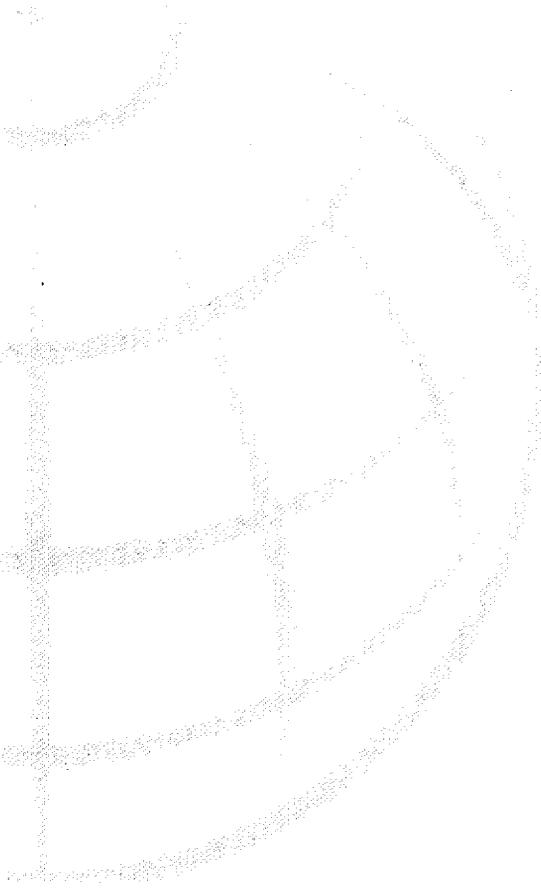




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Medicinal Plants

Rescuing a Global Heritage



John Lambert
Jitendra Sricastava
Noel Vietmeyer

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WORLD BANK TECHNICAL PAPER NO. 355

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Rescuing a Global Heritage

*John Lambert
Jitendra Srivastava
Noel Vietmeyer*

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EXPLANATION OF TERMS

All dollar figures in this report are given in United States dollars.

All figures given in “tons” refer to metric tons (tonnes).

FOREWORD

Since ancient times people have used medicinal plants. Indeed, during the past decade dramatic sales increases attest to a renaissance of both medicinal plants and the traditional health practitioners who prescribe them. Over the last five years in China, for instance, sales have more than doubled, while during the last decade in India exports have soared almost three-fold.

This booming trade—most of it fueled by citizens of the developing world but some of it serving affluent customers in wealthy nations—is damaging the supplies. Most medicinal plants are gathered from the wild. A number are now so overharvested that they feature high on the lists of threatened or endangered species. More are headed in that sorrowful direction and will become extinct unless action is taken.

Nonetheless, what looks like a problem actually provides numerous opportunities for developing nations to advance rural well-being. After all, medicinal plants are one of the few (legal) developing-country natural products that sell at premium prices. Thus, the global clamor for more herbal ingredients creates possibilities for the local cultivation of medicinal crops as well as for the regulated and sustainable harvest of wild stands. Such endeavors could help raise rural employment in the developing countries, boost commerce around the world, and perhaps contribute to the health of millions.

However, creating a regularized production of these species also raises many difficult issues. Some of these issues relate to medical efficacy and its proof. Some relate to the protection of fragile tropical habitats. Yet others relate to local empowerment, gender equity, regulatory measures, and the rights to traditional knowledge.

The present study—jointly funded by the Agriculture and Natural Resources Department and the Research Support Budget of the World Bank—builds upon the authors' brief overview: *Medicinal Plants: An Expanding Role in Development*. The present sequel is designed particularly to alert specialists in sectors such as agriculture, health, rural development, and international trade to the rising swirl of issues around medicinal plants. Although the focus is on China and India, the authors' fundamental conclusion is universal: medicinal plants are not just for health professionals any more.



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ABSTRACT

Traditionally, medicinal plants have been considered solely part of the health sector, but increasingly they are part of agriculture and even of environmental programs. This is because demand for medicinal plants is increasing at such a rate that the natural stocks in the wild are being destroyed. Hundreds of species are overharvested and face extinction if they are not protected or cultivated. China and India are the first countries to seriously grapple with the issue. This report provides an overview of the global situation and it highlights the efforts China and India are making to ensure the long-term health of this resource upon which billions trust their lives.

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EXECUTIVE SUMMARY

This report results from an assessment of the status and promise of medicinal plants in developing countries, with a special focus on China and India. The main conclusions are:

China and India have much to teach the world. These two nations are the greatest users of medicinal plants; their traditions of plant remedies date back at least 7000 years. Between them, they now account for two-fifths of humanity (in other words, more than 2 billion people), the bulk of whom rely heavily on medicinal plants. Certain of the experiences in China and India can be used to facilitate medicinal-plant conservation, cultivation, community participation and sustainable development in the rest of the world.

Medicinal plants are among the most misunderstood of all resources. Reportedly utilized by more than 4 billion people in developing countries, herbal medicines are a fundamental of life for the rural poor. They sell at premium prices, and even in poverty-ridden regions are in increasing demand. Yet, except in China and India, developing-country governments invest little or nothing to enhance the conservation, cultivation, trade and better understanding and improved use of such plants.

Something has got to be done quickly. While other cash crops have received millions of dollars of research support, the production of these exceptionally promising generators of income and well-being are left to languish and are therefore decreasing and many are in danger of disappearing. Yet local consumers, industries, and exporters are clamoring for more herbal ingredients and such demand is likely to continue to soar while supplies of raw materials from wild sources of medicinal plants are rapidly shrinking.

An organized coordination is needed. In medicinal-plant conservation, there is little coordination (let alone, cooperation) between government agencies, the pharmaceutical industry and organizations dealing with environment, natural resources and agriculture. Such a collaboration could do much to protect and enhance threatened medicinal species. Although the World Health Organization and local ministries of health have featured medicinal plants in their programs, their emphasis has been on efficacy and treatment protocols. Arguably, the more immediate need is in the production and conservation of the raw materials. The capabilities of agriculture and of habitat conservation are currently the most vital missing links.

A lack of trade data is hindering the process of preserving medicinal plants. No one can at present designate with certainty the status of individual species nor the state of the overall medicinal-plant trade. Some data are available on production and trade for the organized market, but they are grossly inadequate and seldom identify yields, production

amounts, or market value. For the vast informal market in the rural areas, ethnic communities and urban slums there are no quantitative data whatever. Because of the numbers of users, however, the economic and cultural value of these unregulated markets must be enormous.

Women are the primary users and marketers of medicinal-plant materials. Mothers and grandmothers use herbal products in the home as well as sell them in the rural markets. Such materials make home healthcare affordable and provide much needed income. Sustainability of supply can be greatly assisted if women were included in the process of developing conservation and cultivation.

The use of medicinal plants in animal health is probably extremely important.

Although the use of plants in the medical care of livestock is even less well documented than in human use, much is known to the farmers and “village veterinarians.” This treasure trove of untapped indigenous knowledge likely holds considerable benefit in the vast areas of the developing world where the average farmer can seldom obtain or afford veterinary drugs.

In principle, many of the supply problems can be overcome by cultivating the medicinal plants. The fact that medicinal plants are predominantly harvested in an unregulated manner undermines the whole industry. Yield from the wild is wholly unpredictable. Supplies are at the mercy of the weather, pests, and other uncontrollable variables. Farming these species would help even out the supply, regularize the trade, provide certifiable products of uniform quality, and make available to rural areas new sources of income. However, cultivation is presently constrained by a lack of methodologies and support for proving suitable methodologies.

The World Bank could play a pioneering role in assisting all who hold a stake in the increased and sustainable employment of medicinal plants. To promote conservation and sustainable use of medicinal plants will require actions such as policy dialogue, sector work and the incorporation of medicinal plants into lending operations. There is a need to identify suitable cultivation and storage methods, to develop pharmaceutical industries based on local plants, and to encourage client countries to include medicinal plants in their biodiversity conservation strategy and National Environmental Assessment Plans.

1. THE GLOBAL BACKGROUND

As was noted in the previous volume,¹ plants are still an indispensable source of medicinal preparations, both preventative and curative. Despite immense progress in synthetic chemistry and biotechnology, hundreds of species are recognized as having therapeutic value. Many of those are commonly used to treat and prevent specific ailments and diseases.

While health providers in industrialized nations have reduced their dependence on the Plant Kingdom, the majority of developing nations still rely on herbal remedies. Medicinal plants constitute one of the important overlooked areas of international development. They represent a form of biodiversity with the potential to do much good, and not just in the field of healthcare. Indeed, the production and processing of medicinal plants offers the possibility of fundamentally upgrading the lives and well-being of peoples in rural regions. It can also help the environment and the protection of habitats and biodiversity of the developing world.

Economic Issues

The potential world market of phytomedicines or herbal medicines is very large, but its significance to the global economy can at this point only be inferred from a few sources of diverse and inadequate data. The World Health Organization estimated in 1980, for instance, that the world trade amounted to \$500 million a year. However, information from diverse sources suggest that the overall trade in botanicals has since then greatly increased.² This has been accelerated by a renewed interest in traditional medicines in many developing countries and especially in Europe and North America.³

The developing countries, particularly those in Asia, are the main suppliers to the developed countries of plants used in pharmacy. However, in Africa and Latin America local and regional trade in medicinal plants is growing rapidly along with an increasing demand by international plant traders hoping to discover new “wonder” drugs.

Germany is one of the largest importers of medicinal plants. The Convention on International Trade in Endangered Species (CITES) has determined that Germany's imports include at least 40 threatened or endangered species. Many were originally listed in CITES to protect them from heavy exploitation for the ornamental trade. However, it became apparent that many of these were also used for medicinal purposes.

¹ Srivastava, Lambert and Viemeyer, 1995.

² See, for instance, International Trade Centre (UNCTAD/GATT); Institute of Medical Statistics; Lewington, 1993; Grunwald, 1994; Kuipers, 1995; and Ten Kate, 1995.

³ Eisenberg, et al., 1993; Grunwald, 1994.

There is a reason for Germany's imports of medicinals. Of all the western nations, Germany has made the greatest progress in bridging the gap between traditional and Western medicines. Every medical student there is taught about phytomedicines and more than 80 percent of all German physicians regularly use herbal products.⁴ The government requires that plant drugs must be standardized and of proven safety and efficacy. Safety of long-used natural products is generally assumed, if no side effects have been reported. Clinical experience noted by physicians, scientific evidence published in technical journals, and data supplied by manufacturers are the basis for the doctrine of "reasonable certainty," which Germans accept as a substitute for strict clinical trials.⁵ The German experience is being closely watched by both industrialized and developing countries as it offers an example of how to integrate the two systems.

The global demand for medicinal plants is expressed from four identifiable sources: (i) pharmaceutical industries, (ii) traditional healthcare systems; (iii) individual traditional health practitioners, and (iv) women in family home care. The money values involved depend not only on the extent to which barter or non-monetary exchange is a factor, but also the degree to which the production and sale are concentrated in visible locations, regulated and taxed.

Gauging the extent and growth of the global trade in herbal ingredients is made difficult by unpredictable fluctuations in price. Such fluctuations—typically over six to nine year periods—are common as the availability of many wild medicinal plants goes from over-supply to scarcity very quickly and then slowly stabilizes again. Variations in price due to supply conditions make it difficult to determine the extent to which demand is increasing. Government(s) and the local private sector would probably be more willing to fund research on the extent of existing and potential supply of medicinal plants if they had a better idea of the potential (and existing) market. From that they could tell how much could be sold, at what price, and therefore what profit was to be made.

The regulated trade provides all the present data on the market value of medicinal plants—from raw material to finished product. The unregulated market includes all manner of medicinal plants where there is no market accounting (largely because the government draws no benefit from these sales). This informal use of medicinals includes home use, exchange between neighboring families, collecting and sale in rural markets, use by traditional health practitioners and other undocumented transactions.

The most complete data are, unsurprisingly, available from the official Chinese and Indian healthcare systems, but even that is incomplete. Even where there are local pharmaceutical industries, the figures on general herbal drug sales to the public are often unavailable. Assessing informal medicinal product sales by traditional health practitioners and vendors, primarily peddled by women in local markets, would be very difficult due to a lack of records. Similarly, products grown in home gardens and

⁴ Grunwald, 1994.

⁵ Tyler, 1986.

administered to family members have an unknown value. It is this cultural value, that is rarely, if ever, captured in economic analysis. Yet it is likely to represent a significant portion of the total economic benefit provided by these plants.

A number of Asian countries (including China, India, both Koreas, Thailand, Indonesia and the Philippines) have the technical background, knowledge, and existing pharmaceutical industries to process raw materials and market finished products. However, the majority of developing countries in Latin America and Africa lack the industrial base and financial resources to expand this market rapidly. As a result, 86 percent of finished health products are still manufactured in Europe and North America.⁶ In virtually every developing country, local healthcare needs are satisfied primarily using raw materials from plants. The majority of people just cannot afford to purchase imported pharmaceutical products.

Not much has been done to assist developing countries to develop their medicinal-plant resources. However, two organizations—the International Organization of Chemical Sciences in Development (IOCD), Falls Church, Virginia, USA, and Biotics Ltd., University of Sussex, UK—have taken an active role in this. IOCD has helped establish the Network for Analytical and Bioassay Services in Africa (NABSA), which links cooperating laboratories with capabilities to provide services in chemical spectroscopy and biological evaluation. Services currently offered by NABSA Centers are in Ethiopia (Addis Ababa), Kenya (Nairobi), Madagascar (Antananarivo), and Botswana (Gaborone). Biotics Ltd. provides access to high technology screening through training of phytochemists. As a result, a number of independently-owned companies have been created in developing countries to prepare plant extracts.

Policy Issues

Developing countries are entering a new era when community health services will likely occupy an evermore prominent position in national priorities. The type of production, processing, and manufacturing of a large array of medicinal plants produced in the rural sector—and in turn the ability of developing countries to invest in medicinal plant (phytopharmaceutical) industries—will determine the future quality of those community health services.

To derive optimal benefit from the conservation and cultivation of its medicinal-plant genetic resources, each country must develop an integrated strategy for their management and use, identify policies, and enact legislation that will encourage a broadly-based delivery of the benefits to be realized from these actions rather than allowing the majority of the economic benefits to accrue to a smaller but well-place minority.

So far, however, few developing countries are doing this. In order to stimulate more such action, three regional workshops sponsored by Global Initiatives for Traditional Systems

⁶ Wells, 1983.

of Health (GIFTS) were held in Latin America, Africa and Asia in 1994-95 followed by an international meeting in England in late 1995. All stressed the need for clearly-defined policies promoting the safe utilization of traditional medicine.⁷ Recommendations included:

- the documentation and promotion of traditional medicines with proven efficacy;
- increased funding of research and development programs;
- need to evolve policies which involve local communities in conservation programs;
- document and cultivate endangered plant species known to have medicinal uses;
- recognizing the role of women;
- information exchange; and education at all levels to increase awareness of medicinal plants and their economic potential in drug production.

Regulatory Issues

All countries where medicinal plants and traditional medicines are used are aware of the need for regulating the use of medicinal substances. Indeed, most developing countries have a heritage in the use of plant-based medicine that is far older than the modern of medicine. China probably has the strictest criteria for regulating the sale of traditional plant-based medicines. Chinese authorities are well aware of the problems and constraints facing them in the production, processing, and marketing of herbal medicines. The Government of India, while constantly upgrading its controls, does not exercise any regulatory control over the use of “home-made” remedies that are used by a large segment of the vast Indian population.

The European Scientific Cooperative for Phytotherapy (ESCOP) is currently drafting fifty monographs of product characteristics to be used as a basis for licensing phytotherapeutics in all member states of the European Union (EU). Since January 1995, a decentralized marketing authorization procedure has existed in addition to the national licensing of individual member states. Following enactment in 1994 by the United States Government of the Dietary Supplement and Health Education Act (DSHEA) greater effort has been made to develop guidelines for quality control, good management practice, and to provide a sound scientific basis for ensuring proper identity and purity of finished products⁸. Such activities by the industrialized countries put greater pressure on the developing countries to regulate trade in medicinal plant raw materials.

Social Issues

Sociocultural factors play an important role in the preservation of medicinal plants and the people’s continued reliance on traditional medicine. Often, villagers will use a

⁷ Bodeker, 1995.

⁸ Awang, 1996

modern medicine to relieve their immediate symptoms, while turning to traditional medicine for treating the root cause of the illness. Revival of traditional health systems following decolonization, as well as increased self-determination of indigenous groups, has led an increasing number of developing country governments to re-evaluate and promote their traditional medicine systems. Such systems are a response to the conditions and needs of local populations. To have any chance of success, however, new public health systems must necessarily incorporate the cultural habits handed down through generations.

Traditional Knowledge. Most developing country societies view traditional medicine practices as an integral part of social culture. During colonial times, however, traditional healthcare systems gradually lost patronage and favor especially with the urban populations—due notably to the imposition of Western culture and to the support given to Western (allopathic) medicine. Since the demise of colonialism, there has been a gradual re-establishment of the traditional systems of teaching and dispensary in indigenous medicine. It is in light of this resurgence, both locally and internationally, that pressure is being placed on an important component of that healthcare—the plants.

In some cases, however, traditional practitioners have resisted attempts to document their knowledge. They see such disclosures as being detrimental to their practice. In addition, they treat with skepticism the outsiders' interest in their plants and therapies, rightly believing they will receive no credit or royalties for any future drug discoveries derived from their knowledge.

Yet exchanging experiences and scientific data on various aspects of traditional medicine prevalent in different parts of the world is an important step in helping save the plants and the knowledge of their use. And there are also greater advantages to be reaped. In many parts of the world, for instance, there are no doctors and no Western drugs. Even where doctors are available, import restrictions and government budgeting often mean there are insufficient medicines to distribute. Sometimes, preparations are used even though they have passed their expiration date.

In such circumstances, it would probably be better to use herbal medicines—all of course chosen with care, supplied with a maximum of quality assurance, and prescribed by practitioners the patients trust.

Taken all round, the availability of locally-grown drugs, their relatively low cost, and the minimal side-effects associated with many of the drugs are important factors in providing primary healthcare. For persons who have never experienced sickness or illness without medicines, these are important considerations.

Women's Role. In many of the developing countries women serve as conservators and cultivators of medicinal plants. Through their household practices they use traditional approaches in caring for the health needs of the family. In Africa and Latin America, women constitute the majority of traditional medical practitioners, as well as the primary

gatherers of medicinal plants. Women are the traditional birth attendants, delivering and tending the mother's pre- and post-natal needs.

Although often unappreciated, most mothers are the *de facto* healers of the family tending to accidents and ailments with medicinal-plant remedies cultivated in their home gardens, maintaining the family diet, administering medicines, providing counseling and essential emotional support. It would not be an exaggeration to suggest that virtually every leader of a developing country benefited at some time in his/her formative years from the medicinal-plant knowledge of a mother or grandmother.

Enhancing Social Capital. The importance of traditional medicinal-plant knowledge or social capital is evident by the need for "bioprospectors" (Western specialists seeking new and profitable drugs from nature) to recruit indigenous peoples to identify local flora and describe their uses and healing properties. The need to protect intellectual property rights (IPR) has now become a major issue both for developing countries whose genetic resources are being exploited, and for developed countries whose patent law cannot always be enforced in developing countries.

Legal restrictions over access to, and removal of, medicinal-plant germplasm are easier to enforce than legal protection over the use of the information represented by that genetic material (intellectual property rights). In the past, many countries have failed to adequately enforce such property rights, partly because of a lack of awareness of the potential value contained within their genetic resources. The recognition of IPRs, however, may provide a very important incentive to many countries to institute environmental policies preserving biodiversity.⁹ A careful balance needs to be achieved between restricting access to plants, which may enable economic returns to be achieved, and restricting access to information which may have opportunity costs.

Generating Income. Medicinal plants are both a source of income and a source of affordable healthcare. As described above, many poor people derive their only income from harvesting medicinal plants. This income however, is probably declining in those countries where natural habitats are disappearing. A strategy that integrates conservation and cultivation of medicinal plants could create long-term employment and income opportunities. Agricultural R&D, and production will require qualified professional and technical workers, and labors, many of the latter can be recruited locally. Expanded local pharmaceutical industries would also require additional workers at all levels.

Conservation Issues

If existing medicinal-plant resources are to continue to meet demand now and in the future, they will need to be adequately protected through the development of appropriate policies and legislation. Awareness of the conservation issues and of the importance of sustainable utilization needs to be raised among all stakeholders. Perhaps most

⁹ Walden, 1995.

importantly, local people need to be supported and encouraged to take the necessary steps to protect this valuable resource. The collection of medicinal plants must be guided by an accurate knowledge of the biology of the species concerned, and steps must be taken to avoid over-exploitation, and the collection of rare or otherwise endangered species.

Preserving Wild Genes. Fortunately, many plant species consist of thousands of populations. These together form a gene pool in which a more or less free gene exchange can take place. This is a feature that can be utilized by plant breeders to protect medicinal-plant diversity.

Box 1: The Lost Ancient Plant We Could Use Today

As an example of the importance of preserving medicinal plants consider the case of silphion, a weed once used as a contraceptive. It was apparently so effective that the Ancient Greeks literally revered it. Now, with population growth seemingly out of control a plant like this could have immense significance. Unfortunately, the Greeks used so much of it, it became extinct. Botanists can no longer find the species.

Between 570 and 250 BC the majority of coins minted in ancient Cyrene, a city situated in what is now the eastern part of Libya, carried the embossed picture of the *Silphion* plant. This reflects the enormous economic importance this plant had for the city over four centuries.

The perennial roots and strongly ribbed annual stems of the *Silphion* plant were eaten in the fresh state and were regarded as a perfume, flavoring agent and spice. The juice was employed medicinally against a wide range of symptoms and diseases, especially gynecological ailments—it was a true “multi-purpose species” in the sense of modern economic botany.

It appears that *Silphion* was found only in the dry hinterland. Attempts to cultivate it seem to have failed, so wild plants remained the source of supply. No reasons have been given for its disappearance although overharvesting is considered to be at least one reason for the dramatic decline in its use and final extinction as an economic resource. What we have is an example of overharvesting and probable extinction of an ancient medicinal plant. *Silphion* reflects both the potential wealth through plant utilization and the possible risks and downfall through overharvesting.

Source: IUCN. Medicinal Plant Conservation Newsletter. 1995

For historic (if not biological) reasons, the majority of medicinal plants used in developing countries are located in specific ecosystems. Prohibiting wild collections in these locations could devastate many poor families by cutting off their source of income. It is therefore important that education programs that justify the need for regulations

governing *in-situ* conservation and collecting be developed. The local people should participate in this and the efforts should be linked to *ex-situ* conservation and cultivation programs that would provide an alternative source of income (or perhaps an equal income from smaller harvest through such means as improved quality control).

***In-Situ* Conservation.** The protection of medicinal-plant resources was not identified as a major concern of conservation organizations until 1984.¹⁰ Four years later, the Chiang Mai Declaration recognized medicinal plants as an important component of the globe's biota. It noted that these plants are an essential part of primary healthcare in most of the world; and it viewed with alarm the rapidly increasing loss.¹¹ The Global Biodiversity Strategy recognized the importance of conserving medicinal-plant biodiversity.¹² Its so-called "Action 40" calls for the development of traditional medicines to ensure their appropriate and sustainable use, and "Action 41" promotes recognition of local knowledge, particularly medicinal healers. "Action 67" specifically mentions medicinal plants as a key group deserving increased attention. At the Rio Conference in 1992 the Convention on Biological Diversity ratified these action items.¹³

Nonetheless, only a few countries seem to have pursued their obligations regarding medicinal-plant conservation. One of these is Sri Lanka, where the government has for a long time implanted in its people a strong pride in their natural heritage. Sri Lanka is a good example for other countries to follow. Its flora and fauna enjoy a high level of protection, with over 400 reserves set aside for their conservation.¹⁴ Stringent laws apply in these reserves. The government has an aggressive policy of *in-situ* conservation to save valuable species, and in particular medicinal plants. This action was, in part, linked to the rapid resurgence of Ayurveda following independence and the demand for medicinal plants for Ayurvedic drugs. A Ministry of Indigenous Medicine was established in 1980. In 1986, the World Wide Fund for Nature (WWF) funded the Conservation of Medicinal Plants of Sri Lanka with the objective of establishing an aggressive policy of *in situ* conservation to save valuable species from extinction. The World Conservation Monitoring Center (WCMC) provides services to CITES. The CITES database is the largest of its kind, currently holding some two million entries on trade in wildlife species and their derivatives.

WCMC is the only organization that gathers, analyzes and provides information on plants threatened with extinction on a global scale. The Centre is aware of the growing need to protect and conserve medicinal plants. Because of the potentially large number of medicinal plants requiring protection and the limited funds available categorizing medicinal-plant species the following characteristics could be used to set priorities:

- commonness or rarity;

¹⁰ Hamann, 1991.

¹¹ WHO/IUCN/WWF, 1993.

¹² WRI/IUCN/UNEP, 1992.

¹³ World Bank, 1995b.

¹⁴ Lokubandara, 1991.

- means of propagation;
- sensitivity to environmental conditions;
- plant parts used;
- properties and medicinal uses; and
- community knowledge and use.

A partnership between WCMC and the World Bank established in 1995 will provide full biodiversity data mapping services to the World Bank; seek to extend these services to GEF partners in UNEP and UNDP; capture and mobilize data deriving from investments in biodiversity; repatriate data to the developing world; build capacity for biodiversity information management in the developing world and strengthen information networks. Being able to access medicinal-plant data will enhance the decision-making process regarding protection, research priorities, management objectives, and policies to yield best results using ever scarce financial resources. It is on the basis of such information medicinal-plant diversity can be preserved *in situ*, successfully sustained, and ensure the germplasm for long-term *ex-situ* conservation and cultivation.

Ex-Situ Conservation. In 1989 the Botanic Gardens Conservation International (BGCI), in collaboration with IUCN and WWF, published *The Botanic Gardens Conservation Strategy* as a guide for the development of botanic garden roles in biodiversity conservation. It has developed a computer database listing rare and endangered plants in cultivation in about 350 botanic gardens worldwide, which is used to foster networking and linkages. BGCI considers medicinal plants a priority area for botanic gardens for the future. In July 1995, BGCI launched an appeal for funds to establish an effective network of botanic gardens for medicinal plant *ex-situ* conservation and to strengthen the capacity of botanic gardens in developing countries. The first such gardens will be established in Colombia, Haiti, Uganda and Vietnam.¹⁵

Agricultural Issues

For many medicinal plants, cultivation is the main hope for maintaining supplies at today's levels. The wild resources are decreasing, the supply fluctuating in an unstable manner, the quality control is inadequate. Additionally, the botanical identification of the specimens is often suspect—sometimes because of fraud and other times because of genuine mistakes. Different species of plants (with wholly different chemical constituents) often look alike to the person handling the dried materials, and even sometimes to the gatherers themselves. The people handling the samples may be unreliable, and the chances for adulteration are legion.

Through the process of cultivation, the various plants can be increased on a controllable and sustainable basis, the quality can be better assured, the species identification made secure. In addition, there are possibilities for improving the crop genetically based on the level and mix of ingredients that have the medicinal effects. Yields can be manipulated

¹⁵ P. Wyse-Jackson, pers. com.

by agronomic means, such as fertilizer and pest control. Finally, the handling of the materials can be regularized and the possibilities of adulteration reduced.

But all of this is mostly untapped as yet. While the domestication and cultivation of medicinal plants is several thousand years old, it is apparent that most agriculture ministries in developing countries play little role in cultivating medicinal plants. The present source of the raw materials for the pharmaceutical industries, traditional health practitioners and family users is met basically from wild sources, including places such as field borders, marginal, remote, and waste lands where the wild vegetation is left to grow unattended. The demand is also met by cutting forest trees or uprooting herbs and shrubs on nominal payment or on an unauthorized basis. A much greater awareness needs to be created among agriculturists that cultivation is the primary means of reversing the impact of unsustainable harvesting practices of wild populations.

Palevitch (1991) compared collection versus cultivation for eight important considerations. In light of the continuing loss of biodiversity, the relative advantage of cultivation is even more pronounced. While millions of dollars are invested in supporting food and other crops, little is spent on supporting the world's medicinal-plant resource base. Nevertheless, isolated medicinal-plant breeding programs have already produced a number of high yielding cultivars.¹⁶

The efforts of the medicinal-plant breeder should be aimed at increasing the final yield of the active compounds and enhancing the metabolic functions that result in their accumulation. There will be difficulties as our knowledge of medicinal-plant genetics and physiology is poor, and we know less about the biosynthetic pathways leading to active ingredient formation for which these plants are valued. Another difficulty is that perhaps certain subsidiary compounds must also be present for the herbal cure to be effective.

An especially inhibiting factor in the breeding research is the variability of medicinal-plant populations. Many populations found in their natural habitats are not balanced in terms of chemical characteristics and active compounds. Selective breeding of medicinal plants may follow several lines, including: random selection in populations; landraces with specific chemical characteristics; selection of clones; and hybridization. Commercial cultivation of medicinal plants demands strong and continuing attention to these diverse fields.

The farming of medicinal-plant is coming into a new stage of development that could lead to it becoming a major employer of local labor and an instrument to poverty alleviation in the developing countries. The efficiency and success of medicinal-plant cultivation will depend on the productive ability of plant material and collaboration between researchers and local peoples to enhance and sustain that production. Basic questions that need answers include:

¹⁶ Atal and Kapur, 1982; Ornok, 1992; Chadha and Gupta, 1995.

- Is the plant suitable for cultivation?
- What are its ecological and agronomic requirements (light, moisture, soil, etc.)?
- Does it tolerate intra- and interspecific competitors?
- What insect pests, and plant pathogens are likely to attack it?
- Will harvesting be a problem?
- How well will it store without loss of therapeutic activity?
- Can it be easily processed (purified, packaged, and shipped without losing efficacy)?

Forestry Issues

Forest products are these days being divided into two categories: (i) timber products and (ii) the so-called “non-timber forest products” (NTFPs). Medicinal plants are in the NTFP category and may be considered as non-domesticated crops. Little attempt has been made to objectively assess these natural resources in forest industries. Principe (1995) has suggested that an estimate of medicinal-market value is more easily characterized in forest ecosystems as people can more readily visualize the range of benefits of forests than other ecosystems. Therefore a proper assessment and evaluation of those plants endemic to the forests is a necessary priority to provide acceptable estimates for policy appraisals, research needs and sustainable forest management programs.

At present many important and potentially important forest medicinal plants are destroyed or left to go to waste during logging operations. The forest sector, as a supplier, has little knowledge or appreciation of their value. A notable case in point is the destruction of the small yew trees in the forests of the Northwest of North America. They were long considered useless “weeds” but now provide the current drug of choice against a number of deadly cancers.

Given such discoveries, it is increasingly recognized that the forest sector must re-examine its short-term and long-term objectives and develop a multiple-product management plan that accounts for NTFPs as well as timber products. In the production of forest medicinal plants there is an opportunity for foresters, the pharmaceutical industry, and local practitioners of traditional medicine to work together to their mutual benefits.

Veterinary Issues

The need to conserve and protect the world’s medicinal plants is required not only for man but also for his domesticated animals. In fact all biota, wild and domesticated, within the global ecosystem probably depends at least in part on plants that sustain health.

It has of course long been known that certain plants cause farm stock to be sterile or to abort. Those conditions cause great economic losses in terms of milk, meat and progeny.

Only now, however, are veterinary scientists beginning to study this with conviction and deep interest. The wild species of the Animal Kingdom, no doubt utilized the medicinal powers of plants long before humans appeared on the scene. But herdsman quickly learned about the value of these species. Centuries of observation and experience have resulted in a rich storehouse of ethnoveterinary knowledge and technique among stock-culture peoples. Today, for those cultures where stockraising forms a vital part of their livelihood plants are a primary source of prevention and control of livestock diseases. It is thought that the percentage of animals dependent on medicinal plants is greater than the figure of 80 percent that is given for humans. In some traditional medical systems, human and animal healing are not differentiated.¹⁷ The herbal treatments often overlap and might be administered by the same persons.

Delivering veterinary services to pastoralists can be as difficult as delivering public health and other basic services and far, more complex than for settled peoples. Nonetheless, as traditional medicine is experiencing a revival in human medicine so is the veterinary sector. During the past decade, FAO has commissioned a number of reports on the status of veterinary medicine in Asian countries.¹⁸ All found that ethnoveterinary practices could be usefully incorporated in animal-health services.

Globally, veterinary medicine has followed the industrial countries prejudice for technology over traditional knowledge and self-sufficiency. Happily, the revival traditional medicine is experiencing is occurring in both human and veterinary medicine.

Box 2: The Use of Plants in Animal Medicine

There are many known uses of medicinal plants in the healthcare of livestock in developing countries. A sampling includes:

- In France farmers hang henbane (*Hyoscyamus niger*) in sheep pens to combat sheep pox.
- In Uganda, farmers hang amaranth (*Amaranthus* spp.) in chicken houses to provide vitamin A, often found lacking in scratch feed.
- Researchers in Guatemala tested 84 of the most commonly used plants for gastrointestinal disease in farm animals and found that 40 percent inhibited one or more of the five main bacterial pathogens.
- In Mexico, the traditional therapy for a bloated cow is to tie a branch of the pirule tree (*Polakowskia tacacco*) in her mouth. The bitter taste provokes salivation, which helps to buffer the stomach, while the physical presence of the plant encourages chewing, thus assisting in the release of stomach gas.¹⁹

¹⁷ Mathias, McCorkle, and Schillhorn van Veen, 1996.

¹⁸ Anjaria, 1996.

¹⁹ deMaar, 1992

The International Research Base

By 1991, 27 WHO collaborating centers for traditional medicine had been established worldwide to strengthen national efforts in research and development. The network also serves to collect and disseminate information on both useful and harmful traditional practices. In the early 1980s, FAO compiled an initial list of 22 medicinal plants, used as raw materials for drug production. This work has continued and is coordinated by the FAO collaborating center, the Research Institute for Medicinal Plants, Budakalasz, Hungary. The FAO *Non-Wood News Bulletin*, first published in 1995, provides a wealth of information on medicinal plants (although, given the state of knowledge, much of the information is neither consolidated nor validated).

2. CHINA

In China, medicinal plants have long enjoyed a prominent role in healthcare services. Indeed, Chinese traditional medicine has a history extending back 4000 years²⁰ with the *Yellow Emperor's Classic of Internal Medicine* considered to be the world's oldest extant medical book. The most famous Chinese work on traditional medicine was the *Compendium of Materia Medica* written by Li Shizhen (1518-1593). The fifty-two volumes describe 1,892 kinds of medicines, including 374 new ones, and 11,096 folk prescriptions and proven recipes. *Zhong Yao Da Ci Dian*, published in China in the 1970s describes 5,767 different kinds of herbal medicines (Box 3). In very modern times (1958) *A Barefoot Doctors Manual*, translated into many languages, describes both modern Western medical practices and the traditional Chinese methods of diagnosis and healing. Chinese traditional medicine stands today as the result of countless centuries of valuable practical experience, and is enriching modern medical knowledge throughout the world.

Box 3: The Snake That Knew

A legend from the most ancient times tells of a farmer who found a snake near his hut. He beat it with his hoe and left it for dead. The same snake reappeared a few days later, apparently as healthy as before. Again the farmer beat it. This time he watched the bleeding snake crawl to a particular clump of weeds and begin to eat them. By the next morning its wounds were healing again, and its vitality rapidly returning.

Such was the fabled discovery of *san qi* or *Panax notoginseng*. It is the main ingredient of *Yunnan Baiyao*, a light tan herbal powder that counteracts internal or external bleeding by promoting extremely rapid cell division and thus bonding the edges of wounds. *Yunnan Baiyao* also helps to improve blood circulation, disperse blood clots, and stop inflammation and swelling as well as expelling pus and counteracting poisons. Chinese soldiers have carried it in their first aid kits for many centuries. They call it *jin bu huan*—more precious than gold.

Source: Yuqiu Guo, TONE, 1995.

Production and Trade

Medicinal plants are as important as ever in Chinese commerce. Traditional medicine still retains a 40 percent share of the medicine market nationwide.²¹ In remote districts, however, plant-based preparations may account for 90 percent of drug consumption.²²

²⁰ Wang, 1987.

²¹ Kuipers, 1996.

²² Xiao, 1991.

Accordingly, the quantity of medicinal plants (in traditional medicines and as ingredients in “modern” medicines) is very large. And it is growing larger. Sales of traditional medicines over the last five years in China have increased 113 percent.

The majority of China’s factory-processed drugs are of plant origin. In fact, medicinal-plant preparations are almost as important as synthetic drugs, such as antibiotics. About 6000 plant-based medicinal preparations are processed into 3000 registered preparations and teas made from a crude drug or drug mixtures (these teas are locally known as yingpins). In 1990, Chinese doctors reportedly used for direct use in traditional prescriptions 700,000 tons of plant material.²³ A number of traditional systems of medicine occur in China: Han, Yi, and Bai to name a few.

These efforts are backed up by an industrial enterprise of impressive size. In 1986, for instance, 300,000 persons were working in factories and traditional drugstores all over the country. Of the 519 Chinese traditional pharmaceutical factories in 1985, about 10 employed more than 1000 persons.²⁴ By 1995, there were 2300 designated Traditional Chinese Medical hospitals, 846 manufacturers and 250,000 traditionally trained Chinese doctors. There are over 5000 licensed patent medicines, including 2,500 health products that utilize 11,559 botanical, animal and mineral sources.²⁵

The share of factory-made traditional drugs has continuously increased as a percentage of total pharmaceutical consumption from 1975 to 1995 (see Table 1). The following data are an indication of the level of regulated trade and value which has experienced 113 percent growth between 1990-1995.²⁶ Beyond this regulated trade there is a family-based and local-market trade. The size of this is unknown but it is safe to assume that it is considerable and that it imposes a heavy demand on wild-plant sources since little of it is based on cultivated plants.

Factory-made traditional pharmaceutical preparations are exported to markets where the Chinese system of medicine is practiced. The highest value of shipments from a single factory in 1986 was \$20 million. Figures for production growth are given in Table 2.

The exports go mainly to Asian countries, but plant-based medicinal products are also sent to Europe and, increasingly, the United States and Canada. A single company in the United Kingdom, for example, sells 1500 herbal products, the majority of which are traditional Chinese remedies. The products are sold to medical practitioners and consumers, and are licensed as food supplements. Each comes with information on uses and dosages, but no medicinal claims. In the future, the company intends subjecting some of its products through clinical trials in hopes they can then be marketed as over-the-counter medicines.

²³ Xiao, 1991.

²⁴ UNIDO, 1987.

²⁵ Kuipers, 1996.

²⁶ Kuipers, 1996.

Table 1

Sales 1975-1985 of synthetic pharmaceuticals and traditional medicines and 1990-1995 of traditional medicines in China in regulated markets

Year	Total Sales (\$ million)	Traditional Medicines (\$ million)	Percent Share
1975	3,179	350	10.9
1976	3,209	350	10.9
1977	3,644	400	11.0
1978	4,200	456	10.9
1979	4,779	579	12.1
1980	5,211	696	13.4
1981	4,914	749	15.2
1981	4,945	809	16.4
1982	5,354	920	17.2
1983	4,923	869	17.6
1984	4,107	739	18.0
1985	3,930	710	18.0
1990	n.a.	1,111	n.a.
1991	n.a.	1,317	n.a.
1992	n.a.	1,534	n.a.
1993	n.a.	1,701	n.a.
1994	n.a.	1,395	n.a.
1995	n.a.	1,451*	n.a.

* estimate of the *Eighth Five Year Plan* n.a. not available

Source: 1976-85 *Better Use of Medicinal Plants*. UNIDO, 1987.

1990-95 State TCM Administration. (S.Kuipers, pers. com.)

Table 2

Production Statistics 1979-1986 of Chinese Traditional Medicine Factories (ex-factory price)

Year	Number of		Gross Output		Value added
	establishments	employees	(\$ million)	(thousand tons)	
1979	269	n.a.	448	78	102
1980	352	n.a.	581	84	146
1981	402	86,885	642	103	174
1982	409	98,584	714	130	216
1983	427	104,429	810	141	242
1984	476	110,303	767	137	245
1985	519	118,842	713	156	243
1986	535	125,000	680	160	234

Source: State Pharmaceutical Association of China; 1986 figures are UNIDO estimates.

A well-organized operation lies behind such enterprises. In this case, British importers buy raw and processed plant materials—such as concentrated powders and various extracts—from China. They also import 100 Chinese patent medicines, the selling price of which is about five times the value of the raw materials they contain. Importers repackage and relabel the products, providing information to satisfy British regulatory requirements and using attractive packaging to meet the expectations of the Western consumer.²⁷

Notable Chinese Medicinal Plants

During the past 30 years, the identifications of the historically recorded medicinal plants have been verified and their chemical taxonomy determined.²⁸ The *Encyclopedia of Traditional Chinese Crude Drugs* (1977) describes the botanical and analytical standards of 5646 crude drugs. The latest edition of the Chinese Pharmacopoeia contains a list of 647 crude drugs of botanical origin, their formulations, methods of preparation, requirements and tests for strength and purity, and related information. The Ministry of Health has begun the standardization of the names of all phytopharmaceutical preparations.

Three of the most commonly-used plant species in Chinese medicinal preparations are described below. They give a sense of the botanical wealth to be found in China's natural resource heritage.

Ginseng (*Panax ginseng*). Probably the most famous among Chinese traditional drugs,²⁹ ginseng was first described in *Materia Medica* written almost 2000 years ago in China.³⁰ It is By the 4th Century, centers of production, time of harvesting and morphological characters had been recorded. During the past 1500 years, the value of ginseng has remained high—"equal to its weight in silver."³¹ The plant also occurs and is cultivated in Korea, Japan, Russia and North America. Because the root shape can resemble the human form, it was believed to be effective in curing disease and strengthening the weak (i.e. a general cardiac tonic). Its medicinal value appears to stimulate the pituitary gland resulting in homeostasis (chemical and metabolic balance). This concept is the central principle of traditional Chinese medicine.³²

Production data for ginseng are given in Table 3. Jilin Province in northeast China is the major producing area but in recent years Liaoning and Hailong Provinces have increased production.

²⁷ Kate, 1995.

²⁸ UNIDO, 1987.

²⁹ Sonnenborn and Proppert, 1991.

³⁰ Duke, 1989.

³¹ Hu, 1979.

³² Duke, 1987.

Table 3**Domestic Market Dried Ginseng (tons)**

Province	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Jilin	1800	2500	3200	4100	5400	5500	5000	4000	3500	3000
Liaoning	n.a.	n.a.	n.a.	2000	n.a.	n.a.	n.a.	1300	n.a.	800
Heilong.	n.a.	n.a.	n.a.	500	n.a.	n.a.	n.a.	1000	n.a.	400
Total				6600				6300		4200

Source: He Shan-An, Institute of Botany, Nanjing.

The price while high in 1988 (\$250,000 per ton) dropped in 1989 with record yields to \$80,000 per ton, but has been rebounding in recent years (for instance, in 1995 it was \$150,000 per ton). The significant price difference between 1988 and 1989 might be indicative of what can happen with increased production and no price control at the farm level. Approximately 2000 tons of dried ginseng with a value of \$50,000 per ton are exported annually. Another 2000 tons (undocumented) are also exported. At the same time North American ginseng exports to China doubled between 1993 (1140 tons) and 1995 (2200 tons).

Eucommia (Eucommia ulmoides). This plant, also known as the gutta-percha tree, has been an important economic plant and is endemic to the mountainous regions of China. It is now known only in cultivation, having been harvested into extinction in the wild. All parts of the tree are valuable but the bark is the main medicinal. For many centuries, eucommia bark or *tu-chung* was used traditionally as a rejuvenating tonic to benefit the liver and kidney, and to strengthen the muscles and bones. It was only in 1948 that its antihypertensive activity was discovered.³³ The bark is the source of the active compound pinoresinol di- β -D-glucoside.

This tree's bark, fruit, and leaves contain 6 to 18 percent gutta-percha, a material chemically akin to natural rubber but that is hard and lacks "bounce".³⁴ The extracted rubber has excellent insulation properties, low moisture absorption and is resistant to acid, alkali, oil, and corrosion, and represents one of the important raw materials for the manufacturing of undersea cables and airplane tires. It has excellent bonding properties, serving as materials for filling teeth and setting bones. The seed is the source of high quality cooking oil. The leaves contain vitamin C and may be used as tea. The wood is valued for manufacturing furniture and handicrafts.

The tree is found in more than 260 counties of 16 Chinese provinces. Hunan is the major center of production, producing more than all the other provinces together. The Province has the *Eucommia* Scientific Research Centre located in Cili County. Approximately 0.2

³³ Hu, 1979.

³⁴ In earlier times a well-known use for gutta-percha was the plastic-like covering put on golf balls. Most of the world's commercial gutta-percha comes from a South American tree, rather than this Chinese counterpart.

million hectares are under eucommia plantations. The total annual yield is about 4000 tons of bark, of which about 2000 tons are exported. Production is expected to reach 5000 tons by 2000. While leaf production is more difficult to calculate, exports in 1993 reached 5000 tons.

Despite the quantities produced, there is not enough to meet the demand. Because of its many uses the bark's market prices are high and stable; domestic prices are between \$6 per kilogram and the international market is \$80 per kilogram.³⁵ Production is expected to increase significantly in the future as the plant can be intercropped with food crops and used to rehabilitate degraded hillsides. Provincial medicinal-use production figures are presented in Table 4.

Table 4

Eucommia Cultivation in China, 1993

Regions	Total area (ha)	Bark yield (tons)	Leaf yield (tons)	Output value (\$ million)
Hanghong, Shaanxi	36,000	500	2500	19.5
Ankang, Shaanxi	33,000	990	40,000	30.5
Cili, Hunan*	27,000	2000	40,000	114.9
Anchu, Shandong	800	n.a.	n.a.	n.a.
Jiangxi	7000	n.a.	n.a.	n.a.

Source: He Shan-An, Institute of Botany, Nanjing.

Seabuckthorn (*Hippophae rhamnoides*). Human beings have been using this shrub for at least 1200 years. The plant known in English as seabuckthorn, was recorded in the Tibetan medicinal classics (the *Four Books of Pharmacopoeia*) completed in the Tang Dynasty (618-907 AD). Although China was one of the earliest countries in the world to use seabuckthorn as a medicinal plant, until 1980 its use was limited to Tibet and Mongolia. The processing of seabuckthorn medicinal products did not start in China until 1986. It has proven to be a profitable crop because of its many uses in the medicinal, food, and cosmetic industries.³⁶

At present, 1.2 million hectares (95 percent of world total) of seabuckthorn are under cultivation in 19 provinces. Seven breeding stations have been established to select new varieties adapted to different biogeographic regions.³⁷

³⁵ Anon, 1993b.

³⁶ Lu Rongsen, 1992.

³⁷ Lu Rongsen, pers. com.

In China, there are an estimated 740,000 hectares and 300,000 hectares of natural and cultivated plants. As of 1995, more than 10,000 people were employed on various aspects of plant development, 95 percent are located in rural areas and do not include farmers. Because major economic benefits can be realized quickly (in three or four years) farmers are keen to plant. Approximately 50,000 tons of seabuckthorn berries are harvested annually and processed into 200,000 tons of various products valued at \$35.7 million. The Chinese government has invested more \$25 million in seabuckthorn research and development.³⁸

The shrub has attracted a great deal of attention from scientists and engineers around the world because of its combined ecological and economic benefits. The seabuckthorn root system, for example, is so extensive that its roots can branch many times in a growing season and form a complex underground network that holds the soil from slippage like wire reinforcing mesh in concrete. When plants are buried under sediments massive adventitious roots extend to form new horizontal root systems. An individual plant can propagate massive bushes or a small forest in several years. This is why the seabuckthorn bushes play such a prominent role in protecting river banks, preventing floods and minimizing slope erosion. The plants are considered more effective than any construction work. Furthermore, its role in rehabilitation and upgrading of marginal or fragile slopes through soil-binding is well documented.

Where land degradation and its accompanying poverty occur it can play an important role in soil and water conservation and land rehabilitation. Seabuckthorn is a multipurpose plant, and its potential is far from fully exploited. With further study, more and more uses could be developed in the near future. Its humanitarian and economic benefits can be summarized as follows. The plant is:

- a source of low-priced vitamins, seabuckthorn fruits can benefit millions of children suffering from vitamin A deficiency.
- a means for generating cash income, it has since 1985, in the middle reaches of the Yellow River, provided farmers with earnings of about \$1.06 million from the sale of fruit every year.
- an option for stabilizing mountain slopes it is selected by farmers and engineers because of its extensive root system, soil binding qualities, its provision of good surface cover, and its utility as fodder, food, fuelwood, and supplier of medicine .

It seems no wonder, therefore, that a 1990 assessment put China's total area of seabuckthorn at about 1 million hectares, and the total value of its products at more than \$20 million per year. Moreover, between 1991-1995, an additional 330,000 hectares were scheduled to be bought under seabuckthorn cultivation.

³⁸ Lu Rongsen, pers. Com. This expenditure was under the 7th-9th Year Plans.

Government Initiatives

China's long-term goal is to eventually unify and integrate traditional and Western approaches to medicine, but, given the complexities involved, this will require years to achieve. There has been a movement to speed the process of shared use of hospital facilities, cooperative approaches by traditional medicine and Western medicine. Most importantly, this has involved mobilizing and training traditional medicine practitioners as part of a primary prevention strategy against chronic disease. In this, the Chinese Academies of Science and Medical Sciences play a leading role in medicinal-plant research. The Ministries of Agriculture and Forestry appear to play a very limited role.

One part of the governmental health service deals specifically with the application of traditional medicine. The State Administration of Traditional Chinese Medicine (TCM) was established in 1987 as a separate administrative agency reporting directly to the State Council. A separate TCM structure is present at the Provincial and City levels. The formal TCM structure has, as its lowest level, a series of TCM hospitals. These are sometimes quite large institutions. There are many thousands of both formally trained and informally trained traditional practitioners. TCM practices are found at most Western hospitals and in most clinics and health centers. The separate vertical structure is justified by TCM authorities as being needed to protect TCM institutions and personnel from being overwhelmed and absorbed by the larger and more powerful Western medicine system.³⁹

A government corporation is the leading promoter of medicinal-plant cultivation. The National Corporation of Traditional and Herbal Medicine is an integral part of the State Pharmaceutical Administration of China. Established in the early 1950s, it was given responsibility for the cultivation, collection, and distribution of medicinal substances of natural origin, as well as for the industrial production and domestic distribution of phytopharmaceutical preparations. This organization's importance has been rising ever since. In 1987, for instance, China devoted 300,000 hectares strictly to medicinal-plant cultivation.⁴⁰ By 1995, the area had increased almost 50 percent, to 439,000 hectares, a clear recognition that the government has responded to the need to meet the rising consumer demand (see Table 5). Government policy encourages producers to see their work as a long-term business. Interest-free credit is given to farmers on request.

Table 5

Cultivation of Traditional Chinese Medicinal Plants 1990-1995 (1000 of ha)

Year	1990	1991	1992	1993	1994	1995
Area planted	363	384	426	382	424	439

Source: State TCM Administration (S. Kuipers, pers com.)

³⁹ World Bank, 1989.

⁴⁰ UNIDO, 1987.

In 1987, UNIDO carried out a joint study with the National Corporation of Traditional and Herbal Medicine to determine the needs of an expanded pharmaceutical industry.⁴¹ They concluded that important socioeconomic advantages would be gained by using domestic medicinal-plant raw materials, resulting in the creation of jobs both in agriculture and industry, and the regular availability of safe and effective drugs at an affordable price for primary healthcare. The investment costs to support a pharmaceutical industry were considered relatively small, the dosage form and quality control capacities would be convertible, and the acquired knowledge and experience would prove useful at an eventual diversification date. Programs supporting integration of traditional and modern medicine would include:

- special educational programs to publicize the proper use of plant-derived herbal medicines; and
- consultations at regional levels on various facets of the medicinal-plant industry, stressing quality standards and safety, with a view to promoting the wider use and acceptance of herbal medicines.

In recent years phytopharmacological researchers have isolated and chemically characterized 571 active compounds from crude drugs. Sixty new drugs have been developed that originate directly or indirectly from these substances.⁴² They include:

- a new class of antimalarial/antipyretic properties from the leaf of sweet wormwood (*Artemisia annua*);
- analgesic and nervous system depressants from the rhizomes of yanhusuo (*Corydalis* sp.); and
- antitumor ingredients from bark of the plum yew (*Cephalotaxus harringtonia*).

Links to Modern Medicine

Legal recognition and government patronage granted to traditional medicine are seen as key factors in the future successful integration of the two systems (see Table 6). It is legal to sell medicinal plants and herbs in the free market, both in rural and urban areas. However, if a new medicinal-plant product or crude drug is to be imported from abroad for sale in the Chinese market, then the approval of the provincial department of public health is required. The new product will be assessed according to standards in the *Pharmacopoeia of the People's Republic of China*. The origin of the material must always be clearly marked.

⁴¹ UNIDO, 1987.

⁴² Xiao and Fu, 1987; Kinghorn, 1994.

Table 6

Examples of Traditional Chinese Plant Medicines as Related to Modern Usage

Species	Name - English	Name - Chinese	Modern Application	Plant Part
<i>Aguilaria sinensis</i>		Peimoshan	asthma, cardiac	bark, exudate
<i>Amomum villosum</i>		Sahun	stomach ache	seeds
<i>Begonia finbristipula</i>	Begonia	Qiuhaitang	heat or sunstroke	leaves
<i>Cartharentus roseus</i>		Changchunhwa	anti-tumor	all parts
<i>Chrysanthemum morifolium</i>	Chrysanthemum	Chuhua	cold, influenza	flowers
<i>Eriobotrya japonica</i>	Loquat	Pipa	pulmonary disorders	fruit
<i>Lonicera japonica</i>	Honeysuckle	Chinyen Hua	fever, cold	flower, vine
<i>Cephalotaxus haenensis</i>		Sanjiansan	leukemia, lymph node, tumors	whole plant
<i>Morus alba</i>	White Mulberry	Sang	diuretic, pulmonary soother	leaves
<i>Trichosanthes kirilowii</i>		Tienhwafen	reduce infection	fruits, seeds

Source: Wang, L. 1987. Plants to Keep People Healthy.

All Chinese herbal medicines produced in factories either for local use or for export have to undergo quality control tests before being released. Each factory has its own quality control unit that checks on the quality of different samples of the product. An attempt is being made to ensure that the quality of Chinese traditional medicine produced in China is of a high standard. Among the factors considered in choosing the standard substance against which all preparations will be tested are such factors as climate, soil, and time of collecting.

Rigid criteria are being laid down for assessing patented traditional Chinese medicines. The manufacturer must list the main ingredient and the other ingredients. Reviewing authorities will determine whether there are incompatibilities between the different ingredients. Only after assuring themselves that the product conforms to the Chinese traditional system of medicine, that it is safe, and that the ingredients are not incompatible with each other will the patent medicine be allowed to be released into the market. The review and assessment is largely carried out by persons trained in the traditional Chinese system of medicine.

The Chinese authorities are well aware of the problems and constraints facing them in developing this link with modern medicine and are endeavoring to develop a system that would use similar standards of quality control without detriment to the practice of Chinese traditional medicine and use of plant-based remedies in this system of medicine.

Box 4: New Hope for Malaria

Malaria occurs in 103 countries and strikes 270 million people worldwide annually, killing two million, according to the World Health Organization. The parasites are developing resistance to chloroquin and other synthetic drugs. For more than 2000 years, traditional Chinese healers have relied on an infusion of qing hao (wormwood leaves from *Artemisia annua*, a common weed) in water to cure the potentially fatal fevers of malaria. The active ingredient in qing hao, artemisinin acts by turning the malaria parasite's food into poison. The mosquito-borne parasite that causes malaria settles either in the liver, where the disease becomes chronic, or in blood cells in the brain, where it can lead to coma and death. The parasite feeds on blood but does not metabolize the iron in red blood cells, instead keeping it in a kind of sac.

When the chemicals in artemisinin come in contact with the iron, a toxin is created that kills the parasite, thereby curing the malaria, according to Steven Meshnick, a parasitologist at the University of Michigan School of Public Health, who has tested the drug on malaria patients in Vietnam. Artemisinin is being extracted from plants and formulated into medications in Vietnam at very low cost. The drug is effective against both major types of malaria, the vivax strain, which occurs in the liver, and the falciparum strain in the brain. The drug has been used on more than 2 million patients with no side effects. Other drugs for malaria are mostly synthetic derivatives of quinine, to which the parasite has become resistant.

Researchers in China, United States, The Netherlands, United Kingdom, and Vietnam are studying the therapeutic powers of this ancient remedy. More than a dozen derivatives of artemisinin are being tested around the world in a program sponsored by WHO, United Nations Development Program and the World Bank.

Source: S. Meshnick, University of Michigan School of Public Health, 1996.

Since China had to rely on its own natural and human resources until very recently it developed its own models based on pragmatism and practicality, and this has greatly helped medicinal-plant research.⁴³ Being isolated minimized the constraints placed on traditional Western concepts of research methodology. This afforded them opportunities to make advances and use medicinal plants both for research and therapeutic effect. For example, they have released for widespread evaluation gossypol, a male contraceptive, and artemisinin for malaria control (see Box 4). The working relationship between field scientists, pharmacologists, and clinical investigators is proving effective. Such a strategy could be very rewarding for other developing countries as it clearly recognizes the importance and value of the knowledge of traditional medicinal practitioners in providing affordable healthcare.

⁴³ Chaudhury, 1992.

Links to Agriculture

Apparently, the Ministry of Agriculture has no specific mandate related to the cultivation of medicinal plants. It has, however, identified 1000 species of medicinal plant and 380 species of medicinal fungi of economic importance.⁴⁴ Medicinal plants are seen as a companion crop to food crops, and an additional source of income, especially in remote and highland areas.

The Chinese Academy of Medical Sciences and the Institutes of Botany of the Chinese Academy of Sciences are actively engaged in medicinal-plant research, including cultivation. In 1987, the Chinese Academy of Agricultural Sciences set up a national germplasm bank for crop genetic resources. At present, it has 230,000 accessions, but it is not known if they include medicinal plants.

Links to Forestry

China is poor in forest resources, with a total forested area of 131 million hectares covering 13.6 percent of the land area. The Chinese Ministry of Forestry has prepared a detailed afforestation model, which covers technical silviculture prescriptions, growth targets, establishment costs, financial and economic rates of return, and environmental benefits. Currently, there are about 12.7 million hectares of plantation forests, and representing 65 percent of the area under plantation forest in all of Asia.

A China Forest Resource Development and Protection Project included the medicinal plant eucommia under protection forests.⁴⁵ The component integrates non-consumptive economic activities with afforestation for environmental benefits. Under the project 8700 hectares (3.1 percent) were to be planted to eucommia in Sichuan Province.

In addition to the cultivation figures in Table 4, approximately 10,000 hectares of eucommia and other broadleaved species of medicinal plant have been planted in Guizhou, Guangxi and Yunnan Provinces⁴⁶ plus 1200 hectares in Hunan Province.⁴⁷ In neither project is the Ministry of Forestry involved in species selection regarding climatic and ecological suitability to specific site conditions, environmental management objectives, and the socioeconomic requirements of the afforestation entities for income generation, fuelwood and other forest products. Nevertheless, the Ministry of Forestry has an important role to play in collaboration with the Ministry of Agriculture, Chinese Academy of Medical Sciences, Eucommia Scientific Research Centre, Cili County, Hunan, and other ministries and bureaus to ensure the successful establishment of medicinal-plant cultivation programs.

⁴⁴ Anon., 1994.

⁴⁵ World Bank, 1994a.

⁴⁶ World Bank, 1995a.

⁴⁷ World Bank, 1994b.

Protecting Medicinal-Plant Biodiversity

Due to the destruction of forests, overgrazing of remote and marginal lands, expansion of industry and urbanization, as well as the excessive harvesting of wild rare and endangered plants, biological diversity of medicinal plants is being reduced day by day.⁴⁸ The Institute of Medicinal Plant Development (IMPLAD), a WHO Collaborating Centre of Traditional Medicine under the Chinese Academy of Medical Sciences, specializes in research on medicinal plants. A primary function of IMPLAD is to protect and enlarge medicinal-plant resources and improve their quality.

Examples of threatened species include:

- *Fritillaria cirrhosa* occurring in northwestern Sichuan Province is rarely found today; roots are used for respiratory infections and as a cancer remedy;
- *Dioscorea* spp. Many species of Chinese yam have been eradicated throughout much of their original range during the past 30 years; roots used as an analgesic, seeds as diuretic, leaf against scorpion stings, and the whole plant as a tea;
- *Iphigenia indica* populations are under serious threat in northwestern Yunnan as a result of low fecundity and the effects of overharvesting; the bulb (root) has antitumor compounds; and
- licorice (*Glycyrrhiza glabra*) has also suffered from over-collection and consumption, and exports have been stopped to restore the production base; root extracts used as antidiarrheal, flowers for upper respiratory diseases.

Preserving Wild Genes. It is generally reported that of the 35,000 plant species growing in China, approximately 5136 are used as drugs in Chinese Traditional Medicine (see Table 7).

Table 7

Chinese Medicinal Plants Identified To Date

Origin	Number of Species	Origin	Number of Species
Thallophytes (algae/fungi)	281	Gymnosperms	55
Bryophytes	39	Angiosperms	
Pteridophytes	395	Monocotyledons	676
		Dicotyledons	3690
		Total	5136

Source: Xiao (1991)

⁴⁸ Xiao, 1991.

Of the 389 rare and endangered plant species listed in the *Chinese Red Data Book* (1991) 77 are traditional Chinese medicinal plants. Although more than 50 are being grown in botanical gardens, there is still insufficient research on their protection. A number of important medicinal plants have been preserved in genebanks under the auspices of several agricultural institutions and botanical gardens. Every effort is being made to expand research on population genetic variation. One such example is *Atractylodes lancea*, preparations which inhibit indigestion, edema (fluid build-up), vomiting and chronic gastroenteritis.

In-Situ Conservation. The Biodiversity Conservation Action Plan for China was initiated in 1992 with funding under the Global Environmental Facility (GEF) program.⁴⁹ The in-country process is coordinated by the National Environmental Protection Agency (NEPA), which established a Leading Group to provide overall supervision, direction and coordination. It is composed of those agencies with significant biodiversity responsibilities. To date 700 nature reserves, 480 scenic areas and 510 forest parks have been established. However, for purposes of coordinating departments and solving management issues there is no single authority, nor any state law or unified set of regulations.

NEPA established a Medical Management Department responsible for the national use and protection of precious medicinal materials (plant, animal and mineral). Some geographical regions have been declared protected areas for the growth of vulnerable species (for example licorice). Authorities believe such action is necessary to restore sustainable production levels.

Ex-Situ Conservation and Cultivation. A number of long-term programs have been established to conserve medicinal plants and enhance their value through cultivation. The agricultural area used for cultivation of medicinal plants increased from 300,000 hectares in 1986 to 440,000 hectares by 1995 and produces about 40 percent of the total output of crude drugs. Each year, approximately 200 medicinal plants species are cultivated. More than 700 farms are engaged in cultivating high-quality medicinal plants. In addition, the Chinese Academy of Sciences, Institute of Botany, Nanjing has a 186 hectare farm that includes a Medicinal Plant Garden and a Rare and Endangered Conservation Garden. The institute has recently established the Jiangsu Plant Ex-Situ Conservation Laboratory that works closely with the Phytochemical Laboratory in research on medicinal plants.⁵⁰

Important measures have been adopted to guarantee the continuous supply of raw materials to industry and the market. Government guidelines have been established regarding the protection, exploitation, and utilization of natural resources.⁵¹ As a result of recent research and development programs, a number of previously wild medicinal plants (for example *Glycyrrhiza platycodi*, *G. gentianae*, *G. astragali*, and *G. changii*) have

⁴⁹ Anon., 1994.

⁵⁰ He Shan-An, pers com.

⁵¹ UNIDO, 1987.

been successfully cultivated.⁵² Xiao (1991) identified additional wild growing medicinal plants which are needed in large quantities and now being cultivated:

- Chinese licorice (*Glycyrrhiza uralensis*); roots and lower stem are used as a buffer in herbal prescriptions, act similar to adrenocortical hormones, and are effective against stomach ulcers and Addison's Disease;
- rhubarb (*Rheum palmatum*); root extracts reduce dyspepsia, fever and diarrhea; Chinese researchers are actively studying anticancer properties;
- broomrape (*Cistanche deserticola*); a parasitic herb used against impotency;
- China "root" (*Poria cocos*); a fungus growing on pine tree roots, promotes diuresis; and
- yam (*Dioscorea nipponica*); root extracts used for rheumatoid arthritis.

In addition, modern biotechnology is used for propagating *Lithospermum erythrorhizon*, *Panax quinquefolium*, *Corydalis yanhuosu*, *Scopolia tangutica* and others.⁵³ This has included tissue-culture propagation, for example.

The Beijing Botanical Garden of the Institute of Botany and the Medicinal Botanical Garden of Guangxi Autonomous Region published in 1994 a color atlas of traditional Chinese medicines with text on techniques of their cultivation. The atlas is in two parts and includes: (i) 302 traditional Chinese medicinal plants; plants are listed in eleven categories according to plant parts used; and (ii) cultivation and propagation methods, management, control of pests and diseases, and harvesting and processing of the medicinal products.

Government policy encourages practitioners of traditional medicine to see their work as a long-term business. At the same time, interest-free loans are given to farmers on request as an inducement to grow medicinal plants. Information on demand and supply is widely disseminated. Over-supply of raw materials due to favorable weather conditions is purchased, processed, and held in stock.

⁵² UNIDO, 1987.

⁵³ Xiao, 1991.

3. INDIA

Medicinal plants in India have been collected from the wild and cultivated for millennia. The Rig veda, written in India between 4800 and 1600 BC is the earliest record (in India) of the use of tree, shrub, herb, and grass combinations for curing ailments.⁵⁴ Since then, thousands of books and papers have been written extolling the therapeutic value of Indian medicinal plants. In the Indian commercial market, it is generally accepted that nearly 95 percent of the medicinal plants in use are obtained from the wild. For the rural poor that figure is probably 100 percent.

The Indian Subcontinent contains about 25,000 species of vascular plants, of which at least half are endemic to the region.⁵⁵ The 7000 medicinal plants used by the various traditional medical systems account for 28 percent of the region's flora—a very high percentage.

Production and Trade

India has a special position in the world today because it is one of the few countries that is capable of producing most of the important plants used both in modern as well as traditional systems of medicine—a result of its vast area with a wide variation in climate, soil, altitude, and latitude. India is a major exporter of raw medicinal-plant materials and processed plant-based drugs. Germany, the United Kingdom, France, Switzerland, Japan, and the United States are major importers of Indian medicinal plants, accounting for 75 percent of total exports. Germany is the lead importer,⁵⁶ which translate into \$1.1 billion over the counter phytomedicine retail sales.⁵⁷ Although India ranks as one of the major suppliers of medicinal plants to the world, its export of derivatives (chemical substances derived from medicinal plants) is insignificant when compared with those from developed countries.

At present the marketing and distribution of medicinal-plant raw materials is not well organized or documented. Middlemen are contracted by the pharmaceutical companies to provide raw materials. They in turn contract collectors in the rural areas to provide the plant materials. Few reliable data are available regarding total demand of individual plant materials (roots, bark, leaves, fruit, seed, etc.), their prevailing prices or localized availability in the country. Of increasing concern to industry is the adulteration of plant materials. For example, *Aconitum heterophyllum* is an important constituent of a number of Ayurvedic formulations. Companies utilizing this species find that deliveries invariably include three other *Aconitum* spp. that have to be removed, with an added cost

⁵⁴ Jain and DeFilipps, 1991.

⁵⁵ WWF/IUCN, 1995

⁵⁶ Lewington, 1993.

⁵⁷ Grunwald, 1994.

to processing. To counter such problems, a number of companies have established their own R&D stations and are pursuing cultivation studies on the more vulnerable species used in formulations.

Demand and supply estimates by the Ministry of Health were used by Jain (1987) as an indication of the inability of one region, the North West Himalaya, to satisfy demand in 1986 (see Table 8). The supply/demand ratio is likely to be even worse in 1996, resulting in even greater demand on wild medicinal-plant sources and consequent increased threat to species survival. Another reason for companies to establish cultivation programs.

Table 8

Medicinal Plants: Demand and Supply in North West Himalaya

Botanical Name	Demand (tons)	Supply (tons)
<i>Orchis latifolia</i>	more than 5000	less than 100
<i>Rauvolfia serpentina</i>	“ “ “	“ “ 1000
<i>Gentiana kurroo</i>	“ “ “	“ “ 100
<i>Aconitum heterophyllum</i>	“ “ 1000	“ “ “
<i>Plumbago zeylanica</i>	“ “ “	“ “ “
<i>Onosma bracteatum</i>	“ “ 5000	“ “ “
<i>Picrorhiza kurroo</i>	“ “ “	“ “ “
<i>Dioscorea deltoides</i>	“ “ “	“ “ “

Source: Ministry of Health, New Delhi. in Jain, 1987.

The pharmaceutical industries, large and small, are a powerful socioeconomic force in India. Very recent statistics (see Table 9) for the export of medicinal plants from India reveal that between 1985-86 and 1994-95 the export value of crude drugs increased 2.76 times to a value of \$53.2 million.⁵⁸ Important crude drugs included: *Plantago ovata* (psyllium), *Panax* spp. (ginseng), *Cassia* spp. (senna), *Catharanthus roseus* (periwinkle), and numerous Ayurvedic and Unani herbs. Essential oils included: *Santalum album* (sandalwood), *Mentha arvensis* (peppermint), and *Cymbopogon flexuosus* (lemongrass). The major destinations were: United States, Japan, Germany, France, Spain, Pakistan, and Bangladesh. An important fact is these statistics do not account for the huge volume of the undocumented, illegal medicinal-plant trade. In addition, the values quoted are the returns to India only. In reality, the plants would sell in foreign markets at significantly higher prices. If processed in India the financial returns from such exports would be considerably greater. However, these figures must pale beside the value of the formal internal market.

⁵⁸ CHEMEXCIL, 1996.

Table 9

Export of Crude Drugs and Essential Oils from India between 1985-1995 (\$ million)

Year	Crude Drugs	Essential Oils	Total Revenue
1985-86	19,272	4,553	23,825
1986-87	16,848	6,889	23,737
1987-88	22,489	4,638	27,127
1988-89	17,805	4,974	22,779
1989-90	25,504	8,600	34,104
1990-91	36,802	5,821	42,623
1991-92	41,345	15,592	56,937
1992-93	48,417	15,267	63,684
1993-94	45,355	19,504	64,859
1994-95	53,219	13,250	66,469
Total Revenue	327,056	99,089	426,145

Source: CHEMEXCIL, Bombay. 1996

While India is not self-sufficient in pharmaceutical production, the majority of medicines used in the Indian Medical System (IMS) are manufactured by the private sector. Traditional Indian Ayurveda medicine has a 70 percent share of the formal medicine market in India. i.e. it provides for the needs of more than 600,000 million people. However, there are no estimates of the value of the informal market. Both these economically important internal markets must place a heavy demand on wild medicinal-plant species procured from wild sources in forests, plains, fields, and remote lands. Data for medicinal plant sources, number of workers employed, and income generated (see Table 10) have been provided by Dr. Nambiar, Arya Vaidya Sala, Kottakal, Kerala and are estimates for a typical year.⁵⁹

As of 1987, there were 3349 units licensed to manufacture plant-based pharmaceuticals, but their contribution to the total production was considered only marginal.⁶⁰ The machinery for the collection, production and marketing of plant-based products is not centrally regulated. A legal quality control mechanism exists, but is only partially implementable due to the absence of pharmacopoeial quality and industrial manufacturing standards. Important steps in future development include the publication of the *Ayurvedic Formulary of India (Part I)*, a list of drugs of plant origin currently imported, suggested for domestic cultivation, and medicinal plants approved for export. A sub-group on indigenous systems of medicine has been established within the Working Group of the National Drugs and Pharmaceutical Development Council to consider the evolution of plant-based pharmaceuticals in India.

⁵⁹ Bajaj and Williams, 1995.

⁶⁰ UNIDO, 1987.

Table 10

Resource Use Patterns, Income, Employment and Healthcare Coverage
Arya Vaida Sala, Kottakal, Kerala, India.

Plants "imported" from northern states	
number	Approximately 550
amount	500 tons (dry-weight)
roots/rhizomes	25 percent
origin	Calcutta, Orissa, Assam, Maharashtra, Delhi Madhya Pradesh, Punjab and Kashmir
market value	approx. Rs 5.2 crore (approx \$1.6m)
costs for collecting/transporting	2-3 percent
Plants cultivated in Kerala	
number	Approximately 150
amount	400 tons
percentage roots/rhizomes	40 percent
approx market value	Rs 4 crores (approx \$1.35m)
number of people employed	1600
income generated	Rs 6 crores (approx \$2m)
Medicinal-plant processing in Kerala	
number of people employed	540
approx market sales value	Rs 8 crores (approx \$2.65m)
tons stored annually	540 tons
estimated tonnage lost in storage	0.25 tons
Hospital	
number of staff	200
number of patients	inpatients, 1395; outpatients, 6650
income generated per annum	Rs 79,000 (approx \$263,000)

Source: Bajaj and Williams, 1995.

Today traditional practitioners of the Indian systems of medicine—Ayurveda, Unani and Siddha—are providing prescriptions in the form of manufactured products rather than their own prescriptions. The demands of the pharmaceutical industry have outpaced the existing supply, and one of the major difficulties being experienced by the Indian systems of medicine is that of obtaining sufficient quantities of medicinal plants for the manufacture of genuine remedies.⁶¹ No sources reporting internal production and inter-state trade figures were located at this time.

⁶¹ Alok, 1991; VPK Nambiar, pers. com.

Box 5: A Poor Return on a Natural Resource

The most recent medicinal plant to come under threat is tetu lakda (*Nothatodytes foetida*), a small tree found in the rainforests of southern India and Sri Lanka. Extracts from the wood are used in cancer-fighting drugs in Europe. Twigs are available in India for only U.S. \$0.26 (Rs. 9) per kg, whereas the extract after processing is sold by pharmaceutical companies for U.S. \$15,000 per kg on the world market. Vast quantities of the tree are being cut, pulverized, and exported in powder form with the result that increasing tracts of forest are being laid to waste.

This plant is not included in the Ayurveda pharmacopoeia which partly explains its abundance until recently. However, at the rate it is being exploited it will soon become another threatened Indian medicinal plant species.

Source: A.B. Damania, per com.

Notable Indian Medicinal Plants

Jain (1987) has suggested that the bulk of Indian medicinal plants for the pharmaceutical industries come from forest areas. Today, an increasing number are being collected from non-forest ecosystems, as well as disturbed and degraded lands, and roadsides. The following three medicinal plants exemplify the diversity of habitats and use in medicinal preparations.

Neem (*Azadirachta indica*). The people of India have long revered the neem tree, a broad-leaved evergreen tree that can grow up to 30 m tall with a rounded crown as much as 20 m across. Because products relieve so many different pains, fevers, and infections, and rids households of pests, it is known as the “village pharmacy.”⁶² The earliest Sanskrit medicinal writings refer to the benefits of the fruits, seeds, oil, leaves, roots, and bark of the neem. Each of these has long been used in the Ayurveda and Unani medicinal systems.

Neem chemicals can help control more than 200 pest species, including locusts, borers, mites, termites, nematodes, and beetles.⁶³ Recent results in medical and veterinary studies indicate even wider future uses. Currently, preparations derived from neem are used to treat:

- leaves—malaria, leprosy, cholera, intestinal worms, skin diseases;
- seeds—headaches, antibacterial, peptic/duodenal ulcers, chronic diarrhea;
- roots—amenorrhea (abnormal absence of menstruation);

⁶² NRC, 1992.

⁶³ Ahmed, 1995.

- stem—gum disease (tooth stick);
- bark—antipyretic (fever reducer), analgesic (pain reliever);
- flower—ophthalmic uses;
- fruits—laxative; and
- gum—body stimulant, tonic.

In addition to the pharmaceuticals, pesticides, and veterinary products, neem provides many useful and valuable income-generating materials during the life of the tree. For example, its seed oil goes into soaps, waxes, and lubricants, as well as into fuels for lighting and heating. Solid residues are used as fertilizer. Leaves are used as emergency animal fodder. Neem is a member of the mahogany family, and its wood—harvested when the tree is 35 or more years old—is highly valued for cabinetry and construction.

The multipurpose nature of neem means that its products can provide a range of employment opportunities in rural and urban communities. Individual investors and farmers can expect a net income of \$155 per hectare per year from raising the neem tree.⁶⁴ The collecting and processing of neem products provides employment opportunities from rural to urban levels. Between 1970 and 1993 the price of neem seed has gone up from \$9 per ton to between \$90 and \$120 per ton.⁶⁵ However, this increase has turned a free resource into an exorbitantly priced one, with the local user now competing with industry for the seed. The diversion of the seed to industry may undermine the ability of local sources to provide healthcare to those users whose only affordable products are raw plant materials. However, this is a self-correcting situation that is stimulating both economic development and the planting of many more neem trees.

The multipurpose use and value of neem makes it an ideal species for future research and development programs. Because neem can grow well on poor soils, it opens up great possibilities for rehabilitating and stabilizing degraded lands. Intercropping with seasonal food crops would make marginal lands more profitable. Neem cultivation can be even more profitable if the seed is processed locally. It would not only add value to products, but also generate substantial employment and income in rural sectors.

Sarpagandha (*Rauvolfia serpentina*). Sarpagandha is first mentioned by Sushruta in 600 BC because of its use in numerous Ayurvedic formulations. In rural areas of India, at the first signs of insomnia, melancholia, schizophrenia, or more violent mental disorders, the old women or village physician would soak the roots of sarpagandha in rose water and administer it.⁶⁶ In 1952, the alkaloid reserpine was isolated, confirming the plant's value. Since then the alkaloid extract, as well as purified alkaloids of sarpagandha, have become very important in the treatment and control of hypertension.

⁶⁴ Mruthyunjaya and Jha, 1993.

⁶⁵ Anon, 1993.

⁶⁶ Sethi, et al., 1990.

Following the publication of numerous scientific papers extolling the medicinal powers of the plant, a ruthless search was started all over India, a search that only came to a halt when sarpagandha had disappeared from forest areas. Before 1970, India was a large supplier of roots of sarpagandha to the world market, with exports averaging 40 tons yearly. In 1969, the Indian Government banned the export of roots to help develop a local extraction industry. India's exports of sarpagandha alkaloids have increased considerably since the imposition of the ban; with most going to Japan. While reserpine has been synthesized, sarpagandha-based products are still extensively used for medicinal purposes in India owing to their availability and lower prices. There is considerable opportunity for development by cultivation of high-alkaloid strains of the plant, not only for internal use but also for export to other countries.

Tree turmeric (*Coscinium fenestratum*). Tree turmeric is a woody climbing shrub whose normal habitat is scrub forests, wastelands, and along water courses, but today is extremely rare. The bark containing a drug that is an important constituent in more than 60 Ayurvedic formulations. It is useful for treating debility, fevers, and certain forms of dyspepsia. It is thought to possess antiseptic properties and is used for dressing wounds and ulcers.

Plant regeneration occurs from stumps of old plants and also through seeds, but the rate of regeneration has been found to be extremely low. On-going studies are seeking to propagate the plant outside of its natural environment.⁶⁷ The species distribution is reported to have declined significantly in recent years and is now declared vulnerable.

Government Initiatives

While the cultivation of medicinal plants is of great antiquity in India, except for a few species, little attention has been paid to their systematic cultivation.⁶⁸ A recent publication by Chadha and Gupta (1995) brings together for the first time a detailed accounting of the agronomic, genetic, chemical composition, and contemporary status of agricultural research on 21 medicinal plants as commercial crops in India.

The National Bureau of Plant Genetic Resources and the Central Institute for Medicinal and Aromatic Plants (CIMAP) are actively involved in R&D on medicinal plants. Yet as far as industry is concerned there is little if any collaboration. For example, of the thirty four medicinal plants being investigated by the National Bureau of Plant Genetic Resources only four are of interest to industry and the thirty four CIMAP have developed agrotechnology or processing technology for the vast majority are not used for medicinal purposes. The Basic Chemicals, Pharmaceuticals and Cosmetics Export Promotion Council (CHEMEXCIL) set up by the Ministry of Commerce, GOI lists 111 plants in their *Selected Medicinal Plants of India*.⁶⁹ If India is to be part of the tremendous upsurge in herbal usage then government must respond more actively to industry's needs. Both

⁶⁷ Harinarayanan, et. al., 1994.

⁶⁸ Mitra and Jain, 1991.

⁶⁹ CHEMEXCIL, 1992.

institutions have well established regional field stations and should be able to provide consultative and technical services to industry and farmers for cultivation and training.

As far as day to day procurement, collection, cultivation, sale, purchase, import, and export of medicinal plants is concerned there is no definite procedure and very limited scientific data available in the country. There is no agency or organization with sole responsibility to regulate such an important aspect of the herbal medicines of the Indian Systems of Medicine under one banner. Materials are purchased from drug dealers in Bombay, Delhi, Calcutta, Madras, Hyderabad, Amritsar and many smaller cities by the pharmaceutical industry to manufacture products. The medicinal-plant dealers procure materials from the so-called unknown sources (it forms part of their trade secret). Plants are invariably collected by unskilled laborers not aware of the properties of the derivatives. Adulteration and substitution are a problem, as are the absence of standards relating to the products, storage, transportation, costs, etc. While it would appear a contradiction, large quantities of medicinal plants are known to go to waste because their value is not known to the people of the areas where they occur naturally.⁷⁰ The use of local and trade names, without proper correlation to botanical names, further adds to the general confusion and lack of systematic data on trade in medicinal plants.

A recent conservation initiative by the Ministry of Environment and Forests (MOEF) in collaboration with Wildlife Institute of India and the World Bank seeks to establish a nationwide biodiversity information network. Specific consumers of such biodiversity information include MOEF, CIMAP, the Central Drug Research Institute (CDRI) of the Council of Scientific and Industrial Research (CSIR), the Indian Council of Agricultural Research (ICAR), Ministry of Agriculture (MOA), the All India Medical Research Council (AIMRC), MOEF and NGO advocacy groups. Agro-based and pharmaceutical industries are expected to use biodiversity information for commercial or management purposes.

The Agricultural and Processed Food Products Export Division Act (APEDA) has identified the area related to the export of medicinal and aromatic plants as an "extreme focus sector." In practice, little is actively being done to legitimize exports of medicinal plants. International trade in threatened medicinal plants is regulated by the provisions of Convention on International Trade in Endangered Species of Fauna and Flora (CITES). Only a few medicinal plants have been included in CITES so far. At least forty medicinal plants from countries are listed in CITES. A few CITES-listed medicinal plants from India include:

- eagle wood (*Aquilaria malaccensis*)—wood used to control vomiting and diarrhea;
- yew (*Taxus baccata*)—leaf and fruit to control epilepsy, asthma, and bronchitis; and

⁷⁰ Ahmad, 1993

- *Pterocarpus santalinus*—heartwood of this leguminous tree is used as a stringent (to check bleeding) and diaphoretic (to increase perspiration); fruit antidote for dysentery.

On March 30, 1994, the Ministry of Commerce prohibited the export of 46 groups of plants, including their parts and derivatives, most of which are medicinal plants.⁷¹

Besides the central government, several state governments and some pharmaceutical companies have started their own research and development units and cultivation programs. However, such research programs are invariably restricted to a selected few species of retail value.

During the past four decades, more attention has been focused on the evaluation and standardization of plant-derived drugs. The result has been a broader understanding of such drugs based on their biology and chemistry. However, Indian investigators have cited the rapidity with which, in China, experimental results on plants are passed on to clinical investigators, who provide all support for clinical evaluation of that particular plant.⁷² The Indian investigators concluded that such a strategy has paid good dividends in China and could be even more rewarding in India where the infrastructure already exists.

Links to Modern Medicine

Since independence, India has made sustained efforts, through successive “Five-Year Plans,” to develop the Indian traditional medical systems (Ayurveda, Siddha, and Unani) with the aim of improving the delivery of healthcare to the Indian population. The 1982 Health Policy initiated efforts to dovetail the functioning of traditional health practitioners and their health services in the total healthcare system of the country. In most States, for every two allopathic doctors, a third post of traditional medical doctor has been approved in the primary health centers.

Currently there are 460,000 traditional medicine practitioners in the country. Over 271,000 (223,000 Ayurveda, 30,456 Unani and 18,128 Siddha) practitioners are registered under the state boards. In addition to private pharmacies, almost all State Governments have their own pharmacies for production of standard medicines. There also exist separate directories for traditional systems of medicine in all states. There are, in all, 215 hospitals and 14,000 dispensaries in the country devoted to traditional medicine.⁷³

There are about 540 important medicinal plants used in different formulation in India by the Ayurveda, Unani, and Siddha healthcare systems. Many plants are common to all

⁷¹ D.K. Ved, pers. com.

⁷² Chaudhury, 1992.

⁷³ Bajaj and Williams, 1995.

three systems. Several plants may be used either alone or in combination in the traditional systems. Whatever the combination, the regulations state that if these medicines are prepared in exactly the same way as recommended in the ancient Indian medical books and texts, and if they are preserved in the same way as described therein, then such medicines do not require approval or registration. Whenever a different manner of preparation is proposed the medicine is considered a “new” medicine. This will be treated as any new drug before it is released in the market for use either in the traditional system of medicine or the modern system of medicine. There is nothing in the regulations to indicate that the requirements before the release of such “new” but old herbal medicines are in any way less demanding than for synthetic medicines

With the introduction of traditional medical systems for primary healthcare at the level of primary health centers, guidelines and manuals are being prepared that identify the number and type of drugs to be used for primary healthcare. Lists of such drugs for each of the Indian systems of medicine have been prepared by the Ministry of Health and Family Welfare. The delay experienced in reaching these objectives can, in part, be attributed to a lack of cooperation between botanists, chemists, agronomists, physicians, and traditional healthcare practitioners to integrate the best features of traditional and modern medicine. This both defines the problem and specifies the answer.

It is well-recognized that there is considerable valuable knowledge about the medicinal uses of plants among the many tribal societies, especially those living in remote areas where the intrusion of modern society has been minimal. The Government does not exercise any regulatory control over the use of such “home remedies,” which are used by a majority of the Indian population. The reports of new successes and confirmations of old remedies has stimulated research among government and university institutions.

Links to Agriculture

India has no central agency responsible for cultivation, procurement and regeneration of medicinal plants or to provide data on export and import status of these plant drugs.⁷⁴ An immediate need is to establish collaboration between the Central and State Ministries of Agriculture and other relevant Ministries and departments. This would allow those medicinal plants most in demand to be identified and brought into cultivation if necessary. At the same time, potentially useful biotechnology developed for food crops could be considered for enhancing the active constituents of medicinal plants.

Over the long-term Indian agriculture has evolved a dynamic network of cropping systems that have continually incorporated new crop varieties to boost production, food security and income. Land under rainfed agriculture has not benefited to the same extent as irrigated agriculture, although efforts are being made to develop environmentally tolerant crop varieties for marginal farmers. Pareek and Gupta (1993) report that the introduction of medicinal plants has produced significant changes in the economies of

⁷⁴ Singh and Ghose, 1993.

cultivation due to the increasing demand for raw materials in the country and also for export. For example, higher yields of periwinkle, henbane, licorice, isabgol, and sarpagandha have been achieved on marginal lands with the addition of fertilizer. India, with its vast network of public and private research institutions has a great deal to offer other developing countries with respect to establishing and integrating medicinal plant cultivation with food crop production where appropriate. The activity should generate interest of agronomists and plant geneticists to include in-depth studies of medicinal plants vis-à-vis existing cropping systems, especially on remote, marginal, and degraded lands.

Links to Forestry

Forest timber products contribute about 35 percent of the total forest revenue of the country and exported timber is estimated to be in excess of \$100 million annually. Although it is increasingly recognized that non-wood forest products (including medicinal plants) constitute a large, often overwhelming, source of forest revenues from State forests, these resources continue to be undervalued, and not given due consideration in the development of forest management plans. Currently surveys do not generally consider non-timber species, particularly herbaceous species which constitute the majority of Indian medicinal plants. Since the State forests contain a large percentage of the medicinal-plant wealth, given their good condition and degree of protection, their value should not be underestimated. The Forest Departments in India have an important role to play, they are organized to manage large forest areas, and given the requisite reorientation of their management objectives they are probably the agencies best equipped to help conserve and manage the forest medicinal-plant resources of the country.

Much of the non-timber forest produce is removed by local people free or at nominal concession rates. The gross value of medicinal-plant products can only be estimated. Apart from their monetary value, they are of enormous economic and cultural value to the country in general, and to communities residing in or near to forests. Medicinal plants growing in forest ecosystems meet many of the healthcare needs and requirements of the Indian populace. For example, of the 2000 drug items recorded in the Indian *Materia Medica*, 1800 are of plant origin. About 80 percent of the raw materials required in the manufacture of drugs are forest-based.⁷⁵ At present, these are collected in an unorganized manner and in many cases, through private traders. Eight State Governments have established Forest Corporations to deal with the procurement, sale and distribution of various forest products. These corporations should, as part of their functions, organize their activities to procure medicinal plants from within their own areas and arrange sales inside and outside their own State. The corporations would be well served by having representatives of ISM, NGOs and local communities on their board of directors.

⁷⁵ Ahmad, 1993.

Links to Veterinary Medicine

Veterinary medicinal has a long tradition in India, with many references first appearing in the Rig veda. A number of Indian plants have proven helpful in treating dirresis, calculosis and other urinary disorders in bulls and rams. They include: varuna (*Crateva nurvala*), gokhru (*Tribulus terrestris*), gadahpurna (*Boerhaavia diffusa*) and yavani (*Hyoscyamus niger*). To control helminths in livestock farmers use palas (*Butea frondosa*), and kuda (*Holarrhena antidysenterica*). All these plants are included in *Selected Medicinal Plants of India*, a monograph of identity, safety and human clinical usage.⁷⁶

Protecting Medicinal-Plant Biodiversity

In 1970, the Indian Government banned the export of wild-growing sarpagandha because of over-exploitation. This ban still holds except when special government permission is obtained. Further additions to the list can be made based on the purchases and marketing of medicinal plants by the indigenous pharmaceutical industry. Since a very large proportion of plants used by these industries are collected from the wild, high consumption, especially in a manner that is destructive, is considered a reasonably accurate indicator of the threat to their survival in the wild. This threat is higher wherever the collecting is destructive (i.e. whole plant, root, stem, and bark.).

Furthermore, many medicinal plants are threatened because of the alarming rate of habitat loss and degradation of natural ecosystems. The traditional healthcare systems (Ayurveda, Unani, and Siddha) are conscious of the decline in raw materials and the need to establish cultivation centers to maintain supply. Many of the pharmaceutical companies have not yet accepted the decline in supply as serious.

Many papers have been published on threatened plants of individual States of India. Jain (1987) identifies 120 medicinal plants that can be classified as endangered or rare. A total of 30 plant species known for their medical usage in South India are considered in the "rare and threatened" priority category. Many other species are threatened because of the alarming rate of habitat loss and degradation of natural habitats, including:

- aconite (*Aconitum heterophyllum*)—root used for fever, cholera, rheumatism, and fevers;
- *Saussurea lappa*—root used for chronic skin disorders;
- agar (*Aquillaria agallocha*)—wood used for reducing vomiting and diarrhea, and as a stimulant;
- lesser yam (*Dioscorea deltoides*)—tuber rich in diosgenin (from which steroidal drugs can be made); it is also used for rheumatic and ophthalmic diseases;
- *Justicia beddomei*—whole plant;
- *Myristica malabarica*—seed used for ulcers;

⁷⁶ CHEMEXCIL, 1992

- *Coptis teeta*—rhizome for bacillary dysentery;
- *Dendrobium pauciflorum*—whole plant, leaf; and
- *Podophyllum emodii*.

The Foundation for Revitalisation of Local Health Traditions (FRLHT) has assembled a priority list of 285 medicinal-plant species of South India. They list 34 species classified as weeds.⁷⁷ Many of these weeds are well-known medicinal plants of indigenous healthcare systems. Because of unregulated and large-scale destructive collecting, many of the “weeds” could become threatened. Due to a lack of information on distribution, harvesting intensities, and population structure of wild medicinal plants the FRHLT has used the available secondary data to set its conservation priorities. The data base is being enlarged by adding data on threatened status recorded in the WCMC’s database and also assessments of experts on the rarity of the species.

Preserving Wild Genes. There is a central government sector initiative for the development of medicinal and aromatic plants currently in operation (1992-1997). It is being implemented through 16 state agricultural universities, state horticulture and agriculture departments, regional research laboratories, and one international agricultural research center. The scheme is controlled by the Ministry of Agriculture and involves establishment of herbal gardens, nursery centers, and demonstration seed production centers. Over the years under the auspices of the Indian Council of Agricultural Research many research and teaching projects have been funded and carried out by Central Agricultural Institutes, State Agricultural Universities, and the National Research Centre.⁷⁸

The National Bureau of Plant Genetic Resources initiated an All India Coordinated Research Project on Medicinal and Aromatic Plants in 1972. The project carries out integrated multidisciplinary research studies on 12 mandatory crops (senna, periwinkle, licorice, asgandh, jasmine, opium poppy, palamarosa, lemongrass, vetiver, rose geranium, patchouli, and isabgol); 10 exotic crops including henbane, chamomile, melissa and anise; and 11 native species for domestication (swertia, safedmusli, aloe, babchi, mucuna, pipalanool, satavari, valerian, guggal, galangol and ciloe). Of the thirty four plants being researched only 4 are considered of importance by industry. There is obviously a need for greater collaboration if the needs of both and the nation are to be better served in the future.

An important source of information for creating a list of threatened medicinal plants is the *Red Data Book of Indian Plants*.⁷⁹ It lists more than 600 plant species, which have been categorized as extinct, endangered, rare, or vulnerable. Gupta and Chadha (1995) list 35 important endangered species amongst the medicinal and aromatic plants of India. They

⁷⁷ *Handbook of South Indian Weeds*.

⁷⁸ Chadha and Gupta, 1995.

⁷⁹ Nayar and Sastry, 1990.

suggest the species need detailed studies on their population structure, breeding behavior and habitat protection. Building on this base FRLHT is establishing a chain of medicinal-plant conservation wilderness reserve areas in the western and eastern Ghats. This nongovernmental initiative is seen as the first measure of its kind aimed at conserving medicinal-plant genetic resources in India.

The Indian Medicinal Plants Distribution Databases Network, brings together the collective data of nine nodal agencies which collect, preserve, propagate, and use more than 8000 medicinal-plant species, in a chain of 48 *in-situ* and *ex-situ* conservation areas. The agencies include: the Central Drug Research Institute, Lucknow for pharmacology; CIMAP, Lucknow for agro-technology; Regional Research Laboratory, Jammu for phytochemistry; Publication and Information Directorate, New Delhi for bibliography; Botanical Survey of India, Dehra Dun for taxonomy; Lok Swasthaya Parampara Samvardhan Samiti, Coimbatore for traditional medicine; National Tropical Botanical Garden and Research Institute, Trivandrum for traditional medicine; and Ayurvedic Research Institute, Trivandrum for pharmacognosy. The Indian Medicinal Plants Distribution Databases Network newsletter disseminates information on the data each agency possesses as well as other information on medicinal-plant databases in India and abroad.

The Indira Gandhi Conservation Monitoring Center was established by the WWF India in 1994 with the full support of the national government. The Centre will provide information support to government and non-government programs for environmental conservation in the country. The Indira Gandhi Conservation Monitoring Center will also provide information to assist in the implementation of the Biodiversity Convention. In 1995, WCMC had documentation on 137 Indian medicinal-plant species in 63 Families with 165 references.

In-Situ Conservation. There are no separate policies or regulations for conserving medicinal plants in India. Their conservation is generally covered under existing laws, such as the Forest Act and Wild Life Protection Act (1972), which are enforced by the State Forest Departments and the Indian government's Directorate of Wildlife Preservation. Furthermore, there is no designated national agency or department with a clear mandate for the conservation of medicinal plants. Consequently, there has been no conscious or systematic effort to date at the government level, to conserve medicinal plants *in-situ*. However, the Ministry of Health, has recently started to promote the establishment of small herbal gardens in educational institutions as a means of furthering traditional medicine. The Indian Medicinal Plants Genetic Resources Network is expected to expand in later years to include conservation areas all over India.

An important recent decision by the Government of India gives an indigenous Indian tribe the intellectual property rights to the active ingredient of a plant long known and used by the tribe to combat stress (see Box 6).

Box 6: 'Indian Ginseng' Brings Royalties for Tribe

New Delhi. An indigenous Indian tribe has been awarded the intellectual property rights to the active ingredient of a plant long known to it as helping to combat stress, in a move that the government hopes will help end the 'piracy' of tribal knowledge by both Indian and foreign drug companies.

The drug *jeevani*, which is based on this ingredient and is said also to provide an instant source of energy, has been developed from the plant *Trichopus zeylanicus* by the government-owned Tropical Botanical Garden and Research Institute (TBGRI) in Trivandrum, Kerala. Researchers noticed that the tribe members habitually ate its raw seeds before undertaking strenuous work.

Arya Vaidhya Pharmacy (AVP), a large manufacturer of Ayurvedic drugs paid \$50,000 for manufacturing rights plans to market *jeevani* internationally as a rival to ginseng. The Kani tribe of the Agasthiyar hills in Kerala will receive half of the know-how fee, and will also receive a share of a two percent royalty on any future drug sales. This money will go towards 2,500 families of the Kani tribe who will cultivate and supply the plants to AVP at a price agreed with the TBGRI.

Source: K.S. Jayarama, *Nature*. Vol. 381: 16 May 1996.

To strengthen the *in-situ* conservation of the medicinal-plant resource base in South India, FRLHT is coordinating a major medicinal-plant conservation initiative. The core activities are to establish a network of 30 *in-situ* centers in the three states of Tamil Nadu, Karnataka, and Kerala during 1993-1997. FRLHT's conservation research strategy departs from the conventional approach. Their goals include:

- inventory medicinal plants used both in tribal medicine and the codified traditional systems of medicine (earlier efforts looked at only the economically important medicinal plants);
- document natural distribution of medicinal plants and identify sites for *in-situ* and *ex-situ* conservation;
- document and contribute to the revitalization of local health traditions associated with the biodiversity of medicinal plants; and
- design *in-situ* and *ex-situ* conservation programs that are people oriented and not merely industry-oriented. FRLHT is a pioneer in *in-situ* conservation and has expanded the scope of *ex-situ* conservation and cultivation.

Ex-Situ Conservation and Cultivation. In earlier times, medicinal-plant cultivation was confined to private gardens while plants for general use were collected from forest and village lands. Systematic cultivation was introduced by the East India Company in 1787. In 1930, the government established a program for the development of medicinal and

aromatic plants on a proper scientific basis. Among species cultivated in Kashmir under the Medicinal and Food Poisons Enquiry Committee of the Indian Council of Agricultural Research were:

- pyrethrum (*Chrysanthemum cinerariaefolium*), insecticide
- foxglove (*Digitalis lanata*), leaf used as cardiac stimulant
- henbane (*Hyoscyamus* sp.), leaf and stem used as sedative (narcotic)
- belladonna (*Atropa belladonna*), root and leaf used as diuretic (increases urine), sedative (lessens excitement, nervousness, tension), and anodyne (pain killer).

After independence in 1948, the Indian government set up various organizations for utilizing and cultivating the vast unexplored resources of medicinal and aromatic plants.⁸⁰ Presently this work is being handled by the Central Institute for Medicinal and Aromatic Plants, Regional Research Laboratories of the Council of Scientific and Industrial Research, various agricultural universities, and state horticultural and agricultural departments.

Research over the last four decades has focused on approximately 60 selected commercial species for industrial use, of which 40 are medicinal plants. Raychaudhuri and Ahmad (1992) have identified 144 species of medicinal plant that they believe are suitable for cultivation, 63 of which can be successfully grown in north India. Considering that 7000 species are reportedly in medical use by Indian Medical System and folk practitioners, current research efforts can only be considered minimal. However, medicinal-plant research does not want to go the way of agricultural crops. For instance, it has been estimated that 50 years ago, Indian farmers were growing some 30,000 varieties of rice; however, Maheshwari (1987) predicts that the number of varieties grown will have been reduced to no more than 50 by the year 2000 as a result of agricultural modernization.

Renewed interest in the medicinal properties and potential low cost of cultivation of sarvagandha has given added impetus to conserving the remaining wild variant populations in the forests of the Himalayan foothills and coastal peninsula. Two distinct subspecies, that grow in different environments have been recognized in sarvagandha. Various stocks from Dehra Dun (Himalayas) and Kerala, Karnataka and Goa (western Ghats) are being cultivated for reserpine and related alkaloids at the National Bureau of Plant Genetic Resources, New Delhi. The plant is usually propagated from seeds, although stem and root cuttings can also be used. Seeds are grown in nursery beds and transplanted during the rainy season. Irrigation is usually required during the year. The roots are harvested during winter. Cultivars may be harvested at 18 months and may be intercropped with onion and garlic in the first year profitably. Its demand for fertilizer and irrigation is low, and it grows well on marginal soils.⁸¹

⁸⁰ Parikh, 1993.

⁸¹ Pareek and Gupta, 1993.

FRLHF is promoting *ex-situ* conservation of medicinal plants to conserve rare, endangered and vulnerable species which are threatened in their natural habitats. They have established 15 *ex-situ* centers in the States of Tamil Nadu, Karnataka, and Kerala. This work is being supervised by environmental and health NGOs in the region. Each center has a nursery for propagation, a herbal garden, and a gene bank. In addition, each center is responsible for creating awareness and encouraging the use of locally available medicinal-plant products in primary healthcare and encouraging farmers to grow such species of medicinal plant for which there is an industry demand.

In 1991 the Tropical Forest Research Institute at Jabalpur, Madhya Pradesh established a medicinal-plant germplasm collection with 550 species of medicinal plants found in the dry deciduous forests of Satpura, Maikal, Vindhya, and the eastern Ghat Mountain ranges. These regions contain the largest number of medicinal plants used in the Ayurveda. Surveys classify plants as common, threatened, endangered, and rare. Collections of seeds, rhizomes, roots, and cuttings are taken for cultivation in the Institute's experimental nursery as part of a non-wood forest produce program. The intent is to return plants back to their original habitat for *in-situ* conservation in collaboration with State Forestry Departments,⁸² as well as provide local farmers and pharmaceutical industries with high quality breeding stock.

The Arya Vaidya Sala at Kottakal, Kerala combines the multiple facets of the traditional medicine sector—a family based, hereditary knowledge tradition, hospital and teaching facilities, manufacturing and research and development work. Based on its own usage statistics and experiences with declining availability of plant materials, the Arya Vaidya Sala has identified 10 priority species in collaboration with the International Development Research Centre (IDRC), Canada. They are engaged in a comprehensive program of mapping the ten natural stocks, developing *ex-situ* and farmer-based cultivation strategies and investigating the therapeutic action of these species (see Table 11).

In addition, IDRC initiated in 1994 a Medicinal Plant Research Network operating out of its New Delhi office. The network has adopted a proactive, user-based biodiversity conservation strategy and efforts are targeted at undertaking research partnerships with existing users of the resource base—local communities and indigenous industry. Focal areas of research include folk traditions and knowledge, *in-situ* conservation, developing appropriate harvesting and cultivation techniques, improving quality control, storage and processing techniques.⁸³

⁸² S.S. Bisen, pers. com.

⁸³ Bajaj and Williams, 1995.

Table 11
Species in Ayurvedic Medicines and Quantities Used

Species	No. Ayurvedic Medicines	Kg. Used
<i>Baliospermum montanum</i> (root)	27	1000
<i>Celastrus paniculatus</i> (root, leaf)	15	540
<i>Coscinium fenestratum</i> (bark, root)	70	3300
<i>Crataeva nurvala</i> (root, stem bark)	13	1840
<i>Embelia ribes</i> (fruit)	75	3030
<i>Hemidesmus indicus</i> (root, leaf, stem bark)	30	19000
<i>Holostemma ada-kodien</i> (root)	40	3860
<i>Rubia cordifolia</i> (root, leaf, stem)	40	4200
<i>Saraca asoca</i> (bark, flower, seed)	3	5310
<i>Trichosanthes lobata</i> (root, flower, leaf, seed)	32	5800

Source: Bajal and Williams. 1995.

A number of other Indian government institutions and private agencies are actively engaged in medicinal-plant cultivation and conservation programs. They include: Indian Institute of Horticultural Research, National Research Centre, Central Council of Research in Indian Systems of Medicine, State Ministry's of Agriculture and Forest, State Agricultural Universities, and the Lalbagh, Calcutta, Ootacamund and Lucknow Botanic Gardens.

It is recognized that with an expanding medicinal-plant cultivation program high density plantings, especially if monocropped, are likely to require pesticides to control insect pests, pathogens and weeds. Furthermore, it is well-established that a number of agrochemicals have created health hazards in their application to crops and toxic effects of cultivated foods. When and where such products might be used on medicinal plants in the future, Parikh (1993) recommends readily biodegradable plant-based agroproducts be used to control insect pests. India has a very effective biocide in the common neem tree mentioned above. Active compounds act mainly as hormone blockers that send insect lifecycles down dead-end trails so the populations crash. They can be easily prepared by users and applied at minimal cost.

4. CONCLUSIONS

From the experiences in China and India it can be seen that medicinal plants constitute one of the important overlooked areas of international development. The plants represent a form of biodiversity with the potential to do much good, and not just in the field of healthcare. Indeed, the production and processing of medicinal plants offers the possibility of fundamentally upgrading the lives and well-being of peoples in many rural regions. It can also help the environment and protect habitats and biodiversity throughout the developing world.

Here, for instance, are some of the apparent lessons on why the medicinal plants deserve serious consideration.

Value. Of all the resources in the tropics, medicinal plants are among the most valuable. They sell not by the ton nor even by the kilo, but usually by the gram. They include some of the most sought after natural products. There is a rising export trade and an ever increasing local demand.

Frangibility. Of all the traditional knowledge to be found in Africa, Asia and Latin America, that dealing with medicine is among the most vulnerable, and is being lost perhaps faster than any other body of indigenous intellectual heritage. Yet it is also among the most useful to the nations themselves as well as to the rest of the world.

Helping the Poor. Typically, medicinal plants are more than just high in value, they are non-perishable and are easy to transport and handle (compared to, say, food crops or tree products). Thus they can be produced in small plots or in remote areas where other options are minimal. This feature they share with products from the opium poppy or coca plant, and medicinal plants are a likely source of alternatives. Indeed, the organized production of certain medicinal plants could help millions stay on the land, and it might even lure millions more back from the cities.

Conserving Natural Habitats. Medicinal plants are among the best candidates for helping conserve natural habitats. The suggestion has been made, for example, that the organized production of forest medicinal plants in India's tiger reserves will help make the reserves financially self-sustaining without affecting the animal life. It would also provide local jobs and may swing the public's attitudes solidly in favor of protecting the reserves, especially from land-grabbers. Around the developing world, opportunities like this are legion, but they are not being exploited while plants, animals and whole habitats plunge toward extinction.

Increasing Sustainability. Of all the possibilities for making agroforestry work, medicinal plants are among the best. The various vines and herbs and shrubs lend themselves to mixed cultivation systems better than to the monocultures that produce

cereals and roots and pastures. Some, such as ginseng, work as understory crops that can transform the economics of, and attitudes towards, tree planting and conservation forestry. After all, a ton of ginseng root sells for a quarter of a million dollars, wholesale.

Healthcare and Rural Well-Being. Of all the options for helping the well-being of the poorest segments of global society, the medicinal plants are among the best. Whether or not the efficacy is up to the standards of the West is irrelevant when the people cannot afford pharmaceuticals, as is the case for several billion souls. Inexpensive and seemingly effective herbal treatments exist for skin ailments, minor pain, infections, anemia, other nutritional disorders, and many more complaints that are mundane rather than life-threatening.

China and India

So far, only China and India have solidly grasped the possibilities inherent in medicinal plants. In its own way each is starting to confront the threat to its medicinal-plant heritage.

As of now, China and India are the only countries where government policies seek to integrate the traditional and Western medical systems at all levels of healthcare. This has put an especially heavy burden on their stocks of wild medicinal plants. These plants are becoming increasingly rare or expensive due to overharvesting and loss of natural habitat.

With no precedents for medicinal-plant conservation and cultivation research, the examples of China and India must serve as the role models for the rest of the world. This is important also because either India or China could become the world's largest pharmaceutical market. Together they would dominate the traditional medicine usage worldwide.

In China it is the government that is endeavoring to utilize available traditional field and clinical knowledge at all levels of medicinal-plant production: breeding, cultivation, harvesting, processing and marketing. This experience offers many lessons to other developing countries.

India, with its free-market system, has the necessary infrastructure to support the integration of the two healthcare systems. So far, however, there has been little effort to bring together public research institutions (government and university) and the private sector (industry and NGOs) to focus on the plight of the healing herbs.

As it now stands, local collectors in India receive minimal benefit from wild-plant collections. They are unorganized and typically sell their products into markets controlled by unscrupulous middlemen. To date, there has been no significant effort to organize small rural enterprises that can provide income and employment to rural women and men for cultivating, processing and marketing herbal products.

Socioeconomic Impacts

Of all the possibilities for improving the lives of the rural poor, medicinal plants are one of the best. It is unlikely that the vast majority of peoples in developing countries will ever be self-reliant in their primary healthcare needs without recourse to these plants. Indeed, it is unlikely that drastic social, technical or economic changes are going to upset the medicinal-plant situation in the majority of developing countries during the next decade. Hence, the establishment of local herbal-product industries would go a long way to provide for local healthcare needs.

Women in many parts of the world are the key to the future integration of traditional and Western medical practices. They must play a pivotal role in defining future medicinal-plant conservation, cultivation and enhancement strategies.

Immediate research efforts should be directed towards those traditional medicines that may be of use: (i) in combating “refractory diseases” for which Western medicine has no long-lasting remedies; and (ii) as supplements to Western drug products.

An important first step to characterize this informal sector is the development of appropriate value indicators that reflect the perceptions of different stakeholder groups. Such indicators should include aspects of indigenous medical, cultural, ecological, and environmental values placed upon medicinal plants by local people in developing countries. The investment costs would be relatively small, and the acquired knowledge and experience would prove useful when the diversification stage is reached.

Traditional Knowledge

It is the rural people who have the most to lose if medicinal-plant diversity continues to decline. It is also the rural people who have the most to gain by the establishment of programs to conserve, cultivate and market medicinal plants.

The protection and revival of traditional medicine knowledge and practice in thousands of ethnic communities is an important means of providing affordable and sustainable healthcare. The knowledge that traditional health practitioners, women and farmers can bring to identifying, implementing and managing medicinal-plant conservation and cultivation programs is seldom sought or utilized. Consequently, local health traditions—many of which are oral in nature and therefore largely undocumented—are being lost. Many of those rely on medicinal plants.

The first step in developing a successful strategy to conserve, enhance and sustainably utilize medicinal-plant resources is to document the medicinal plants and their use in herbal formulations, and establish cultivation programs in collaboration with farmers and agricultural research stations.

Information Transfer

Of all the developing nations, only China and India have so far officially accepted traditional medicine as an integral part of the formal health system. However, an increasing number of developing countries (Ghana and Zimbabwe among them) recognize the benefits of preserving and more fully exploiting traditional medicine, and are actively seeking ways and means of integrating the traditional and Western medicine systems.

China and India can play an important role in transferring knowledge (South-North as well as South-South) relating to medicinal-plant conservation, cultivation methodologies, harvesting, storage, processing and marketing. However, although these two may serve as role models, Africa and Latin America have their own medicinal plants and traditional healthcare systems. Moreover, different countries have different cultural backgrounds, and healthcare needs.

The revolution in electronic communication is providing unprecedented opportunities to learn about and to efficiently manage resources. This should allow traditional expertise to be more readily integrated with Western medical knowledge in addressing local, regional and global healthcare issues.

Various international agencies—among them WCMC, IUCN, WWF, IDRC, and UNESCO—are involved to some extent in medicinal-plant biodiversity conservation. The International Council for Medicinal and Aromatic Plants (ICMAP) was formed in 1993 and includes representatives of supporting and affiliated organizations. Recently a Medicinal Plant Specialist Group was formed that concentrates its efforts on the medicinal-plant species with high conservation priority. All such agencies should be encouraged to include efforts to establish cultivation programs as part of their medicinal-plant conservation objectives.

The use of advanced information and communications systems (GIS database, multimedia) can lead to a greater awareness of, and sensitivity to, indigenous medicinal-plant knowledge.⁸⁴

Policy and Regulatory Considerations

With the possible exception of China, developing countries lack a national or regional agency with an exclusive mandate for medicinal-plant conservation and cultivation. Action is needed to produce clearly-defined policies to regulate medicinal-plant conservation, cultivation, and trade practices. This requires that governments recognize the inter-sectoral relationship between natural resource management, agriculture and forestry, trade and commerce, and healthcare.

⁸⁴ Thomas, 1994.

Recognizing the widespread reliance of rural and urban peoples on medicinal plants for their basic healthcare needs, a biodiversity policy should explicitly identify the importance of sustainable use of medicinal plants and their habitat conservation.

An active education and awareness program that recognizes the needs of indigenous peoples, local communities (especially women), private businesses and government agencies (state and national) is imperative if regulatory policies are to promote successfully the conservation and protection of medicinal plants.

Clear policies and legislation that recognize the legal rights of individuals and communities who use and depend on medicinal plants for the healthcare needs should be affirmed by governments to protect the rights of customary knowledge holders.

To inhibit trade of threatened and vulnerable medicinal-plant species both developing and developed countries must create a statutory framework and then fully fund its implementation. A closer link with CITES would be appropriate.

A major constraint to the identification of national policies and regulations is the lack of national inventories and prescription guidelines (pharmacopoeias).

Economic Considerations

Medicinal plants already contribute substantially to the poor people's well-being and will continue to do so. Indeed, without recourse to medicinal plants it seems unlikely that the vast majority of peoples in developing countries will ever be able to meet their primary healthcare needs.

Two separate commerces in medicinal plants, the formal and informal markets, co-exist side by side. The first is regulated by governments (at least to some extent) and provides both crude and processed herbal products to the public with a certain measure of quality control. The informal market, on the other hand, operates without oversight. It provides basic healthcare needs to the majority of peoples in many developing countries but without consumer protections.

The informal market is extremely difficult to evaluate. Many healthcare needs are provided without a cash transaction. Instead payment is made in labor or other "in-kind" services. Furthermore, the unregulated informal market has yet to recognize the need to be involved in conservation programs. Neither China nor India have any comprehensive understanding of the extent or economic value of the informal market—a commerce that must contribute billions of dollars annually to their economies. As difficult as it might be to document these transactions, attempts must be made, even if they result in only rough estimates.

The case has been made recently that the market returns from bioprospecting are insufficient and the incentives for habitat conservation by private pharmaceutical research

to be modest.⁸⁵ Such might be the case for multinational pharmaceutical companies. However, such is not the case for the established traditional pharmaceutical companies. For the foreseeable future, they will rely totally on medicinal plants for drug preparation. Consequently their incentives to be involved in conservation and cultivation are legitimate and economically necessary. At the same time it has been suggested the need for new economic models and strategies for the world's agricultural and pharmaceutical industries offers opportunities for enlightened bioprospecting that replaces the spectrum of paternalism with the spectrum of equity.⁸⁶

Recognizing the needs of pharmaceutical industries (where present) to meet the increasing public demand for plant-derived drugs, every effort must be made to promote sustainable production and procurement of unadulterated raw material. The economic advantages of using domestic raw materials must consider job creation opportunities in agriculture and industry, and the availability of affordable plant-derived drugs for healthcare. Financial investment in the establishment of developing country R&D capability should encourage a greater interest for conservation and cultivation by local pharmaceutical industries.

Apparently no studies have been carried out in either China or India to document total annual tonnage purchased, sustainability of raw material supply, future trends in hospital- and consumer use, and industry growth potential. Neither is there any information to identify the precise problems facing the industry.

Even though the trade cannot be quantified, some measure of its size can be deduced by considering what would happen if supplies of medicinal-plant raw materials were eliminated. The local (and especially poor) populations would have to rely on synthetic drugs—local and/or imported. The result would be a potentially catastrophic blow to productivity, balance of payments, national debt and gross domestic product.

Conservation Considerations

Looking forward, it is clear that national governments, foreign-aid agencies, and development banks must think about creating infrastructures for the conservation, and cultivation of medicinal plants. These social and commercial underpinnings are needed to link the production of medicinal plants with the provision of affordable healthcare to those in need. Such a step will enhance the rational convergence between traditional and modern medicine that is increasingly being advocated. In almost every case conservation will have to provide a big part of the production.

As has been noted, medicinal plants are predominantly harvested from the wild. This means that production is often unpredictable and supplies can quickly vary between

⁸⁵ Simpson, Sedjo and

⁸⁶ Anon, 1996.

scarcity and over-supply. This is not a good situation in a time when demand is dramatically increasing.

The probable loss of genetic diversity within each species is a special concern. As with all plant species, certain specimens or locations will have exceptional levels of activity. It seems likely that the medicinally more active stands will attract the greatest exploitation. This could destroy the effectiveness of the species. Medicinal-plant biodiversity in developing countries is often poorly characterized, and there is a critical lack of research on management methods that combine biological, physical, economic and social variables.

The unsustainable, unregulated and indiscriminate harvesting of medicinal plants is being compounded by the very poor level of awareness of the biology and ecology of the species concerned. Even the collectors and traders who make their livelihood from such species often know little. Thus, large quantities of medicinal plants go to waste during such operations as logging, slash-and-burn, plowing, and the burning of what look like mere “weeds.”

Globally, the number of medicinal plants currently protected under rare and endangered species legislation is minuscule. Signatories to the Convention on Biological Diversity are obliged to protect their medicinal-plant resources, but often lack the necessary resources and skilled staff to do so, and may even be unaware of their importance.

While natural ecosystems such as forests, wetlands and grasslands can be protected by legislation, many other medicinal-plant habitats—such as marginal, remote, wastelands, roadsides, or even gardens—cannot. An education program developed in collaboration with local collectors, dispensaries, and beneficiaries should be a priority. The intention should be to reverse the rising tendency to exploit unprotected wild stocks with scant respect for the adverse effects such random extraction has on natural populations. Such a program should clearly identify the value of medicinal plants, the reasons for conserving the habitats, the close link to individual and family health needs, and the long-term economic returns that can accrue from protecting medicinal plants and their associated wild species.

Research and Development.

It is important that the development, or expansion, of a botanically-based pharmaceutical industry be backed by active research and development. This will permit successful transfer and adaptation of technology on a north-south or south-south basis and ensure proper growth and maintenance of the industry. The outcome would be the production of:

- standardized traditional medicines, galenicals, and extracts;
- the formulation and development of dosage forms;
- the development of new preparations based on traditional pharmacopoeias;
- research and development in processing and formulation; and

- basic chemical and pharmacological studies.

There is a need to document the ideal season and time for harvesting of bulk collections and storage conditions necessary to protect the active principals and preserve their optimum therapeutic value. This is best achieved if they are cultivated and processed under quality-controlled conditions preferably close to the site of harvest. Homogeneity of product and correct drying often represents the most delicate and essential step in the entire manufacturing process.

Technical assistance will be required. The introduction of pilot-plant processing facilities requires investment. This perhaps may be achieved through various forms of joint industrial venture between local sponsors and with foreign partners. The link between medicinal-plant conservation, affordable healthcare, industrial development, and 4 billion stakeholders should be appealing to potential investors.

Cultivation

For the immediate future, medicinal-plant farming will be a vital complement and alternative to collecting plants from the wild. Such cultivation will permit improved reliability of supply, and uniform quality of raw materials whose properties can be standardized. Presently cultivation is constrained by a lack of proven methodologies and research funds.

The breeding of medicinal-plant cultivars with desirable agronomic and therapeutic chemical derivatives makes it possible to conserve and selectively utilize highly valuable *in-situ* germplasm, and *ex-situ* germplasm in botanic gardens, and in field seedbanks. Cultivation will permit production of uniform materials whose properties can be standardized and from which crude drugs can be obtained unadulterated.

As of now, there are few proven or transferable cultivation methodologies for medicinal plants. Data on plants held in botanic gardens is most readily accessible and a useful starting point. However, the knowledge and collaboration of women, farmers, and traditional health practitioners would be very helpful in identifying, implementing and managing future medicinal-plant cultivation. Many medicinal plants grow well on marginal, remote, or degraded lands with low monetary inputs. Needed are intensive studies on selected medicinal plants to determine optimum environmental requirements for sustainable production. These should be done in collaboration with local farmers.

Farmers and rural communities also have an important role to play developing new sustainable cultivation practices that make medicinal plants compatible with existing food cropping systems and create income generation opportunities to larger numbers of poor people.

The breeding of improved cultivars adapted to different agro-ecological regions will allow cultivation of medicinal plants under a wide range of conditions outside the present

sites of collection. An objective, pragmatic approach is required to selecting a realistic number species among the many hundreds potentially available for cultivation trials. The needs, quantities, and frequency of use by traditional health practitioners, women, and pharmaceutical industries in each developing country must be taken into account.

Of all the new frontiers of agriculture, the cultivation of medicinal plants is among the most powerful for doing good for the world. It has the possibility of contributing to all the above-mentioned features: of providing the poor with a (legal) route out of poverty, of saving a heritage of human knowledge and putting it to global use, of revitalizing the economies of run-down rural regions, of saving natural biodiversity as distinct as the Bengal tiger, and of improving the output from tree plantations and natural forests of various kinds. In a sense, medicinal plants can become a financial and biological underpinning that makes numerous agricultural and forestry production systems—including some that are the most fragile and worrisome to the world—sustainable.

All in all, medicinal-plant conservation and cultivation research and development programs can have a major impact by increasing community participation, income generation, poverty alleviation, and affordable healthcare.

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