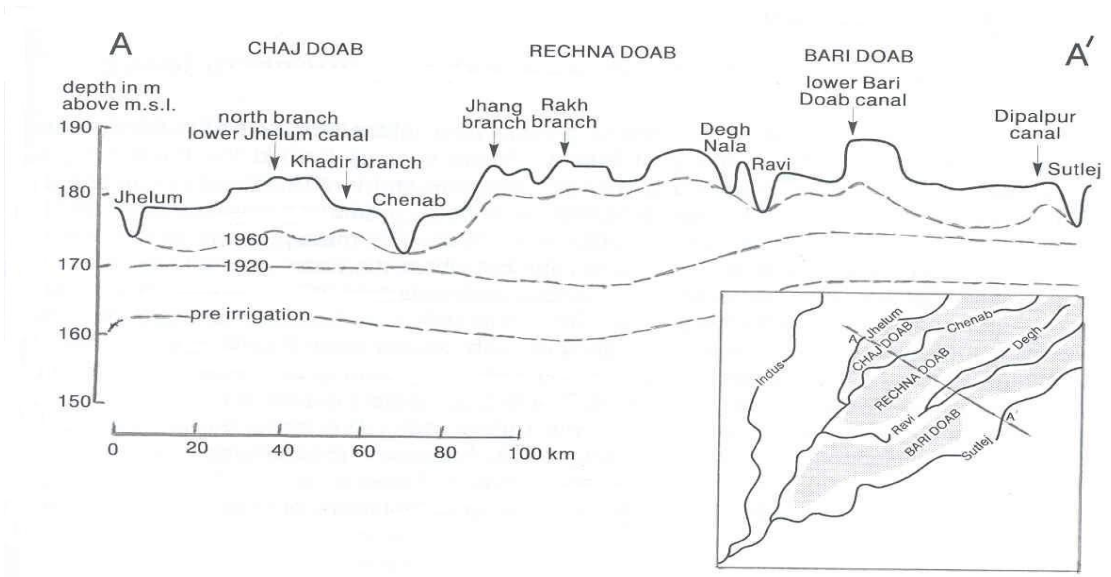

Figure 3. Irrigation induced rises of the watertables in a cross-section over the irrigated land of Northern Punjab, 1860-1950

3.1 Inherent Environmental Hazards

Given the arid zone climatic conditions and alluvial plain type of geomorphological setting in which irrigation in the Indus Basin was developed and the applied large scale river diversion/unlined canal type of irrigation conveyance/distribution technology, the occurrence of large scale waterlogging and salinisation of the irrigated lands actually was to be expected. In the 1850-1950 period over which much of this development took place, insight in the basic causes of irrigation induced waterlogging and salinisation, however, were still quite limited, specially during the early period. Experiences from elsewhere (California, Middle East) provided little guidance as there engineers were similarly struggling for control.

Due to differences in annual rainfall, geological history and geomorphology, conditions in the northern part of the basin (Punjab) were actually less hazard prone than in the South (Sindh). Due to its more elevated position, older age and natural better drainage/leaching conditions, upper soil strata in the North were mostly salt free. Here, the nature of problem was more waterlogging than salinisation. The latter problem was mostly restricted to areas where in the geological history of these plains, outcropping saline rock formations or pockets of fossil salts had been formed.

As mentioned earlier, much of the southern part of the basin (most of Sindh) was formed by alleviation in the Arabian Sea with much of the entrapped marine salts still remaining at shallow depths in the soil, substrata and groundwater. Three successive delta stages have been identified, the latest more or less coinciding with the present Kotri command area. Under the prevailing low rainfall and natural poor drainage conditions (low elevation above MSL, flatness and poor tidal outfall conditions), little leaching occurred with soils remaining highly saline at shallow depths and groundwater highly saline to great depths. Natural salinity conditions in the Middle Basin (lower part of Punjab and upper parts of Sindh) were transitional to the Upper Basin and the Lower Basin.

The expansion of the unlined canal systems (the main source of the increased groundwater recharge) and rise of the watertables, reached its peak in the 1940-50ties and the twin problem reached its peak some 15-25 years later in the 1960-80ties, (the time span over which the generated deep percolation losses could safely be stored above the originally deep water tables). Expansion of the canal irrigation came to a standstill in the early 1980's and as groundwater rises, even in the latest developments, have reached their equilibria, no further expansion of the affected area is to be expected. On the contrary, under the impact of the remedial measures taken, the area is shrinking.

3.2 History of combat

The combat of the waterlogging and salinity problems started in earnest in the early part of the 19th century, first in the Punjab (which established a Drainage Board in 1917), latter also in the other provinces. A range of remedial approaches, programs and measures has been applied, with variable impacts. The affected area reached its maximum extent in the 1970-80ties when up to 20-30% of the irrigated lands in the Indus Basin were reportedly under serious threat of loss of

productivity. The recent waterlogging and salinity statistics, however, indicate that the past trends of annually increasing affected areas, have come to a halt and in large parts of the basin are even on the reverse (Figure 4). While most of the latter may be attributed to the various preventive and remedial measures undertaken in the past (discussed in the next chapter), the reverse is at least also partly due to the prevailing drought conditions of the last 4-5 years.

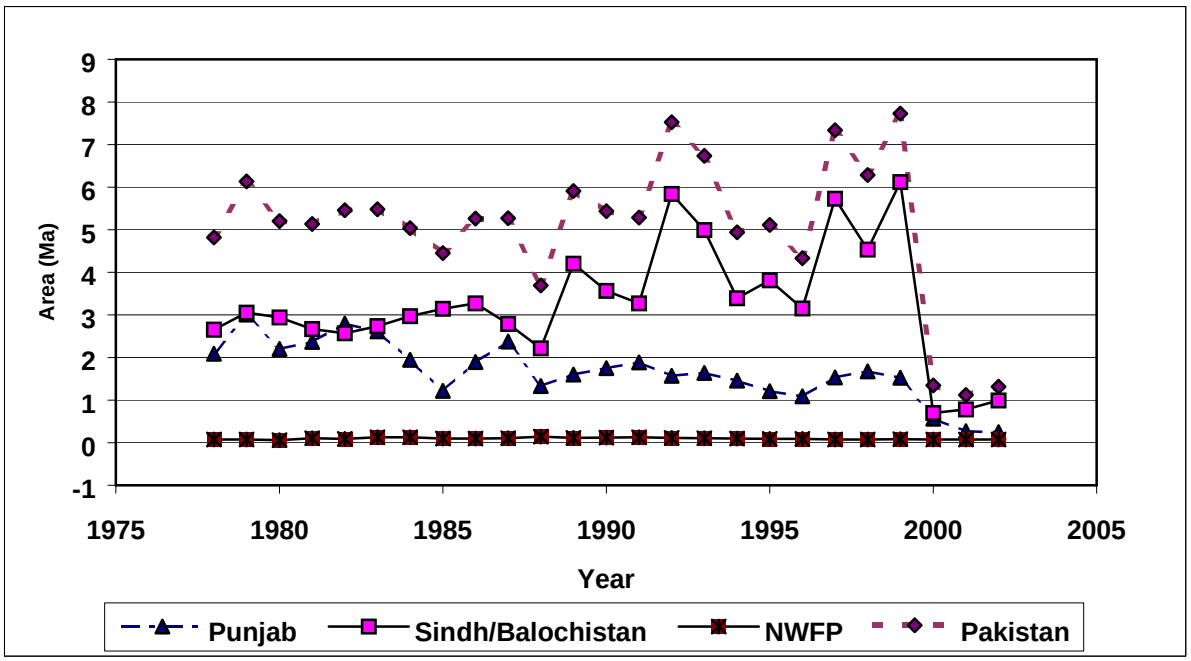

Figure 4. Long term trends in the extent of the severely waterlogged area (pre-monsoon watertable at depth of < 150 cm)

Especially the extent of the waterlogged area has decreased, with currently only some 10% the land being classified in the disaster category (pre-monsoon groundwater table depth of < 150 cm). The impact of the present drought conditions on the soil salinity has been less apparent in the recent salinity statistics. The seriously affected area is currently indicated to be in the order of some 10-15%. By far the most of the waterlogging and salinity affected area is located in Sindh province.

Sodicity was always combated alongside with salinity, using gypsum were appropriate, but has recently drawn separate attention as the widespread use of low quality tubewell water is conceived to pose serious future sodicity hazards.[1]

4. REVIEW OF REMEDIAL APPROACHES AND MEASURES

The history of waterlogging and salinity control of irrigated land in the Indus Basin by now covers almost a century long period (1900-2000). Underlying rationales and the conceptional and technical soundness of the followed approaches and applied measures as well as lessons learned have reviewed in this chapter. Relevant specifics of the undertaken projects and studies have been provided in Annex 1.

4.1 Technical measures I (water balance interventions)

Recognising that rising watertables and related waterlogging and salinity problems are due to groundwater recharge exceeding the groundwater drainage, quite properly most measures have aimed at restoring the groundwater balance. The applied specific measures may be grouped as:

Reducing canal seepage losses, with the applied measures ranging from: lowering of FSL's and canal closure, installation of interceptor drains/tubewells, tree planting (bio-drainage) and canal lining. These measures were amongst the first applied, mostly by the Punjab Irrigation Department (PID) and mostly at small pilot scale. Interest faded when evaluation showed that most of these measures were either impractical (lowering FSL/canal closure), had a low effectivity (interception, bio-drainage, lining) and/or had a high cost (lining). Interest faded further when most of the losses started to be retrieved by the spreading of the TW pumping. The measures still have some relevance in the SGW zones but even there, present application is minimal (although some lining and interceptor measures have until quite recently been included in some SCARP and other WAPDA projects).

Reducing on- farm deep percolation losses: most of these measures are based on the work done at the Mona station in collaboration with Colorado State University during the early seventies

[1] Saline Soil: The soil for which the conductivity of saturated extract is more than 4 dS/m and exchangeable Sodium percentage is less than 15.
Sodic Soil: The the soil for which exchangeable Sodium percentage is more than 15.

(water course lining, land leveling and improved on-farm irrigation). Especially the first two measures have been widely implemented, either as dedicated projects or as components of SCARP or other Provincial or Federal projects. In all cases, implementation was done of the PDA-OFWM ‘s, mostly in Punjab. Farmers were found to value the measures more for the water saving than for the impact on waterlogging and salinisation of the lands. Little is known on the present state of the implemented measures and their lasting recharge reduction impact. Even though some of these OFWM measures has lost some of its former relevance in the pumped FGW zone, they remain valid for other reasons (improved yield, rationalization of farm operations). The measures are still applied either as provincial projects or as components of SCARP projects.

Improved surface drainage: this measures was conceived to provide better crop drainage (less ponding/inundation) but also reduce the groundwater recharge and thus help to keep water table down. (watertables are known to rise pronouncedly during the rainy season). As such improved surface drainage (mostly rehabilitation of existing systems) was incorporated as a standard component in many SCARP projects. Significant benefits on both accounts have been observed but lasting impact was often not achieved as drains could not be properly maintained. For optimal results, the existing surface drainage systems also would have to be densified so as to provide outlet for the many medium/small size depressions which are presently not connected with the main system.

G*roundwater drainage by TW pumping:* although most of the involved TW’s were actually installed for irrigation purposes, this measure by far has been the most effective intervention which has lowered watertables to safe depth in almost all FGW zones in the Punjab and also in most other provinces. Where the originally installed public TW‘s became non-operational, their function in most FGW zone had in most cases already been taken over by the private TW’s. Present Govt. policy is not to replace any public TW, not in the FGW zones where they clearly are no longer needed but also not in the SGW zones as here watertables in future are planned to be controlled by pipe systems which mine less of the fossil salts and as such reduce the salt water loading of the disposal drainage systems

Groundwater drainage by pipe drainage: in the SCARP projects, this measure was identified as the technology of choice for SGW zones in which substrata conditions were unsuitable for TW drainage. As such it was first introduced in the 1970-ties in the Khairpur area. This project and also some of the other early pipe drainage projects suffered from inexperience and technology challenges but these were largely overcome in the more recent projects. Further application will, however, be quite selectively. Where pipe drainage is not feasible, other solutions based on low costs partial watertable control by open drains and/or bio-drains and adapted land use (saline agriculture, forestry, fishery, etc), will be advocated.

4.2 Technical measures II (reclamation of salinised land)

The reclamation approach was mostly applied on a small scale (single farms or blocks of farms), under the guidance and with technical and finacial support of the provincial DoA's. In most cases, satisfactory levels of reclamation could be achieved using low costs conventional leaching methods but in incidental cases other (suuporting) methods have also been used (breaking of hard pans, application of filter mud from sugar factories, planting of deep rooting tolerant grasses, etc). Where necessary, extra irrigation water was made available to the involved farmers (usually supplied from a public tubewell). Where necessary , gypsum, (abundantly available in the country) was provided at subsidised rates. In such cases (low value difficult reclaimable land), faremers are also advised to adopt saline agricultural practices (see also discussion of reseach results and Drainage Master Plan furtheron)

4.3 Policy/institutional measures

Although the earlier described waterlogging and salinity problems and the underlying shortcomings in the drainage technology and in the drainage and salinity management are mostly of a technical nature and call for technical interventions, some of these problems and shortcomings can to some extent also be alleviated by adopting appropriate policies and institutional reforms. Conducive policies and institutional arrangements is some cases could also act preventive by discouraging undesired water management and cropping practices and/or promote the proper implementation and effectivity of the technical interventions. Measures taken in this respect have been reviewed in this section. The use of policy/institutional measures started

much later and have been applied less widely than the technical measures. There are also fewer solid long term impact evaluations.

Irrigation management: major policy and institutional reform measures were initiated under the National Drainage Program (1995-2004) and although most of these measures were not specifically designed to combat waterlogging and salinity, they certainly were expected to contribute. The Provincial Irrigation Departments (PIDs) are planned to be transformed into PIDA's (Provincial Irrigation and Drainage Authorities) while the O&M of the various canal systems to be entrusted to self-accountable Areas Water Board (AWB), which in turn would entrust the O&M of the distributaries and minor canals to Farmers Organizations (FOs). These reforms are at different stages in different provinces. Formation of AWBs and FOs are in progress although progress remains slow. At present, the O&M of the irrigation and drainage infrastructure in most provinces continuous to be undertaken by the PID's and, in fact, in most provinces, except for Sindh, the programme of reforms, has stalled.

Pricing and subsidies: water pricing has been advocated by various groups as an instrument to combat over-use of irrigation water but is for as yet not been applied as such in Pakistan. Present water use is to some extent accounted for in the variable water rates (abiana) per crop (higher rates for high delta than for low delta crops) but the rates are too low to have any impacts on the water use by the farmers.

TW pumping is heavily subsidised, especially the public TW pumping have always been a heavy burden on the meagre financial resources of the PIDs. Fortunately many have become non-operational while policy is that all public TW will be phased out. Private tubewells are also subsidised, mostly by the provision of low costs electricity connections and favorable electricity and fuel rates. Although this subsidizing was motivated the wish of lowering farmer irrigation costs, it should be duly realised that most of these wells also perform a welcome watertable control and thus waterlogging and salinity control function.

Subsidies are also widely used to encourage the adoption of desirable land and water management practices (subsidising land levelling, water course lining, on-farm surface drainage,

use of gypsum and other OFWM improvements). Reclamation of salinised land, adoption of bio-saline agriculture are also encouraged by providing low costs loans, low costs renting of equipment and free technical assistance. Most provinces have this type of policies, usually implemented by the PDA's, although specifics may vary somewhat per provinces. These measures have had little impact at the national level, even though local impacts may been quite significant.

4.4 Implementation

Although the implementation of the involved projects had their shortcomings, these can generally not be held responsible for their lack of success. In fact most of the success failures were inhearent to the project design and/or in the project implementation plan. Considering the rapidly changing technical approaches, the engineering performance has actually been reasonably up to standards. The engineering shortcomings, if any, were mostly arising from the unfamiliar technological requirements of the projects (rapidly changing from interception to TW drainage to pipe drainage technologies). More disruptive to the implementation were the shortcomings in the timeless and adequacy of the budget and in the project/contract administration.

The most glaring shortcoming in almost projects was that the project were planned, designed and implemented without consultation with the stakeholders and with the future project operators. Most projects were planned, designed and implemented by WAPDA (usually heavily relying on consultants) and after completion, without much prior involvement and without proper budget provisions, handed over to the concerned PID. Not surprisingly, many of the handed-over projects were not operated and maintained to planned standards, did not achieve the planned targets and at the end were not sustainable. This has unfortunately been the recurrent history and fate of too many projects, except for the private TW projects

4.5 Research and monitoring

Research and monitoring has contributed significantly to steering the general approach of the combat and to the design of the instrumental measures. Specific mentioning is made of the following contributions:

Hydrogeological investigations: the mapping of the geo-stratification of the Indus sediments actually formed the basis of the successful TW programs

Mona/Colorado: all the mentioned OFWM programs were based on this work. Research results were translated into fairly detailed packages, ready for implementation.

IWASRI: has been particularly successful in operational research tied to ongoing WAPDA investment projects (Drainage IV project, FESS project; specifically to be credited for the following contributions:

- sharpening of the pipe drainage design criteria (drainage coefficients, drain depth, envelope design, construction technology.
- development of the SGMP groundwater modeling methodology for assessing natural drainage conditions and evaluating alternative drainage approaches.
- guidelines for the design and assessing the impact of interceptor drains meant to control canal seepage losses.
- pioneer work on the highly successful project scale application of saline agriculture and bio drainage, including the demonstration of best practices for participatory project design, implementation and management.

Monitoring:

SCARP Monitoring Organization, WAPDA has installed observations wells throughout the irrigated area for monitoring of watertable depths. Measurements are taken twice a year i.e. before monsoon (April-June) and after monsoon. River water qualities are also measured. Groundwater qualities are measured in projects only. Environment monitoring initiatives have been taken at provincial and Federal level but are not regular.

5. DRAINAGE MASTER PLAN

During the last two years WAPDA (Planning Divison) and IWASRI have been working on the prepartion of a Drainage Master Plan (DMP) which would guide the medium-term drainage development and waterlooging and salinity control in the Indus Basin. A draft version of the

DMP was reviewed by a joint International/National Panel of Experts (POE) during October 2004.

The DMP extends over a total area of 4,87 million acres (about 12 % of the irrigated land in the Indus Basin), roughly half-half divided over the FGW and the SGW zones. It covers all of the 4.68 million acres of severely waterlogged land (disaster land with pre-monsoon watertable depth of <150 cm), most of which land is also severely salinized. Although it does not cover all salinized land, this DMP would clearly go a long way to bring almost all of the severest affected land under control.

In the NDP the Indus Basin is subdivided in 20 regional drainage basins (see Figure 5) in which a total some 50 drainage projects have been formulated. Drainage problems in the FGW zones are planned to be addressed by the promotion of private sector TW development while for the SGW zones, three types of drainage measures are foreseen (improved surface drainage, pipe drainage and bio-saline agriculture each resp covering some 61%, 30% and 9% of the covered area). The recommended priorities are: 1) improved surface drainage, 2) pipe drainage, 3) private TW development FGR zones, 4) bio-drainage/saline agriculture solutions for land which cannot feasible be improved by conventional methods**.**

The DMP is estimated to generate an average saline drainage discharge of 1,155 cusecs (32.7 m3/s). The salinity of this drainage water varies considerably for the different drainage basins (3,000-6,000 ppm in the North up to 12,000 ppm in the South). In total, the DMP is estimated to generate an annual salt load of 6.2 million tons, made up by 0.7 Mt from Punjab, 0.1 Mt from Balochistan and 5.5 Mt from Sindh. This salt load can be disposed off without the need for a transboundary outfall drain (TBOD) as the salt load generated in Sindh and Balochistan can readily be disposed via the existing/planned LBOD and RBOD outfall drains while the Punjab salt load be accommodated locally.

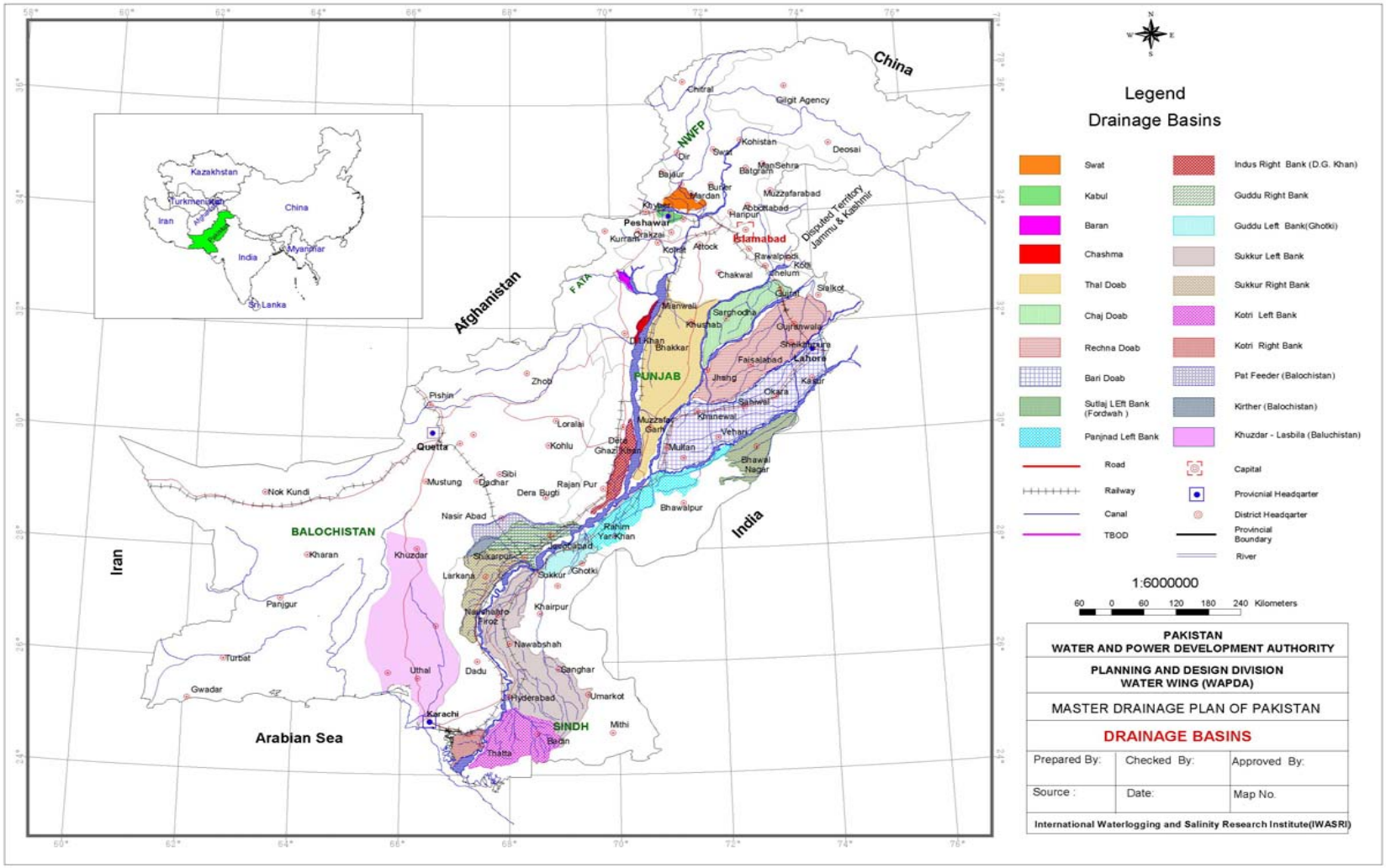

Figure 5. Drainage Basins of the Irrigated Area of the Indus Basin / Flood Irrigation Schemes of Balochistan.

6. UNSOLVED CRITICAL ISSUES

This chapter presents an analysis of the current strategically most critical drainage and salinity management issues and of the available option to address these issues. As such it provides the background for the proposals made in Chapter 7.

6.1 Institutional reform

The reason for the present stagnation in the full implementation of the NDP initiated institutional reforms varies per province. In some cases, it may not be more than a needed pause for evaluation, reflection and stock taking. In some provinces, however, it is a sign of unresolved poltical debate and decison making. Some improvments in the institutional organisation and management of the irrigation and drainage sector at the provincial level is, however, needed as without such improvements the financial sustainability of the irrigation and drainage infarstructure remains in jeopardy.

6.2 Salt Balance and Salt Mobilisation

The available salt balance data for the Indus Basin clearly indicate that the rate at which salts are imported by the river irrigation water and mobilised by the pumped tubewell water for exceeds the rate at which salts are being disposed to the sea, evaporation ponds or to other ultimate salt sinks (see Figure 6).

Clearly, on aggregate salts are accumulating in the basin at a quite alarming rate. Salt balance calculations at the basin level of course show the aggregate result of a wide range of salt movement conditions and processes and as such these results may be overly alarming or disguising. Not all of the ongoing salt accumulation in the basin is necessarily harmful and a much more detailed understanding and quantification of the salt dynamics of the basin and mapping of the accumulation sites is necessarily before the significance of these alarming salt balance figures can be fully assessed and needed remedial measures can be defined and planned. For a start, this could be done by breaking down the Indus Basin salt balances into separate salt balances for the main commands and drainage basins. In this break-up, efforts could also be made to quantify some of the so far neglected underground salt flows (from the bordering mountain ranges, to the sea/rivers/deserts), salt removal by storm drainage and salt mobilisation/immobilisation by geochemical processes.

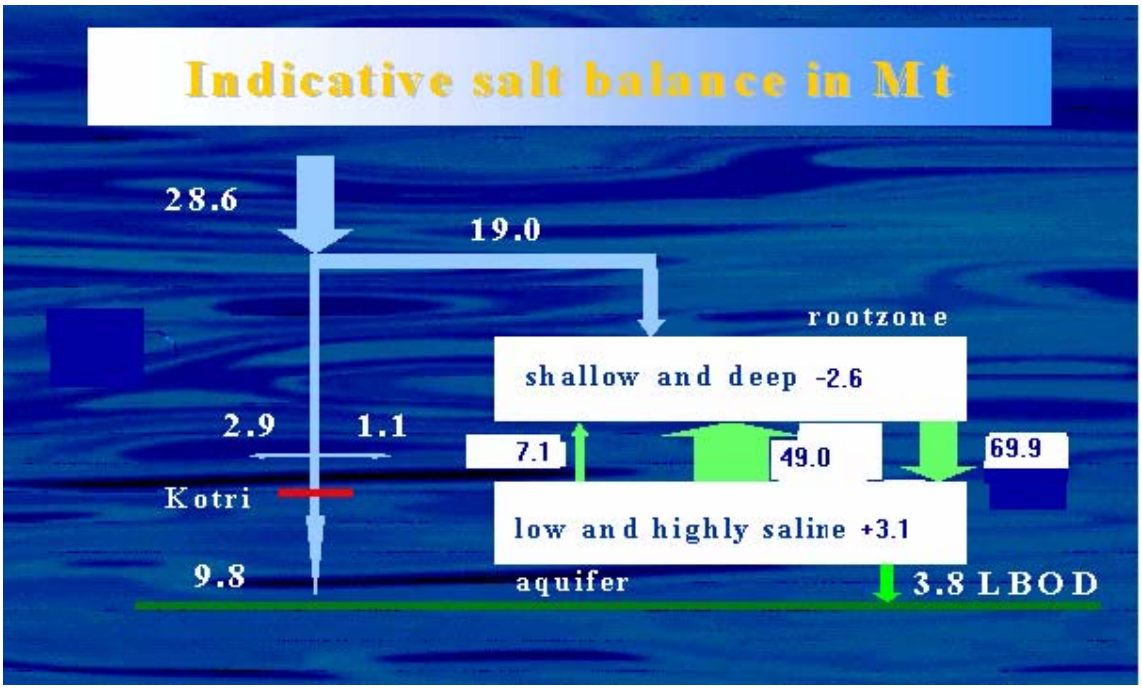

Figure 6: Indicative Salt Balance of Indus Basin

6.3 Salt Disposal and Provincial Conflicts

A main unresolved drainage issue is the outfall of low quality drainage water. As in all other river basins, the natural outfall is by way of the river systems to the sea. Almost all storm drainage water from Punjab and much of Northern Sindh is suitable discharged by this route while for much of Southern Sindh it is discharged directly to the sea. For saline drainage water, river disposal is less acceptable as the river water is reused downstreams. Some alternative disposal solutions have been found in the form of dedicated saline water outfall drains (the LBOD and RBOD systems constructed/planned in Sindh) and evaporation ponds constructed for South-Eastern Punjab (see Figure 2). These alternative solutions, however, do not yet fully meet all disposal requirement while the soundness of these solutions is still widely debated.

6.4 Improved Irrigation

In spite of this marginal irrigation water availability, much (up to 30-40%) of the applied irrigation water is lost by seepage from the irrigation canals and deep percolation in the fields. Even though much of these loses are now being recaptured by the extensive groundwater pumping this does not apply to the SGW zone while anyway the pumping involves an extra costs. Improved irrigation water management therefore is one of the first and foremost measures to be taken. It not only helps to control the groundwater tables but also reduces the drainable surplus.

As shown in Chapter 4, various remedial measures have already been taken but little impact has been achieved. Efficiencies have remained low and more could be done to rationalise the inflexible water allocation and distribution rules. More could also be done to reduce the irrigation water losses due to water stealing and over-irrigation by powerful head-end farmers. Water pricing structures which make water saving and drainable surplus reduction financially attractive to farmers are unlikely to be introduced in the near future

6.5 Improved Drainage

In spite of the efforts already made, there is still a pregnant need for further improved drainage. Without adequate drainage to leach the salts from the soils and carry them to the sea or to other safe disposal sites, salinity in the land and in the aquifers will continue to build up. Existing systems needs to be extended, new systems to be installed while most of all, drainage systems need to kept in a good functional state (see also section 6.6).

Attention to storm drainage has in many respects been overtaken by salt drainage. The recent drought years should, however, not lead to ill-considered invigilance and the extensive inundation following the high rainfall of July 2003 in Sindh may serve as a reminder. Issues to be addressed include the adequacy of the capacity and density present surface drainage system, the disposal and outfall of storm drainage water, the separate or combined discharge of storm water and saline water discharge, suitable canal sections, the balance between rainfall conservation/retention and rainfall disposal, and the merits of providing for holding ponds/wetland restoration (moving towards controlled drainage).

6.6 Implementation and management

Under the earlier discussed institutional reforms (see sections 4.3 and 6.1), it is envisioned that all main system drainage would come under the responsibility of the self-accountable PIDA's and AWB's while all on-farm drainage work would in the future in principle be a private sector responsibility, undertaken by Farmer Organisations (FO's). The role of the public sector would in principle be restricted to helping these FO's to become operational and providing the necessary technical assistance and limited financial incentives.

At present almost all drainage development in the country, including the on-farm development, almost fully relies on Gvt initiative, funding and implementation while in fact the Gvt does even do almost all of the O&M. Experiences in the few cases private sector drainage development has been attempted, have mostly not been very promising. The feasibility of the envisoned drainage development approach would seem to need for review.

Recoveries from the beneficiaries of the irrigation services are insufficient to meet the normal O&M expenses. It is also significant that the revenues collected go directly to the Provincial Financial Departments and not to the Provincial Irrigation Departments. There is no connection between abiana, which is essentially an irrigation service fee, and funding for O&M in the irrigation systems.

6.7 Social Wellbeing and Environmental Protection

More recognition ad attention should. be given to the social and environmental conflicts posed by the land scale use of the drains for the disposal of saline drainage effluent, sewage water, industrial waste and agro-chemicals and the downstreams reuse/use of the drainage water for irrigation, drinkwater, bathing, fishing and locally variable other purposes. This also applies to the uncontrolled final disposal of polluted drainage water into rivers, lakes and coastal waters (adverse impacts on drinkwater quality and riverine /coastal fishery and ecology). As long as pollution control at source is not a realistically expectation, alleviative and/or mitigative measures need to be devised to addrtess these impacts nad conflicts.

6.8 Research and Monitoring

A priority research need is a better understanding and mapping of the salt dynamics, geochemistry, mobilisation, storage of the fossil salts in the deeper substrata and aquifers. Other items would be further development of saline agriculture, appropriate on-farm drainage technology and improved maintenance practices.

All the present developments of the waterlogging and salinity conditions in the Indus Basin assessed on basis the monitoring work done by SMO. Important strategy and program/project design decisions are made on basis on this monitoring. The SMO methods are very conventional and have not been modernised during the last 20-30 yrs. In view of its strategic importance, it

would seem to be opportune to review the reliability and quality of the presently applied SMO survey methods.

Present monitoring of rivers and drains water quality is inadequate. Actual flows in the drains are not known for years. Recently telemetry system has been installed to ensure monitoring of discharges in the Indus River and its tributaries.

7. WORLDBANK CONTRIBUTION

This final chapter presents an brief overview of past and current World Bank engagements in the drainage/salinity management sub-sector and a few proposal for possible further medium-term engagements.

Reviewing the remedial efforts of the past century, it is concluded that the overall strategies and approaches have generally been conceptionally sound and appropriate. Nevertheless., mostly due to the applied mode of implementation and due to shortcomings in the O&M arrangements, many of the applied remedial measures have proved to be not sustainable. The reviews also indicate the instruments of policy/institutional measures have not yet been effectively used Clearly, the most severely affected areas are located in the Lower Sindh. These conclusions have shaped the agenda for the future as proposed in Section 7.2

7.1 Past and current engagements

The past Worldbank supported projects in the field of drainage and salinity management have included :

Link Canals and Indus Basin Treaty: after the partition, a number of Link canals were built for transferring water from western rivers to the eastern part of the country. IBRD of the World Bank offered its good offices in developing a comprehensive plan for addressing the new situation and full utilization of Indus Waters. This lead to an agreement called the “Indus Basin Treaty 1960”. The treaty was signed by the President of Pakistan, Indian Prime Minister and President of the World Bank on September 19, 1960. The World Bank also facitated the financing of the required works .

Planning Studies: in 1973, the Bank assisted Pakistan to formulate the Revised Action Plan, which was the perspective plan for the sector's development in the 1970s. The physical targets of the SCARPs and Revised Action Plan programmes have been achieved albeit behind schedule.

Drainage Projects: the World Bank has been a major source of external assistance for a number of drainage projects in Pakistan, i.e. the East Khairpur Tile Drainage Project, SCARP VI project, the Fourth Drainage Project and the FESS project.

Drainage Sector Environment Assessment (DSEA): Pakistan and IDA commissioned this study in response to perceived deterioration of drainage and environment status of IBIS. It was financed by a grant from UNDP Umbrella Trust Fund, managed by the Bank and completed in June 1993. The DSEA made recommendations for medium term and was adapted as country strategy.

National Drainage Programme: the NDP covers an approx multi year effort, at estimated total cost of $875 million, to upgrade the technical and financial performance of the drainage sector. It has three complementary components, namely: (i) sector planning and research component; (ii) institutional reform component; (iii) investment component.

Panel of Experts (POE): at the request of Government of Pakistan, the Bank has organized two Panel of Experts to give an independent opinion on two major drainage developmnet proposals, i.e. the NSDS proposal and DMP proposal.

7.2 Agenda for the future

Considering the present state of waterlogging and salinity and the related state of drainage and salinity management in the country as emerging from the analytical work described in the previous chapters, also considering the previous and current engagements as well as the opportunities offered by contnued engagement of the World Bank, the following proposal for further joint work in this subsector are being proposed :

***Institutional reform* (*policy dialogue*):** continued institutional reform as initiated under the NDP is essential to achieving sustainable progress in the combat of irrigation induced waterlogging and salinisation, and it is suggested that the WB, in its policy dialogues with the GOP, continues to stress the importance or otherwise helps to implement these reforms.

Follow-up on DMP: it may be considered that the WB supports some of the planned DMP follow-up activities such as:

a) Preparation of specific plans for waterlogging and salinity control in each of the identified 20 regional basins on basis of the principles as defined in the DMP and following the WB developed DRAIN FRAME planning methodology
b) Development, demonstration and promotion of the concept of multi functional drainage systems (combining storm drainage, salt drainage, rain water conservation/groundwater recharge, reuse, waste water disposal and other relevant functions)
c) Improved waterlogging and salinity monitoring, priority drainage/salinity research and expert consultation

The WB support could be arranged, administered and implemented jointly through WAPDA and the involved Provincial Departments.

***OFWM project**:* the focus of this project would be on establishing within the provincial DOA-OFWM directorates a professional capacity for supporting the FO's with the planning, design, construction and O&M of on-farm drainage . All development would follow a participatory mode and focus on sustainability. The projects could also include reclamation of abandoned salinised land and continuation of the conventional OFWM activities (water course lining. ;land levelling and improved on-farm irrigation).

This project would be administrated and implemented by the DOA's of the involved provinces and all project activities would be coordinated with the DMP-II activities.

ANNEXURE-I

WATERLOGGING AND SALINTY CONTROL PROGRAMMES AND PROJECTS

The combat of the waterlogging and salinisation of irrigated land in the British period was led by the provinces. After independence in 1947 and the establishment of WAPDA in 1958, it increasing became a Federal Government responsibility. This chapter summarises, more or less in chronological order, the efforts made to bring the problem under control.

A) Combat of Canal Seepage: as these seepage losses were clearly a main cause of the rising groundwater levels, initial efforts (starting around 1900) very much focused on this aspect by taking such measures as :

Lowering of full-supply level and winter closure of canals: although these measures had some local effect in draining out the water retained in ponds, borrow pits and other depressions along the canals, they were soon found to be impractical and discontinued.

Tree plantation along the canals: trials conducted by the Irrigation Research Institute and the Land Reclamation Directorate concluded these measures to be ineffective due to non-interception of deep seepage flows, low transpiration rates in comparison to canal losses and low percentage of tree survival.

Canal lining: the first canal lining, using double brick layers was undertaken in 1943 over a portion of Jhang Branch. Some of the canals constructed in the 1950 ties such as Haveli, BRBD, Balloki-Sulemanki, and Sidhnai-Mailsi-Bahawal links were also lined. High costs and interruption in canal operations led to fading interest

Construction of seepage drains along canals : these drains were found to intercept only a very small percentage of the total groundwater recharge by the canals

B) Storm Water Drainage*:* to counter the observed rise of the watertable during the monsoon rains, large scale construction of storm water drains was undertaken from 1933-1947. Siltation

and weed growth, often exceeding the available maintenance capacities, and poor outfall conditions adversely affected the drain performance.

C) Early Tubewell Projects: tubewells as a mean of intercepting the canal seepage were initiated around 1940 in the "Rasul Tubewell Project" comprising 1,860 interceptor tubewells sited at 6o ft distance of 60 feet and 600 ft spacing along major canals in Rechna and Chaj Doab. This scheme did have its effect on lowering the waterlogging but affected only a small belt along the canals.

In 1950 a FAO group of experts recommended, as an interim measure the "Chuharkana Tubewell Drainage Pilot Project" which was constructed during 1954 and comprised 24 regular vertical drainage tubewells. It was followed by 145 tubewells in Jaranwala Scheme (1957), 21 tubewells in Pindi Bhattian Scheme (1958) and 12 tubewells in Chichoki Mallian Scheme (1960).

D) Hydrogeological Investigations*:* to develop scientific insight on the problem and develop a comprehensive solution, the Groundwater Development Organization (GWDO) was established in the Punjab Irrigation Department in 1954 (in 1958 later transferred to WAPDA and renamed into "Water and Soil Investigation Division", WASID). The Federal Government arranged assistance from the United States Geological Survey (U.S.G.S.). These investigations confirmed the basin wide presence of extensive aquifer system saturated with comparatively fresh water**,** a finding which formed the backbone of the SCARP program (Salinity Control and Reclamation Projects).

E) Various Planning Studies: during the 1960-70 period, with early support of the US Govt. a number of planning studies were undertaken which laid the foundation for the two major investment program (SCARP and LBOD) which dominated the developments during much of the 1970-90 ties.

Harza Master Plan: a 12 year national plan (1963-75)for the Water and Power Development including the control of waterlogging and salinity in the Indus Basin.

Lieftinck Report/Indus Special Planning Group (1965): a follow-up study to the Indus Water Treaty (allocation of water resources to India and Pakistan at Independence) sponsored by the World Bank, outlining a 20 yr development plan (1965-85) and a 10 yrs action plan (1975-85) for agricultural and water resources development for the Indus Basin.

Lower Indus Plan (1966) and Regional Plan-Norther Indus Basin (1967): regional elaborations of the above study. As the focus of the Lower Indus Plan was mostly on the Lower Left Bank in Sindh, in 1992 a similar type regional plan was also prepared for the *Lower Right Bank,* covering both Balochistan and Sindh.

These planning studies have subsequently been revised and updated in the various FYP's: the RAP (Revised Action Plan) of the 5th FYP (1978-83 and 6th FYP (1983-88) and the WISP_ (Water Sector Investment Plan) of the 7th FYP (1989-93) and 8th FYP (1993-98)

F) SCARP Program*:* with funding the World Bank, WAPDA has since 1960, up to June 2003, completed 61 SCARP projects. In addition PID's have also completed a number of projects. Most projects involved a package of the following interventions:

- improved open drainage (mostly rehabilitation of poorly maintained main and branch drains) but also construction of some new drains
- watertable control by the installation of large capacity public tubewells in all waterloggedareas underlain by suitable permeable substrata with the pumped water, depending on its salinity, either being reused for irrigation (directly or after mixture with canal water) or being discharged into nearby drains
- watertable control by the installation of pipe drainage in all waterlogged areas which could not feasibly be treated by tubewell drainage with the effluent, depending on its salinity either being discharged in nearby irrigation canals or nearly drains.
- improved irrigation mostly by canal rehabilitation, watercourse lining and land levelling
- miscellaneous other measures such as reclamation of salinised land, gypsum application and introduction of improved agronomic and field irrigation practices.

The completed SCARP projects cover a total irrigated area of 40.03 Ma of which 15.793 Ma (about 39.45%) has been provided with improved drainage while the remaining 24.237 Ma have not yet been fully covered. The constructed drainage works have been summarised in the table below (refers to works completed as per June 2002). Most of originally installed SCARP TW's have completed their physical life. and more than 50% tubewells have been closed. while the pumping capacity of remaining tubewells has been significantly reduced. Pipe drainage systems were installed in an area of 0.390 Ma. including a total of 212 sumps for the effluent disposal. At

present only few sumps are being operated. Some of the sumps are not being operated as the water table level has gone down.

Province	Public Sector Tubewells (Nr)		Surface Drains (Km)	Interceptor Drains (Km)
	FGW	SGW		
Balochistan	-	-	322	-
NWFP	755	-	1,829	6,577
Punjab	11,321	2,248	4,379	2,813
Sindh	4,640	2,143	8,964	2,709
Total	**16,724**	**4,391**	**15,464**	**12,099**

Source: ACE-Halscrow, 2004. Efficacy of past drainage investments.

G) Left Bank Outfall Drain Project (LBOD): for the northern parts of Sindh a spinal drain, the Left Bank Outfall Drain (LBOD) 250 km long with a capacity at the outfall of 113 cumecs (4000 cfs) has been constructed. The LBOD Stage-I serves the areas of Nawabshah, Sangar and Mirpurkhas of the left bank of Sukkur Barrage. LBOD conveys the highly saline subsurface drainage effluent from 0.580 Mha (1.426 Ma) and the rainfall excess from in and around the area to the Sea. The disposal of the drainage water to Sea, through the LBOD and other smaller surface drains, could pose problems of back water effects at high tides and it actually happened in May, 1999 when cyclone ‘2A’ swept through the coastal areas of Sindh. The storm affected some morphological changes at Tidal Link and adjacent areas, which include breaches in embankment of drain, changed its bathymetry and topography of the area. The influence of sea water extended up to RD 35+000 of Kahdam Pateji Outfall Drain (KPOD).

H) OFWM programs/projects: these programs/projects were to a large extent based on the findings of the on-farm water management research work done under the Mona Reclamation and Experimental Project (MERP) in collaboration with Colorado University during the 1970-ties. Most programs/projects were undertaken in Punjab by the Punjab DoA-OFWM, although on a more modest scale similar work was also undertaken in the other provinces. They also were the first program/projects implemented with (still limited) beneficiary participation and under which FO’s where established (WUA for all water course lining projects)

Watercourse lining: in direct response to the measured large loss and based on a package developed at Mona

Land levelling and introduction of improved field irrigation methods: also a Mona package of which actually only the land levelling component was implemented at a large scale

Tertiary surface drainage: this involved a densification of the existing main surface drainage system to provide better outlet to storm and irrigation waste water from the smaller depressions. These projects did not originate from Mona but on the finding of pilot work done in the Muzzafagrah area.

I) Reclamation of Salinised Land : individual farmers or groups of farmers, usually under the guidance and with support of the DoA's have applied following measures to reclaim and/or to improve badly affected land :

Leaching with irrigation water: this approach was applied to well-drained saline soils and gypsiferous saline-sodic soils with good structure and high rate of infiltration. Extra irrigation was applied (usually from tubewells). Leaching with brackish water has been successful for the initial reclamation of sodic soils of low permeability. However, use of better quality water was necessary in the final leaching stages, often with gypsum to prevent deterioration of soil structure.

Use of gypsum: gypsum is the cheapest source of soluble calcium available in Pakistan. The use of gypsum on saline-sodic and sodic soils improved rates of water infiltration and the leaching of salt into the subsoil. One reason for the popularity of gypsum with farmers is that its price is currently subsidised by the government. In theoary, sodic soils containing calcium in insoluble forms (like limestone nodules) may also be treated with acids to mobilise the calcium. These amendments are not popular because of their high cost and the need to great care in their handling, transport and application.

Use of wastes: agricultural and industrial wastes (such as farmyard manure and pressmud) have been used to improve soils affected by high sodicity. Farmyard manure was especially beneficial as it improves soil physical structure as well as providing nutrients for plants. Pressmud from sugar mills is another excellent source of organic matter for improving the physical condition of

soil. Following changes in the sugar extraction process, pressmud now also contains sulfur which generates acids and as such helps to mobilise soil calcium.

Physical method: some farmers have practiced scraping salt from the land surface, and chiselling or deep ploughing land with a hardpan or low permeability. Surface scraping may be of short-term benefit. However, it rendered a small part of the land completely unproductive and it remove many of the plant nutrients found close to the soil surface. Furthermore, the salt can easily leach out of the scraped heaps to make the adjoining land salt affected. Deep ploughing and chiselling are not always helpful, especially with saline-sodic soils with unstable structure. In these cases, the soil 'slumps' again when method and sets hard when dry.

Biological methods: a number of farmers reclaimed soils through the use of salt and waterlogging tolerant plants. These treatments improve soil structure in two ways, they add organic matter to the soil, and they have an acidifying action which molilises insoluable soil calcium. Soils have reclaimed by growing kallar grass (*Leptochloa fusca*) for a number of years, followed by dhuncha (*Sesbania bispinosa*) as a green manure, and then normal crops.

J) Drainage Sector Environmental Assessment (DSEA) 1993: a first effort to identify and to assess the environmental impacts of the past and ongoing irrigation induced waterlogging and salinsation and of the remedial measures taken to control the problem. It specifically alerts to the huge annual excess of the imported salts over the salts disposed to the sea , leading to an accumulation of salts in the Indus Basin to the tune of some 16 million tons year.

K) National Drainage Program 1995-2004 : the most salient features of this landmark project have been summarised below

i) **Project Area:** the project is the Phase-1 of a National Drainage Programme Project, which currently will go side by side with the individual projects being implemented `under project approach'. However, its future phases are expected to gradually absorb the entire drainage sub-sector, and all future improvements in irrigation related drainage will be financed and implemented through the programme. The sphere of its activity extends over the entire irrigated area of the Indus Basin and adjoining areas.

ii) **Project Components:** NDP has been formulated into four components, comprising of physical and non-physical interventions. Non-physical nature of investments are associated with the sector planning, research/studies, policy reforms, institutional development, improved canals management, communication and education for the drainage sector. The only identifiable interventions in physical terms are investments targeted towards existing and new drainage schemes and O&M through performance contracts.

Sector Planning and Research: NDP will support long term priority research in water resources in general and drainage in particular. The component will cover studies relating to planning, design and implementation of sustainable drainage systems. Long term sectoral plans will also be financed under the programme. A detailed evaluation of the research/studies proposal will be a prerequisite. Sectoral planning and research studies so far identified include the following:

Sectoral Planning and Feasibility Studies:

- National water policy;
- Water rights in selected canal commands;
- Gypsum marketing and distribution study;
- Promoting private investment in drainage and long term financing options;
- Exploitation and regulation of FGW;
- Preparation of irrigation and drainage Atlas of Pakistan;
- Revenue options and prospects for WAPDA's Water Wing;
- Revenue options and prospects for PIDAs/AWBs and FOs/WUAs;
- Efficacy of past drainage investments;
- Wetland management plan;
- Reactivation of IBMR and Hydraulic Modelling of Canal Command;
- Balochistan effluent disposal;
- Flood protection and drainage of Peshawar Valley;
- National Surface Drainage System (NSDS);
- Preparation of NDP Phase-II;
- Portfolio implementation monitoring system;
- Impact monitoring and evaluation;
- Soil salinity and waterlogging surveys of irrigated areas;
- Institutionalized environmental monitoring of land and water conditions; and

- Baseline environmental monitoring of land and water conditions of the Indus Basin.

Research Studies:

- Design and maintenance of surface drains;
- Collaborative (community) pilot tile drainage;
- Sectoral approach to resource monitoring using GIS;
- Use of brackish drainage effluent for agriculture and forestry;
- Impact of tile drainage systems on land and water;
- Design and management of evaporation ponds;
- Root zone salinity using fractional skimming wells;
- Protection of drainage water quality from pollution by municipal effluent;
- Institutionalized framework for improved sustainability and productivity of irrigated agriculture in Pakistan; and
- Any other research/study which may be brought up by Federal/Provincial research institutes.

Institutional Reforms: Capacity building for WAPDA; WAPDA Institutional reform programme; institutional reform programme for provinces; public participation, dissemination, education and communication programme; financial management system; training, media out reach programme; and NGOs Forum.

- Re-define role of public and private sector in irrigation and drainage and facilitate legislative reforms to effect these changes.
- Support establishment of AWBs/FOs/WUAs on Pilot basis, in selected canal commands.
- Technical and financial assistance to support re-organization, training and capacity building of WAPDA (Water), PIDs/PIDAs and PADs; to perform their re-defined role in project planning and programming, portfolio management, financial management, project management monitoring and evaluation, environmental monitoring and management, establishment of GIS, resettlement and land acquisition plans, etc.
- Support and finance technical assistance to improve cost sharing and water allocation.
- Finance technical assistance and equipment to improve irrigation system management in selected canal command;

- Support and finance technical assistance to conduct public information and awareness campaign on causes, dangers and remedies of waterlogging and salinity; create effective demand for drainage, and build public constituencies for drainage.

Drainage Investment: New drainage facilities (final inclusion of these schemes will be based on eligibility criteria). Funding of LBOD remaining works (Mirpurkhas drainage tubewells, tile drains and interceptor drains). Works under MNVD remodelling and Dera Ghazi Khan integrated Irrigation and Drainage Project, which meet the selection and eligibility criteria. Rehabilitation of existing outfall, main, branch and sub-drains. Construction of new drains within existing systems to provide missing links; and cross drainage works. Rehabilitation and or replacement of deteriorated SGW tubewells (SGW tubewellls may be replaced with tile drains, where feasible). Support decentralization of O&M of off-farm drainage and SGW tubewells through multi-year performance contract. Transfer of construction and O&M of existing and new surface and sub-surface on-farm drainage and FGW tubewells to farmers. Reducing drainable surplus by improvement and lining of distributaries/minors/watercourses in SGW areas, interceptor drains and through biological control. Rehabilitation and modernization of canal commands including sophisticated communication system and improved flow gauging.

Policy Papers : National drainage effluent disposal, a strategy for Indus Basin*:* Opportunities and alternatives mentioned for drainage disposals are following:

i) Monsoon disposal to sea;
ii) Precision land leveling;
iii) Terminal lakes;
iv) Evaporation ponds;
v) Canal/disty/watercourse seepage reduction; and
vi) Improved irrigation distribution management

Drainage Master Plan 2004: Drainage Master Plan (DMP) aims to sustainability of irrigated agriculture in Pakistan. The broad objectives of DMP are:

i) Food security through increased agricultural production;
ii) Protection of environment;
iii) Poverty alleviation; and
iv) Social uplift of the people.

Specific objectives are:

i) Control of waterlogging and salinity;

ii) Protection of irrigation water quality;

iii) Safe disposal and management of brackish drainage effluent;

iv) Reduction of drainage effluent;

v) Reduction of government ability of O&M; and

vi) Improve knowledge of implementing and operating agencies through research and training.