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The Cost of Environmental Degradation in Pakistan — An Analysis of Physical and Monetary Losses in Environmental Health and Natural Resources

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ACRONYMS AND ABBREVIATIONS

AQS	Air Quality Standards
CETP	Combined Effluent Treatment Plant
DALY	Disability Adjusted Life Years
EA	Environmental Assessment
ECNEC	Executive Committee of the National Economic Council
EIA	Environmental Impact Assessment
EIS	Environmental Information System
EPRCP	Environmental Protection and Resource Conservation Project
ESI	Environmental Sustainability Index
FAO	Food and Agricultural Organization
FERTS	Fuel Efficiency Improvements in the Road Transport Sector
GHG	Greenhouse Gases
I&M	Inspection and Maintenance
IEE	Initial Environmental Examination
MTDF	Medium Term Development Framework
NCCWS	National Coordination Committee on Water and Sanitation
NCS	National Conservation Strategy
NEAP	National Environmental Action Plan
NEP	National Environment Policy
NEPF	National Environmental Protection Fund
NEPPS	National Environmental Performance Partnership System
NEQS	National Environmental Quality Standard
NGO	Non-Government Organizations
NWFP	North West Frontier Province
P&D	Planning and Development
PCAP	Pakistan Clean Air Program
PCRWR	Pakistan Council for Research in Water Resources
PEPA	Pakistan Environmental Protection Act of 1997
PEPC	Pakistan Environmental Protection Council
PHED	Public Health Engineering Department
PM	Particulate Matter
PRSP	Poverty Reduction Strategy Paper
PSQCA	Pakistan Standards and Quality Control Authority
PWRC	Provincial Water Regulatory Commissions
SCEA	Strategic Country Environment Analysis
T&D	Transmission & Distribution
TMA	Tehsil Municipal Administration
USEPA	United States Environment Protection Agency
VES	Vehicular Emission Standards
WASA	Water and Sanitation Authority

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The Cost of Environmental Degradation in Pakistan: An Analysis of Physical and Monetary Losses in Environmental Health and Natural Resources

1. This annex provides a comprehensive overview of the data and methods used to estimate the costs of environmental degradation in three environmental damage categories and three natural resource damage categories: (i) urban air pollution, including particulate matter and lead, (ii) water supply, sanitation and hygiene, (iii) indoor air pollution, (iv) agricultural damage from soil salinity and erosion, (v) rangeland degradation, and (vi) deforestation. Data limitations have prevented estimation of degradation costs at the national level for coastal zones, municipal waste disposal and inadequate industrial and hospital waste management. It is hoped that the detailed analysis outlined in this annex will stimulate greater research on the costs of degradation and will be used to update and refine damage estimates.

2. At the outset a number of caveats are in order. Unfortunately, much of the information needed to estimate social costs is lacking. To overcome this problem greater reliance has been placed on observable measures, such as financial costs. Such costs are generally thought to be lower bounds to social costs, but this is not always the case. Presumably, if those being damaged allocate their resources to mitigate that damage (e.g., by a doctor visit), we expect that this outlay is at least equal to the monetary value of the damage they are feeling, assuming they expect the visit to be very effective. If they think it will not be effective, this outlay will underestimate social cost to them. On the other hand, if insurance picks up the tab, this link between preferences and outlays is broken and medical (financial) costs could exceed social cost. Though this report relies on financial costs for a significant part of the analysis, it is likely that this substantially underestimates the true economic costs.

3. The other option is to perform a benefit transfer. The simplest such transfer involves taking a social cost-based monetary measure of damage from another country, say the U.S., which has many such estimates, and applying it to the target country, e.g., Pakistan. An adjustment is usually made for income differentials across the two countries, on the theory that income should constrain preferences for non-market goods (such as health), just as it does for market goods. This adjustment factor, called the income elasticity of willingness to pay, has been estimated to be in the range of about 0.3 to 1.0, the latter meaning that the transferred value would be proportional to the income differential; the former meaning that the value would be adjusted far less. This report uses benefits transfer, with a conservative income elasticity of 1.0.

4. Finally, whenever there are choices to be made - between models, or parameters, we take a conservative approach and make assumptions that provide lower bounds to guard against exaggeration.

I. URBAN AIR POLLUTION

5. The focus of this report is the health effects of fine particulates (PM10 and PM2.5). There are three main steps to quantifying the health impacts from air pollution. First, the pollutant needs to be identified and its ambient concentration measured. Second, the number of people exposed to that pollutant and its concentration needs to be calculated. Third, the health impacts from this exposure should be estimated based on epidemiological assessments. Once the health impacts are quantified, the value of this damage can be estimated.

Baseline Data

6. About 35 % of the Pakistan population of 149 million lives in urban areas (WDI, 2004). Only major cities have TSP and PM10 monitoring data. The monitoring data on PM10 concentrations are presented in Table 1. Population in each city was estimated from 1998 Census data (http://www.statpak.gov.pk) and applying a 1.034% annual population growth rate. Population in these major cities totals 21 million.

Table 1: Average Annual Concentrations Of PM10 ($\mu g/m^3$) And Population In Major Pakistan Cities

	1st Cycle, mean	2nd cycle, mean	3rd cycle, mean	4th cycle, mean	Average annual	Population in 2004, thousand
Islamabad	190	174	181	207	188	625
Karachi	196	184	190	204	194	10956
Lahore	195	174	180	257	202	5985
Peshavar	221	176	188	222	202	1168
Quetta	287	257	194	260	250	662
Rawalpindi	185	200	147	230	191	1662

Source: SUPARCO (2004).

7. Table 2 presents population figures for "other cities" with population above 100 thousand that do not have PM monitoring data. These cities have a total population of almost 15.2 million. Excluding them from estimating the health impacts of urban air pollution would therefore represent a serious omission. Annual average PM 10 levels were therefore assigned to these cities based on scaling up of the World Bank modeling PM 10 concentrations (worldbank.org/nipr/Atrium/mapping.html.url), using an average factor for the major cities from the Table 1. Modeled concentrations were compared with actual monitoring data for each of these cities. Modeled concentrations and actual monitoring data were fond to differ by a factor of 1.8. To incorporate this uncertainty, we present two scenarios of annual average PM10 concentrations for cities without monitors. In the higher case we applied the average scaling factor equal to 1.8 to all cities without monitors. In the lower case we did not apply the scaling factor to the PM10 concentrations in the cities with population 0.1-1 million.

Table 2: PM 10 Estimates and Population for Cities with no Monitoring Data

	PM 10 Average Annual Concentration, ug/m3		**Population 2004**
	Low case	High case	
Cities with population above 1 million			
Faisalabad(Lyallpur)	205	205	2337
Multan	193	193	1398
Hyderabad	187	187	1360
Gujranwala	199	199	1330
Cities with population above 0.5-1 million			
Sargodha	101	183	538
Sialkote	105	190	494
Bahawalpur	120	217	476
Cities with population 0.1-0.5 million			
Sukkur	122	221	389
Jhang	95	171	345

Sheikhu Pura	93	169	321
Larkana	122	221	319
Gujrat	100	180	295
Mardan	106	192	290
Kasur	106	191	286
Rahimyar Khan	130	234	271
Sahiwal	112	203	245
Okara	103	186	238
Wah Cantt	101	183	235
Dera Ghazi Khan	111	200	222
Mirpur Khas	112	203	219
Nawabshah	113	205	216
Mingora	107	193	206
Chiniot	98	177	200
Kamoke	96	174	178
Burewala	115	207	177
Jehlum	98	177	173
Sadiqabad	129	234	168
Jacobabad	122	219	163
Khanewal	100	181	157
Shikarpur	118	213	157
Hafizabad	96	173	154
Kohat	109	196	148
Muzaffargarh	119	214	144
Khanpur	132	238	139
Gojra	104	188	136
Bahawalnager	116	209	130
Muridke	97	176	129
Pakpattan	112	201	128
Abbottabad	100	181	125
Jaranwala	100	181	122
Tando Adam	106	191	122
Chishtian	114	206	121
Daska	94	170	121
Khaipur	117	211	121

8. The age distribution of the urban population was estimated using urban population parameters from a 2003 Pakistan Demographic Survey. PM10 were transformed into PM2.5 using the ratio 0.5 based on evidence from India (TERI, 2001).

Concentration-Response Coefficients

9. The risk ratios, or concentration-response coefficients from Pope et al (2002) are likely to be the best available evidence of the mortality effects of ambient particulate pollution (PM 2.5). These coefficients were applied by the WHO in the World Health Report 2002, which provided a global estimate of the health effects of environmental risk factors. For acute child mortality concentration-response coefficients from Ostro (2004) were applied. The mortality and morbidity coefficients are

presented in Table 3. We applied coefficients from Ostro (1994) per 100 000 of population where baseline data for Pakistan were not available.

Table 3: Urban Air Pollution Concentration-Response Coefficients

Annual Health Effect	Concentration-response Coefficient	Per 1 ug/m^3 annual average ambient concentration of:
Long term mortality (% change in cardiopulmonary and lung cancer mortality)	0.8% *	PM 2.5
Acute mortality children under five (% change in ARI deaths)	0.166%	PM10
Chronic bronchitis (% change in annual incidence)	0.9%	PM10
Respiratory hospital admissions (per 100,000 population)	1.2	PM10
Emergency room visits (per 100,000 population)	24	PM10
Restricted activity days (% change in annual incidence)	0.475%	PM10
Lower respiratory illness in children (per 100,000 children)	169	PM10
Respiratory symptoms (per 100,000 adults)	18,300	PM10

*Mid-range coefficient from Pope et al (2002) reflecting a linear function of relative risk.
Source: Pope et al (2002), Ostro (2004) for the mortality coefficients. Ostro (1994, 1998) and Abbey et al (1995) for the morbidity coefficients.

10. In order to apply the mortality coefficients in Table 3 to estimate mortality from urban air pollution, baseline data on total annual cardiopulmonary and lung cancer deaths are required. The PDS 2003 data for this purpose. Urban crude mortality rate of 6.3 per 1,000 was used, along with an average cardiopulmonary and lung cancer mortality rate of 39 percent of total deaths.[1] A background level of 7.5 ug/m^3 of PM 2.5 has been assumed. This is the same procedure used in the World Health Report 2002 (WHO). No background level has been used for morbidity. An estimate of annual incidence of chronic bronchitis (CB) is required in order to apply the CB coefficient in Table 3.1.4. In the absence of CB incidence data for Pakistan, the rate is from WHO (2001) and Shibuya et al (2001).Restricted activity days from ARI prevalence for the adult population is estimated to last 5 days (out of a total of 7). This is based on global studies.

11. Other morbidity health endpoints considered are hospital admissions of patients with respiratory problems, emergency room visits (or hospital out-patient visits), lower respiratory infections in children, and respiratory symptoms. These are the most common health endpoints considered in most of the worldwide studies on air pollution. The coefficients are expressed as cases per 10,000 in the absence of incidence data for Pakistan.

12. The health effects of air pollution can be converted to disability adjusted life years (DALYs) to facilitate a comparison to health effects from other environmental risk factors. DALYs per 10 thousand cases of various health end-points are presented in Table 4.

[1] PDS 2003 presents that 23 percent of all deaths are from heart attacks, pneumonia and asthma. Using GBD 2002 for Emro D and Sear D WHO regions, another 10 percent could be added for hypertensive mortality and strokes and 5 percent for other ARI. A correction factor of 0.79 specific for the combination of the Amro D and Sear D was applied reflecting deaths of those over 30. Annual ARI deaths for children under 5 were estimated applying GBD 2002 mortality estimates for the WHO subregions. ARI deaths are about 11-18 percent of total urban children under 5 mortality, which is 79 per 1000 (estimated from PDS 2003 and GBD 2002).

Table 4: DALYs for Health Effects

Health Effect	DALYs lost per 10,000 cases
Mortality adults	75,000
Mortality children under 5	340,000
Chronic Bronchitis (adults)	22,000
Respiratory hospital admissions	160
Emergency Room visits	45
Restricted activity days (adults)	3
Lower respiratory illness in children	65
Respiratory symptoms (adults)	0.75

Note: DALYs are calculated using a discount rate of 3% and full age weighting based on WHO tables.

13. Table 5 presents the disability weights and average duration of illness that have been used in this report to calculate the DALYs as presented in Table 7. The weights for lower respiratory illness (LRI) and chronic bronchitis (CB) are disability weights presented by the National Institute of Health, United States.[2] Disability weights for the other morbidity end-points are not readily available, and are estimates by Larsen (2004a) based on weights for other comparable illnesses.[3] Average duration of CB is estimated based on age distribution in Pakistan and age-specific CB incidence in Shibuya et al (2001). Years lost to premature mortality from air pollution is estimated from age-specific mortality data for cardiopulmonary and lung cancer deaths, and have been discounted at 3 percent per year. Average duration of illness for the other health end-points is from Larsen (2004a).

Table 5: Calculation of DALYs Per Case of Health Effects

	Disability Weight	Average Duration of Illness
Mortality	1.0	(7.5 years lost) or 70 years lost for children under 5
Lower respiratory Illness - Children	0.28	10 days
Respiratory Symptoms – Adults	0.05	0.5 days
Restricted Activity Days - Adults	0.1	1 day
Emergency Room Visits	0.30	5 days
Hospital Admissions	0.40	14 days*
Chronic Bronchitis	0.2	20 years

* Includes days of hospitalization and recovery period after hospitalization.

Estimated Health Impacts

14. Using the information in Tables 2-5, the annual health effects of ambient particulate air pollution in Pakistan are presented in Table 6. Urban air particulate pollution is estimated to cause around 22,000 premature deaths among adults and 700 deaths among children under 5 annually. Estimated new cases of chronic bronchitis are about 8,000 per year. Annual hospitalizations due to pollution are estimated at close to 80 thousand, and emergency room visits/outpatient hospitalizations at 1600 thousand per year. In

[2] See: http://www.fic.nih.gov/dcpp/weights.xls

[3] The disability weight for mortality is 1.0.

terms of annual DALYs lost, mortality accounts for an estimated 60 percent, chronic bronchitis around 5 percent, restricted activity days (RADs) for 7 percent, and respiratory symptoms for 25 percent.

Table 6: Estimated Health Impact of Urban Air Pollution

Health end-points	Total Cases	Total DALYs
Premature mortality adults	21,791	163,432
Mortality children under 5	658	22,385
Chronic bronchitis	7,825	17,215
Hospital admissions	81,312	1,301
Emergency room visits/Outpatient hospital visits	1,595,080	7,178
Restricted activity days	81,541,893	24,463
Lower respiratory illness in children	4,924,148	32,007
Respiratory symptoms	706,808,732	53,011
TOTAL		320,992

Estimated Cost of Health Impacts

15. The estimated annual cost of urban air pollution health effects is presented in Table 7. Cost of mortality is based on the human capital approach (HCA) for children and the value of statistical life (VSL) for adults. The range in cost is due to the uncertainty of monitoring data in Pakistan. For VSL we used benefit transfer from the United States and Europe with a conservative approach using market exchange rate and income elasticity of WTP equal to one.

16. A measure of the welfare cost of morbidity is often based on the willingness-to-pay (WTP) to avoid or reduce the risk of illness. This measure is often found to be several times higher than the cost of medical treatment and the value of time losses (Cropper and Oates 1992), and reflects the value that individuals place on avoiding pain and discomfort. There are however not a sufficient number of WTP studies from Pakistan. For this reason, the cost-of-illness (COI) approach (mainly medical cost and value of time losses) was applied as the only measure of morbidity cost (see cost of morbidity in Table 7).

Table 7: Estimated Annual Cost of Health Impacts (Billion Rs.)

Health categories	Total Annual Cost*	Percent of Total Cost* (Mean)
Mortality		
Adults	58-61	92.5%
Children under 5	0.83	1.3%
Morbidity:		
Chronic bronchitis	0.06	0.1%
Hospital admissions	0.28	0.4%
Emergency room visits/Outpatient hospital visits	0.80	1.2%
Restricted activity days (adults)	2.06	3.2%
Lower respiratory illness in children	0.84	1.3%
Respiratory symptoms (adults)	0.00	0.0%

Total cost of Morbidity	4.05	6.3%
TOTAL COST (Mortality and Morbidity)	62 – 65	100 %

* Percentages are rounded to nearest percent.

17. Since for morbidity we estimated only cost of illness, no values were assigned to respiratory symptoms, therefore they have zero cost in the Table 7.

18. Table 8 presents the estimated cost per case of mortality and illness (health end-point) based on the data in Table 9. Some of these require explanation. The value of time for adults is based on urban wages. Economists commonly apply a range of 50-100 percent of wage rates to reflect the value of time. The rate of Rs135 per day is an average urban wage in Pakistan. Furthermore 75 percent of this rate has been applied for both income earning and non-income earning individuals. There are two reasons for applying the rate to non-income earning individuals. First, most non-income earning adult individuals provide a household function that has a value. Second, there is an opportunity cost to the time of non-income earning individuals, because they could choose to join the paid labor force.[4]

Table 8: Estimated Unit Cost by Health End-Point (000' Rs.)

Health categories	Cost Per Case	Cost-of-Illness Per Case
Mortality adults	2740	-
Mortality children under 5	1260	-
Chronic bronchitis		7.92
Hospital admissions		3.41
Emergency room visits/Outpatient hospital visits		0.50
Restricted activity days (adults)		0.03
Lower respiratory illness in children		0.17
Respiratory symptoms (adults)		0.00

19. There is very little information about the frequency of doctor visits, emergency visits and hospitalization for CB patients in any country in the world. Schulman et al (2001) and Niederman et al (1999) provide some information on this from the United States and Europe.[5] Figures derived from these studies have been applied to Pakistan. Estimated lost work-days per year is based on frequency of estimated medical treatment plus an additional 7 days for each hospitalization and one extra day for each doctor and emergency visit. These days are added to reflect time needed for recovery from illness.

20. To estimate the cost of a new case of CB, the medical cost and value of time losses have been discounted over a 20-year duration of illness. An annual real increase of 2 percent in medical cost and value of time has been applied to reflect an average expected increase in annual labor productivity and real wages. The costs are discounted at 3 percent per year, a rate commonly applied by WHO for health effects.

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[4] Some may argue that the value of time based on wage rates should be adjusted by the unemployment rate to reflect the probability of obtaining paid work.

[5] CB is a major component of COPD which is the focus of the referenced studies.

Table 9: Baseline Data for Cost Estimation

	Baseline	Source:
Cost Data for All Health End-Points:		
Cost of hospitalization (Rs per day)	400	Per consultations with medical service providers, and health authorities
Cost of emergency visit (Rs) - urban	300	
Cost of doctor visit (Rs) (mainly private doctors) – urban	70	
Value of time lost to illness (Rs per day)	101.5	75% of urban wages in Pakistan
Chronic Bronchitis (CB):		
Average duration of Illness (years)	20	Based on Shibuya et al (2001)
Percent of CB patients being hospitalized per year	1.5 %	From Schulman et al (2001) and Niederman et al (1999)
Average length of hospitalization (days)	10	
Average number of doctor visits per CB patient per year	1	
Percent of CB patients with an emergency doctor/hospital outpatient visit per year	15 %	
Estimated lost work days (including household work days) per year per CB patient	2.6	Estimated based on frequency of doctor visits, emergency visits, and hospitalization
Annual real increases in economic cost of health services and value of time (real wages)	2 %	Estimate
Annual discount rate	3 %	Applied by WHO for health effects
Hospital Admissions:		
Average length of hospitalization (days)	6	Estimates
Average number of days lost to illness (after hospitalization)	4	
Emergency Room Visits:		
Average number of days lost to illness	2	
Restricted Activity Days:		
Average number of days of illness (per 10 cases)	2.5	
Lower Respiratory Illness in Children:		
Number of doctor visits	1	
Total time of care giving by adult (days)	1	Estimated at 1-2 hours per day

Lead Exposure

21. The annual cost of lead (Pb) exposure is estimated at 38-52 billion Rs per year, with a mean estimate of 45 billion Rs, or 0.7 percent of GDP in 2004. This estimate is based on lead exposure from all sources (leaded gasoline, industry and possible other sources such as water, soil, paint and food) for the population living in cities with more than 100 thousand inhabitants, totaling nearly 36.3 million people or about 26 percent of the Pakistan population.[6] IQ losses (reduced intelligence) represent 78 percent of total cost, and mild mental retardation (MMR) 15 percent. Cardiovascular mortality and elevated blood pressure morbidity in adults constitute only 7 percent of total cost. In addition, lead exposure is estimated to cause 660,000 annual new cases of gastrointestinal effects in children, and 580,000 new cases of anemia in children.

[6] This corresponds to the population for which the cost of PM pollution was estimated.

22. The estimated cost of lead exposure is based on blood lead level (BLL) measurements in children from 1994-2003 and rough estimates for adults. As little is known about current blood lead levels in the urban population, the cost estimates are highly uncertain.

Baseline Data

23. Lead exposure can come through breathing, drinking and eating lead particles. The original sources of lead can include leaded gasoline, industrial lead emissions to air, water, and land (e.g., from smelters), leached lead from lead pipes carrying drinking water, contaminated food, lead paint, and pottery. And once in the environment, lead accumulates in soil and water. Significant amounts of lead were found in gasoline in the 1990s (0.42 g/l in regular gasoline and 0.84 g/l in high octane gasoline). In 2001-2002 all four major refineries announced that they would move to production of lead free gasoline (Paul et al, 2003). However, it will be quite some time until the lead phase-out policy brings significant results.

24. A number of studies were identified that analyzed the BLL in Pakistan. Table 10 below presents major results of the studies:

Table 10: Blood Lead Levels in Children in Urban Areas

Blood lead, mean (ug/dl)	Year of study	Sample size	Study
15.6	2000	400	White F. et al., 2001
21.6	2003	53	Hozhabri S., et al, 2004
21.2	1994	374	Khwaija M., 2003
16.8	1994	126	Khwaija M., 2003
22.8	1995	230	Khwaija M., 2003
16.1	2002	138	White F. et al, 2001

25. No studies were identified with the BLL in adults. We applied BLL equal to mean BLL of 16 ug/dl in children, as recommended by WHO if BLL in adults is unknown (Pruss-Ustin et al, 2004).

Estimated Health Impacts from Lead Exposure

26. BLL from Table 10 was applied to the Fewrell et al model with two major adjustments. Some of the studies of BLL in Pakistan date back to 1994 and the average BLL does not reflect the recent phase-out program of lead in gasoline. While there is great uncertainty about how much BLL will decline from a lead phase-out program, international experience indicates that a program over a five-year period could lead to a 40 percent reduction in BLL. Applying this adjustment factor for a two year period gives an average BLL of 16 ug/dl in children, which is well above any threshold for health effects. Of course, a part of the population has a BLL below 16 ug/dl as reflected by the standard deviation reported in the studies.

Table 11: Estimated Health Effects per 1000 People

	Age		
Rate of event/ illness per 1000 people	0 to 4	5 to 14	15+
IQ (1) - loss of 1.95 points	98		
IQ (2) - loss of 3.25 points	71		
IQ (3) - loss of 3.5 points	453		
BP (1) +1.975 mmHg (10-15BPb)			167
BP (2) + 3.125 mmHg (15-20BPb)			124
BP (3) + 3.75 mmHg (>20BPb)			403
Gastrointestinal effects	42	42	
Anaemia – children	37	37	
Anaemia – adults			8
MMR for age 0-4, incidence	3.3		

Notes: IQ is in reference to intelligence; BP = blood pressure; MMR = mild mental retardation.

27. The adjusted BLL and the range in standard deviation are applied in the model to estimate population BLL. The result suggests that an estimated 62 percent of the children and 61 percent of the adults have BLL>10 ug/dl and an estimated 44-45 percent of the children and adults have BLL>20 ug/dl. These are extraordinarily large estimates. Estimated health effects per 1000 children and per 1000 adults are presented in Table 11. It is assumed that IQ losses take place during the first 5 years of a child's life, while gastrointestinal effects and anemia can occur in children under 15 years of age. In adults, the health effects are increased blood pressure (BP) and anemia.

28. **Loss of Intelligence:** Studies have found an average loss of 1.3 IQ points per 5 ug/dl BLL in children. Fewtrell et al (2003) apply a lower threshold of 5 ug/dl BLL below which no IQ loss occurs, and an upper threshold of 20 ug/dl BLL above which no further IQ losses are expected (i.e., a loss of about 3.5 IQ points for BLL > 20 ug/dl).[7] As we noted above, we adjusted the model, applying a threshold of 10 ug/dl. For some children an IQ loss will cause mild mental retardation (MMR), occurring at an IQ of 50-70 points. Thus children with an IQ of 70.5-73.5 points are at risk of MMR from lead exposure. Following the assumption of a normal distribution of IQ in the population, the number of children with MMR from lead exposure is estimated by applying the results in Table 3.2.3 to the estimated children with IQ of 70-73.5 points. Estimated annual loss of intelligence from lead exposure are presented in Table 12, totaling about 2,200 thousand IQ points and 18,000 cases of MMR.

Table 12: Estimated Annual IQ Losses and Cases of MMR from Lead Exposure

IQ Point Losses (thousands)	
IQ (1) - loss of 1.95 points per child	199
IQ (2) - loss of 3.25 points per child	239
IQ (3) - loss of 3.50 points per child	1,649
Total Losses (thousands)	2,188
MMR	
Number of children with MMR	17,000

29. **Other Health Effects:** Other health effects of lead exposure are gastrointestinal effects in children, anemia in children and adults, and elevated blood pressure in adults resulting in a higher risk of

[7] Fewtrell et al (2003) apply a linear relationship through the mid-point of each 5 ug/dl BLL interval with a maximum loss of 3.5 IQ points.

cardiovascular disease and mortality. Gastrointestinal effects and anemia are found to develop at BLL exceeding 60-80 ug/dl. Estimated number of cases is presented in Table 13.

Table 13: Estimated Annual Cases of "Other Health Effects" from Lead Exposure

	0 to 4	5 to 14	15+
Gastrointestinal effects	220,000	440,000	
Anaemia - children	195,000	385,000	
Anaemia - adults			655,000

30. **Elevated Blood Pressure.** The level of cardiovascular disease resulting from lead exposure is estimated using the attributable fraction. The proportions of the adult population with different BLL are equated with the relative risks for cardiovascular diseases to calculate the attributable fraction (AF), which was associated with the increased blood pressure.

$$AF = \frac{\sum P_i RR_i - 1}{\sum P_i RR_i},$$

where:

Pi – proportion of population at exposure interval for different BLL;

RRi – relative risk at exposure interval i compared to the reference point.

The following relative risk values were applied as presented in Table 14.

Table 14: Relative Risks of Cardiovascular Disease of Increases In Blood Pressure

Disease	**Age (yrs)**				
	15–29	**30–44**	**45–59**	**60–69**	**70–79**
Males					
1.875 mmHg increase					
IHD	1.13	1.13	1.1	1.055	1.043
CVA	1.177	1.177	1.137	1.089	1.061
Hypertensive disease	1.413	1.413	1.189	1.111	1.083
Other cardiac diseases	1.039	1.039	1.026	1.017	1.01
3.125 mmHg increase					
IHD	1.225	1.225	1.172	1.093	1.072
CVA	1.312	1.312	1.239	1.152	1.104
Hypertensive disease	1.779	1.779	1.334	1.192	1.142
Other cardiac diseases	1.067	1.067	1.044	1.029	1.017
3.750 mmHg increase					
IHD	1.276	1.276	1.21	1.112	1.087
CVA	1.385	1.385	1.293	1.185	1.126
Hypertensive disease	1.996	1.996	1.413	1.235	1.172
Other cardiac diseases	1.081	1.081	1.053	1.035	1.02
Females					
1.2 mmHg increase					
IHD	1.081	1.081	1.063	1.035	1.027
CVA	1.11	1.11	1.086	1.056	1.039
Hypertensive disease	1.247	1.247	1.117	1.07	1.052
Other cardiac diseases	1.025	1.025	1.017	1.011	1.006
2.0 mmHg increase					
IHD	1.139	1.139	1.107	1.058	1.046

Disease	Age (yrs)				
	15–29	**30–44**	**45–59**	**60–69**	**70–79**
CVA	1.19	1.19	1.147	1.095	1.065
Hypertensive disease	1.446	1.446	1.203	1.119	1.088
Other cardiac diseases	1.042	1.042	1.028	1.018	1.011
2.4 mmHg increase					
IHD	1.169	1.169	1.13	1.07	1.055
CVA	1.232	1.232	1.179	1.115	1.079
Hypertensive disease	1.556	1.556	1.248	1.145	1.107
Other cardiac diseases	1.051	1.051	1.033	1.022	1.013

Source: Fewtrell L., et al, 2003

31. Attributable fractions for cerebrovascular, hypertensive, ischaemic heart and other cardiac disease were estimated (See tables 15 and 16). They were applied to the background corresponding cardiovascular mortality rate and disability DALYs loss by age in Emro D WHO subregion (GBD, 2002).

Table 15: Estimated Attributable Fractions For Cardiovascular Diseases Due To Lead Exposure For Mortality

	AF male +49	AF female +49	AF average +49
Cerebrovascular disease	3.57%	1.82%	2.69%
Hypertensive disease	4.44%	2.52%	3.48%
Ischaemic heart disease	3.11%	1.55%	2.33%
Other cardiac diseases	0.59%	0.31%	0.45%

Table 16: Estimated Attributable Fractions For Cardiovascular Diseases Due To Lead Exposure For Disability DALYs loss

	AF male +49	AF female +49	AF average +49
Cerebrovascular disease	4.60%	3.33%	3.96%
Hypertensive disease	2.70%	2.02%	2.36%
Ischaemic heart disease	3.41%	2.12%	2.76%
Other cardiac diseases	0.92%	2.49%	1.70%

32. Lead exposure-attributed mortality and DALYs loss due to increased blood pressure is presented in the table 17.

Table 17. Estimated Lead Exposure-Attributed Mortality and DALYs loss

	Mortality	**Disability DALYs Loss**
Cerebrovascular disease	290	8,330
Hypertensive disease	156	8,864
Ischaemic heart disease	616	782
Other cardiac diseases	52	3,120
Total	1114	21,095

33. The DALYs lost to MMR, gastrointestinal effects and anaemia were estimated using WHO DALYs tables (www.who.int/evidence/nbd). A disability weight was selected as recommended by WHO.

It is 0.0361 for MMR, 0.01 for anaemia and 0.1 for gastrointestinal effects. Table 18 presents DALYs losses for different age groups.

Table 18: Estimated Loss Of Disability DALYs Associated With Lead Exposure

	Age		
	0-4	5-14	+15
GI effects	40,632	81,264	
Anaemia – children (DALYs)	3,554	7,107	
Anaemia – adults (DALYs)			12,085
MMR for age 0-4 (DALYs)	177,940		
Cardiovascular diseases-adults			21,095
	40,632	81,264	
Total DALYs	3,554	7,107	

Estimated Cost of Health Impacts

34. Estimated annual costs of health effects from lead exposure are presented in Table 19, totaling 38-52 billion Rs per year. The main costs are associated with IQ losses and mild mental retardation (MMR). Cost of IQ losses are estimated based on expected lifetime income losses, using a 1.3-1.9 percent decline in income for every one point loss in IQ from studies in the United States (Schwartz 1994 and Salkever 1995).[8] Studies of income losses from MMR are not readily available. Income losses are therefore estimated as proportional to MMR disability, using a disability weight of 0.36 provided by WHO. Cost of cardiovascular mortality is the transferred value of statistical life (VSL). Cost of gastrointestinal effects is based on the COI of diarrheal illness. On average, one case of diarrhea implies Rs200. of expenses, which includes doctor visit, medication cost and time losses of care givers. Cost of elevated blood pressure morbidity and anemia are not included because of data limitations.

Table 19: Annual Cost of Health Impacts from Lead Exposure (Billion Rs)

	Total cost	Percent of mean cost
IQ loss in children	28-42	78%
Mild mental retardation (MMR)	6.5	15%
Cardiovascular mortality in adults	3	7%
Gastrointestinal effects in children	0.1	0.3%
Total annual cost	38-52	100%

35. It should be noted again that the costs presented are only for the urban population in cities with more than 100 thousand inhabitants, and that the estimates are based on adjusted BLL measurements from 1994 to 2003. As there is great uncertainty about current BLL in the urban population as a whole (and the rural population), it is necessary to undertake new studies of BLL in children and adults to provide a more accurate estimate of health effects and their costs.

[8] This reflects a lower and upper bounds of estimated income losses. An annual discount rate of 3 percent and a real increase in annual income of 2 percent is applied. A 0.5 percentage point income loss attributed to a reduced likelihood of labor force participation from a decline in IQ is not included because of inadequate comparable data on factors influencing labor force participation in Pakistan vs the United States.

II. WATER, SANITATION, AND HYGIENE

36. Inadequate quantity and quality of potable water supply, sanitation facilities and practices, and hygiene conditions are associated with various illnesses both in adults and children. Esrey et al (1991) provides a comprehensive review of studies documenting this relationship for diseases such as schistosomiasis (bilharzia), intestinal worms, diarrhea etc. Fewtrell and Colford (2004) provides a meta-analysis of studies of water supply, sanitation and hygiene that updates the findings on diarrheal illness by Esrey et al. While diarrheal illness is generally not as serious as some other waterborne illnesses, it is more common and affects a larger number of people.

Baseline Health Data

37. Mortality for children under 5 and diarrheal-based child mortality are high in Pakistan. Baseline health data for estimating the health impacts of inadequate water supply, sanitation and hygiene are presented in Table 4.1. Data from PDS 2003 indicate that 11 percent of child mortality was due to intestinal diseases. This is used as a low bound for diarrheal mortality estimation. The Global Burden of Disease 2002 (WHO) indicates that 17 percent of child mortality could be from diarrheal illness in Pakistan, which takes into account possible substantial under-reporting of child mortality. This is used as the upper bound.

38. For diarrheal morbidity, it is very difficult or practically impossible to identify all cases of diarrhea. The main reason is that substantial numbers of cases are not treated or do not require treatment at health facilities, and are therefore never recorded. A second reason is that cases treated by private doctors or clinics are often not reported to public health authorities. The PIHS 2001/2002 survey provides data on diarrheal prevalence in children under the age of five years. It reports a diarrheal prevalence (preceding 30 days) rate of 12 percent. This rate is used to estimate annual cases per child under 5, and then total annual cases in all children under 5. The PIHS household survey does not (nor does any other household survey in Pakistan) provide information on diarrheal illness in the population above 5 years of age. However, the information about quarterly reported diarrheal morbidity from the Government of Pakistan among people under 5 and over 5 is available.[9] This database provides an indication of the annual incidence of diarrhea per child relative to annual incidence for the rest of the population. An analysis of the database suggests that diarrheal incidence in the population above 5 years of age is 22 percent of incidence in children under 5 years. It should be noted however that the database is cases of diarrhea treated at health facilities. In general, the percentage of cases of diarrhea that are treated at health facilities is higher among young children than older children and adults. The annual cases of diarrhea per person among the population above 5 years of age, presented in Table 20, is therefore estimated in the range of 0.22 to 0.31 [(1/(0.7))*0.22] of the annual cases per child under 5.

39. Sometimes diarrheal illness requires hospitalization. There are no readily available centralized records in Pakistan that provide data on the annual number of diarrheal hospitalizations. A hospitalization rate of 0.75 percent for children and 0.5 percent for population over 5 was applied to all cases of diarrhea estimated above. Table 20 also presents DALYs per cases of diarrheal illness, which are used to estimate the number of DALYs lost because of inadequate water supply, sanitation and hygiene. The disability weight for diarrheal morbidity is 0.119 for children under 5 and 0.086 for the rest of the population, and the duration of illness is assumed to be 7 days for children (PIHS, 2001/2002) and 3-4 days for adults.

40. For typhoid, the disability weight is estimated at 0.2. Duration of illness is estimated from the study in India (Sinha et al, 1999). Average duration is about 11 days for children under 5 and 13 for people above 5 (average age is 10 years old).

[9] Information about Priority Diseases at pakistan.gov.pk.

41. However, the DALYs per 100 thousand cases of diarrheal illness are much higher for the population over 5 years of age. This is because DALY calculations involve age weighting that attaches a low weight to young children and a higher weight to adults that corresponds to physical and mental development stages.[10] For diarrheal and typhoid child mortality the number of DALYs lost is 34 for those under 5, and 32 for those above 5 (they are mostly under 14 years old on average for typhoid). This reflects an annual discount rate of 3 percent of life years lost.

Table 20: Baseline Data for Estimating Health Impacts

	Baseline	**Source:**
Under-5 child mortality rate in 2003	102	PDS 2003
Diarrheal mortality in children under 5 years (% of child mortality)	11-17 %	PDS 2003, GBD2002 (WHO)
Total annual diarrheal mortality in children under 5	35,500-56,500	
Diarrheal 2-week Prevalence in Children under 5 years	12 %	PIHS2001/2002
Estimated annual diarrheal cases per child under 5 years	1.4	Estimated from PIHS2001/2002
Estimated annual diarrheal cases per person (> 5 years)	0.32-0.46	Estimated from a combination of priority disease registered from (pakistan.gov.pk) and PIHS2001/2002
Hospitalization rate (% of all diarrheal cases) –children under 5 years	0.75 %	International experience
Hospitalization rate (% of all diarrheal cases) –children under 5 years	0.5 %	
Percent of diarrheal cases attributable to inadequate water supply, sanitation and hygiene	90 %	WHO (2002b)
DALYs per 100 thousand cases of diarrhea in children under 5	70	Estimated from WHO tables
DALYs per 100 thousand cases of diarrhea in persons >5 years	100-130	
DALYs per 100 thousand cases of typhoid in persons under 5 and over 5	190-820	
DALYs per case of diarrheal and typhoid mortality in children over 5 and under 5	32-34	

Estimated Health Impacts from Inadequate Water, Sanitation and Hygiene.

42. Table 21 presents the estimated health impacts from inadequate water, sanitation and hygiene. The estimates are based on the data in Table 19, taking into account the WHO estimate that 90 percent of diarrheal illness is attributable to water, sanitation and hygiene.

[10] It should be noted that some researchers elect not to use age weighting, or reports DALYs with and without age weighting.

Table 21: Estimated Annual Health Impacts from Water, Sanitation, Hygiene

	Estimated Annual Cases	
	"Low"	"High"
Diarrheal child mortality	35,505	56,470
Diarrheal child morbidity	24,477,300	24,477,300
Diarrheal adults morbidity	34,421,400	50,067,900
Typhoid/paratyphoid mortality	27,000	27,000
Typhoid/paratyphoid morbidity	1,350,000	1,350,000
Total Disability Adjusted Life Years (DALYs)-mortality and morbidity (mean)	2,522,755	

Table 22: Estimated DALYs Lost to Mortality and Morbidity

	Estimated Annual DALYs		
	"Low"	"High"	% of Total DALYs
Children (under the age of 5 years) – increased diarrheal mortality	1,207,179	1,919,989	56-66 %
Children (under the age of 5 years) – increased diarrheal morbidity	17,134	17,134	1%
Population over 5 years of age – increased diarrheal morbidity	34,077	66,090	2-3 %
Children (under the age of 5 years) – increased typhoid morbidity	965	965	0
Population over 5 years of age – increased typhoid morbidity	6,989	6,989	0
Children (under the age of 5 years) – increased typhoid mortality	340,000	340,000	12-16%
Population over 5 years of age – increased typhoid mortality	544,000	544,000	19-25%
TOTAL	2,150,344	2,895,167	

Estimated Cost of Diarrheal Health Impacts.

43. Total annual cost of diarrheal illness associated with inadequate water, sanitation and hygiene is estimated at 55-84 billion Rs. (Table 4.4). The cost of mortality is based on the human capital approach (HCA) since both diarrheal and typhoid mortality predominantly affects children. The cost of morbidity includes the cost of illness (medical treatment, medicines, and value of lost time). Cost-of-illness is presented in Table 24 for diarrheal morbidity. About 50 percent of these costs are associated with the value of time lost to illness (including care giving), and another 50 percent are from cost of treatment and medicines.

Table 23: Estimated Annual Cost of Diarrheal Illness (Rs. Billion)

	Estimated Annual Cost	
	"Low"	**"High"**
Mortality		
Children under age 5 diarrheal mortality	45	72
Morbidity		
Diarrheal morbidity	10	12
TOTAL ANNUAL COST	55	84

	Estimated Annual Cost (Billion S/.)	
	"Low"	"High"
Cost of medical treatments (doctors, hospitals, clinics)	2	3
Cost of medicines	3	3
Cost of time lost to illness	5	6
TOTAL ANNUAL COST	10	12

Baseline data for the cost estimates are presented in Table 25.

Table 25: Baseline Data for Cost Estimation

	Baseline	**Source:**
Percent of diarrheal cases treated at medical facilities (children <5 years) and with medicines	82%	PIHS2001/2002
Percent of diarrheal cases treated with ORS (children <5 years)	54%	PIHS2001/2002
Percent of diarrheal cases treated at medical facilities (population > 5 years) and with medicines	56-82%	Estimated from a combination of Pakistan DHS 1990/91 and priority disease statistics at www.pakistan.gov.pk
Average Cost of doctor visits (urban and rural) – Rs.	50	Per consultations with pharmacies, medical service providers, and health authorities
Average Cost of medicines for treatment of diarrhea – Rs.	50	
Average cost of ORS per diarrheal case in children (Rs.)	30	
Average duration of diarrheal illness in days (adults and children)	3-7	PIHS2001/2002
Hours per day of care giving per case of diarrhea in children	2	Assumption
Hours per day lost to illness per case of diarrhea in adults	2	Assumption
Value of time for adults (care giving and ill adults) – Rs./hour	7.71	Based on urban and rural wages in Pakistan (see Outdoor air pollution section)
Hospitalization rate (% of all diarrheal cases) –children under 5 years	0.75 %	Adjusted based on evidence from Egypt (Larsen 2004)
Hospitalization rate (% of all diarrheal cases) –population over 5	0.5 %	
Average length of hospitalization (days)	2	Adjusted from (Larsen 2004)
Time spent on visitation (hours per day)	4	Assumption
Average cost of hospitalization (Rs. per day)	500	Per consultations with hospitals
Percent of diarrheal cases attributable to water, sanitation and hygiene	90 %	(WHO 2002b)

Typhoid and Paratyphoid

44. Recorded annual deaths of typhoid/paratyphoid in Pakistan by age are available from PDS 2003. Using the India typhoid study by Sinha et al, 1999, annual cases of typhoid fever were estimated. The resulting mortality rate is about 2 percent, which is consistent with the evidence from the literature (1 percent mortality in the US) (See Louisiana Department of Public Health, 2004). Results of the estimation are presented in Table 4.7 for the year 2000-2003.

Table 26: Annual Cases of Typhoid/Paratyphoid (2000-2003) by Age

	0-4 years	5+ years	All groups
Typhoid/Paratyphoid mortality	10,000	17,000	27,000
Typhoid/Paratyphoid morbidity	500,000	850,000	1,350,000

45. The estimated annual cost of these illnesses is presented in Table 27. Mortality is 95 percent of total cost. About 13 percent of estimated morbidity cost is from hospitalization and doctor visits, 52 percent is from time losses for the ill individuals and their caregivers during illness. More than 70 percent of the cost of time losses is associated with ill individuals and almost 30 percent with care giving.

Table 27: Estimated Annual Cost of Typhoid/Paratyphoid

	Estimated Total Annual Cost (Billion Rs.)
Mortality	
Children under age 5 typhoid mortality	12.7
People over 5 typhoid mortality	23.5
Morbidity	
Cost of Hospitalization and doctor visits	0.2
Cost of Medication	0.7
Cost of time losses	1.0
Total Annual Cost	38.1

Averting Expenditures

46. In the presence of perceived health risks, individuals often take averting measures to avoid these risks. Economists usually consider these measures a cost of health risks. If consumers perceive there is a risk of illness from the municipal water supply, or from other sources of water supply they rely, some consumers are likely to purchase bottled water for drinking purposes, or boil their water, or install water purification filters.

Bottled Water. Rosemann (2003) estimates that about 70 Million liters of bottled water are sold in Pakistan annually and some market growth is predicted. We use 100 Million liters as a high bound bottled water consumption estimate. Total annual cost of bottled water consumption is estimated at 1-1.5 billion Rs. The lower bound represents a 75 percent mark-up of average factory price. The upper bound represents an arithmetic average of retail prices for the most commonly sold quantities of bottles and containers. Average retail price was about 15 Rs./liter.

Boiling of Water. According to the Luby et al, (2001) study for Karachi, 40 percent of households boil their drinking water, either all the time or sometimes. Table 4.9 presents the estimated annual cost of boiling water for those households, totaling 2-5 billion Rs. per year.

47. Tables 28 and 29 present the data used to estimate the annual cost of boiling drinking water. It is assumed that the average daily consumption of drinking water per person is 0.5-1.0 liters among households boiling water. Residential cost of energy is estimated based on data from *Pakistan 2004 Statistical Yearbook*. The average stove efficiency is for electric, natural gas and kerosene. Lower efficiency was applied for wood stove.

Table 28: Estimated Annual Cost of Boiling Drinking Water

	Estimated Annual Cost (Billion Rs.)	
	"Low"	**"High"**
Annual cost--using fuel wood for water boiling	1.37	3.43
Annual cost--using kerosene for water boiling	0.05	0.14
Annual cost--using natural gas for water boiling	0.40	0.99
Annual cost--using other types of energy for water boiling	0.14	0.35
Total Annual Cost	1.96	4.90

Table 29: Baseline Data for Cost Estimation

	Data:	
Percentage of households that boil their drinking water	40 %	Luby et al, (2001)
Average daily consumption of drinking water	0.5-1.0	Liters per person per day
Percent of households using fuel wood for cooking	69%	Census 1998
Percent of households using kerosene for cooking	4%	
Percent of households using natural gas for cooking	20%	
Percent of households using other types of energy for cooking	7%	
Energy requirement of heating of water (100% efficiency)	4200	Joules/ltr/1 degree C
Average Stove efficiency for heating of water	50 %	Varies by type of stove
Average wood Stove efficiency for heating of water	20 %	
Average time of boiling water (after bringing water to boiling point)	10	Minutes
Cost of LPG	1000	Rs/ per 17.7 gl
Cost of kerosene	7	Rs/liter
Average cost of fuel wood	70 Rs per 40 kg	Pakistan 2004 Statistical Yearbook

Table 30: Estimated Total Annual Household Cost of Averting Expenditures

	Total Annual Cost (Billion Rs.)	
	"Low"	**"High"**
Cost of bottled water consumption	1.0	1.5
Cost of household boiling drinking water	2.0	5.1
Total annual cost	**3**	**6.6**

III. INDOOR AIR POLLUTION

48. There are two main steps in quantifying the health effects. First, the number of people or households exposed to pollution from solid fuels needs to be calculated, and the extent of pollution, or concentration, should ideally be measured. Second, the health impacts from this exposure should be estimated based on epidemiological assessments. Once the health impacts are quantified, the value of this damage can be estimated.

Traditional Fuel Use

49. The Pakistan Census conducted in 1998 reports that 86 percent of rural and 32 percent of urban households use solid fuels for cooking in Pakistan. The national weighted average is about 67 percent.

Health Risk Assessment

50. Desai et al (2004) provides are review of research studies around the world that have assessed the magnitude of health effects from indoor air pollution from solid fuels. The odds ratios for acute respiratory illness (ARI) and chronic obstructive pulmonary disease (COPD) are presented in Table 31. The odds ratios represent the risk of illness for those who are exposed to indoor air pollution compared to the risk for those who are not exposed. The exact odds ratio depends on several factors such as concentration level of pollution in the indoor environment and the amount of time individuals are exposed to the pollution. A range of ratios reflects the bounds of uncertainty. The odds ratios have been applied to young children under the age of five years (for ARI) and adult females (for ARI and COPD) to estimate the increase in mortality and morbidity associated with indoor air pollution.[11] It is these population groups who suffer the most from indoor air pollution. This is because they spend much more of their time at home, and/or more time cooking than older children and adult males.

Table 31: Health Risks of Indoor Air Pollution

	Odds Ratios (OR)	
	"Low"	"High"
Acute Respiratory Illness (ARI)	1.9	2.7
Chronic obstructive pulmonary disease (COPD)	2.3	4.8

Source: Desai et al (2004).

Baseline Health Data.

51. To estimate the health effects of indoor air pollution from the odds ratios baseline data for ARI and COPD need to be established. These data are presented in Table 32, along with unit figures for disability adjusted life years (DALYs) lost to illness and mortality. Data on COPD mortality and especially morbidity incidence, according to international disease classifications, are not readily available for Pakistan. The national average two-week prevalence rate of ARI in children under 5 years as in MICS database (1996) is used to estimate total annual cases of ARI in children under 5. The average duration of ARI is assumed to be about 7 days. This implies that the two-week prevalence captures half of the ARI prevalence in the week prior to and the week after the two-week prevalence period.

[11] Although Desai et al (2004) present odds ratios for lung cancer, this effect of pollution is not estimated in this report. This is because the incidence of lung cancer among rural women is generally very low. The number of cases in rural Pakistan associated with indoor air pollution is therefore likely to be minimal.

52. There is no information on ARI prevalence in adults. However, the information is available for quarterly ARI-reported morbidity among people under and over 5 years of age.[12] This database provides an indication of the annual incidence of ARI per child relative to annual incidence for the rest of the population. An analysis of the database suggests that ARI incidence in the population above 5 years of age is 0.36 of the incidence in children under 5 years. It should be noted however that the database contains information on cases of ARI treated at health facilities. In general, the percentage of cases of ARI that are treated at health facilities is higher among young children than older children and adults. The annual cases of ARI per person among the population above 5 years of age, presented in Table 5.3, is therefore estimated in the range of 0.36 to 0.42 [(1/(0.85))*0.36] of the annual cases per child under-5.

53. ARI mortality in children under 5 years is presented in Table 5.3. The low bound of ARI mortality of 11 percent is estimated from PDS 2003, the high bound of 18 percent is estimated from a combination of GBD 2002 mortality tables for Searo D and Emro D regions of WHO, reflecting uncertainty over all-cause and cause-specific child mortality statistics.

54. Table 32 also presents DALY per cases of ARI and COPD, which are used to estimate the number of DALYs lost because of indoor air pollution. The disability weight for ARI morbidity is the same for children and adults (i.e., 0.28), and the duration of illness is assumed to be the same (i.e., 7 days). The DALYs per 100 thousand cases of ARI is however much higher for adults. This is because DALY calculations involve age weighting that attaches a low weight to young children, and a higher weight to adults, that corresponds to physical and mental development stages.[13] For ARI child mortality the number of DALYs lost is 34. This reflects an annual discount rate of 3 percent of life years lost.

Table 32: Baseline Data for Estimating Health Impacts

	Baseline		Source:
	Urban	Rural	
Female COPD mortality rate (% of total female deaths)	3.1 %		WHO (2002) and Shibuya et al (2001)
Female COPD incidence rate (per 100,000)	63		
ARI 2-week Prevalence in Children under 5 years	24%	24%	MICS 1996
Estimated annual cases of ARI per child under 5 years	4.1	4.1	Estimated from MICS 1996
Estimated annual cases of ARI per adult female (> 30 years)	1.5	1.75	Estimated from a combination of MICS 1996 and pakistan.gov.pk
ARI mortality in children under 5 years (% of child mortality)	11-18%		PDS 2003, GBD 2002 (WHO) for Searo D and Emro D
DALYs per 100 thousand cases of ARI in children under 5	165	165	Estimated from WHO tables
DALYs per 100 thousand cases of ARI in female adults (>30)	700	700	
DALYs per case of ARI mortality in children under 5	34	34	
DALYs per case of COPD morbidity in adult females	2.25	2.25	
DALYs per case of COPD mortality in adult females	6	6	

[12] Information about Priority Diseases at pakistan.gov.pk.

[13] It should be noted that some researchers elect not to use age weighting, or reports DALYs with and without age weighting.

Estimated Health Impacts

55. Annual new cases of ARI and COPD morbidity and mortality (D_i) from fuel wood smoke was estimated from the following equation:

$$D_i = PAR * D_i^B \qquad (1)$$

where D_i^B is baseline cases of illness or mortality, i (estimated from the baseline data in Table 5.2), and PAR is given by:

$$PAR = PP*(OR-1)/(PP*(OR-1)+1) \qquad (2)$$

where PP is the percentage of population exposed to fuel wood smoke (32 percent of the urban and 86 percent of rural population according to Pakistan Census 1998), and OR is the odds ratios.
The results are presented in Table 33. Estimated cases of ARI child mortality and ARI morbidity (children and female adults) from indoor air pollution represent about 38-53 percent of total ARI in Pakistan. Similarly, the estimated cases of COPD mortality and morbidity represent about 46-72 percent of total estimated female COPD from all causes.

Table 33: Estimated Annual Health Impacts of Indoor Air Pollution

	Estimated Annual Cases	
	"Low"	"High"
Acute Respiratory Illness (ARI):		
Children (under the age of 5 years) – increased mortality	21,933	31,060
Children (under the age of 5 years) – increased morbidity	29,508,800	41,788,200
Females (30 years and older) – increased morbidity	10,754,600	15,229,800
Chronic obstructive pulmonary disease (COPD):		
Adult females – increased mortality	7,408	11,433
Adult females – increased morbidity	21,850	33,721
Total Disability Adjusted Life Years (DALYs)-mortality and morbidity	963,302	1,376,062

Table 34: Estimated DALYs Lost to Indoor Air Pollution

	Estimated Annual DALYs		
	"Low"	"High"	% of Total DALYs
Acute Respiratory Illness (ARI):			
Children (under the age of 5 years) – increased mortality	745,718	1,056,029	77%
Children (under the age of 5 years) – increased morbidity	48,690	68,951	5%
Females (30 years and older) – increased morbidity	75,282	106,609	8%
Chronic obstructive pulmonary disease (COPD):			
Adult females – increased mortality	44,450	68,600	5%
Adult females – increased morbidity	49,163	75,873	5%

56. Table 34 presents the estimated health impacts in terms of disability adjusted life years (DALYs). An estimated 963-1,376 thousand DALYs are lost each year due to indoor air pollution. About 77 percent is from mortality, and about 30 percent from morbidity.

Estimated Cost of Health Impacts

57. Total annual cost of indoor air pollution is estimated at 55-70 billion Rs, with a mean estimate of 62 billion (Table 35). The cost of mortality for adults is based on the value of statistical life (VSL) and for children on HCA. The cost of morbidity includes the cost of illness (medical treatment, value of lost time, etc).

Table 35: Estimated Annual Cost of Indoor Air Pollution

	Estimated Annual Cost (Million Rs)	
	"Low"	"High"
Acute Respiratory Illness (ARI):		
Children (under the age of 5 years) – increased mortality	27.83	39.40
Children (under the age of 5 years) – increased morbidity	4.26	6.03
Adult females – increased morbidity	2.04	2.89
Chronic obstructive pulmonary disease (COPD):		
Adult females – increased mortality	25.84	25.84
Adult females – increased morbidity	0.12	0.18
TOTAL	60.08	74.34

58. Baseline data for the cost estimates of morbidity in Table 5.5 are presented in Table 36. The percentage of ARI cases in the age group older than 5 years treated at medical facilities is estimated from percent of treated cases among children (MICS 1995) and the ratio of treated cases among children under 5 to treated cases among the population above 5 years of age. There is very little information about the frequency of doctor visits, emergency visits and hospitalization for COPD patients in any country in the world. Schulman et al (2001) and Niederman et al (1999) provide some information on this from the United States and Europe. Figures derived from these studies are applied to Pakistan in this report. Estimated lost work-days per year is based on frequency of estimated medical treatment plus an additional 7 days for each hospitalization and one extra day for each doctor and emergency visit. These days are added to reflect time needed for recovery from illness. To estimate the cost of a new case of COPD, the medical cost and value of time losses have been discounted over an assumed 20-year duration of illness. An annual real increase of 2 percent in medical cost and value of time has been applied to reflect an average expected increase in annual labor productivity and real wages. The costs are discounted at 3 percent per year, a rate commonly applied by WHO for health effects

.

Table 36: Baseline Data for Cost Estimation

		Source:
Percent of ARI cases treated at medical facilities (children < 5 years)	53	MICS 1995
Cost of medicines for treatment of acute respiratory illness (population < 5 years)	50	Per consultations with pharmacies
Percent of ARI cases treated at medical facilities (females > 30 years)	49	International experience
Cost of medicines for treatment of acute respiratory illness (females > 30 years) (Rs)	50	Per consultations with pharmacies
Percent of COPD patients being hospitalized per year	1.5	Assumption based on Schulman et al (2001) and Niederman et al (1999)
Percent of COPD patients with an emergency doctor/hospital outpatient visits per year	15	

Average number of doctor visits per COPD patient per year	1	
Estimated lost workdays (including household work days) per year per COPD patient	2.6	Estimated based on frequency of doctor visits, emergency visits, and hospitalization
Cost of doctor visit Rs. per visit (rural)	40	Per consultations with pharmacies, medical service providers, and health authorities
Cost of hospitalization (Rs. per day)	500	
Cost of emergency visit (Rs.)	250	
Average duration of ARI in days (children and adults)	7	Assumption
Hours per day of care giving per case of ARI in children	2	Assumption
Hours per day lost to illness per case of ARI in adults	3	Assumption
Value of time for adults (care giving and ill adults) – Rs/hour	7	75% of rural wages in Pakistan
Average length of hospitalization for COPD (days)	10	Larsen (2004b)

IV. NATURAL RESOURCE DAMAGES IN PAKISTAN

59. Natural resources damages are estimated for croplands, rangelands and forests. Cropland losses include losses from soil salinity due to improper irrigation practice and human-induced soil erosion. In the absence of data on the annual increase in salinity and eroded croplands and rangelands, the annual loss of agricultural production (crop and rangeland fodder) is estimated based on accumulated degradation. This estimate may be more or less than the net present value (NPV) of annual production losses depending on the rate of annual increase in degradation. Annual deforestation data are available and annual losses resulting from deforestation are therefore estimated based on NPV of lost forested area.

V. COST TO AGRICULTURE OF SOIL SALINITY

60. Soil salinity reduces the productivity of agricultural lands and, if salinity levels are high enough, can eliminate cultivation. From conventional welfare economics and assuming agricultural markets are competitive, the economic costs of salinity are the losses in consumer surplus (consumer willingness to pay above market price) and producer surplus (profit) associated with this loss in productivity. Such losses could be direct, in the sense of crops that cannot be planted or, if planted, yield lower output than if planted in less saline soil. They could also be related to losses from crop substitution to more saline-tolerant but less profitable crops. Because of a lack of data, these losses are approximated by the value of "lost" output related to the salinity, with some simple adjustment for changes in cropping patterns.
Total irrigated land in Pakistan is about 18.2 million hectares (Table 37). Nearly 25 percent of this land suffers from various levels of salinity[14]. Table 38 presents salinity levels of irrigated lands in Pakistan. About 1.4 million hectares of lands with salinity 15-20 dS/m are no longer cultivated. Table 39 presents soil salinity thresholds and yield effects of salinity from the international empirical literature.[15]

[14] In addition, as much as 2.0 million hectares are reported to have soil salinity exceeding 20 dS/m (Agricultural Statistics of Pakistan 2003-2004. Economic Wing, Ministry of Food, Agriculture and Livestock, Government of Pakistan, Islamabad). Even the most salt tolerant crops, such as cotton, wheat, and barley, would have severe difficulties in such saline conditions. We assume that these 2 million ha of land were never cultivated.
[15] The dS/m values are rounded to nearest integer and percent, and relatively conservative values have been used.

Table 37: Irrigated land in Pakistan (2002-2003)

	Million hectares
Punjab	13.94
Sindh	2.16
N.W.F.P.	0.96
Balochistan	1.17
Total	18.2

Source: Agricultural Statistics of Pakistan. (2003-2004).

Table 38: Salinity Levels of Irrigated Lands

Salinity Level		Irrigated	
	dS/m	(million ha)	%
Minimal salinity, cultivated	0-4	13.97	77%
Slight salinity , cultivated	4-8	0.6	3%
Moderate salinity, cultivated	8-15	1.23	7%
Severe salinity, cultivated	15-20	1	5%
Severe salinity, uncultivated	15-20	1.4	8%
Total irrigated land		18.2	100%

Source: Agricultural Statistics of Pakistan 2003-2004.

Table 39: Crop Salinity Tolerance and Yield Effects

	Salinity	Yield decline
	Threshold	per 1 dS/m
	(dS/m)	over threshold
Pulses	1.5	15%
Sugar cane	1.7	7%
Fodder	2	7%
Vegetables	2	10%
Maize	2	12%
Rice	3	12%
Soybean	5	20%
Wheat	6	5%
Barley	8	5%
Cotton	8	5%

Source: Salinity threshold and yield declines are from FAO (1998), Gratten et al (2002), Kotuby-Amacher, J. et al (1997), and Cullu M.A. (2002).

61. There are no comprehensive data available on cropping patterns in relation to specific levels of soil salinity in Pakistan. To estimate the cost of salinity, it is therefore necessary to make a simplifying assumption that more salt sensitive crops are cultivated on the lands with lower salinity. Optimal adaptation, if salinity was the only soil characteristic affecting crop choices, would imply that the salt sensitive crops are cultivated on the land that has salinity lower than 4 dS/m while crops on more saline land are mainly wheat, barley and cotton.

62. We consider two scenarios of cropping patterns on saline land. The first scenario assumes that only cotton is cultivated on the most saline lands (15-20 dS/m), and that more cotton than wheat is cultivated on land with salinity 8-15 dS/m. The second scenario assumes that only wheat is cultivated on the most saline lands, and that more wheat than cotton is cultivated on land with salinity 8-15 dS/m. These cropping patterns are in practice unlikely. The two scenarios therefore represent an upper and lower bound of the cost of salinity because of the different market value and salinity tolerance of cotton and wheat.

Table 40: Assumed Cropping Patterns on Irrigated Lands

Salinity Level	dS/m	Scenario (1)	Scenario (2)
Minimal salinity	0-4	Pulses, sugar cane, vegetables, maize, fodder, rice, and soybean; plus Wheat (6.3 mill ha), cotton (0.6 mill. ha)	Pulses, sugar cane, vegetables, maize, fodder, rice, and soybean; plus Wheat (4.7 mill ha) and cotton (2.2 mill ha)
Slight salinity	4-8	Wheat (0.4 mill ha), cotton (0.4 mill ha)	Wheat (0.4 mill ha), cotton (0.4 mill ha)
Moderate salinity	8-15	Wheat (0.4 mill ha), cotton (1.0 mill ha), barley (0.06 mill ha)	Wheat (1.0 mill ha), cotton (0.4 mill ha), barley (0.06 mill ha)
Severe salinity	15-20	Cotton (1 mill ha)	Wheat (1 mill ha)

63. The assumed cropping patterns on saline land correspond to a cropping intensity of 1.4 on the land with minimal salinity, 1.3 on the land with slight salinity, 1.2 on land with moderate salinity, and 1.0 on land with severe salinity. These cropping intensities are estimated based on provincial cropping intensities reported by the provincial agriculture departments in Pakistan and on distribution of saline land.

64. To estimate crop losses from salinity it is necessary to estimate crop yields that would prevail in the absence of salinity. The following equations are solved for cotton, wheat and barley for this purpose:

$$aX_1+bX_2+cX_3=X \qquad (1)$$
$$X_1/(1-d_1)=X_2/(1-d_2)=X_3/(1-d_3) \qquad (2)$$

where X is observed average yield; X_i is yield on land with salinity="i"; a, b and c are share of land with salinity level="i"; and d_i is yield reduction on land with salinity level="i". Observed average yields, and estimated yields in the absence of salinity and on severely saline land are presented in Table 41.

Table 41: Observed and Estimated Yields

	Observed average yield on irrigated land (tons/ha)	Estimated yield in absence of salinity (tons/ha)	Estimated yield on severely saline land (tons/ha)*
Seed Cotton	1.8	1.9-2.3	1.2
Wheat	2.5	2.6-2.9	1.2
Barley	1.0	1.2	NA

* Estimated at midpoint of 15-20 dS/m of salinity.

65. Tables 42-43 present the estimated annual cost to agriculture of soil salinity (scenario 1, 2). World prices were applied for wheat and barley, and producer prices in 2005 for seed cotton, i.e., 9400 Rs, 5300 Rs and 22500 Rs, respectively. The total annual cost of crop loss from salinity is estimated at 15-55 billion Rs, not including lost opportunities from cropping on the 1.4 million hectares of land with salinity that has reached 15-20 dS/m (unproductive land). The cost of salinity on this land is estimated at net farm income on land with minimal levels of salinity, i.e., 10-18 thousand Rs. per hectare (Dost 2002). This brings the total estimated cost of salinity to 30-80 billion Rs., with a mean cost of 55 billion Rs, or 0.9 percent of GDP in 2004.

Table 42: Estimated Annual Cost of Crop Losses from Soil Salinity (Scenario 1)

	Salinity	Total Loss (billion Rs)			% of GDP
	dS/m	Low	Mean	High	2004
Wheat	4-8	0	0.5	1	0.01%
Wheat	8-15	1	2.7	4	0.04%
Barley	8-15	0	0.1	0	0.00%
Cotton	8-15	0	9.0	18	0.15%
Cotton	15-20	18	24.6	31	0.40%
Unproductive land	15-20	14	20	25	0.32%
Total Loss		33	57	80	0.92%

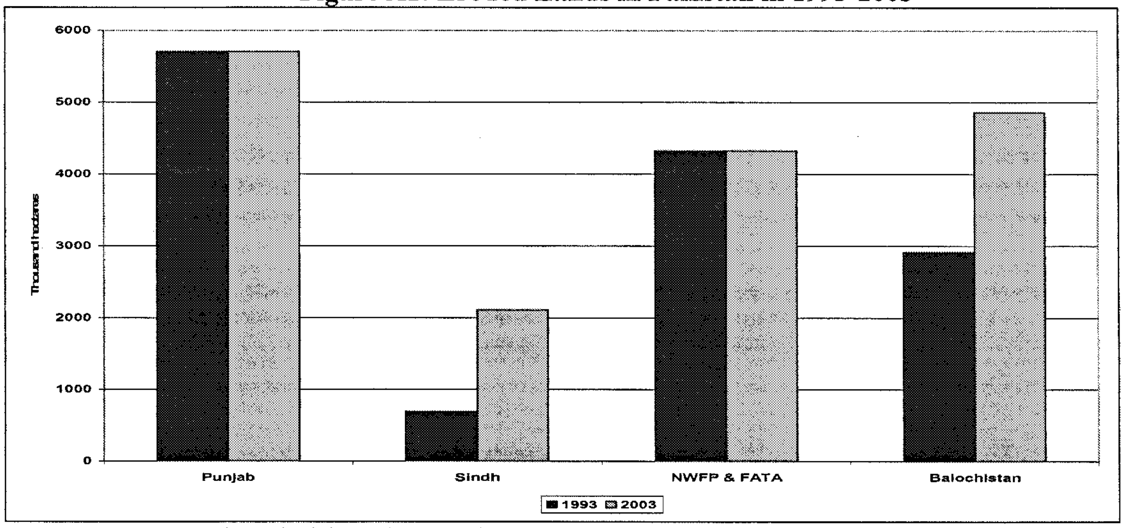
Table 43: Estimated Annual Crop Damage from Soil Salinity (Scenario 2)

	Salinity	Total Loss (billion Rs)			% of GDP
	dS/m	Low	Mean	High	2004
Wheat	4-8	0	0.5	1	0.01%
Wheat	8-15	3	7.5	12	0.12%
Wheat	15-20	12	15.7	19	0.26%
Barley	8-15	0	0.1	0	0.00%
Cotton	8-15	0	2.9	6	0.05%
Unproductive land	15-20	14	20	25	0.32%
Total Loss (including unproductive land)		29	47	64	0.76%

VI. COST OF AGRICULTURAL SOIL EROSION

66. Land degradation caused by wind and water erosion increased by almost 3.5 million hectares from 1993 to 2003 (Ahmed and Rashid 2003; Brandon 1995) and comprised about 18 million hectares in total in 2003. Figure A1 presents the increase in eroded lands by province. The provinces most affected by soil erosion during this period are Sindh (about 1.5 million hectare increase in eroded land of which an estimated 360 thousand hectares is an increase in eroded crop lands) and Balochistan (about 2 million hectares increase in eroded land of which an estimated 500 thousand hectares is an increase in eroded crop lands).

Figure A1: Eroded Lands in Pakistan in 1993-2003



Source: Ahmed and Rashid (2003); Brandon (1995).

67. We applied the same assumptions as in Brandon (1995) about cropping patterns and yield loss due to soil erosion for five major crops. The analysis is based on three categories of soil erosion (light, moderate and severe) disaggregated by province. Each type of degraded land was allocated in Brandon (1995) across the cropping pattern for each province, and a corresponding yield reduction factor was applied. Table 44 presents yield reduction factors for different crops (Brandon, 1995).

Table 44: Yield Reduction on the Eroded Lands

Crop	Level of erosion		
	Light	Moderate	Severe
Paddy	2%	50%	60%
Wheat	2%	5%	10%
Maize	2%	5%	10%
Cotton	2%	5%	10%
Sugarcane	2%	5%	10%

Source: Brandon (1995).

68. After the eroded cropping area in Sindh and Balochistan was adjusted assuming the increase of eroded croplands presented above, the eroded area under five major crops was estimated, utilizing initial estimates from Brandon (1995).

Table 45: The Eroded Area under Five Major Crops in 2003

SLIGHT DEGRADATION						
	Paddy	Wheat	Maize	Cotton	Sugarcane	Total 000 ha
NWFP	1,927	29,461	16,375	12	3,099	51
Punjab	177,994	837,638	47,117	355,318	78,106	1,496
Sindh	**84,071**	**157,592**	**1,727**	**56,742**	**35,409**	**336**
Balochistan	**1,999**	**6,390**	**70**	**4**	**12**	**8**
						0
Sum 000 ha	266	1,031	65	412	117	1,891

MEDIUM DEGRADATION						
	Paddy	Wheat	Maize	Cotton	Sugarcane	Total 000 ha
NWFP	9,754	149,153	82,901	63	15,691	258
Punjab	78,191	367,965	20,698	156,088	34,311	657
Sindh	**20,007**	**37,502**	**410**	**13,503**	**8,428**	**80**
Balochistan	**108,269**	**345,866**	**3,766**	**179**	**540**	**459**
Sum 000 ha	216	900	108	170	59	1,453
SEVERE DEGRADATION						
	Paddy	Wheat	Maize	Cotton	Sugarcane	Total 000 ha
NWFP	20,187	308,690	171,574	130	32,474	533
Punjab	88,135	414,762	23,331	175,938	38,675	741
Sindh	**33,001**	**61,861**	**678**	**22,272**	**13,901**	**132**
Balochistan	**48,898**	**156,204**	**1,700**	**82**	**241**	**207**
Sum 000 ha	190	942	197	198	85	1,613
TOTAL DEGRADATION						
	Paddy	Wheat	Maize	Cotton	Sugarcane	Total 000 ha
NWFP	31,868	487,304	270,850	205	51,264	841
Punjab	344,320	1,620,365	91,146	687,344	151,092	2,894
Sindh	**137,080**	**256,956**	**2,815**	**92,517**	**57,738**	**547**
Balochistan	**159,166**	**508,460**	**5,536**	**264**	**792**	**674**
Sum 000 ha	672	2,873	370	780	261	4,957

Source: Estimated applying assumptions from Brandon (2005)

69. Using data from 2003 on eroded crop land, and applying world prices for wheat, maize, paddy and cotton lint and producer prices for sugar cane, we estimate economic losses from soil erosion in Pakistan at around 15 billion Rs per year, or 0.25 percent of GDP

Table 46: Prices of Major Crops

	USD/t
Paddy	220
Wheat	160
Maize	100
Cotton lint	1100
Sugarcane	22

Source: http://www.fapri.iastate.edu/outlook2005/tables/6_ComPrices.xls; http://www.oryza.com/prices/asia.shtml; http://64.233.179.104/search?q=cache:3rParkkb7-EJ:www.paktribune.com/news/index.php%3Fid%3D127995+price+sugarcane+Pakistan&hl=en&gl=us&ct=clnk&cd=3

Table 47: Annual Erosion-Related Losses by Crop and Province in Pakistan (tons)

	NWFP	Punjub	Sindh	Balochistan	Pakistan
Paddy	66,054	151,917	88,341	476,285	782,596
Wheat	52,666	158,077	25,680	74,521	310,944
Maize	34,326	5,547	64	385	40,322
Cotton	5	19,588	1,473	8	21,074
Sugarcane	197,013	280,474	144,024	1,590	623,101
Pakistan	350,064	615,603	259,582	552,788	1,778,038

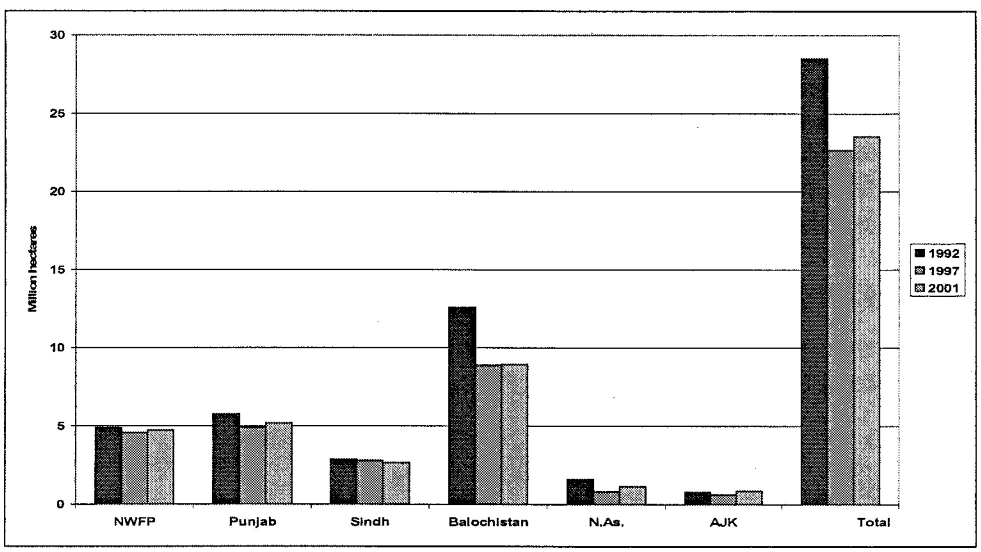
Table 48: Annual Erosion-Related Losses by Province

	Billion Rs	Percent GDP
NWFP	1.8	0.03%
Punjab	5.1	0.08%
Sindh	1.7	0.03%
Balochistan	6.9	0.11%
Pakistan	15.5	0.25%

VII. COST OF RANGELAND DEGRADATION

70. The National Forest and Rangeland Resource Assessment Study (NFRRAS) (2004) presents estimates of rangelands in Pakistan over a period of ten years, reporting that rangeland area declined from 28.5 million hectares in 1992 to about 23.5 million hectares in 2001. The net decrease is 5 million hectares, which is a rate of 2 percent per year. Figure A2 presents rangeland area in Pakistan in 1992-2001.

Figure A2: Rangeland Area in 1992-2001

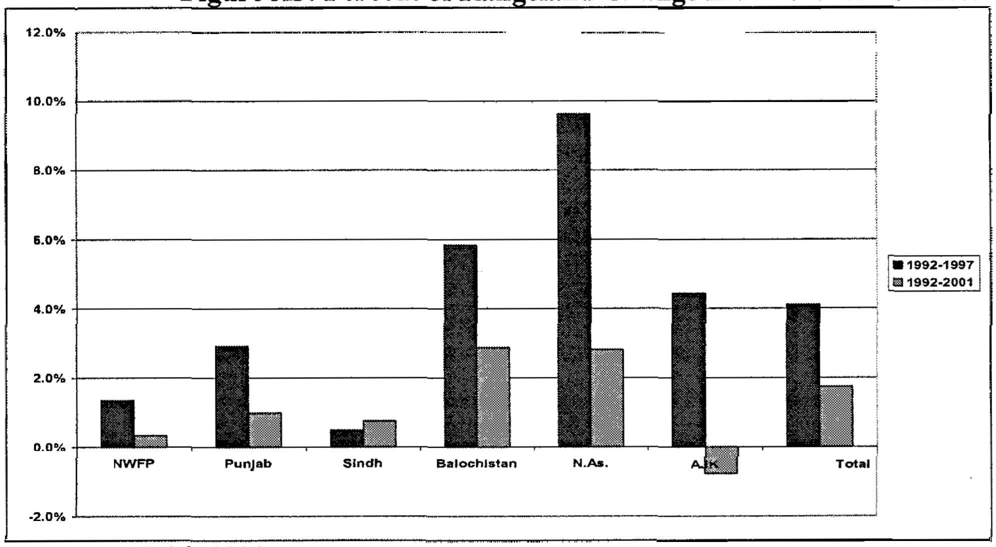


Source: NFRRAS, 2004.

71. The most substantial reduction occurred in 1992-1997. Figure A3 presents annual reduction of rangelands as percent of total province land area. The most substantial relative reduction of rangelands occurred in Northern Areas (N.As) and Balochistan in 1992-1997. In absolute terms rangelands in Balochistan declined the most. The province was losing annually about 527,000 hectares of grazing lands.

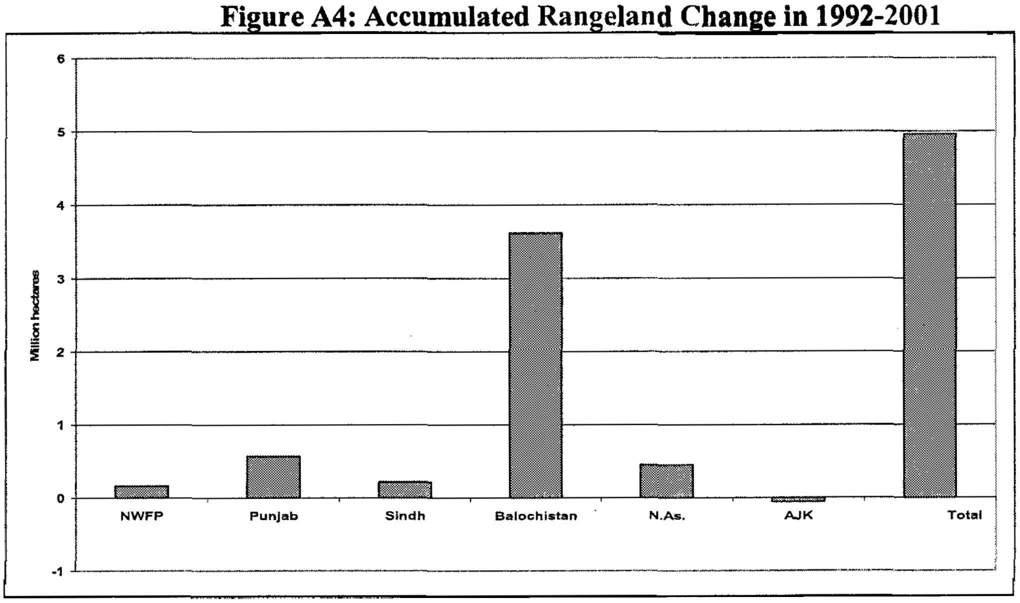
In total about 3.6 million hectares were lost in Balochistan in 1992-2001 as result of desertification and denudation of vegetation from drought and continuous overgrazing.

Figure A3: Percent of Rangeland Change in Different Provinces



ource; NFRRAS, 2004

Figure A4: Accumulated Rangeland Change in 1992-2001



Source: NFRRAS, 2004

72. In 1995 FAO presented estimates of land use based on satellite imagery. Both degraded and non-degraded rangelands were estimated as well as alpine rangelands, which are mostly non-degraded (Table 49). Nearly 25 million hectares were classified as degraded, or 85 percent of total rangelands.

Table 49: Degraded and Non-degraded Rangelands in 1995

	Degraded, 000' ha	Non-degraded, 000' ha	Alpine, 000' ha
Azad Kashmir	731		79
Balochistan	11,674	892	
Northern Areas	896		705
NWFP	4,106	519	269
Punjab	4,466	1,293	
Sindh	2,809	68	
Total Area	24,682	2,772	1,053

Source: Ma (1999).

73. Two methods are used to estimate the cost of rangeland degradation and losses. The first method is an estimate of losses of rangeland fodder yield valued at the price of fodder. The second method is an estimate of foregone livestock income from loss of fodder based on livestock feed requirement.

74. Very limited data are available on rangeland fodder yields. Mackintosh (1993) reports an average yield of nearly 0.4 tons of dry matter (DM) per hectare in 1974. According to interviews with rangeland experts in Pakistan in the process of preparing this report, average yield is now estimated at 0.2 tons of DM per hectare on degraded rangelands. This implies that the yield decline from cumulative degradation is at least 0.2 tons per hectare. Based on a rangeland area of 23.5 million hectares in 2001, and assuming that the area of non-degraded rangeland was constant from 1995 to 2001, degraded rangeland area in 2001 was nearly 20 million hectares. Applying the yield decline to this area suggests a total loss of 4 million tons of DM per year from cumulative degradation. At a fodder price of 1000-1500 Rs per ton of DM (Dost 2000), this loss represents a cost of 2.4-3.6 billion Rs per year based on a sustainable rangeland fodder utilization rate of 60 percent, as applied in Brandon (1995). In addition, the loss of 5 million hectares of rangeland from 1992 to 2001 suggests a loss of nearly 2 million tons of DM per year, assuming the original yield on this rangeland was 0.4 tons per hectare. At current fodder prices, and a sustainable utilization rate of 60 percent, this represents a cost of 1.2-1.8 billion Rs per year. The total cost of rangeland degradation over the last 30 years and rangeland losses over the last decade is therefore estimated at 3.6-5.4 billion Rs per year.

75. Data needed to estimate foregone livestock income (i.e., the second method of estimating the cost of rangeland degradation and losses) are presented in Table 50. Total feed requirement in DM for the animal stock in Pakistan is estimated at 145 million tons per year. In the absence of the rangeland yield decline of 4 million tons of DM per year, of which 60 percent could be sustainably utilized, rangelands could have supported an additional 1.7 percent of current animal stock. Total household net income from livestock is around 150 billion Rs per year (PIES 2001-02). The loss in rangeland yield is therefore equivalent to 2.5 billion Rs in foregone livestock income. Also, the loss of 5 million hectares of rangeland from 1992-2001, with a fodder loss of 2 million tons of DM per year, of which 60 percent could be utilized, could have supported an additional 0.85 percent of animal stock. This is equivalent to 1.3 billion Rs in foregone livestock income per year. Total cost of rangeland degradation and losses is therefore estimated at 3.8 billion Rs per year.

Table 50: Total Livestock and Estimated Annual Feed Requirement

	Weight, kg	Feed requirement, TDM t/year	Total animal, mill 2000	Total TDM, mill t
Buffalo	550	4	18.64	75
Cattle	450	3.3	17.30	57
Sheep	75	0.5	13.13	7
Goat	20	0.1	34.76	5
Total			83.84	145
Annual average per animal		1.7		

76. The estimated annual cost of rangeland degradation for the two methods applied is summarized in Table 51. The two methods provide quite similar estimate of annual cost, with a mean estimate of 4.2 billion Rs.

Table 51: Annual Cost of Rangelands Degradation in Pakistan

	Billion Rs	Percent of GDP
Market value of fodder losses	3.6-5.4	0.06-0.09%
Foregone livestock income from fodder losses	3.8	0.06%
Mean cost	4.2	0.07%

VIII. DEFORESTATION

77. The cost of forest degradation is the aggregate social loss associated with degraded or deforested lands. These costs include, in theory, a wide range of local, regional, national, and even global costs. Examples include timber, fuel wood and non-timber product losses (see below), recreation and tourism losses, indirect use losses (such as those associated with damages to ecosystem services, such as water supply and carbon sequestration), and non-use value loss associated with loss of forests. This section examines each of these categories as data permits, but refrains from presenting the carbon sequestration values.

78. The cost of deforestation is very difficult to estimate. Deforestation may contribute to increased frequency and severity of flooding and landslides, and is likely contributing to agricultural land erosion problems. It is also associated with impacts on water resources quality. However, it is practically very difficult to identify and isolate these costs of deforestation at the national level, and they are not included in the estimated cost in this section. Further, studies in Pakistan are insufficient to estimate the full economic value of the country's forests, and thus the cost of deforestation. Estimates of forest values for the forests in other countries are therefore applied in this report, using a range of values to reflect the uncertainties of applying these values to Pakistan.

79. Because of the high degree of uncertainty about these costs, we present average as well as high and low estimates, drawing on background studies by Pearce et al (1999) and Lampietti and Dixon (1994). High-end estimates are based on the assumption that it is possible to internalize all forest benefits based on a forest "inventory" by the local community in the short term, which is obviously an overestimation. Low-end estimates are based on the possibility that almost no forest benefits can be internalized because of an absence of market infrastructure, roads, favorable public policy and very high discount rates.

80. Social forest values should be considered from a long-term perspective. Therefore, financial flows from concessions and profit of predatory logging are not estimated. Only flows out of sustainable forest management are analyzed. Although it is generally accepted that in the short-term profits from predatory logging are higher than from sustainable forest management, in the long term with a real discount rate less than 20 percent, sustainable management theoretically has a higher net present value (Pearce et al, 1999). Pearce et al (1999) reviews an abundant literature that debunks common perceptions about higher profitability of predatory logging.

81. We start by considering diverse estimates of forested and deforested lands in Pakistan. Forests in Pakistan in 1990 were estimated to cover about 3 percent of total land area (FAO, 2005). Today, forest cover is less than 2 percent (FAO, 2005). Even with irrigated plantations and other wooded areas, forest land was estimated to be no more than 4.3 percent of the Pakistan territory. However, there is a great controversy about this estimate in Pakistan. Government sources suggest that forested areas are about 5 percent of Pakistan territory and growing (Table 52).

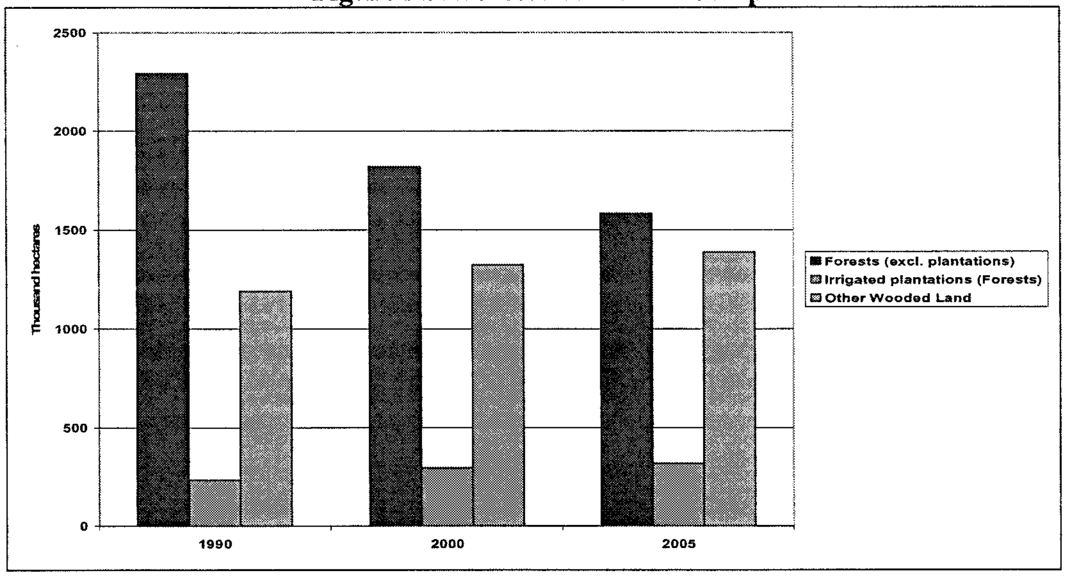
Table 52: Forest Area in Pakistan in 1990-2005

Year	Forest area (million ha)	% increase or decrease
1990-1991	3.46	
1991-1992	3.47	0.3%
1992-1993	3.48	0.3%
1993-1994	3.45	-0.9%
1994-1995	3.6	4.3%
1995-1996	3.61	0.3%
1996-1997	3.58	-0.8%
1997-1998	3.6	0.6%
1998-1999	3.6	0.0%
1999-2000	3.78	5.0%
2000-2001	3.77	-0.3%
2001-2002	3.81	1.1%
2002-2003	4.04	6.0%
2003-2004	4.04	0.0%
Average annual change		1.2%

Source: Pakistan Economic Survey 2004-2005, Economic Advisors Wing, Ministry of Finanace, Government of Pakistan

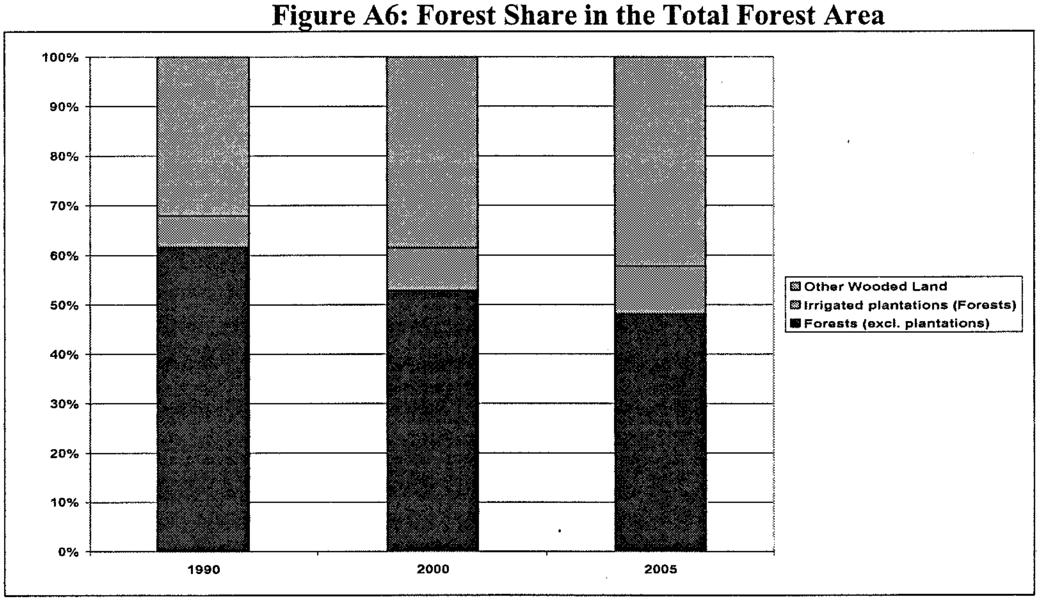
82. The National Forest Institute of Pakistan facilitated the FAO effort on the Global Forest Resource Assessment for Pakistan in 2005. In our judgment, the FAO effort is the more reliable. The figures A5 and A6 present details of these estimates, covering forest land area composition and the relative share of natural forest in the total forest area in 1990-2005, as presented in FAO, 2005.

Figure A5: Forest Land Area Composition



Source: FAO, 2005

Figure A6: Forest Share in the Total Forest Area

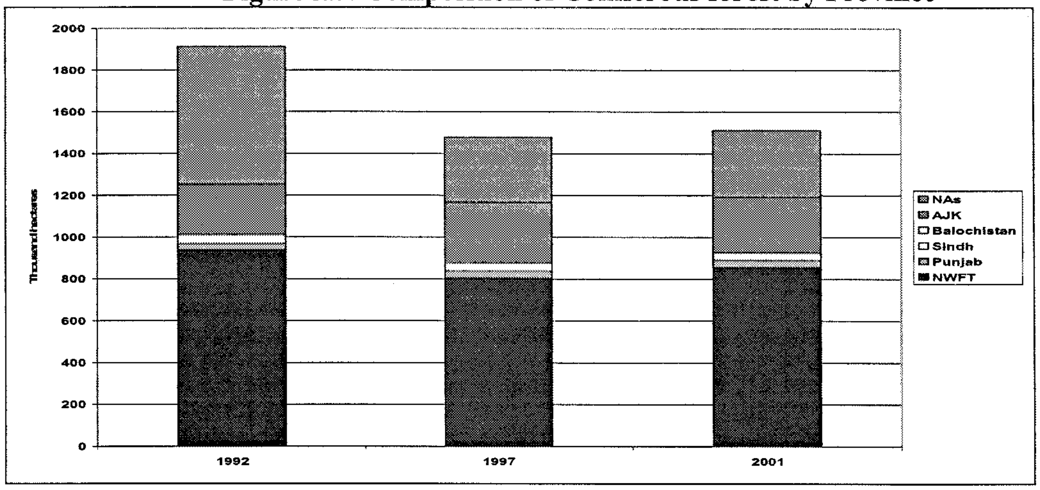


Source: FAO, 2005

83. Figure A5 demonstrates that the forest (FAO definition, NFRAS, 2004) is declining in Pakistan. The estimated deforestation rate over the 1990-2005 period is 2.1 percent or 47 thousand hectares annually. Forest types included in the FAO definition of forests are coniferous forest, riverain and mangrove forest. The most valuable coniferous forest is declining at the rate 40,000 hectares annually. Northern Areas and NWFT have the highest annual rates of deforestation (about 34,000 hectares in Northern Areas and 8000 hectares in NWFT[16]).

[16] Coniferous forests area increased for about 2,000 hectares annually in AJK

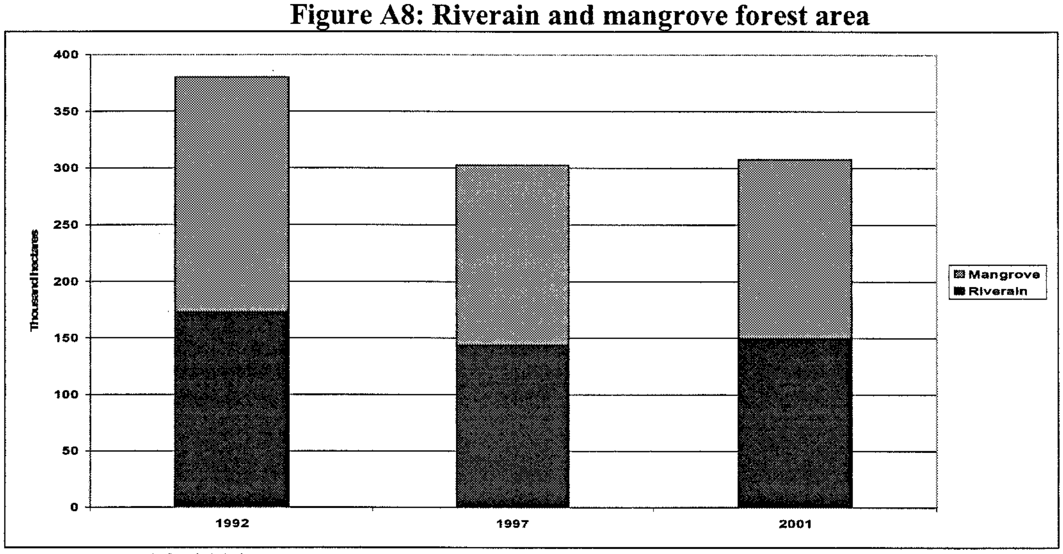
Figure A7: Composition of Coniferous forest by Province



Source: NFRAS, 2004

84. Riverain and mangrove forests are also decreasing in area at the rate of 2,300 and 4,900 hectares annually, respectively (Figure A8). This is an alarming rate given the quite high ecological value of these types of forest (NFRAS, 2004).

Figure A8: Riverain and mangrove forest area



Source: NFRAS, 2004

85. In FAO 2005 the share of productive forest was estimated as 32 percent in 2005. We apply this rate to the total area of deforestation of coniferous forest (40,000 hectares) and get about 13 thousand hectares. Brandon (1995) reported an annual average sustainable yield of 1-2 cubic meters of timber per hectare of productive forest. This is quite a reasonable estimate given that the commercial growing stock in coniferous forests is estimated in NFRAS (2004) at about 40 cubic meters of timber per hectare.

86. The annual timber loss from deforestation is estimated at about 114 million Rs by applying a net stumpage value of 100 USD per cubic meter of sustainable timber harvest (Brandon, 1995) on one hectare of productive forest (upper bound estimate).[17] If we apply the domestic timber price in 2005 (2925 Rs per

[17] This assumes an average sustainable yield of 1.5 cubic meters of timber per hectare of productive forest.

cubic meter from FAO, 2005) and assume 50 percent production cost, then the corresponding timber value loss is 28 million Rs. (lower bound estimate).

87. Following RWEDPA (1997) estimates that one hectare of coniferous forests in Pakistan supplies 1.1-1.25 ton of fuel wood (1.17 on average), it is possible to estimate fuel wood losses from deforestation. We apply 50 percent of the current price of fuel wood to account for fuel wood production cost.[18] The estimated value of one hectare of forest related to fuel wood production is then about 1025 Rs. The annual cost of fuel wood losses from 40 thousand hectares of coniferous forest losses per year is then about 41 million Rs.

88. FAO, 2004 estimates non-timber values for the Pakistan forest. Excluding fodder value that we already accounted for in the rangeland degradation section, non-timber value per hectare of forest is estimated at 9 USD. This value is close to estimates in Lampietti and Dixon (1994) for non-timber values in Central and South America equal to US $9-10 per hectare. We apply the value of 9 USD per hectare of deforested land (including riverain and mangrove forest losses). The annual cost of non-timber losses is then 25 million Rs.

89. Another direct use value is ecotourism. Pearce et al (1999) estimates these values in the range of US $5-10 per hectare of forest and stresses their local-specific character. We use 10 USD per hectare as a lower estimate, implying a total cost of 28 million Rs. from annual loss of recreational forest value. In Khan 2004 recreational value of a Natural Park near Islamabad was estimated at about 25 USD per hectare. Using this as an upper estimate gives 70 million Rs. in annual loss of recreational forest value.

90. Indirect use values of forest include watershed protection, nutritional and erosion/flood prevention, and water/nutrient recycling. Although there is no definite agreement in the literature about the magnitude of this forest value, Pearce et al (1999) presents a higher end estimate of USD 30 per hectare of forest generalized from the literature review. Applying this value to the annual forest losses in Pakistan gives an annual cost of 84 million Rs.

91. Pierce et al also give a wide range for the option value of forest (bioprospecting, i.e. prospects of new drugs to be developed in the future using rich forest biodiversity) in the range of USD 0.01-21 per hectare. Applying the highest value in this range gives a high-end cost of deforestation of 58 million Rs per year. We assign zero as the low-end estimate. Existence value of forest associated with forest preservation is estimated in Pearce et al (1999) at USD 13-27 per hectare, derived from his literature review. This implies an annual deforestation cost of 36-75 million Rs.

92. As mentioned before, this section refrains from including lost carbon storage values of forest as a cost of deforestation due to the uncertain magnitude of the carbon price at this point in time. Carbon markets are only just emerging and currently deforestation reduction is not eligible for any compensation. However, the situation could change in the near future. Then forest values should be updated using carbon market prices and the eligible share of the forest that can be counted for carbon sequestration.

93. The estimated costs of deforestation in Pakistan are summarized in Table 53. NPV is the present value of the stream of costs from one year of deforestation. The direct use values, reflecting local private forest losses, include the losses from sustainable logging, non-timber products and tourism and recreation. "Low" and "high" non-use values differ by a factor of three. This reflects an essential disadvantage of non-use value estimation. The studies use contingent valuation approaches that are based on the solicitation of the values from respondents in surveys. Different survey questionnaires will result in a different non-use value, and will often vary substantially across countries and for different locations

[18] 70 Rs. per 40 kg of fuelwood (Pakistan Statistical yearbook, 2004).

within a country. The non-use forest values are therefore not included in the estimate of the cost of deforestation for Pakistan in this report.

Table 53: Costs of Annual Deforestation (Million Rs.)

Forest service	Annual Cost			NPV* (mean)
	Low estimate	Mean	High estimate	
Direct use values	122	186	250	1860
Sustainable timber production	28	71	114	710
Fuelwood production	41	41	41	410
Non timber products	25	25	25	250
Tourism and recreation	28	49	70	490
Indirect use values	84	84	84	840
Non-use values	36	84.5	133	845
Option value (bioprospecting)	0	29	58	290
Existence value	36	55.5	75	555
Direct Plus Indirect	206	270	334	2700
Total value	242	354.5	467	3545

Source: Pearce D. et al, 1999; NFRAS, 2004; Khan 2004; Lampietti and Dixon, 1994. * An annual discount rate of 10 percent is used to calculate NPV.

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