A NEW STRATEGY FOR A.I.D. IN INDIA'S AGRICULTURAL SECTOR

Applications of science and technology
for sustainable increases in the productivity of
India's soil, water and biological resources

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OUTLINE

A

ANNEXES

EXECUTIVE SUMMARY

India's enormous economic potential and problems are of strategic importance to the United States. India is the world's second-most populous nation and largest democracy. From the difficult decades after independence, India has achieved food security, attained substantial rate of economic growth and now has a middle-income consumer class as large as any European nation. However, India is still critically handicapped by having a third of the world's population living in absolute poverty. This poverty, the large and growing population, and rapidly expanding economy place increasingly competitive demands on India's semi-arid, natural resource base upon which the agricultural sector and hundreds of millions of livelihoods depend.

Despite recent modernization in the economy, agriculture remains the bedrock of India's economy. This sector has changed markedly over the last decade and is now producing adequate foodgrain supplies for India's enormous population, primarily due to Green Revolution technologies and investment policies. Yet, many of India's current agricultural production systems, both surplus and subsistence, are incurring higher costs and inefficient use of soil, water and biotic resources. Cropland erosion, water logging, degraded pastures, loss of mixed forest cover, and mined aquifers are symptomatic. Faltering sectoral productivity and, more specifically, low productivity of natural resource inputs is a worsening constraint to economic growth and rural incomes in the near-term. Over the longer-term, these high costs and inefficiencies will lead to financial deficits and decapitalization of the natural resource base. Moreover, by the millenium India's agriculture will be reaching the economic frontiers of irrigated area and current high-yield technologies; and this will occur concurrently with a population reaching the one-billion mark. There is a pressing need for new production functions beyond those of the Green Revolution and these will be derived from new applications of science and technology and related enabling policies.

The effective application of science and technology is fundamental to increasing and sustaining natural resource productivity. New biological and information "systems" technologies contribute to efficient land and water management and stable, diversified agriculture production which in turn lead to substainable increases in the productivity of soil, water and biomass. Economic, regulatory and organizational policies conducive to this technological change will also enable sustainable increases in the productivity of the natural resource base.

Despite the size and maturity of India's institutional network, the scientific and technological capabilities and processes in the agricultural sector are currently hampered by poor research quality and methodology, limited information bases and communications, slow and uneven translation from research to utilization, and related policy constraints or incentives. New scientific and technological capabilities are crucial to India's agriculture, irrigation, forestry and associated institutional networks both to develop and apply new productivity-enhancing biological and information technologies as well as to inform the increasing debate on policies which affect resource productivity.

Notwithstanding its limited development assistance levels, the U.S. has the professional reputation and relevant technological experience in agricultural research and in natural resource management which is of increasing interest and timely necessity to India's decision-makers and professionals. Through select investments in India's agricultural and related institutions targeted on technological, methodological or policy constraints, A.I.D. programs have been able to improve India's efforts to resolve natural resource productivity problems. Project evaluations and subsectoral reviews indicate that the current portfolio in agricultural research, irrigation and forestry is resulting in the improvement of professional and institutional capabilities in several States and leading to positive impacts on productivity of the agricultural resource base. The emphasis of these project efforts is also shifting towards higher-impact opportunities in technological innovation, systems research and policy studies and broader natural resource management capabilities. A new appreciation of U.S. comparative advantages and Indo-U.S. mutual interests is leading to a new approach to professional development and exchange and sectoral assistance which is increasingly in the scientific, commercial and environmental interests of both nations.

A.I.D.'s future assistance in India's agricultural sector will therefore promote the improvements in the science and technology processes and related policy analyses which will result in sustainable increases in the productivity of India's soil, water and biological resources. Although it builds upon the implementation experiences of the current project portfolio and GOI plan objectives, the new strategy is a shift away from sub-sectoral infrastructure and institutional development. It focuses "horizontally" on select improvements in scientific and technological capabilities in two fundamental components of increased resource productivity: (1) biological production systems with specific emphasis on biodiversity, disease resistance, mixed planting, and processing and (2) resource management systems with specific emphasis on modeling, geo-information systems, communications, and hydro-meteorology. This will be supplemented by analyses of policies affecting these systems productivity.

The strategy will be implemented through broad sectoral projects which will initiate, facilitate and/or strengthen intermediary collaborative relationships between Indian public and private institutions and interested U.S. and international counterparts. The involvement of intermediary, collaborating institutions, based upon their particular mutual interests, will play an increasingly important role as A.I.D. proceeds towards a more mature development relationship of mutual cooperation with India. This strategy fully supports the GOI's modernization efforts and calls for close coordination with Embassy STI and FERRO programs through a joint research council. It will also complement other donor's capital investment in agricultural research and natural resources development.

To implement this strategy the Mission is restructuring several current projects and is developing two broad-based sectoral projects, Agricultural Science and Technology Exchange and Resource Management Analysis and Technology, and has also initiated two major grants to international institutes for policy-related studies. Initially, the Mission's agricultural staffing will be somewhat reduced and the current divisions will be consolidated into two offices: Agricultural Research and Natural Resources Management. In FY92, after the phase-out of the current large loans, a further reduction in agricultural staff and consolidation of offices is forseen. Program achievement will be gauged by a strengthened evaluation unit and two sectoral science and technology advisors, and a set of scientific, technological, institutional and policy indicators.

I. CONTEXT AND BACKGROUND

A. India's Economy and Importance

India must be seen in the perspective of its importance to U.S. political and economic interests now and in the near future. India is the world's largest democracy and, despite honest differences in international fora, identifies itself closely with the world's oldest democracy, the United States. This provides a unique basis for cooperation between the two countries. Preservation of this commitment to democracy will in part depend upon India's success in grappling with the massive problems of its development. India is also emerging as a regional power, reflecting the inevitable impact of its population size and its strong military capability.

India's achievements since independence in 1947 are impressive, more so when measured against the fact that the population has grown from 330 million to over 800 million today. Government investment and Indian entrepreneurship have resulted in the infrastructure, technology and institutions which have enabled India to achieve food self-sufficiency, an industrial base and a consumer economy despite a huge and fast-growing, heterogeneous population.

This decade has seen important and positive changes in the Indian economy. Agriculture now has excellent export potential and industry has become more diversified. A new generation of entrepreneurs and managers has made it more likely that industrial growth will continue. Most important, the GOI has recently made some important changes in policies, which raise the hope that yet more of the country's economic potential will be brought into play. With greater reliance on price incentives and on the world market, the external environment facing India has become increasingly important.

The Indian economy is responding well to liberalization measures instituted a few years ago. There is an emergent middle-income population of 100-million consumers, equivalent to the combined populations of England and France. India's long-protected internal market is opening up. The U.S. is now India's largest trading partner with $4.5 billion in trade in 1987. But the competition for this market is heated with Europe and Japan making major efforts to expand their trade links. Investment is also reviving up with the U.S. being a leader in establishing joint ventures with Indian firms but facing fierce competition from others who also recognize the potential of the economy. In the first six months of 1988, West Germany supplanted the U.S.'s leading position in the field of foreign collaboration with Indian industries.

However, this economic momentum is restrained by India's massive poverty problem. Over 300-million Indians, approximately the population of sub-Saharan Africa, live in absolute poverty. The problem is evident in comparative quality of life indicators: A per capita GNP lower than that of Sudan; infant mortality greater than Zambia's; and per capita calorie supply less than Niger. Moreover, by the millenium, India will have a population of one billion which will generate a massive demand for both basic foodgrains (about 225 million tons) and equivalent amounts of dairy, horticultural, fibre, forage and wood products. India will also need hundreds of millions of new income-generating opportunities to economically complement this demand with productive employment for the workforce of a half-billion people. By the millenium, India will also reach the economic "frontiers" of irrigation-based, Green Revolution production systems which have enabled agricultural expansion to support population and economic growth. Furthermore, the productivity of India's larger upland tracts is declining due to devegetation. India's continued growth will depend upon an increasingly-stressed physical resource base.

Meanwhile, there has been inadequate recognition in the United States of the changes that have taken place in India in the last decade, especially in more recent years. In view of the clear scientific and political importance and enormous economic potential of an enhanced, complementary Indo-U.S. development relationship, the U.S. has a strategic interest in encouraging and facilitating the involvement of U.S. business, academic and scientific institutions in India's development (Conference on Indian Economy, Boston, 1986).

B. A.I.D.'s New Country Development Strategy

In July 1988, the Agency approved a new Country Development Strategy for India for the period FY 1990-94. The new strategy was based upon the recognition of the vital importance of Indian development to the U.S. and the need for a continued, but essentially new development relationship with India in the 1990s. This CDSS called for a major shift from traditional, field-oriented, budget support activities to a program which emphasizes the importance of the entire science and technology process to economic growth and poverty alleviation .
The CDSS described India's com-

mendable economic growth, the country's recent strides towards modernization; it also described the faltering momentum of this growth due to high production inefficiencies, institutional rigidities and policy distortions. For example, dropping returns and low output per unit of capital investment are leading to waste of limited capital and development resources. Low marginal productivity is a fundamental constraint to growth and modernization across sectors, not the least of which is agriculture.

Despite recent modernization and agriculture's declining share of GDP, the CDSS pointed out that the agricultural sector remains the underlying bedrock of the Indian economy, accounting for 36 percent of GDP and almost 70 percent of all employment and consumption expenditures. A strong and growing agricultural economy has clear and immediate effects on poverty. For example, the high growth area of Punjab/Haryana has the lowest proportion of population below the poverty line and per capita incomes 50 percent higher than all-India averages. Further evidence from South India indicates that a one percent rise in agricultural production translates into a two percent rise in non-farm employment and industrialization (IFPRI, 1987). Yet the output of both modern and subsistence agricultural production systems, although substantial and expanding, is requiring alarming, inordinate increases in the use of India's fixed natural assets: soil, water and biological resources.

The CDSS argued that more attention to improving India's science and technology processes (Annex A) would lead to overall improved production efficiencies and economic productivity in the sector, alleviating these constraints to national growth and incomes; and further, that A.I.D. could make an important contribution to the improvement of science and technology in India because of U.S. comparative advantages and Indo-U.S. mutual interests in "S&T" applications. India already has strong professional ties with the U.S. which grow out of early bilateral developmental assistance and the U.S. role as the largest educator of India's professionals through government-sponsored programs as well as private participants. India's 2.6 million technical and scientific community has traditionally seen and continues to look to the U.S. as its professional mentor and many Indian public and private institutions were developed on U.S. models. Scientific and technological exchange was the foundation of the improved Indo-U.S. bilateral relationship of the early 1980s.

Based upon the Mission's substantial

project portfolio experience and associated evaluations and analyses, the CDSS outlined an approach for further, albeit limited assistance in the agricultural sector focused on agricultural sciences and natural resource management and related policies. Four specific objectives were described: (1) improved applied and operational research/testing of agricultural production systems and technologies, (2) introduction of state-of-art planning, evaluation and information systems, (3) studies and analyses of related policy issues, and (4) associated professional exchange, collaboration, and development. A fifth element, commercialization of agro-technology, would also be included within the context of the Mission's non-sectoral private enterprise program. These objectives would be implemented through intermediary institutions and collaborative relationships, increasingly reflective of mutual interests. In U.S. and Indian agricultural networks there is a keen mutual interest and special goodwill rooted in the early U.S. contributions to India's "Green Revolution" which continues due to professional needs and Indo-U.S. agroclimatological similarities.

The following sections clarify and elaborate upon this new approach to the agricultural sector, as well as the relationship between agricultural and natural resources productivity objectives and the science and technology objectives set forth in the Mission's CDSS. This paper is not a detailed analysis of India's entire agricultural sector, but rather focuses on the Mission's new science and technology strategy within the sector.

II. OVERVIEW OF ISSUES AND CONSTRAINTS

This section describes the current issues and constraints in India's agricultural sector with particular reference to the productivity of the soil, water and biological resources base. Although India's production successes and economic achievements in the sector are substantial, the emphasis of this section is on the problems which are continuing and future constraints to productivity. It begins with an overview of the natural resource base and its limitations and the agricultural economy and trends. Following this is a discussion of the salient characteristics of the policy environment and then a description of India's public investments and institutional network in the sector. The section concludes with a discussion of science and technology in India's agricultural sector.

A. Natural Resources Base

India's land, water and biological resource base is of continental size and diversity. It ranges from the heavily-cultivated, deep alluviums of the Indus-Gangetic Basin to the semi-arid, hard-rock Deccan plateau; from the Sahelian-like deserts of Rajasthan to the humid, tropical forests of Kerala; from the temperate, well-watered Himalayan foothills of Himachal and Kashmir to the semi-arid, lateritic plains of Andhra Pradesh. India's population of over 800-million is growing at over 2.1 percent per annum - India is already 17 times more densely-populated than North America - and its economy is expanding at about 4.8 percent yearly (World Bank, 1988). This population and economic growth places enormous demands upon India's agricultural production systems and upon the underlying natural resource base which supports them.

Despite India's large and varied physiographic regions and semi-arid average precipitation, the subcontinent's highly-variable monsoon climate generally dominates its agricultural systems (Annex B). Over most of India, 80% of total precipitation occurs during the Southwest Monsoon from June to September, prior to which evapotranspiration peaks with average temperatures exceeding 100 F. Given these extremes of climate and hydrology, soil moisture is probably the primary constraint variable in India's agricultural production systems (Yadav, 1987).

India has a land base of 329 million hectares. Approximately 143 million hectares of this land area are currently cultivated; the ultimate potential cropped area is optimistically estimated to be 187 million hectares with about 60% potentially irrigable. Currently, cropping intensities average about 130% across India, with about half of the 112-million irrigable hectares (and most of the optimal sites) already served by irrigation. Tree crops and orchards currently account for about three million hectares, although significant, if localized expansion of new tree plantations is evident.

A total of 175 million hectares or over half of India's total land area can be classified as in some way "degraded". This total includes one-quarter of India's agricultural land due to erosion and water logging/salinization, and almost one-half of the 75 million hectares of productive forest area due to deforestation (Annex B). Devegetation and the consequent deterioration in soil fertility and moisture retention is probably the greatest long-term threat to India's agricultural production systems (Vohra, 1987). Soil erosion alone removes nutrients worth approximately $6-million a year in chemical fertilizer replacements (World Bank, 1987).

A total of about 45,000 species of plant life are said to occur in India. Over 60 percent of the 15,000 species of vascular plants are endemic to the region, and this only represents discovered plants. Preliminary inventories indicate 135 rare and endangered plants are threatened. Wild varieties of domesticated crop plants still flourish in India's forests and thousands of cultivators of field crops grow in farm fields where the single strains of the Green Revolution have not penetrated. The origin or a center of the genetic diversity of many important crops is in India, e.g. rice, eggplant, okra, melon, mung bean, pigeon pea, amaranth, cotton, millet, bamboo, citrus, sugarcane, jute and spices. India's forests also represent a storehouse of tree species with multiple uses. About 20 species of trees and several bamboo species are in danger of extinction. Those with cottage industry uses (furniture, crates, tools, etc.) are particularly endangered, especially in arid and semi-arid tracts where vegetation is already sparse. Preservation of India's remaining biodiversity is critical to ensure the biological genetic resources necessary for sustainable improvements in India's, if not the world's, agricultural productivity (PGR Project Paper/Annex P).

B. Agricultural Economy

India's $60-billion agricultural economy is similarly massive and diverse. India's agricultural output has grown at an annual trend-rate of about 2.4

percent (2.8 percent for foodgrains) during the past two and a half decades. This performance, although less than the all-Asian average of 3.6 percent, is ostensibly adequate to outpace the annual population growth rate of 2.1 percent — a major achievement when set against recurrent famines as late as the 1960s. Over one-half of this agricultural growth rate can be attributed to the expansion of irrigated area (2.1 percent annually) and concomitant changes in crop mix; yield increases due to HYV seeds and fertilizer use are responsible for the rest. Both result from concerted GOI investments and policies in the 1970s. Five-year trends earlier this decade also indicate substantial growth in the production of wheat (30%), milk (40%), leather (80%) and fruits/vegetables (100%), while the production of pulses, oilseeds and sugar remain about constant and below demand (Annex E).

India's growing absolute number of rural poor (about 40 percent of the population), and the stagnation of per capita foodgrain consumption amidst substantial stocks (25 MMT before last year's drought) are evidence of a continuing anomoly in the economy. While aggregate foodgrains output has increased because of the investments in irrigation and high-yielding wheat and to a lesser extent rice — the "Green Revolution" — many of these higher-cost production systems are now absorbing an inordinately large share of the sector's limited investment resources for water, power, credit and support prices (Jha, 1988). Meanwhile, the continuing increase in the number of marginal farms (60 percent of total holdings by 2000) and rural un-/under-employment do not provide sufficient incomes to purchase the surplus production from these Green Revolution cropping systems (Annex D).

The rate of agricultural output growth since 1984 has also been flattened due to poor monsoons and last year the growth rate was negative (minus ten percent) due to a major drought. This has exacerbated the distortions, putting additional demands on current agricultural production systems and stress on the supporting soil, water and biotic resource base. Due to this year's abundant monsoon, foodgrain production should increase substantially and mitigate this downward trend. Yet, given India's increasingly hard-pressed natural resources and growing budgetary limitations, future increases in agricultural growth and incomes must increasingly be achieved through improvements in the productivity of India's soil, water and biological resources, as the economic "frontiers" of expanded land and water development are approached (Seckler and Sampath, 1985).

Recent trends in overall agricultural productivity are mixed. According to work by Evanson (1988), the introduction of Green Revolution technologies during the decade 1973-83, resulted in an increase of 2.4 times in total factor productivity of major crops during this period. However, factor productivity has probably declined somewhat since 1983-84. Although data limitations do not enable firm conclusions, indices for the following four poor-monsoon years of 1983-87 indicate that the same value of agricultural output absorbed about 20% greater value of non-labor/non-land inputs (Annex E). Based upon 1983-84 data, Mellor (1987) also found that the marginal productivity of fertilizer, irrigation, labor and agricultural research inputs was declining. While estimates of total factor productivity are difficult to develop, land productivity is readily measurable: the GOI's Index Number of Crop Yields (1969-70=100) has also stagnated within a narrow range of 142-148 since 1983-84. The low productivity of public investments in the rural development program, IRDP (World Bank, 1988) is likewise indicative. The returns to the original technology combinations which prompted the Green Revolution (HYV wheat/rice, irrigation and nitrogen fertilizer) are in many areas diminishing, as capital and input costs have increased rapidly while overall production increases are localized and less readily achieved.

With respect to outputs, most agricultural yields in India are low in both quantitative values and qualitative terms (Annex E). Beyond wheat, the yields for most crops, irrigated or otherwise, are well below potential of current yields in comparable countries. The average yields of rice (2.8 tons/ha) and of rapeseed (700 kg/ha) in India are below worldwide norms (about 3.0 tons/ha and 1250 kg/ha respectively). Even within India, crop yields vary widely, well-below potentials. Average wheat yields in Madhya Pradesh and Uttar Pradesh are two-thirds of the yields in Punjab which are half again of yields demonstrated at research stations. Average yields of oilseeds and, most critical to the diets of the poor, pulses are particularly low.

Although yields in some irrigated areas have increased dramatically (i.e. Punjab-Haryana), overall cropping intensities have not changed substantially in the last decade (World Bank, 1988). Nor have there been any significant improvements in dryland cropping patterns or in grassland and forest yields, the subsistence production systems upon which the rural poor depend. The actual quality of produce is also often poor, limiting export sales potential and losing markets to competitors. Tea and certain fruits are recent examples.

The expansion of many current forms of agricultural production systems (including, livestock, forestry, etc.) also involves increasingly high economic costs. Although contributing to overall agricultural growth, production subsidies and supports are significant and have increased in real terms about one and a half times in the last decade, and are becoming an increasing budgetary outlay (Annexes E & G). Total State government underwriting of water and power costs probably surpasses the amount of central GOI subsidies. Public irrigation systems are operating at losses of several billion rupees annually (Annex G). Despite the clear achievements in agricultural production, a major shortcoming of this investment pattern is the emphasis placed on the creation of capital assets (infrastructure or "hardware" investments) without concomitant action to ensure effective utilization and maintenance of those assets. This emphasis often results in waste of natural resources and consequent low productivity of the capital investment (Carruthers, 1987).

Most alarming, the high physical costs of the inefficiencies in many current agricultural production systems are leading to a longer-term "decapitalization" of India's soil, water, and biological resources (Annexes B, N & P). Competitive production pressures on the natural resource base are increasing exponentially due to population growth and an expanding economy: Hundreds of millions of rural poor are subsisting on increasingly smaller holdings, marginal uplands or arid lands, while expanding, urbanizing (4.6% annual growth rate) populations demand increasing amounts and varieties of food and resource-extractive products.

Deforestation, overgrazed pasturage, wasted or contaminated water and intensive-cropping on hills are trends evident throughout rural India. The total number of various types of livestock doubled in the last generation and the annual deficit of pasture grasses and green fodders is estimated at a quarter billion tons. The current demand for wood is about three times greater than the sustainable yields from plantations and forests, leading to a loss of forest cover estimated at 1.5 million hectares/year. Approximately 10 million hectares (20 percent of India's irrigated land) are now threatened by waterlogging and/or salinization, due to over-irrigation and inadequate drainage while many groundwater aquifers are endangered by overpumping and mining. The capacity of all of India's major reservoirs is being reduced by high rates of siltation. Deterioration of India's natural resource base constrains current food, fuel and fiber production systems and results in the loss of the irreplaceable soil, water, and biological "capital" upon which future growth depends (Johnson, 1988).

Although India's agricultural growth has been substantial, the low levels of output and the increasing, often unaccounted, financial and physical costs of current agricultural production systems reflect a clear need for new efficiency-improving, cost-reducing innovations and related economic incentives which will lead to sustainable increases in the productivity of natural resource use across the sector (NCAER, 1988).

C. Policy Environment

GOI and State policies in the sector, although responsible for substantial agricultural growth in the past and showing signs of future change, are geared towards regulating markets, encouraging cereals production, and assuaging constituencies. Large, centralized technocracies at the national and state-levels to implement the policies are also prevalent. Most policies are biased towards overall expansion of HYV cereals production in irrigated areas and are often not conducive to increased efficiency and resource productivity in other crops and areas (IIED/WRI, 1987).

Input subsidies and crop pricing policies have led to growth, but also some distortions. Low pricing of irrigation water (in terms of the costs of infrastructure or power) contributes to shifts to uneconomically water-intensive crops, skewed distribution of water supplies, lack of funds for maintenance and reinvestment, and waterlogging, overuse of agro-chemicals, or worse salinization. Government-fixed fertilizer pricing is resulting in unavailability of different types of fertilizers and consequent imbalanced applications and excessive use of nitrates. This affects yields and depletes other soil nutrients and contaminates groundwater (World Bank, 1987).

The price support policies for wheat and rice, although leading to current surpluses, have also induced a shift out of coarse grains and pulses and appear to have increased the sensitivity of the total cereal crop to rainfall due to increases in rainfed HYV plantings. This shift may also have affected some export crops such as fibers. These subsidies are beginning to represent an important part of the GOI's rising current expenditures, holding investment resources in HYV cereals and away from other production activities.

Both the Planning Commission and Agricultural Prices Commission are considering reallocation of certain subsidies, but a vocal farm lobby and the comparatively greater investments and inefficiencies in the industrial and urban sectors make such reallocation politically problematic.

Further sets of national and state policies influence land use. The current uncertainities and conflicting access and ownership rights to common vegetation and water resources on village and public lands hinder cooperative management of these resources and contribute to over-exploitation of pastures, forests and aquifers. Clarification of these rights is now an important agenda of the National Wasteland Board and National Water Resources Council. In forestry, prices for wood from public forests do not reflect the true value of the natural resource and its regeneration, while cutting and transportation controls hamper private agro-forestry production. The Ministry of Forestry and Environment has recently initiated studies on these pricing and marketing issues.

Finally, an overall structural constraint within the agricultural sector is the relative over-administration of programs. This is characterized by large centralized (and stratified) technocracies, a preponderance of complex and sometimes anachronistic regulations, and unreliable production services, all resulting in disincentives to local decision-making and private entrepreneurship. Rajiv Gandhi's initial liberalization of the economy has not yet penetrated deeply into the very traditional agricultural sector and the results show in limited productivity of soil, water and biological resources.

D. Programs and Institutions

The GOI's major goals in the agricultural sector in the perspective plan to the year 2000 may be summarized as follows :

- Maximize growth of all crop outputs (including output from animal husbandry, forestry and fisheries);
- Maintain self-sufficiency in foodgrain and attain self sufficiency in pulses, oilseeds and fibres;
- Maximize employment opportunities in agriculture (including animal husbandry, forestry and fishery subsectors); and
- Promote conservation and environmental protection measures.

The Eighth Five-Year Plan is also likely to include a goal of increasing agricultural exports, as well as a priority on agriculture. These goals are pursued through strategies and policies that also satisfy the needs of overall social justice.

These strategies are straightforward and generally commended by the major donors, i.e. the World Bank, the EEC and most-recently the Japanese. For example, investments for the expansion of irrigation and extension of new agricultural technologies are made to achieve the first two goals. Irrigation development raises cropping intensity to absorb additional labor in downstream production. Reforestation of degraded land promotes conservation while also generating new employment. Major policy instruments for these strategies include incentive pricing of selected outputs and subsidized pricing of certain inputs as earlier discussed.

To implement these strategies, the GOI with minimal donor support (about three percent of the development budget) combines a massive effort to consolidate and spread the agricultural gains of the Green Revolution with equally mammoth, but targeted rural development programs. One set of programs emphasizes agricultural infrastructure and input supplies (especially irrigation, HYV seeds and fertilizer). The other set consists primarily of the National Rural Employment Program (rural works, forestry, soil conservation, including food for work) and the Integrated Rural Development Program (IRDP) which includes small and marginal farmers, dairying, and rural enterprise development.

The GOI's investment in both the physical and institutional infrastructure of the agricultural sector has been enormous. The current Seventh Five-Year Plan (Annex J) budgeted about $25 billion for irrigation, agriculture and forestry. This is 15 percent of total plan outlays, a decrease of about 12 percent relative to the earlier Sixth Plan. The Eighth Five-Year Plan currently in preparation will likely increase the relative share of agricultural outlays.

The public and, to a lesser extent, private institutional network which implements these investment programs is also massive: 40 agricultural and engineering universities with 12,000 graduates yearly and an agricultural research network carrying out 600-odd individual and national research projects (Annex I). The public technical "service" agencies which implement the various rural programs are the large departments of agriculture, forestry, irrigation and rural development in each State, with technical staffs of tens of thousands. For example, the State of Maharashtra (population: 70 million) has a nation-sized Irrigation Department numbering 12,000 technical personnel and an Agriculture Department numbering 8,000. More recently, several new national investment programs focused on land and water resource production problems have also been initiated: Social Forestry, Minor Irrigation, Critical Watersheds, Command Area Development, and Oil Seeds Production, all with substantial donor support.

Associated with these large technical institutions and investment programs are equally large national credit and input suppliers: agricultural banks, seed companies, fertilizer companies, commodities cooperatives, etc. The agricultural sector is also served by thousands of small enterprises dealing in pumps, agro-chemicals, machinery, transport, food wholesaling and packaging. The fast-growing food processing industry conducted over a billion dollars of business last year even with government controls on licensing.

These large annual investments and this massive, maturing institutional infrastructure have enabled India's commendable long-term growth in agricultural production since the 1960s. However, in recent years not only has capital investment in the sector declined by 17 percent, but many sectoral institutions are having difficulty dealing with pressing issues of the productivity of soil, water and biological resources. For example, public system irrigation efficiencies average less than 50 percent and the actual areas irrigated seldom exceed half of that planned; hence, the return on investment is low. A recent GOI evaluation indicated low 5-year survival rates and poor species selection in national social forestry programs. There have been few new biological technologies and little public research on village-level agroprocessing or natural resource use strategies.

The strong bias of these institutions has been the creation of capital assets, i.e. facilities, works, plantations etc. or "hardware" rather than the performance or productivity of those assets over time. The faltering productivity of India's agricultural systems can in part be attributed to the inability of these large agro-institutional networks to analyze, develop and promulgate new systems technologies and related policies for lower-cost, efficient management of the soil, water and biological resources under increasingly-competitive, consumption pressures.

E. Science and Technology

Science and technology makes critical contributions to improved productivity in India's agricultural sector. Agricultural production is particularly subject to diminishing returns. With continued attempts to stimulate production, the inelastic supply of India's land area causes the productivity of other inputs to decline; thus, each increase in output requires more inputs of other resources and this results in declining productivity, increasing costs, and decreasing incomes. Science and technology can increase the productivity of soil, water and biological resources upon which agricultural production depends, decreasing costs and therefore decreasing prices (World Bank, 1988). The very high returns to agricultural research investments are well-documented (Evenson, 1978).

In the last two decades scientific and technological advances (and targeted policies) have helped make increasing land yields through new varieties the engine of agricultural growth in India. Between 1961 and 1980, output per hectare of major food crops rose by 1.8 percent annually and accounted for more than half of total growth in food production. Technological change in agricultural production systems has important employment and income linkages to the non-farm economy as well, by raising incomes from increased production and diversification (IFPRI, 1987). An improved technological base is necessary for the agricultural diversification characteristic of a modernizing economy (Timmer, 1988). Likewise, scientific and technological advances are critical to understanding and managing the soil, water, and biological capabilities upon which sustained productivity depends. Both biologically-based production sciences and the more operational, planning or management technologies are necessary to these advances (Myers, 1987).

Operationally-efficient infrastructure is also needed to ensure continuous services, access and information throughout the entire sector. New biological technologies have spread at almost twice the rate when the necessary technical support infrastructure is in place and operational (Ahmed, 1988). Physical and institutional infrastructure is vital to science and technology "translation" and an important part of the process (World Bank, 1986). A common feature of Japan and Taiwan as well as the Punjab is first-class research institutions, good communications, reliable water control, and broad-based educational and information systems. These are the basic infrastructure of technological change and consequent sectoral growth.

India has made great strides since independence to build its scientific and technological base. The successive plan investments in agricultural infrastructure research and education made the Green Revolution possible and have made India an agricultural leader among developing nations. However, since the early 1980s, some disturbing trends are evident. Direct public investment in the agricultural sector has declined as a portion of overall GOI budgets, and an increasing share of this investment expenditure is now being consumed by the aggregated price supports and inadequate revenues from power and water investments. Research budgets have declined in real per capita terms. Institutional and physical agricultural infrastructure has been hampered by rapidly escalating costs and by overall poor operational performance and inefficiency.

There is also a striking variability and some feel an overall weakening in the quality and relevance of agricultural and related engineering research and education relative to the enormity of the problems and changing needs of the sector (Smuckler, 1987 and Busch, 1988). Despite its size and maturity, India's agricultural scientific community is actually small by world standards in terms of population and land area served. Although a number of Indian institutions in the sector are of world-class standard (Punjab Agricultural University, IIT/Bombay, Institute of Development Studies/Madras, etc.) and indeed are leading institutions to other developing countries, the rest of India's educational network is having difficulties meeting the challenges of the massive and diversified, rapidly changing agricultural system. Curriculums are little-changed, laboratory and experimental facilities are ill-equipped or antiquated, few faculty are recruited externally or widely-traveled, modern pedagogic methodologies are rare and the linkages between the education and sectoral economy or employers are weak (Sullivan et al, 1987).

These weaknesses in training and education are also found in India's agricultural research systems. Recent articles, discussions and ICAR's own internal review bemoan the current isolation of much of the sizeable agricultural research establishment, both in terms of professional inter-connections within its own networks and world-wide, and of its vertical connections with farmers and private client groups. The results are evident in excessive duplication of experiments, research on economically-questionable or unessential topics (Chambers, 1985), and the high proportion of individual, basic research on a single commodity or variable as opposed to systems constraints (Francis, 1986). The relationship between public research activities and actual, field-level sectoral productivity constraints has become an issue of national concern and the poor results of several programs, Lab-to-Land, Operations Research, etc., much discussed. Strengthening and modernization of India's research capabilities across the agricultural sector and fulfillment of its clear potential for excellence is fundamental to increasing the productivity of India's soil, water and biological resources.

Many of India's large technical agencies serving the sector are also ill-equipped in technological and related organizational terms to meet the enormous, increased demands of data and systems management for the growing rural client groups (Lewis, 1987), increasingly stressed natural resource base, and the diversifying, expanding economy. Indian agriculture is changing more rapidly than many of the institutions which guide and support it. Several scientific and technological needs are apparent: (1) new analytical skills in "upstream" systems planning, design and testing are required by the professional cadre as the role of these institutions change, i.e. from irrigation construction to water resources planning and management, or from forest guards to land-use planners and counselors; (2) new systems "tools" and automation are necessary to enable the collection and processing of huge quantities of field data into useful information, the information studied and transformed into accurate analyses, and planning/investment decisions communicated and implemented based upon the analyses (Myers, 1988 and Morian, 1988); and (3) new organizational structures and procedures are needed to promote internal professional dynamism and mobilize external resources to facilitate these institutions' ability to guide and support productivity improvements (Chambers, 1987).

Scientific and technological innovation in the lab, office or field is also inter-related with a set of policies which enable, if not induce, economic and organizational change (Schuh, _). For example, pricing is the major instrument which guides resource use. When natural resource prices reflect true economic costs there is likely to be use of more efficient production or management technologies (Warford, 1987). Application of science and technology is facilitated where restrictions on movement, sales, and distribution of inputs and outputs are the minimum. The regulatory environment includes interstate movement of agricultural commodities, harvesting and transit of farm forestry products, private sector adaptive research, and distribution of agricultural inputs. Recently, the GOI has liberalized the import, development and distribution of certain types of seeds, yet similar issues exist in other areas.

Investment priorities are also critical to the development and translation of new technology. As earlier noted, the budgetary resources of the GOI are beginning to be affected by the cost of support and maintenance of the huge public sector investments in agriculture. The issue is not only of budgetary priorities and new management technologies, but also mobilization of private investment to improve technology through greater orientation towards enterprise, be it seed/sapling production or water management.

The relationship between the application of science and technology and the policies which affect it is double-bladed. While the policy environment affects scientific and technological innovation, the converse is equally true: science and technology can contribute to policy change as well. New biological and information management technologies lead to new ideas and innovations which often force decision-makers to address policy issues. This was the case with remote sensing in afforestation investments and seed technology in sales liberalization in India. Scientists and technologists are often the most knowledgeable of the potential of innovation and the policy constraints which hinder it. Accordingly, they are usually effective spokepersons for policy change. Dr. Swaminathan, former Director of IRRI, is a case in point. The Planning Commission has also recently formed agricultural investment working groups composed largely of research administrators. Finally, policies and their effects are themselves an important topic for scientific research; policy can be researched and tested just as any technological product or process.

To summarize, the effective application of science and technology is fundamental to the improvement and sustenance of the productivity of India's natural resources across the maturing agricultural sector. Technological innovation enables overall increases in production, more efficient use of inputs, and better husbandry of the resource base. Despite India's achievements in science and technology, the current performance in agriculture is mixed. Science and technology processes within the sector are in need of modernization and strengthening to meet the demands of expanding agricultural systems and a growing modern economy on a limited natural resource base. These needs include high-quality institutional and individual research capabilities, facilitated flows of ideas and information (both vertically and horizontally), expeditious translation of technology to users, and enabling pricing, regulatory and organizational policies.

III. A.I.D.'s EXPERIENCE AND NEW OPPORTUNITIES

This section reviews A.I.D.'s past and present involvement in India's agricultural sector. It describes how a new strategy has been derived from the implementation experience, and associated technical and economic analysis, and project evaluations/redesigns in three sub-sectoral portfolios. The hard-won experiences as a relatively small donor in an enormous, changing sector over the past decade have provided in large part the analytical base for the definition of our new strategy.

A. Historical Perspectives

A.I.D.'s longest involvement in India's development has in fact been in the agricultural sector. In the 1960's, A.I.D.-funded participant training technical expertise and project loans assisted India to develop its agricultural universities, research institutions, and water and power infrastructure. Many Indian institutions were based upon U.S. models (Land Grant Universities, River Basin Authorities, Geographical Surveys, etc.). However, most of these nascent institutional relationships were ruptured during the Indo-U.S. political hiatus in the 1970s.

A.I.D. assistance to India was reestablished in 1978 with large, primarily State-focused infrastructure loans, first in rural electrification, then in irrigation, and later in social forestry. These projects were primarily resource transfers to increase agricultural production through widespread application of improved design and technical "packages". A more recent agricultural research effort responded to specific research priorities set by the Indo-U.S. Subcommission on Agriculture. As this portfolio matured, more emphasis was placed on institutional support through grant-funded training, study and technical assistance (eg. the Irrigation Management and Training Project), although the greater part of the existing portfolio remains tied to widespread rural works in irrigation and forestry.

B. Evaluations, Analyses and Findings

Over the last year, intensive analyses, reviews and evaluations of the Mission's portfolio in the agricultural sector have substantiated achievements while pointing out opportunities and new directions.

Agricultural Research:

The current Agricultural Research Project (ARP) Evaluation (Annex O) and an Agricultural University Impact Evaluation described the enormous potential, yet faltering performance, of India's agricultural education and research institutions. The problems identified were poor research quality, lack of peer review and priorities, isolation from client groups and the international community as well as within the research institutions themselves. Both emphasized the unique opportunities for U.S. assistance through long-term Indo-U.S. collaborative relationships, and the direct mutual interest in agricultural research and scientific development. The Evaluation also pointed out the need to target less commodity-specific research activities and to establish a streamlined longer-term assistance on a more selective, collaborative basis coordinated with similar USDA (FERRO) programs. Policy needs were cited in setting research priorities, scientific property rights, and relationships with the private sector. Further underscored was the importance of and U.S. interest in professional ties and exchange between Indian and U.S. agricultural research institutions both to strengthen Indian capabilities and to extend the range of potential U.S. biotechnologies due to India's agroclimatic and genetic diversity.

Irrigation:

The 1987 Irrigation Water Resources (IWR) Strategy, the Maharashtra Assessment and Hill Areas Project Evaluations (Annex H) have all reiterated the central importance of water resources management to India's economic growth, the high economic returns to management improvements, and the increasing need for new analytical capabilities and technologies at both the operational and institutional levels. These reviews affirmed the impacts of A.I.D.-sponsored efforts in modern planning, operation and training procedures in improving irrigation productivity; there are also indications of effects on policy formulation in investment planning and agency-beneficiary relationships. It was further noted that intensive involvement in infrastructure development and farm-level efforts can detract from underlying objectives of systems performance and associated managerial and technological capabilities.

Both the Strategy and Assessment called for emphasis on broader water resources management and systems efficiencies with focus on improving resource productivity in groundwater supply and utilization, main systems operations, and river basin investment planning through professional training and exchange, information management, and operations research and pilots. The Hill Areas Project Evaluation emphasized upstream water resource problems and the need for new capabilities in land and water use planning, technologies and policies. Three sets of policy issues were identified as critical to water resource productivity: operations cost recovery and reinvestment, beneficiary water rights and cost-sharing responsibilities, and autonomy in management organizations.

Forestry:

A draft Resources Management Strategy and the recent National Social Forestry (NSF) Project Evaluation (Annex N) reiterated the critical rates of devegetation and the increasing gap between supply and demand of forestry products for both rural populations and industrial growth. The Evaluation found that private tree planting in/around farm fields was successful and could meet much of India's future industrial demand. However, community management in public wasteland afforestation was found to be problematical and the environmental benefits of current plantation technologies were found lacking.

The Evaluation also argued for a shift in focus from merely tree planting to development and demonstration of more productive agroforestry technologies, land use/capability information systems, and site-specific conservation models for various land classes, community and government. Both the draft Strategy and the Evaluation also identified requisite policy changes: privatization of seedling distribution, rationalization of public land use, deregulation of markets which support farm forestry, and clarification of access rights to common forest lands. Needs were identified: policy-oriented studies, new technologies, related research and training, and pilot organizational and commercial production systems for marginal wastelands. The compatibility and leverage of A.I.D. grants with larger World Bank loans was also noted.

C. Conclusions and Opportunities

The Mission's intensive involvement in irrigation, forestry and agricultural research provide important indications of sectoral priorities and constraints which lead to the formulation of our strategy for the 1990s.

Affects on Resource Productivity:

The Mission's reviews, evaluations and supporting agro-economic studies (i.e. Daines,1987; Seckler,1987; and Evanson,1988) have shown the direct and fundamental relationship of a variety of technological and institutional changes to increasing resource productivity; and further, the powerful effect of the right combinations of technologies and policies on optimizing natural resource productivity over the long-term (Repetto,1987). Techno-institutional innovations can lead to new, diversified, higher-value crop mixes and agro-forestry combinations in stabilized soil, water and genetic resource systems (Bajaj and Singh,1988 and Panayotou,1988). Yet, India's irrigation, forestry and agricultural institutions are having difficulty meeting this challenge and require new technology and analytical capabilities to promote the requisite, site-specific soil, water, and biological resource systems (Walter,1985 and Myers,1987). The reviews and evaluations indicate that A.I.D's involvement in each of the three areas has begun to address critical soil and water productivity issues within the sector; and furthermore, that A.I.D. can have an impact upon improved performance of large Indian institutional networks (Peabody et al,1987 and Campbell,1987). However, the implementation demands of large works programs or complicated government-to-government administrative arrangements can overwhelm technological and institutional objectives.

Examples of impacts include A.I.D.'s efforts in agricultural research which capitalized on the clear U.S. technological supremacy in agricultural science. Based upon Indo-U.S. Subcommission priorities, A.I.D. is helping to strengthen post-Green Revolution research in oilseeds and livestock despite some implementation difficulties. This involvement can broaden to include more Indo-U.S. agricultural exchanges to improve productivity-enhancing research capabilities. A.I.D.'s involvement in irrigation, despite the long gestation period of a large loan portfolio, has enabled the Mission to play a role in the growing national debate and actions necessary to improve the productivity of investments in this economically-critical subsector. A.I.D. is having a modest, but replicable influence on the modernization of irrigation capabilities, on the formulation of new nation-wide irrigation/water resources curricula and research methodology, and on studies of public irrigation policies in several States.

The involvement in forestry was similarly responsive to a critical sectoral need: sustainable productivity of the nation's non-cultivated lands in the face of heavy demands for fuelwood, fodder, and lumber. Although implementation of grant-funded activities has been problematical, A.I.D. loan and advisory assistance is guiding several large forestry departments towards consideration of various alternatives in mixed-plantings and woodland management, in reducing sapling subsidies, in extension for farm forestry, and in related monitoring and evaluation capabilities. Recent dialogue is leading to studies of wood marketing deregulation.

The current portfolio of projects has proven that A.I.D. assistance can be targeted within India's large and complex institutional framework to affect the issues of productivity of land, water and biotic resources.

Move towards Technological and Policy Issues:

The emphasis of the sectoral portfolio has also slowly, but progressively, shifted from resource transfers (constructing reservoirs, planting trees, procuring equipment, long-term training, etc.) and related institution building towards professional development, exchange and collaboration directed increasingly at broad technological and policy constraints. This shift is evident in each of the three original sub-programs, but is most obvious in agricultural research and irrigation where the key projects (ARP and WRM&T) are essentially grant-funded professional and research development efforts.

The ARP was designed with strengthening selected research as its focus. A new project is now being initiated to strengthen the scientific and technological capacity to collect, evaluate, conserve and exchange India's plant genetic resources. The WRM&T Project stresses improved technical capabilities, action research and organizational procedures; it will also establish professional exchanges and technical information networks. Modifications were also made to two other major projects to link loan disbursements to specific irrigation technology and operational policy changes. Other initiatives include micro-computerization, groundwater monitoring, river basin planning, and linkages between India's water management institutes and the international water resources management network. A State-wide economic impact analysis is underway and a cost-recovery workshop with Planning Commission involvement is planned.

In forestry the movement towards technological issues is illustrated by a new ARP subproject in agro-forestry research and education with the ICAR and Agricultural Universities. Changes to the NSF Project will also emphasize new technologies for spatial planning, mixed planting, and monitoring/evaluation. A comprehensive program in micro-computerization and geo-information systems has also been initiated. A number of policy issues are also being addressed in studies on seedling price subsidies, private nursery production, and common property resources.

Finally, the Mission provided a small initial A.I.D. grant to the International Food Policy Research Institute (IFPRI) to develop a program for a collaborative research effort with ICAR focused on fertilizers, irrigation and technology transfer issues.

This concerted, if incremental movement towards cross-cutting technology and policy issues is blurring the earlier, three way divisions of the program (irrigation, forestry, and agricultural research) and is leading to a broadened program definition based upon a common sectoral thrust in technology development and applications and collaborative policy analysis and studies.

Natural Resources Management Objectives:

As the Mission's project experiences in irrigation and forestry have matured, many of the efforts and objectives in these two sub-sectors have begun to converge. A common theme of improved management of India's natural resources has emerged as experience in each subsector indicates the severe reductions in productivity due to the loss of soil, water and biological resources. The analyses and the evaluations in both irrigation and forestry projects agreed that the analytical capabilities in systems research, "upstream" planning and "downstream" monitoring are inadequate and result in sub-optimal, if not unsustainable, investment decisions, technical packages, operational performance and associated policies (Dixon,1988; Barbier,1988). In both subsectors, new technologies and methodologies are required by large, public (land and water) management agencies and associated institutes to deal with the increasingly competitive demands on limited land and water resources (Walter,1985; Bajaj and Singh,1988). Adaptive or operational research, resource data information systems, and measurement/gauging technologies are needed to inform and implement decision-making across subsectors (Myers, 1988).

Irrigation and forestry management both involve a similar complex of policy issues in land tenure, water rights, pricing/privatization of services, distributional equity, and site selection criteria. Furthermore, work by the Ford Foundation and others (Brooks et al, 1982) indicate the potential for reinforcing linkages in small reservoirs between upstream watershed rights and downstream water rights. A collaborative research agenda recently proposed to the Mission by the World Resources Institute (WRI) would focus, inter alia, on economic rent-seeking in both land and water resource management systems. These growing linkages and common elements are leading to a covergence of efforts towards a broader goal of longer-term productivity of India's soil, water and biological, or "natural" resources.

U.S. Comparative Advantages:

Despite the hiatus during the 1970s and its relatively limited funding levels, A.I.D. still enjoys a professional reputation in agriculture unsurpassed by any other external development agency (Lele and Agarwal,1987). The participant training, institutional development and water and power infrastructure investments of the 1950-60s, as well as A.I.D.'s re-established, albeit limited, involvement in these sectors have produced indelibly positive relationships at the institutional, professional, and personal levels.

The U.S. also has considerable relevant institutional and technological experience in agricultural resource management, both domestically and internationally (Harwood,1988). The U.S. agricultural science and research capabilities, its land and water resource institutions and technologies, its large network of private firms, planning and training consultants, and environmental groups experienced in agriculture and resource management are unequaled in the world and Indian professionals know it. The U.S. is also the only major donor with both arid and subtropical agroclimatologies similar to India's. The U.S. experience in land-use analysis, arid land development, pasture conservation, snow hydrology, aquifer exploration, and multi-use forest management is singularly relevant to India. Moreover, there is considerable mutual interest in technological collaboration in agriculture and natural resources as is evident in the popularity of the Indo-U.S. Subcommissions and the Science and Technology Initiative.

Finally, with regard to operational considerations, A.I.D.'s grant funded assistance can provide the GOI and other donor-assisted loan projects with critical additional resources for traditionally underbudgeted efforts which enhance technological capacity: professional training and exchange, adaptive and operational research, special studies and pilots, and associated technology import and development. This operational advantage enables A.I.D. to be a uniquely responsive and relevant donor to India in providing science and technology "software" assistance.

Indo-U.S. Mutual Interests:

The past decade has also demonstrated the potential, if not necessity, of tapping the dynamism of mutual interests in the maturing Indo-U.S. relationship to attain developmental objectives within the agricultural sector. These mutual interests can be roughly categorized as scientific, commercial and environmental.

On the scientific level, U.S. scientists, engineers and researchers have keen interests in the Indian subcontinent and its agricultural sector. For example, U.S. agricultural scientists and engineers look towards India's research network, the broad genetic diversity found in Indian plant life, and the 128 distinct agro-climatological zones for both new genetic materials and possible testing of crop genotypes. U.S. hydrogeologists are interested in hard-rock aquifer characteristics in India, given the generally higher rates of extraction and shorter duration of recharge. U.S. meteorologists are also studying the effects of changes in the Himalayan snowpack on world weather systems. In view of the central importance of plant genetics and water to agricultural productivity in India, Indo-U.S. scientific collaboration in these areas would also contribute to productivity-enhancing technological innovation in the sector.

U.S. direct commercial interests in improving productivity in India's enormous agricultural sector center on potential joint-ventures in input and food processing technologies. A number of joint ventures have begun in hydrid seed production (Pioneer and Dekalb) and most recently fruit and vegetable processing (Pepsi-Cola). The GOI views such ventures in the national interest and has recently further loosened regulations on import of seed technology and further joint-ventures are expected. The Mission's private enterprise projects are ideally positioned to facilitate such commercial collaboration. In a larger sense, the well-being of India's agricultural sector and its impact on incomes and the economy at large are also in the direct commercial interests of the U.S. as India's largest trading partner.

Environmental concern is one of the most critical and widely-publicized U.S. interest in agricultural and related resources issues world-wide. U.S.-based and international environmental groups are politically important and reflect popular concern over the potential for natural calamity from the loss of forests and wildlife and contamination of water and the atmosphere. Recent examples of Indo-U.S. environmental concerns in India are the effects of the multi-purpose dam projects in the Narmada Valley, increased cultivation in the Himalayan watersheds and its effects on downstream flooding and estuaries, devegetation of the sub-continent vis-a-vis global warming trends, and the preservation of subcontinental biodiversity. As the Indian economy and policy continues to modernize, Indo-U.S. concern over natural resource preservation and environmental safeguards are expected to increase apace.

The Mission's experience in the sector indicates ample strategic rationale for a special U.S. interest in efforts to improve sustainable resource productivity. Indo-U.S. collaborations will broaden the base of scientific knowledge in plant genetics and global hydrology, offer new opportunities for agro-industrial and resource management consultancies, and enable informed assessment and action on critical environmental issues.

D. Summary

The preceding discussion linked the overview of India's agricultural sector and its productivity constraints with the Mission's experience and current insights in the sector. The Mission's analyses indicate that the productivity of India's current agricultural production systems is faltering and their increasing costs in terms of financing and natural resources call for new technologies to shift sectoral production functions upward and to increase and sustain efficiencies, as well as for selected policy changes to encourage these shifts. The evaluations and reviews indicated that A.I.D. can influence productivity-enhancing organizational and technological changes within India's agricultural science and technology institutional networks. Recent experience also indicates the desirability and opportunity for a new sectoral "modus operandi" which, although building upon earlier sub-sectoral relationships, is a cross-cutting approach directed at the applications of science and technology in the sector. This effort would focus on qualitative improvements in research and testing, in expanded information exchange, in product/process "translation" from experimentation to utilization, and in analysis of identified policy constraints, all increasingly accomplished through topical fora, professional exchange and collaborative research based upon Indo-U.S. mutual interests. The following section elaborates this new strategy.

IV. A SECTORAL STRATEGY FOR THE 1990s

Although the Mission's CDSS and strategy for the agricultural sector are intended to guide A.I.D.'s efforts for the next five years, this strategy is directed towards the longer-term challenge facing India's agricultural sector after the millenium. India has little time to enjoy the agricultural successes of its Green Revolution. As the new millenium begins, India will face a new crisis: the economic limits of new cultivated and irrigated land will be reached and returns to the earlier genetic and agro-chemical technologies will diminish while a population of one billion will need 50% more foodgrains (IFPRI, 1987), hundreds of millions of jobs, and equivalent quantities of building materials, fuelwood and fodder-the demand for which is already double existing supplies (World Bank, 1987). Furthermore, the entire subcontinental biosphere will be acutely stressed by enormous production pressures and a variety of contaminents. Meanwhile, the poor returns to and decreasing amount of public investments in agriculture and growing budgetary and environmental concerns have spurred a period of technological and institutional change, professional concern and public debate on sectoral programs, organizations and policies.

The Mission's strategy for the agricultural sector must assist India to apply the best scientific and technological capabilities to these challenges and it can do so effectively given four parameters:

- it must assist the GOI/States to fulfill critical development Plan objectives;
- it must build on A.I.D.'s current sub-sectoral/institutional experience, relationships and U.S. comparative advantages;
- it must consolidate and target activities on systemic constraints to the applications of science and technology in the sector; and
- it must initiate potentially self-sustaining collaboration based upon longer-term, Indo-U.S. professional and national interest and capabilities.

A. Goal and Objectives

The Mission's overall goal for assistance in India's agricultural sector is sustainable increases in the productivityof soil, water and biological (or natural) resources. This goal is being pursued exclusively through improvements in the application of science and technology to the biological and informational constraints of long-term natural resource productivity. The strategy has a horizontal focus on science and technology across the agricultural sector, rather than traditional, "vertical" focii on particular subsector or resource problems. The strategy focuses on two fundamental components of sectoral productivity: bioligical production systems (microbial, plant and animal productivity with an emphasis on biotechnologies) and natural resource management systems (land and water productivity with emphasis on informatics). Each has a related set of professional development and policy issues. Thus, the Mission's overall objectives for the sector are:

- improved professional and institutional capacity to conduct and utilize scientific approaches to alleviate the biological and systems/operations constraints to natural resource productivity, as well as necessary policy related research;
- expanded communications, data bases and information exchanges among scientists, engineers, and technical officers in both the public and private sectors on biological production and resource management systems;
- wider testing and utilization of new productivity-related biological and information processes both within public and private institutions and by private enterpreneurs and farmers; and
- empirical studies and fora to recognize and analyze policies which affect productivity-enhancing scientific and technology innovation, specifically resource valuation, private enterp mobilization, and organizational change.

These objectives will contribute to India's long-term capability to improve productivity and maintain its resource base. India's ability to preserve its biodiversity and overall biosphere is critical for the nation and the world. The application of the most advanced scientific methods available (e.g. biotechnology and informatics) to important sectoral productivity constraints will have multiple effects: the scientific methodology used will allow particularly recalcitrant production problems to be addressed (e.g. crop tolerance or aquifer dynamics to particular stress conditions); linkages between U.S. and Indian institutions will contribute to the growth, experience and desired access of both communities; and new programming modalities will address some of the important problems inherent in the Indian institutional mix. (Programs will not be limited to large, public institutions.)

These overall objectives will be achieved through broad-based bilateral projects which will provide direct or cooperative grant assistance to select institutions for collaborative Indo-U.S. professional and institutional programs. All assistance will be closely coordinated with the other USG science and technology programs in India, the STI and FERRO, will be complementary to related institutional or infrastructure development programs of the GOI and other donors (i.e. World Bank, Japanese OECF, etc.), and will be linked with the programs of the international research network.

B. Biological Production Systems

This set of activities primarily involves improvement of the quality and relevance of research and testing of biological systems central to natural resource productivity. These biological production systems consist of agriculturally-beneficial microbes, plants and animals and their interactions. The specific objectives will be :

- quality research, especially biotechnology, for crop and livestock improvement;
- research on and improvement of diversified production systems and genetic resources to protect biological diversity;

The objectives will be achieved through enhancing Indo-U.S. public, quasi-public and private inter-institutional research and education linkages; improving professional capabilities through post-doctoral and collaborative research efforts; expanding exchange of information, ideas and publications; and increasing mutual collaboration between Indo-U.S. centers of excellence. All research activities will be highly focused, result-oriented endeavors. The emphasis will be on high quality research in areas critical to sustainable natural resource productivity such as agroforestry, disease diagnosis and control, multiple cropping systems, conservation of plant, animal, fish and microbial genetic resources. All activities will be closely coordinated with the Embassy's STI and USDA's FERRO programs through a joint research council.

This set of activities builds on the priorities set by the Indo-U.S. Subcommission on Agriculture, the management lessons of the ARP, and the institutional weaknesses cited by the SAU Impact Evaluation. It also includes an agro-forestry initiative recommended in the NSF Evaluation. The emphasis is on high quality biotechnological research in areas critical to sustainable natural resource productivity such as agroforestry, disease diagnosis and control, multiple cropping systems, conservation of plant, animal, fish and microbial genetic resources as well as problem-driven biotechnology. This emphasis supports new GOI research priorities and parallels the recommendations of the recent meeting of the Consultative Group on International Agricultural Research (CGIAR).

The key GOI institutions will initially be the ICAR and State Agricultural Universities; however, the emphasis and institutional framework will be broadened by Indo-U.S. mutual interests and consequent collaboration to include a broader range of public, quasi-public and private research and educational linkages. Careful selection of collaborating institutions and an evolutionary range of initially uneven collaborative relationships is necessary, given the various degrees of institutional capability in India.

This set of activities will be implemented through three bilateral projects. The Agricultural Research Project (ARP) was a beginning toward strengthened institutional capabilities of ICAR and the SAU's to conduct research in priority areas identified by the Indo-U.S. Subcommission as important and of mutual interest. Currently ten subprojects are being implemented covering such diverse topics as soybean processing and utilization, post harvest technology of fruits and vegetables, livestock improvement through embryo transfer and vaccine development, agroforestry and agrometeorology. However, implementation has moved slowly, and based upon two reviews by the National Academy of Agricultural Research Management (NAARM) and by a Mission consultant, the Project is being streamlined to overcome cumbersome implementation procedures.

The new 7-year Plant Genetic Resources (PGR) Project is a major initiative to assist India to preserve its rich and diverse plant genetic resources, particularly for use in sustaining agricultural advances through traditional and biotechnology techniques. The Project is designed to (1) assist India to fully develop the physical, administrative and technical resources to manage a national system that will undertake all aspects of exploration, collection, preservation and exchange (nationally and internationally, public and private) of plant germplasm; and (2) to enhance India's regional and global capability of plant genetic resources conservation and use. The PRG Project is the largest A.I.D. biodiversity project in the world.

The Agricultural Science and Technology Exchange (ASTE) Project will be the first of two sectoral projects for the 1990s. This program will expand Indo-U.S. public and private research and education linkages to exchange production and management systems technologies in the agricultural and agro-industries. The central features of the ASTE Program will be a fund which provides financial grants to Indian and U.S. research entities (government research institutions, universities, private voluntary organizations, cooperatives, and commercial organizations) for mutually agreed-upon research and technology exchange activities. Such activities include technology transfer, collaborative research and cooperative research programs. All activities will be time-bound, output driven, reviewed and evaluated by peer groups, and require matching commitments from participating entities. The program will continue to strengthen the Indo-U.S. science and technology exchange linkages established over the decade of the 1980s.

This Project will also explore various means to enhance availability and exchange of information via linkages with USDA computer-based data management systems (i.e. CRIS - Current Resources Information System and GRIN - Genetic Resources Information Networks) as well as linkages with the NAL (National Agricultural Library). In addition, ASTE program participants will attend technical meetings, workshop and seminars and publish research results in internationally recognized scientific journals. This project's new "modality" is further discussed later in section IV.F.

C. Resource Management Systems

This set of activities involves improvement of technological capabilities to obtain and manage information to plan, guide, regulate and evaluate the development and utilization of natural resource systems. These systems include topsoil, substrata, surface water, aquifers, grasslands, forests, crops, wastelands, and wetlands. The specific objectives are:

- new natural resource information technologies and management systems;
- quality systems and operations research programs on land, water and biotic resource interactions; and
- improved empirical analyses and modelling for economic and environmental assessment of land and water resource development.

These objectives will be achieved by upgrading analytical skills and selected technologies of professional cadre in natural resource management systems (i.e. soil conservation, public forestry, irrigation etc.), and initiating Indo-U.S. collaborative research and joint ventures among institutions, consultants and interest groups in natural resource management.

This set of activities will address the planning and management constraints identified in the three irrigation and forestry evaluations by accessing the considerable U.S. experience with land and water management to assist India to deter a growing natural resource "crisis." It supports the concerted GOI efforts to modernize institutional and information systems in the agricultural sector. Modern resource planning and management methodologies and technologies such as remote sensing, adaptive or operational research, databases, geographic and management information systems, measurement and gauging networks and systems modeling enable large water, forestry and conservation public and private institutional networks to deal with site-specific land and water use problems. Pilot field activities will be required to test these systems, but these will generally be implemented through collaboration with or supplemental grants to other GOI or donors' loan projects.

The primary GOI implementing institutions will be the Planning Commission, Ministries of Water Resources and of Forestry and Environment, associated State departments, and concerned public and private institutes. Efforts will be made to establish self-sustaining professional, technological and commercial linkages in land and water resources management and conservation between the Indian and U.S. institutional networks. Activities will also be coordinated with the Embassy's science program and supportive of the Indo-U.S. Subcommission on Agriculture.

Several current and proposed bilateral projects will serve to implement this set of activities. First, the recent evaluations of both the Hill Areas Land and Water Development Project and the National Social Forestry Project are leading not only to streamlined management but also an emphasis on interdisciplinary systems planning and research and the application of new design, management, and conservation technologies to improve soil and water productivity. Opportunities for common activity and management between these and other projects will also be pursued. In discussions prompted by the drought, the GOI also informally requested A.I.D. grant-funded support in Groundwater Research and Training. This would be a collaborative program between the Ministry of Water Resources/Central Groundwater Board and the U.S. Geological Survey/Water Resources Division to introduce new technologies and methodologies for ground-water exploration, analysis and monitoring, with related technical training. Given the increasingly critical contribution (and consequences) of ground-water use in India, the Mission has included the start-up of this initiative within its restructured, national Water Resources Management and Training (WRM&T) Project and will decide later whether the second phase justifies a separate new project. This exemplifies Indo-U.S. collaboration in a nationally-vital aspect of land and water resources management.

In order to meet the increasingly common technology needs in land, water and biomass management, a cross-cutting Resources Analysis and Management Technologies Project will be designed as the other major sectoral project for the 1990s. It will assist the testing, transfer, application, and/or adoption of such innovations as solid-state sensors, resource database and management, hydrological/land-use models, satellite imagery applications, geographic information systems, and operations/systems research methodologies. The U.S. network of Federal and State agencies, universities, private consultants and/or firms would be the collaborative intermediaries; the Ministries of Water Resources and Forestry and Environment would provide GOI oversight and guidance. The project would involve dollar funding for the import of U.S. technologies and related services in land, water and biomass management. Some rupee funding would be provided to collaborating Indian institutions to cover local costs. Opportunities to complement other donor loans through technology and service "imports" would also be explored. This project's new modality is discussed further, later in IV.F.

Finally, based upon discussions with other donors, primarily the Japanese Overseas Economic Development Fund (OECF) and the World Bank, the Mission may provide very small grants for studies and research to complement and supplement large capital loans in irrigation, forestry or watershed development. Two immediate possibilities are small grants for planning studies to supplement an OECF irrigation loan in Orissa and a World Bank national watershed management project. Such small grants for technological inputs enable A.I.D.'s limited-funding to be more effective by "piggybacking" with the other donors' larger, less-flexible loan assistance. The Mission would identify joint-venture contractual arrangements and/or central project support (ISPANE, FENR, etc.) to minimize management requirements.

D. Policy Analysis and Study

Supplemental to and supportive of the primarily technological activities above, the new strategy will support efforts to study and analyze policy issues related to the applications of science and technology. As earlier discussed, certain government policies enable and encourage the application of science and technology to resource productivity problems. Yet, the mature and politically-charged nature of the Indo-U.S. relationship combined with A.I.D.'s small and decreasing program size do not enable direct, high-level dialogue with the GOI on internal policy issues. Moreover, recent GOI actions to improve pricing, regulatory and investment policies, often in the face of strong internal political pressure have been exemplary. Therefore, A.I.D.'s efforts will be limited to supporting study and analysis of specific policy constraints and effects through indigenous Indian institutions.

The agenda focuses on the specific sets of policies identified in the previously discussed sub-sectoral reviews and project evaluations which directly affect the application of science and technology to the productivity of natural resources use:

- the valuation, pricing and productivity of natural resource use in agricultural production systems;
- the mobilization of private enterprise and investment in the sector through ownership/access rights and deregulation; and
- changes in organizational roles, responsibilities and procedures in public sectoral institutions and their beneficiaries.

Natural resource valuation and pricing has a direct effect on the prudence or prolificacy of resource use, and provides the economic incentives necessary to ensure market demand for resource-saving technologies. This is no better illustrated than by the inefficiencies and environmental impacts of unregulated irrigation water or over-regulated phosphate fertilizers. This grouping, therefore, will include input pricing, resource access and utilization rights, economic and environmental assessments, conservation incentives and overall issues of natural resource productivity. These issues are of particular concern to the Planning Commission's Agricultural Division.

Private enterprise mobilization is the acknowledgement that private individuals have both the incentive and resources to carry out on a sustained basis the adaption and dissemination of new technology. This is critical to productivity-enhancing technological improvements. Sapling nursery management, seed production, or field-channel maintenance are all examples of activities cost-effectively carried out through private enterprise. However, this involves government sharing or divestiture of some of the rights and responsibilities for technology adaption, dissemination, and systems operations to interested retailers or end-users ranging from tree farmers and marketers and water user associations to agribusinesses and design consultants. It is often a question of the appropriate level and specificity of government regulations and is currently the subject of active public discussion throughout India.

Finally, as India's economy modernizes so must its institutions through changes in objectives, organization and procedures. As natural resources come under increasing pressure, State departments of irrigation and forestry must become resource managers and planners. As farmers become better informed, agricultural research must become more oriented toward dynamic markets and clients. Local groups also require new organizational mandates and roles, such as village panchayats, water or watershed user groups, etc. These changes are both prompted by and facilitate science and technology "translation" and include all institutions and groups involved in the process. Specific issues will include autonomy and delegation of authorities, organizational and manpower assessments, facilitated public-private sector linkages and limitations on transfers, opportunities for women, prerequisite dialogue with farmers, and new skills training. Decentralization is the guiding principle and is repeatedly emphasized by the Prime Minister himself.

To assist India with empirical study of policy effects, the Mission will support collaborative efforts by U.S. and international intermediaries with selected Indian institutions to inform and support public discussion on the effects of various policy alternatives. Initially, two intermediary international organizations will develop and implement these efforts: the International Food Policy and Research Institute (IFPRI) and the World Resources Institute (WRI).

IFPRI with Mission guidance and ICAR approval has developed a program and just received a large A.I.D. grant to begin implementing a broad policy study and research agenda on the following issues:

Economic Efficiency in Agricultural Growth: The economics and major

implications of technological change in agriculture.
- Future Growth in Fertilizer Use: Key policy issues in the future growth of fertilizer use covering the fertilizer response functions, farmers' constraints, and fertility management in dryland agriculture.
- Intensifying Irrigation and the Implications for Management: Projections of the likely impacts of alternative policy and investment decisions on food grains production, employment, and government expenditures, and an examination of alternative modes of organization and operation.
- Transfer of Agricultural Technology: The information base and communications underlying technology generation, dissemination and adoption of innovations and suggested improvements in the concerned institutions.
- Rural Infrastructure and Agricultural Growth: The relationships between rural infrastructure and growth, the relationships between the 'hard' and the 'soft' infrastructure, and understanding the impacts of the public investment policies.

WRI has just initiated work under a small AID grant to define a collaborative policy research agenda on natural resource productivity issues. Based upon an initial visit to India, WRI proposed to collaborate with a network of indigenous universities, research institutions and scientists to carry out research on the following topics:

- the impact of incentive programs on efficient external input use in irrigated/dryland agriculture and deforestation of public lands;
- 'rent seeking' behavior in irrigation in a specific watershed area and implications for improved state irrigation efficiency/equity;
- the 'greenhouse' phenomena effects on dryland and irrigated agriculture and water resources;
- policies affecting cooperative management of common property resources.

Outside of the IFPRI and WRI efforts, selected policy-related studies and analyses are also included in modifications to several projects. The Planning Commission Agricultural Advisors have expressed interest in economic impact and cost recovery issues studied under two current irrigation projects, MITM and WRM&T. The NSF Project will support changes in wood pricing and marketing and a major common property resource study. The HALWD Project will support studies and pilots in community management and irrigation cost recovery. Both of the new proposed sectoral projects, ASTE and RAMT, will also include follow on activities in organizational, research and common resource use policies.

E. Special Concerns

Biodiversity:

In India biodiversity can be viewed at three levels. The first level of immediate human interest encompasses the genetic pool of present and potential agronomic species and species producing bioactive substances. Since this gene pool provides the raw material for bio-technology, it is a crucial component of a science and technology directed program in which the common interest of society is immediate. This is currently addressed by the Mission through the Agricultural Research Project (ARP) and the new Plant Genetic Resources (PGR) Project. The Agroforestry Subproject of ARP encompasses a germplasm program in which regional centres are expected to lead their respective regions in a nationally-coordinated, agroforestry germplasm collection and screening program. The goal of the PGR Project itself is the preservation of India's plant genetic resources, particularly those of agricultural importance, through a greatly strengthened system for collecting, preserving and using indigenous and exotic plant materials. Thus, cooperation in biodiversity at this first level is a major part of the program under the new strategy.

The second level of biodiversity is that of the general landscape or human ecosystem. Here again there is direct human economic interest, for example integrated pest management systems. The greater the diversity of floral and faunal elements in the landscape as a whole, the greater the stability of the system in terms of reduced likelihood of large-scale outbreaks of pests and disease. Furthermore, the Indian subcontinent has for decades been subject to increasing deforestation, unsustainable agricultural practices, and lack of soil/water conservation practices. The growing extent of wastelands with near zero biodiversity and progressive aridification indicate the seriousness of the problem.

Progress is being made through A.I.D programs to address landscape diversity. The National Social Forestry Project is promoting research, testing and application of new technical models for mixed successional development and agroforestry mixed cropping systems. The Maharashtra Minor Irrigation Project and Hill Areas Land and Water Development Project are likewise promoting landscape biodiversity through catchment area treatment and watershed development programs. In this aspect of biodiversity the need is enormous. Given reduced funding levels and new science and technology thrust, the Mission will address these concerns through improving research and study on technological and organizational issues in watershed management, supplemental to other donors' large development loans where possible.

The third level of biodiversity is that most often embraced by conservation advocates, the "ecological diversity" of natural areas. With the intense population pressures on India's land, this level of biodiversity appears possible only in reserves and protected areas. Combined efforts of indigenous conservation advocates, international counterparts and the GOI are generating considerable public awareness and some successes. The Mission will assist in this effort through encouraging institutional linkages between indigenous advocacy groups such as the Bombay Natural History Society and international counterparts such as World Wildlife Fund, or professional exchange between entities such as the Indian Wildlife Institute and counterparts in the U.S. like the Fish and Wildlife Service. The proposed Resource Management Analysis and Technologies Project will be able to support such linkages.

Private Enterprise:

The Mission will continue to pursue opportunities to impact positively on privatization in India. The policy environment and current Mission activities have been described in detail in the FY89 ABS. In essence, privatization remains a highly-politicized option which is being pursued primarily by State governments facing financial losses with poorly-performing public sector organizations or manufacturing units. While Mission activities in support of privatization have primarily focussed to date on urban services, there are a number of opportunities in the agricultural sector. Some initial steps have been taken in both forestry and irrigation projects to encourage greater involvement of indigenous private enterprise: support of farm forestry, private seedling distributors, irrigation design firms, autonomous water and commons' user groups are all examples.

Two A.I.D. projects are directly supporting the growth of agri-business. Under the Program for Advancement of Commercial Technology (PACT) Project, several agribusiness-type R&D proposals have been supported. These involve spent-wash treatment by membrane technology of alcohol distillery waste; continuous de-waxing of rice-bran oil; synthesis of pheromones for pest control in cotton cultivation; high yield prime button mushrooms; and isoproturon manufacture. As PACT funds are only 30 percent committed, the Mission expects further agribusiness-type proposals.

The Center for Technology Development (CTD) Project, when obligated, will provide, inter alia, support to the food processing industries and for arid lands development in the State of Karnataka. The CTD project will be a channel for resources to strengthen cooperation among local industry, academic, financial and governmental communities. Karnataka State has placed strong emphasis on upgrading of the rural economy through commercialization of new products that can create backward linkages to farmers. The CTD will also serve as a channel for interaction between U.S. agribusiness firms and Indian companies anxious to expand their product line.

The proposed ASTE and RMAT Projects will also include possibilities to strengthen the Indian private sector by initiating Indo-U.S. joint ventures of both research/testing groups and planning/design consultants. The current link-up of Harza Engineering Co. with India's Consulting Engineering Services (CES) under the WRM&T Project is an initial example. Also, as discussed earlier, private enterprise mobilization will be a major thrust of A.I.D. supported policy studies and analyses in the sector.

Trade and Investment:

The scope for foreign direct investment in India remains limited by GOI policy, and actual investment is a fraction of the levels achieved in comparable countries such as Brazil, the PRC, and Mexico. India nonetheless represents a strong magnet for U.S. corporate interests because of its enormous internal market and growing middle class. In recent years, the United States has led the list of approved collaborations and also leads in direct investment. U.S. firms, while primarily interested in market penetration, are also beginning to approach India as a base for production-sharing (sourcing) and for research and development (viz. over 300 inquiries under PACT to date). Recent project experience in agricultural research and water resources indicates interest among Indian and U.S. consulting and technology groups for joint ventures.

In response to other guidance regarding the CDSS, the Mission is preparing a detailed investigation into Indo-U.S. trade and investment patterns and will formulate a strategy that addresses barriers to increased trade and investment, especially as it relates to science and technology cooperation. This work will be carried out in part by an American academic expert who has special interest in Indo-U.S. economic relations. The trade and investment strategy will not emphasize agriculture and agribusiness in particular, but will focus on broader policy parameters which impact all sectors of the economy.

F. New Modalities

As discussed earlier and in the CDSS, a more mature development assistance relationship with India calls for a new A.I.D. "modus operandi." Furthermore, reduced funding and staff levels and a new science and technology strategy force major changes in the way the Mission develops and implements projects. Fortunately, A.I.D.'s long relationships in the agricultural sector have yielded a range of activities and relationships upon which a new kind of program can be built.

Institutional Intermediaries:

Collaborative relationships based on mutual interests between U.S. and Indian counterpart organizations and institutions provide a sound, sustainable way to achieve A.I.D's development objectives with more professional maturity and less intensive management. The Mission has already initiated or is initiating several such collaborative institutional relationships in agricultural research, groundwater evaluation, and resource productivity policies. Most of these are funded by grants or PASAs, although there are several direct contracts involved. Key among them is the IFPRI-ICAR relationship described earlier which allows the Mission to be substantially involved in the agricultural policy debate without direct involvement. Others will include the U.S. Geological Survey, U.S. Fish and Wildlife Service, International Water Resources Association, International Irrigation Management Institute, World Resources Insitute, U.S. Soil Conservation Service, and appropriate institutes associated with various U.S. Universities. Also, there are several agro-business relationships which have been formed under the PACT project.

The Mission expects to identify and match-up a broader range of relationships over the next decade to include a larger number of self-interested and therefore self-sustaining relationships. It should be noted, however, that although A.I.D. can specify the nature and overall purposes and objectives of these relationships, decisions on specific activities and objectives will be made by the parties involved.

Therefore, the increased prevalence of intermediary collaborative relationships in the program will to some extent limit A.I.D.'s ability to mandate the specifics of the collaborative agendas.

Other USG Programs:

Given the prominence of science and technology interests in the Indo-U.S. relationship, several other U.S. programs encourage and support scientific, technological and related educational exchange. Two programs of specific relevance to A.I.D.'s development agenda and new directions are the Far Eastern Regional Research Office (FERRO) and the Science and Technology Initiative (STI).

FERRO is supported with the rupees generated from the PL-480 sales managed by the USDA. In January, 1987, the Department of State and the GOI signed an agreement establishing the U.S.-India Fund (Endowment) using the remaining U.S. PL-480 rupees (110 million dollars). The FERRO office supports a wide range of agricultural research activities of mutual interest to India and to the U.S. Research projects focus on applied aspects of forest, fruit, vegetables, cereal, legume and pulse improvement as well as basic studies into fungal toxins and taxonomy, insect behavior and pests and pesticides. Currently the office is funding nearly ninety individual projects ranging in value from $80-100,000 in rupee equivalents and averaging five years in duration. Continued funding is now firm and assured for the next ten years. In 1986 and in 1987, the USDA received approximately two million dollars equivalent of rupees to fund its program. This amount will increase in each of the next few years until a peak of approximately $4-5 million/year is reached in about four years. The Mission and USDA are exploring ways to cooperate in supporting certain research projects in the near future. An Embassy Agricultural Research and Education Council has just been set-up to ensure coordination among programs and to provide guidance to the Ambassdor and the Indo-U.S. Subcommission on Agriculture.

The Science and Technology Initiative (STI) with India is an example of a new approach to scientific cooperation which has three key design features. First, the program focuses on areas where both countries participate as scientific equals, with joint resources for mutual benefit. Second, endorsement by the U.S. President and Indian Prime Minister has given high visibility to the research activities and streamlined administrative procedures. Third, the high level of support has enabled STI to draw on some of the best scientific and engineering talent in both countries. STI includes four major research areas: agriculture, health, monsoons and photovoltaics. Agriculture research activities focus on Biological Nitrogen Fixation (BNF), Nitrogen Fertilizer Effiency (NFE) and biomass fuelwood production. The BNF work links leading U.S. and Indian research institutions to investigate molecular genetics, Rhizobia-legume symbiosis and basic investigations of Azolla and Blue-green algae. The NFE research investigates nitrogen use in paddy rice and upland soils systems. The biomass research is in the initial planning stage. These activities will also be coordinated with the Mission's overall program through the newly-formed research and education council.

New Types of Projects:

The new Indo-U.S. development relationship discussed earlier and in the CDSS emphasizes professional and technological exchange. Current A.I.D. (Handbook 3) project-type assistance is administratively-intensive, highly-structured and predictive; it places large demands on staffing and does not allow the flexibility necessary for the type of technological, demand-driven relationship necessary for timely responses to modern professional and institutional needs. Although the Mission has made modifications to key subsectoral projects (WRM&T and NSF) to broaden them and increase flexibility, the administrative and procedural requirements for both A.I.D and the GOI are still prohibitively intensive. Therefore, the Mission will explore the possibility of including more grants, cooperative agreements and under umbrella assistance projects such as the proposed grant-financed Agricultural Science and Technology Exchange (ASTE) Project. Another possibility might be a technology and professional "import" program along the lines of a Commodity Import Program (CIP) as defined in AID's Handbook 4. The latter could be a highly-responsive mechanism for the dollar-funded portion of a collaborative technology procedure placing the host-country requestor in more direct contact with appropriate donor suppliers.

The ASTE Project will explore new procedures under the aegis/guidance of the Indo-U.S. Subcommission on Agriculture to expand Indo-U.S. public and private, professional and institutional collaboration. Grants would be made to Indian, U.S. and international research entities (government research institutions, universities, cooperatives, and commercial organizations) for agreed upon activities in agricultural technology transfer, collaborative and cooperative research programs which are expected to benefit both sets of professionals involved. The first phase of the Program would be funded from the Mission's annual FN-103 development assistance program and would cover the U.S.-based dollar and India-based rupee costs of the activities described above. However, if the initial phase is successful it's expected that the demands of the program will quickly exceed the resources available. Thus, other financing sources will have to be considered/ identified such as a U.S.-India Fund spend down.

The Mission is actively engaged in dialogue with the GOI to resolve several key issues associated with the implementation of ASTE. The first is that much of the funding will be in the form of direct dollar contracts or grants to U.S. entities. Such funding may not have to be "reflected" in GOI budgets and could simply represent a level of access to U.S. science and technology, universities and research systems. Secondly, the variety of activities proposed may necessarily involve several different GOI agencies; thus, the responsibilities for the implementing agency need to be worked out and the process for obtaining clearances for technical exchanges simplified and regularized.

The Resource Analysis and Management Technologies (RAMT) Project will be configured as an umbrella for funding activities primarily involved with information technologies and systems research. Each will involve the ultimate generation of a pilot field installation of an information system, a systems model, or a mechanism for process propogation such as workshops or packages of training materials. Development or refinement of resource management technologies, microplanning systems, production systems, predictive and diagnostic process models, and teaching and extension methodologies are priorities. Development of resource information systems and data collection and analysis units will also be supported. The RAMT Project mechanism would be similar to ASTE.

G. The CDSS vs. Sectoral Strategy Objectives

The Mission's new CDSS outlined a strategy for the agricultural sector which shifted away from field-oriented programs and associated institution building in agriculture, forestry, and irrigation towards a new emphasis on the performance (rather than the creation) of institutional assets and capital investments. The performance and hence, productivity of these investments would be improved through the applications of biological production sciences and resource management technologies, and related policy changes. The relationship between this strategy for the agricultural sector and the Mission's overall longer-term program objectives is outlined below:

CDSS Objectives	Sectoral Strategy Objectives
Emergence of science and technology as the primary integrative focus	Focus on biological production sciences and resource manage ment technologies to improve the productivity of natural resource base.
Identification of new modalities for supporting efforts including stimulation of self-sustaining linkages between U.S. and Indian institutions	Initiation of several new Indo-U.S. linkages between research institutes, public agencies, land-grant university groups, private consulting firms, and agro-businesses
Phased reduction of traditional approach to program/project identification	New projects consisting of collaborative research grants, participating agency programs, technology and technological services funds, and a sectoral agricultural science and technology exchange program
Heightened sensitivity to the "mutuality of U.S. and Indian interests in identification of areas of cooperation"	U.S. environmental interest in India's soil, water and biotic resources; U.S. scientific interests in collaborative biotechnology research; U.S. commercial interest in trade relationships in agricultural science and resource management technologies in India.

H. Implementation and Staffing

The Mission has over the last year made major efforts to streamline its portfolio to minimize the A.I.D. management demands of the seven remaining large projects in irrigation, agricultural research and forestry. The Mission is combining the project management and technical offices in irrigation and forestry, expanding the use of intermediary contract organizations, and calling for greater responsibility on the part of government implementing agencies.

However, for the next two to three years the Mission will require a continued substantial staff to ensure adequate supervision redesign, and evaluation of the seven older projects, ARP, WRM&TP, NSFP, MSFP, MMIP, HALWDP and MPMIP (totalling approximately $270 million in A.I.D. assistance), and of one new project, PGR, while developing two or three new sectoral projects over the next few years. The current, well-qualified and experienced staff of FSNs will be able to carry out most of these project implementation responsibilities under guidance of four appropriately-experienced USDH supervisors and several science and technology advisors. JCC or contract advisors will fulfill a vital role in ensuring the technological and professional feed back necessary to guide the current program and implement the new strategy. Their expertise and professional relationships will be critical in developing the two major new collaborative programs described earlier, ASTE and RAMT.

After completion of the larger projects in FY 92, the program will consist primarily of the large ASTE and RAMT programs and smaller grants and could be managed by three experienced USDH officers supported by several FSN technical officers and two Advisors. Soon thereafter, the two agricultural offices would also be combined. This office configuration and staff size conforms to the substantially-reduced Mission operating funds and staffing foreseen for the 1990s. A project and staffing time-line follows under the next heading.

I. <u>Summary Matrix and Timeline</u>:

Overall, the targets of the new strategy can be illustrated in the following matrix form:

	Biological Production Sciences	Resources Management Technologies
Research/ Testing	. Nutrient Cycling . Post-harvest Processing . Disease/Pest Resistance . Multiple Crop/Agroforestry . Biodiversity	. Monitoring/Control Sensors . Hydrology/Land-Use Models . Geo-Information Systems . Remote Sensing Applications . Management Information Systems
	. Operations/Systems Research . Agro-meteorology	
Professional Development/ Exchange	. Post-Doctorate Study . Scientist Exchange . Senior Seminars . Research Workshops	. Cadre Modernization: Needs Assessment, Curricula Development, Training of Trainers, Pedagogic Methods and Technologies, Study Tours, Workshops, etc.
Policy Analysis/ Study	. Natural Resource Valuation . Input pricing and cost recovery . Common resource rights . Economic and environmental assessment . Private Sector Mobilization . Technology testing and marketing . Intellectual property rights . Cost sharing . Organizational/Procedural Change. . Decentralization and automony . Personnel policies . Beneficiary involvement	

Project Portfolio:

Project No. and Title	ProAg Date	Funding/Obligated $ 000s	Fiscal Year 89 90 91 92 93 94 95 96 97 98
0481 Maharashtra Irrg. Technology & Management	8/82	47000/47000	E XX
0483 Madhya Pradesh Minor Irrigation (Redesign)	7/83	46000/46000	E XXXXXXXXX
0484 Water Resources Management and Training (Redesign)	7/84	51000/30000	E XXXXXXXXX
0489 Hill Areas Land and Water Development (Redesign)	7/84	54000/52000	R XXXXXXXXXXXXXXXXX
0490 Maharashtra Minor Irrigation	7/84	50000/50000	E XXXXXXXXX
0478 Maharashtra Social Forestry	8/82	30000/30000	E XXXXXXXXXX
0495 National Social Forestry	6/85	80000/52000	E XXXXXXXXXXX
0470 Agricultural Research	6/83	20000/20000	R E XXXXXXXXXXXXXX
0513 Plant Genetic Resources	9/88		E XXXXXXXXXXXXXXXXXXXXXXXXX
0515 Agricultural Science and Technology Exchange(New)	90	20000/—	D XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
0000 Resources Management Analysis and Technology (New)	91	20000/—	D XXXXXXXXXXXXXXXXXXXXXXXXXXXX
0000 Water Resources Systems Research and Planning	92	10000/—	D XXXXXXXXXXXXXXXXXXXXXX
Grants: IFPRI	9/88	400/2900	XXXXXXXXXXXXXXXXXXXXXXXXX
WRI	89		XXXXXXXXXXXXXXXXXXXXXXXXX

Note:
E indicates Evaluation
R indicates Restructuring/Redesign
D indicates Desgin

Office and Staffing:

	Fiscal Year 89 90 91 92 93 (Combine Offices) 94 95 96 97 98
Office of Agricultural Research and Education (ARE)	
Office Director USDH-SADO	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Deputy Director USDH-ADO	XXXXXXXXXXXXXXXXXXXXXXXXXX
Project Officer FSN	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Project Officer FNPSC	XXXXXXXXXXXXXXX
Project Officer FNPSC	XXXXXXXXXXX
S&T Advisor JCC/USPSC	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Office of Natural Resources Management (NRM)	(Combine Offices)
Office Director USDH-SADO	XXXXXXXXXXXXXXXXXXX
Deputy Director USDH-ADO	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Project Officer FSN	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Project Officer FSN	XXXXXXXXXXXXXXXXXXXX
Project Officer FSN	XXXXXXXX
Project Officer FNPSC	XXXXXXXXXXXX
Project Officer FNPSC	XXXXXXXXXX
S&T Advisor JCC/USPSC	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
S&T Advisor JCC/USPSC	XXXXXXXXXX

Contractors/P.A.S.A.s and Grantees

Winrock International
Louis Berger International-w/WAPCOS
Sheladia Associates
Harza Engineering Co. w/ CES
U.S. Geological Survey
International Food Policy Research Institute
World Resources Institute
U.S. Soil Conservation Service
International Irrigation Management Institute
University of Pennsylvania
University of New Mexico
Colorado State University
Utah State University

J. Sectoral Performance Benchmarks:

The effects and national "payoffs" of science and technology in natural resource productivity are not easily measured in the short-term, less so in a country of the size and heterogeneity of India. For example, the surge in U.S. agricultural production did not occur until 60 years after the establishment of Agricultural Research Stations (Paarlberg, 1988). The impact of the Green Revolution technologies introduced in India in the late 1960s was not fully appreciated for a decade. Nor would any authoritive source gauge the promise of biotechnology. However, over the last two years the Mission has undertaken three major studies of agricultural productivity issues (Seckler, Daines and Evenson) and five evaluations of its sub-sectoral projects (ARP, NSF, Maharashtra Irrigation, HALWD, and WRM&T). These have enabled substantiation of the productivity effects of a range of resource management and agricultural research activities, and prompted significant changes in the projects to emphasize those activities which result in highest returns. This strategy is a product of these efforts and its implementation will be measured by similar efforts.

The Mission does plan to undertake a comprehensive overview of appropriate indicators to track program-level progress later this FY in conjunction with its Action Plan. Indicators for the program in the agricultural sector will be finalized at that time. Examples of indicators that appear appropriate for the sector include the following:

1. An improved scientific knowledge base in support of improvements in agricultural productivity and natural resource sustainability. Examples might include: new germ plasms available for the production of higher yielding, drought-resistant, or less fertilizer-intensive crops.

2. New technologies applied to specific improvements in the management of India's land, water, and biotic resources. Examples should include such things as the use of remote sensing for improved planning and monitoring or management information systems to improve operations.

3. Improved or new collaborative relationships and linkages between U.S. and Indian organizations involved with agricultural productivity and natural resource sustainability. Examples would include agricultural scientists and agricultural institutions and universities involved in Indo-US collaboration projects or an exchange program of foresters or water resource engineers.

4. Increased public debate on policies

that constrain agricultural productivity and natural resource sustainability. Examples would include deregulation of wood marketing or regulations enabling water user associations or cost recovery in irrigation systems.

5. Institutional/human resource capabilities to make effective use of the new knowledge and technologies. Examples might include a national center established for surface and ground water resource analysis or new planning cells within State irrigation or forestry departments.

The Mission also intends to continue an active project/PD&S-funded effort of program evaluations and productivity studies. The Mission's evaluation unit has been strengthened with a full-time USDH, a USPSC and an FNPSC specialist and the PD&S request for FY89 includes a study of resource productivity trends. Two irrigation projects are also slated for evaluation in 1989. The sectoral science and technology advisors will actively participate in these evaluations and studies to ensure continuation of an iterative monitoring process.

Based upon the objectives of the existing project portfolio the following group of physical and institutional output indicators are foreseen:

* 250,000 hectares under diversified, higher-value crops due to reliable irrigation.
* 200,000 hectares of degraded, public lands stablized with mixed plantings.
* 500,000 hectares of private land producing commerical wood products.
* 10,000 engineers and 2,000 foresters trained in-country in improved resource management.
* 500 irrigation and 200 forestry officers participated in U.S. training programs.
* 50 agricultural scientists and ten agricultural universities involved in Indo-U.S. collaborative research projects.
* Institutional data management and analysis systems installed and operational in Irrigation and Forestry departments in at least five States.
* Permanent, budgeted in-service training programs within State Irrigation and Forestry Departments.
* Private firms and Indo-U.S. joint-ventures engaged in water resources planning and design.
* Use of computerized information systems for planning and monitoring by three State Irrigation and Forestry Departments.
* Information systems connecting Indian agricultural and natural resource institutions to world-wide information networks.
* Six Indian institutions carrying out program-related policy studies in collaboration with U.S. professionals.

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A NEW STRATEGY FOR A.I.D. IN INDIA'S AGRICULTURAL SECTOR

Applications of science and technology
for sustainable increases in the productivity of
India's soil, water and biological resources

ANNEXES

November 29, 1988

USAID/India

55

TABLE OF CONTENTS

ANNEXES

56

ANNEX A

Executive Summary of USAID/India's Country Development Strategy Statement

I. The Development Environment

India has just weathered one of this century's worst droughts, an event which just 20 years ago would have spelled economic and human disaster on a massive scale. India's resilience in the face of the drought is the best recent evidence we have of the remarkable progress it has made since Independence. This includes virtual self-sufficiency in foodgrain production and industry; the improvement of socio-economic conditions with life expectancy increasing by 33 percent, literacy by nearly 90 percent and infant mortality declining from 146 per thousand to 90 per thousand.

Macroeconomic performance, low but steady at a 3.5 percent average annual growth of GDP during the first 35 years of independence, elevated to a new plane of 4.9 percent per year in the 1980s, bringing India within reach of middle-income status by the end of this century. The deepening of its institutional and human resource base and the increasing sophistication of its response to many of its most critical development problems are critical factors uderlying these achievements.

Notwithstanding these accomplishments, India remains one of the world's poorest countries with 40 percent of its people below the poverty line, a stubbornly persistent population growth rate above 2.0 percent and an increasing strain on its financial, institutional and natural resources. India's primary challenge in the next decade will be to sustain and accelerate its recent achievements in the face of these pressures.

It is unlikely that significantly greater amounts of resources can be generated from domestic or foreign sources, at least in the near/medium term. Only by increasing the productivity and efficiency of its resources and investments across the board, will India be able to maintain a growth path to middle-income status in the next 12-15 years.

India has begun to recognize this problem, at least in the industrial sector; it has embarked on a liberalization program which, while slow in its pace, has accelerated industrial growth and stimulated exports to the highest levels ever. Efficiencies in agriculture, energy and the social sectors must be pursued as well, however, if growth is to proceed on an equitable, as well as steady basis.

II. Strategy Summary

The new strategy presented in the CDSS represents, in our view, the convergent streams of several interrelated forces: India's rapidly evolving status as a modernizing Asian economy, the identification of an appropriate role for U.S. assistance in the context of this modernization and a realistic assessment of the resources that will be available to us in the coming years.

It is an evolutionary strategy which is meant to play off our two nations' primary strengths in laying the groundwork for a new relationship in the 1990s. To accomplish this, however, we must reverse many of the assumptions which governed our strategy throughout the early 1980s; to wit, that AID could make a major impact on Indian poverty through resource transfer programs in agriculture, forestry and health; and we must reinforce our conviction (and those of many eminent development theorists and practitioners who have helped us think through our role in India) that the most appropriate focus for U.S. assistance to India in the 1990s is a strategy based on the contributions of science and technology to economic growth, productivity gains and poverty alleviation.

A. Science and Technology as a Strategy

Science and technology have always played a critical role in solving development problems; this is reflected in the achievements of the Green Revolution, the fight against malaria and the development of family planning technologies. Our current program contains many projects which address similar sectoral problems and objectives. We have come to understand, however, that when a country such as India reaches a stage of relative sophistication in its science and technology infrastructure and it begins to devote increasing amounts of resources to science and technology (India spent one percent of its GDP on S&T in 1986-87), many cross-cutting constraints and issues relating to the environment and "process" of science and technology become a legitimate focus for attention.

This process refers to the stages of development that every technical product or system must go through, including basic and applied research, testing, adoption and commercialization. Some of the needs we have identified which affect the application of science and technology in India across the board include improvement of the quality of research, increased communication and exchange of information, the translation of technology into useful products and greater attention to S&T policy issues. In this CDSS we have chosen to address both the generic constraints to an efficient S&T process in India and the accelerated solution to sectoral development problems through an expanded emphasis on science and technology. Thus, our objectives are:

1. To support the establishment of an efficient science and technology process.

2. To promote sustainable increases in the productivity of land, water and biotic resources for improved systems efficiencies through the application of new agricultural production and resource management technologies.

3. To enhance India's capacity to improve public health through increased systems efficiencies.

4. To increase the efficiency of energy generation and use in the Indian economy.

58

Each of these objectives will be pursued by improving India's institutional and human resource capacity to apply new scientific methodologies and technological innovation.

B. Poverty Alleviation

We believe that the long range solution to India's heavy burden of poverty is accelerated and sustained economic growth. However, we also believe that shorter range "safety-net" programs can have a major impact on easing the worst features of poverty. We will continue to play a critical role in this area through the integration of our child survival and Title II food aid programs, through increasing attention to the gender implications of poverty and through our shelter-based urban development program.

C. Program Modalities (How To Do It)

This CDSS does not present a phase-out strategy but it does begin laying the foundation for a replacement of traditional bilateral AID activities with elements of a new, more collaborative relationship based on mutual interests. It proposes an increasingly large role for non-project activities, collaborative research and exchange programs like the Science and Technology Initiative (STI) and exploration of an endowment relationship.

To accomplish this task, a virtual overhaul in the way we do business in India will have to take place. We propose to begin this process now and we seek flexibility from both India and AID/W in support of this process. Flexibility will be required in the way we obligate our funds (bilaterally vs. unilaterally), in the consideration of alternate sources of resources (monetization of food aid, loan reflows) and in the oversight responsibility we are expected to maintain for "non-traditional" activities.

We believe it may be appropriate for a senior AID delegation led by the Bureau Assistant Administrator or the Agency Counselor to discuss the future of the AID program in India with the GOI in the near future.

INDIA'S LAND AND WATER RESOURCES

Located in South Asia with extensive coastlines on both the Arabian Sea and the Bay of Bengal, India, covering a territory of 3.28 million square kilometers (about two-fifths the size of the continental U.S.), is the world's seventh largest country in terms of land. The Indian subcontinent, a region which India occupies along with Pakistan, Nepal and Bangladesh, may be divided into major geographic regions: the Himalayan region, formed by the mountains of the North; the Indo-Gangetic Plain, the generally flat area which forms an east-west band varying from about 160 to 480 kilometers in width south of the Himalayas; and the tableland which forms most of the triangular Indian or Deccan peninusla. Together the Himalayas and the Indo-Gangetic Plain are referred to as Northern India, while the peninsula is called Southern India.

I. DESCRIPTION OF THE MAJOR GEOGRAPHIC REGIONS

A. Himalayan

The Himalayas, the world's highest mountains, comprise three ranges: most spectacular are the great or main Himalayas with heights of up to 6,000 meters; fringing these to the South are the lesser Himalayas, with peaks of 1,500 to 3,600 meters; between the lesser Himalayas and the Indo-Gangetic Plains run the outer, or southern Himalayas, a system of low foothills with heights ranging from 300 to 1,000 meters. As illustrated in Figure 1, an important formation of this outer fringe are the Siwaliks, a highly erodible hill range composed mostly of loosely consolidated materials with some sand and silt.

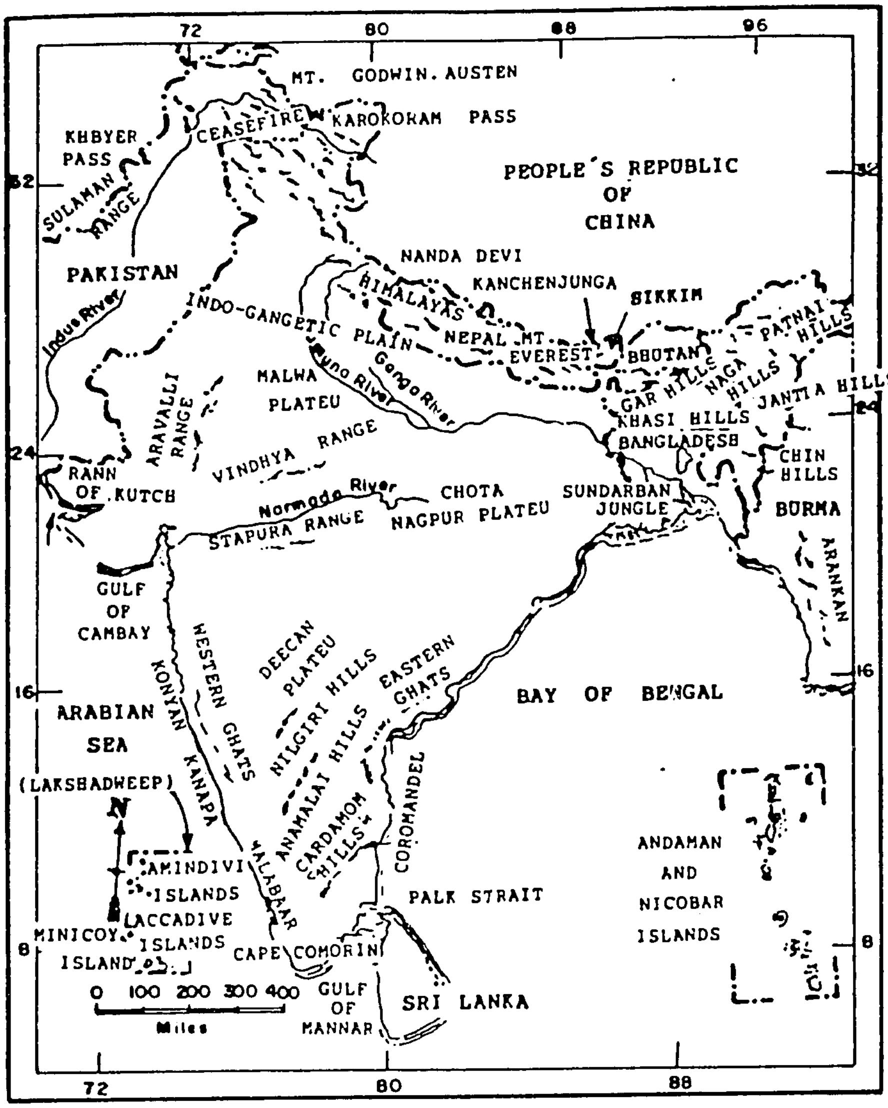
Much of the Himalayan range falls outside of India, in Nepal, China and Pakistan. These mountains, however, play an important role for the country. They are the source of the most important rivers of the region: the Ganges or Ganga; the Brahmaputra; and the Indus, most of whose flow is outside of India itself. These rivers not only bring water but also carry loads of silt which enrich the soils of the Indo-Gangetic plains. Furthermore, the Himalayas exert important influences on the climate of India, forming a barrier to keep out the cold northern winds from Tibet and serving as a screen in which the important monsoon system operates.

Within the Himalayan ranges the southern slopes are generally too steep to allow either snow accumulation or more than sparse tree growth. The northern slopes, on the other hand, are generally forested below the snow line. Between the ranges are deep gorges, and in some places, fertile valleys such as the Vales of Kashmir and Kulu. Economic activity is limited within the Himalayan region, although there are important agricultural activities such as the tea plantations of Darjeeling and in the last 30 years apples and other temperate fruit have become increasingly important. Subsistence grazing is by far the most widespread activity.

60

Figure 1

MOUNTAINS AND PLAINS OF INDIA



B. Indo-Gangetic Plain

The Indo-Gangetic Plain, covering about 780,000 square kilometers, runs some 2,400 kilometers from the delta of the Brahmaputra in the east through Pakistan to the border of Afghanistan in the west. Once a gulf running between the Himalayas to the north and the Plateau to the south, the Plain is actually a trough that over the centuries has been filled with alluvium, as deep as 3,000 meters in some places, carried from the mountains in the north. The Plain varies in width from 160 kilometers in the east to 480 kilometers in the west. The Indo-Gangetic plain has several sub-regional geographic groupings: the Indus Delta, Kathiawar and Kutch, much of which falls in Pakistan; the Thar Desert of Rajasthan; the Ganges Valleys; the Ganges-Brahmaputra Delta; and the Brahmaputra Valley. The portion of the Indus

Delta falling within India, designated as Kutch, is a desolate, wind blown region consisting of hard salt flats for half of a normal year and swamps for the other half. To the south and east of Kutch, the peninsula of Kathiawar has sections as high as 600 meters even though it's generally considered to be low in elevation. The Thar or Rajasthan Desert is an arid region whose only year round river, the Luni, does not produce flows that are significant enough to compensate for the low level of rainfall. Much of the area is covered by a veneer of loose soil and rock materials of varying thicknesses, below which is a base of crystalline rock of the same type which also underlies the Deccan peninsula.

The Ganges Valley, a region of wide rivers, level plains and fertile alluvial soils, has for centuries been the center of economic and political life in the Indian subcontinent. Much of this area consists of an active floodplain, on which rivers constantly shift their channels. The rich soil of this low-lying area is called "khada," while the less fertile soils of the higher areas or "doabs" are called "bhangar." The proportion of "khadar" to "bhangar" increases from west to east, until east of Patna (the point of convergence of most of the major tributaries of the Ganges), "bhangar" almost completely disappears. Villages in the Ganges plain are found mostly on bluffs and levees to avoid the potential danger of rapidly rising floodwaters.

To the north between the Gangetic plain and the lower foothills of the Himalayas was a swampy, malarial area, extending northwards into Nepal, known as the Terai. Before the middle of this century the Terai contrasted sharply with the plain immediately to the south because of its sparse population, the prevalence of malaria, and its abundant wildlife; drainage and mosquito control have now brought the area into production. To the east of the Ganges Valley proper is the Brahmaputra Valley, which like the Ganges Valley is also fringed by a low marshy area known as the "duars." This valley also exhibits the contrast between active floodplain and doab, but here the floodplain dominates. South of the Brahmaputra Valley in northeastern India is the Shillong Plateau, an upland area geographically isolated from but actually belonging to the crystalline block that forms the southern peninsula. With heights of up to 1500 meters, the plateau is characterized by rolling hills.

C. Southern (Peninsular) India

The Deccan (southern) peninsula is a geologically very old and stable area. The Deccan peninsula proper, that area south of the Satpura Range and the Chota Nagpur Plateau, is a large block that has been upraised and tilted towards the east. It is composed for the most part of crystalline rocks and metamorphized sedimentary rock, which in the northeastern quarter of the peninsula are covered by a thick sheet of basaltic lava. The uplifting of the plateau block and its inclination toward the east was responsible for the formation along its western edge of a line of hills (the western Ghats), some of which reach heights of 600-900 meters. The western ghats run in an almost unbroken chain from the Tapti river in the north about 1600 kilometers to the tip of the peninsula in the south. Along the eastern side of the peninsula run the eastern Ghats, a disconnected series of hills marking the eastern edge of the plateau. Because of the eastward tilt of the peninsula, most of the significant rivers of southern India have courses that run west to east.

The Deccan plateau itself is a series of plateaus covered by rolling hills and intersected by many rivers. For the most part it consists of thin soils underlain by crystalline rocks, although alluvial soils occur in areas where rivers have deposited silt along their banks. This crystalline shield underlying the peninsula holds India's most significant mineral deposits: iron ore, bauxite, manganese, gold, chromite and copper. The balsatic lavas of the northeastern quarter, occuring in thicknesses of up to 3,000 meters in the area of Bombay, provide the basis for the fertile black soils that are characteristic of this area. Towards the tip of the peninsula, where the western Ghats and the easter Ghats converge, are several hill areas, including the Cardamon Hills. These hills, with their waterfalls, are also the site of important hydroelectric projects as well as many of the country's tea and rubber plantations.

Fringing the peninsula along its entire extent is a generally continuous coastal plain. On the western side the plain is narrower in the north (the Konkan coast), where it is more characterized by tidal marshes, drowned valleys and estuaries, than in the south (Malabar coast), which is an area of elongated lagoons, marshes and intervening beach ridges. The coasts of the eastern peninsula, considerably wider than the western coasts, are dominated by the deltas of large rivers, which have become the focus of settlement and other human activities.

To the north of the Deccan peninsula proper are the Central Highlands of India, dominated by two ranges, the north-south Aravalli range and the east-west Vindhya range. The former is the dominant chain of southern India consisting of eroded Pre-cambrian crystalline rocks, which gradually lost height toward the north. New Delhi is built on the last spur of the range, just before it is lost in the Indo-Gangetic plain. The Aravallis serve as a barrier to the encroaching Thar Desert in the west, while the Malwa Plateau, running between the Aravallis and the Vindhya Ranges has served for centuries to channel movements of people and political power from Delhi to southern India. The Vindhya range and the Narbada River directly on its southern flank have provided a major route westward from the Arabian Sea to the Gangetic Plain at Benares. Other ranges are the Satpura in the western sector; Mahadeo, Mailkal and Bhanrer hills in the center; and the Kaimur, Hazaribagh and the jungle hills of the Chota Nagpur occur in the west. The Chota Nagpur plateau of southern Bihar in the east is the site of extensive mining and industrial development, centered in Jamshedpur.

D. Off-Shore Islands

Comprising only about 0.25 percent of India's total territory are two sets of offshore islands. The first is the Andaman and Nicobar Islands (about 8,300 square kilometers) in the Bay of Bengal, which are actually closer to the Malay peninsula than to India itself. The second set is the Laccadive, Minicoy and Amindivi Islands (together as the Union Territory of Lakshadweep covering only about 30 square kilometers) off the Malabar coast in the Arabian Sea. The heavily forested, low-lying, and thinly populated Andaman and Nicobar Islands are a center of timber production, while fishing and coconut farming are the major economic activities of the low-lying, densely populated islands of Lakshadweep.

II. Soils

Indian soils have been classified into 25 broad groups based on variations in the parent materials, a wide range of climatic conditions, and varieties of vegetation. This classification is indicated on the map contained by Figure 2 which lists the soils by the Indian territory in which they occur, and their equivalents according to the USDA classification. Four major soils groups: red, black, alluvial and laterite soils occupy nearly 65 percent of the total geographical area of India.

A. Red Soils (groups 1 & 2)

Occuring in both high and low rainfall areas, red soils are shallow to deep (20 to more than 100 cm), with a surface texture ranging from light to medium and from sandy to loamy. Red loamy soils have a pH which is neutral or slightly on the acid side, with a pH as high as 8.0 in those soils containing lime. Red sandy soils have a pH generally on the acid side (from 4.5 to 6.5), but some may also be alkaline. Available moisture ranges from 5 to 10 percent which is low to medium. Because of evapotranspiration needs, the stored moisture of a staurated red soil profile will sustain a standing crop from only two to four weeks. These soils, therefore, are mostly used for crops depending on the monsoon rains (kharif). With regard to soil nutrients, these soils are generally low in nitrogen, low to medium in phosphorus and medium to high in potassium. The soils present no drainage problems when irrigated.

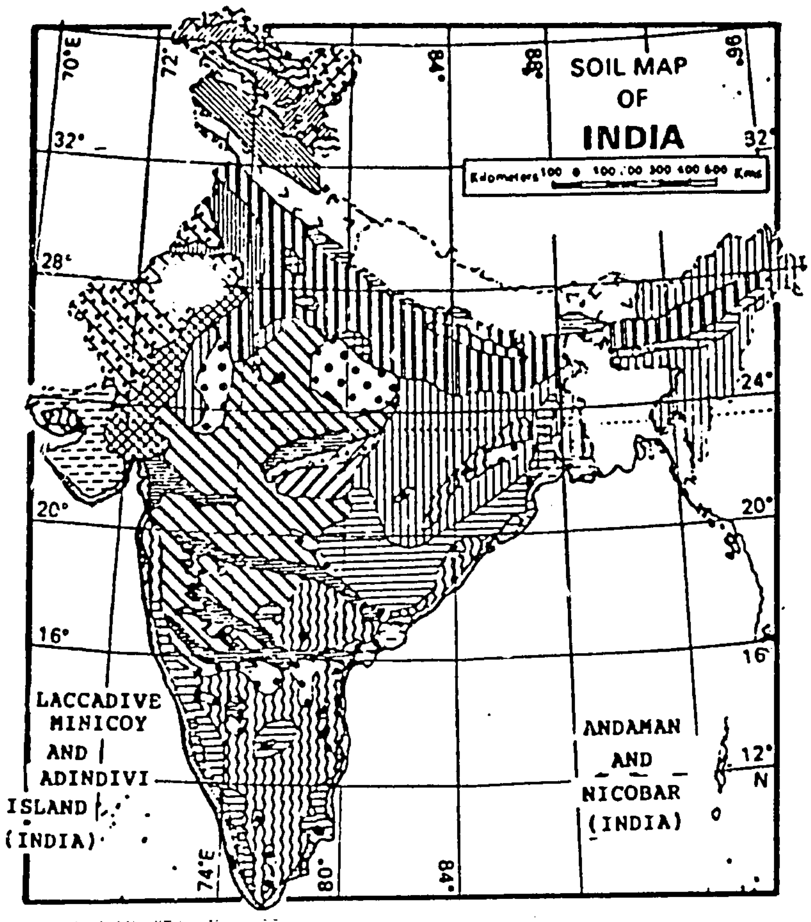
B. Black Soils (groups 5,6,7,8)

Occurring in regions of low to medium rainfall (500 to 1220 mm per year), the majority of the black soils are medium deep (30 to 100 cm) with some deep black soils reaching depths as great as 200 centimeters. The texture of the soils is generally heavy, clay content ranging from 40 to 60 percent; they are plastic and sticky when wet and very hard when dry. Available moisture capacity varies from about 12 to 20 percent depending on the texture. Stored moisture is low in shallow black soils, which are, accordingly used only for kharif crops. The nutrient status of black soils is generally low to very low. The soils have low infiltration and permeability rates, and drainage and erosion are major problems. Provisions are therefore required to provide drainage and soil conservation when these soils are brought under irrigation.

C. Alluvial Soils

With the exception of those occurring in the Brahmaputra valley, most of the alluvial soils in the Indo-Gangetic basin occur in areas with rainfall

Figure 2



SOIL MAP OF INDIA

LEGEND

1 red loamy
2 red sandy
3 laterite
4 red and yellow
5 shallow black
6 medium black
7 deep black
8 mixed red and black
9 coastal alluvium
10 coastal sands
11 deltaic alluvium
12 alluvial: recent old
13 alluvial (highly calcareous)
14 calcareous sierozemic
15 grey brown
16 desert/regosolic
17 desert/lithosolic
18 terai
19 brown hill (over sandstones and shales)
20 sub-montane (podsolic)
21 mountain meadow
22 saline and alkaline
23 peaty and saline peaty
24 skeletal

varying from 500 to 1000 mm per year. These soils are deep and variable in texture, with soil moisture, correlated with silt content, ranging from 6 to about 20 percent. For those alluvial soils with coarse to fine loamy textures, available moisture is about 12 to 15 cm per 100 cm of soil column, which make them capable of supporting a standing crop for 4 to 6 weeks or even longer in winter, when evapotranspiration needs are lower. These soils are used for both kharif and rabi crops. The soils are mostly base but low in available nutrients. Much of the region of alluvial soils is under irrigation. Problems with these soils, especially in places where the water table is high, are salinity and alkalinity.

D. Laterite Soils

Occurring chiefly in areas of rolling to undulating topography and on steep slopes in regions of higher rainfall (1200-3000 mm), the laterite soils are deep, well-drained and medium to fine in texture, with favorable available moisture capacity (8-16 cm per 100 cm of soil column). Rainfall occurs from May to November in laterite soil areas, which suffer from a moisture deficit during the remainder of the year.

E. Other Soils (16 and 17)

The desert soils occurring chiefly in Rajasthan are mostly coarse textured with a weak horizon development. Some contain a high percentage of soluble salts (predominately sodium) in the lower horizons. The pH is high and hard pan of CaCo3 (calcium carbonate) occurs at shallow depths. The soils are poor in organic matter and are frequently subjected to drought. Kharif crops are sown when rainfall is sufficient, although some irrigated Rabi crops are also grown.

F. Mountain Soils (19, 20, 21)

The mountain soils are of course mainly found in the Himalayan region. Brown hill soils, from loam to silt in texture and occuring in the foothills of the Siwalik ranges, are moderately rich in organic matter, with a pH that is neutral to slightly acidic. Sub-montane soils, mostly loam to sandy loam, are acidic and non-calcareous. Their surface layers, extending to 10 to 15 cm, consist of undecomposed organic matter. The mountain meadow soils are characterized by a sandy loam texture, shallow depth, weakly developed horizons and neutral to alkaline in pH.

III. FORESTS

Forest types and distribution are shown on the map contained in Figure 3. The map only indicates areas where the type of forest or vegetation is native to that area. As discussed in the last section of this annex, much of the vegetation has been removed from many of these areas by animal and human populations. Figure 3 shows the density of forested area in relationship to area for individual Indian states which is indicative of where forests still occur.

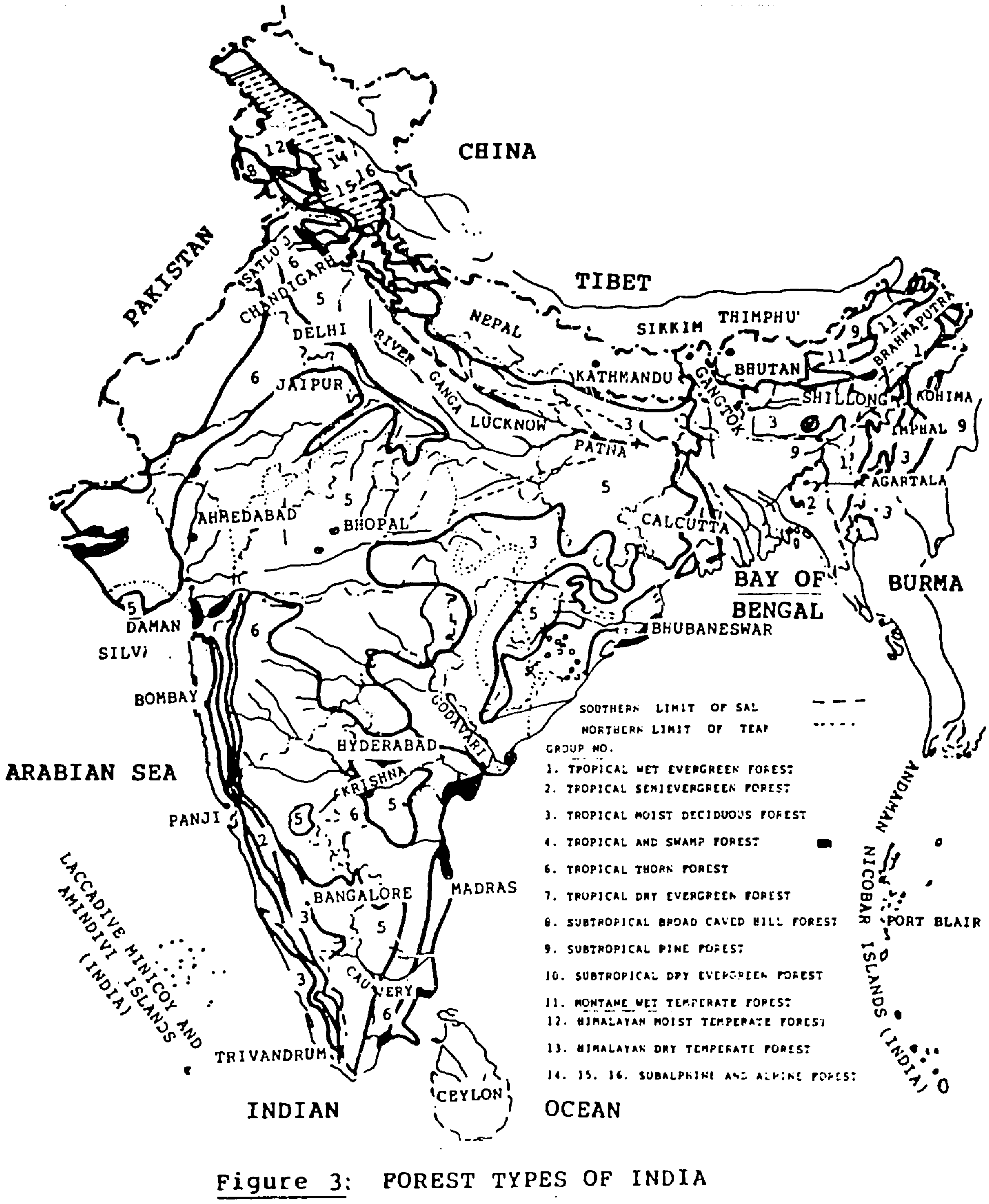


Figure 3: FOREST TYPES OF INDIA
(DIAGRAMMATIC)

A. Moist Tropical Forests (1-4)

1. Tropical Wet Evergreen Forests

Southern tropical wet evergreen forests occur on the Deccan peninsula (Maharashtra, Karnataka, Tamil Nadu and Kerala) and in the Andaman Islands. The most widely distributed genera are Dipterocarpus and Hopea, while other typical genera are: Guttiferae, Anacardiaceae, Sapotaceae, Meliaceae, Artocarpus, Eugenia and Elaeocarpus. Northern tropical wet evergreen forests, occurring in West Bengal, Assam, and Orissa, are very similar to their southern counterparts. Dipterocarpus and Shorea form the only large trees. Lauraceaa, Magnoliaceae, Quercus, and Castanopis are more important and varied than in the south, and bamboos are more usually present in the south.

2. Tropical Semi-Evergreen Forests

In the southern area these occur only in the moist western Ghats. Typically occurring deciduous species are Xylia and Terminalia, but evergreen Dipterocarpus, Balanocarpus and Hopea also occur. Bamboos are usually present. In the northern areas these are found in the moderately heavy to heavy rainfall areas of Assam and Bengal, extending down the east coast of the peninsula to Puri in Orissa. The forest is dense-storeyed high forest with evergreens (chiefly Syzgium, Cinnamomum, Magnoliaceae and Artocarpus) predominating, particularly in the lower canopy, but with a mixture of deciduous trees, particularly Terminalia, Tetrameles, and Stereospermum. Bamboos are often absent.

3. Tropical Deciduous Forests

In the southern area these occur only in the moist western Ghats. Typically occurring deciduous species are Xylia and Terminalia, but evergreen Dipterocarpus, Balanocarpus also occur. Bamboos are usually present. In the northern areas these are found in the moderately heavy to heavy rainfall areas of Assam and Bengal, extending down the east coast of the peninsula to Puri in Orissa. The forest has the same characteristics described for the tropical wet evergreen forests in the northern areas described above.

4. Tropical Moist Deciduous Forests

Nearly half of the Andaman Islands are covered with tropical moist deciduous forest with species such as Pterocarpus dabergiodes and Terminalia spp. Moist deciduous forests have existed in all parts of south India with medium rainfall. These closed high forests are found in M.P., Gujarat, Maharashtra, Karanataka, and Kerala. They include the important teak bearing forests (Tectona grandis). Other important species are Terminalia spp., Pterocarpus spp., and Lagerstroemia spp. Tropical moist deciduous forests in northern India occur in U.P., Bihar, Orissa, West Bengal, Assam, and M.P. and are quite similar to their southern counterparts. However, sal (Shorea

68

robusta) replaces teak as the ecologically characteristic and economically most important species.

5. Littoral and Swamp Forests

Also designated as beach and dune forests, littoral forests are distributed all along the coast, wherever permitted by a fair width of sand beach. The most common species is the tall evergreen but very light foilaged Casuarina often fringes the sandy beaches. In the Andamans, Manilkara littoralis occurs in its place. Considerable tidal swamp forests occur in the mouths of creeks and short rivers, while remnants occur at the estuaries of the Mahandadi, Krisnana and Godavari rivers on the east coast but very little on the west coast. The most dominant species of these forests are mangroves (Rhizophoraceae). Mangrove scrub occurs in the river deltas along the edge of tidal waterways on sheltered muddy coasts from Gujarat to Bengal and is common over a large area of western Sundebans, while actual mangrove forest is more common on the muddy coasts of the east side of Bengal.

Tropical freshwater swamp forests (fairly dense evergreen closed forests, dominated by Myristica magnifica) occur in tropical hill valleys in the Himalayan and other regions and in low lying sites in the Brahmaputra Valley. Tropical seasonal swamp forests with species such as Alotingia excelsa, Machiulus gamblei, and Szygium cumini, occur in the Ganges and Brahmaputra valleys, while tropical riparian fringe forests dominated by Terminalia arjuna and Lagerstremia species are found along the banks of most of the large streams in the hilly tracts.

B. Dry Tropical Forests (5 to 7)

1. Tropical Dry Deciduous Forests

Southern tropical deciduous forests occur throughout the Indian peninsula with the exception of the moist western Ghats: M.P., Gujarat, Maharashtra, A.P., Karnataka, and Tamil Nadu. It merges into thorn forest wherever the rainfall drops below 750 mm. There are two basic types: those in which teak occurs and those non-teak bearing forests where Anogeissus and Terminalia, accompanied by Diospyros, Bosellia and Sterculia dominate. Bamboos are often present. Northern tropical dry deciduous forests occur throughout northern India, except in the overly moist and the overly dry eastern parts; the most extensive occurrences are in U.P., Bihar, Orissa and Punjab. Teak and other southern species do not occur in these forests. The most common species are those common to the moist deciduous forest and the dry thorn forest including: Anogfeissus latifola, Buicnanania lanzan, Sterculai, Bauhinia spp., and Terminalia tomentosa. Three types of sal forest occur: dry Siwalik, dry plains and dry peninsular forests. Only one species of bamboo occurs.

69

2. Tropical Thorn Forests

Southern tropical thorn forests occur in the dry peninsular tract to the lee of the western Ghats from the extreme south up to Indore and Bhopal. They are most important in Maharashtra, A.P., Karnataka, and Tamil Nadu. These are open low forests dominated by thorny usually hardwood species, particualarly Acacia spp. Apart from Acacia and related genera there are fleshy Euphorbiae, while Capparis and Opuntia also frequently occur. Tropical thorn forests occur in semi-arid regions of U.P., M.P., and in the major portion of the semi-arid regions of the Punjab, Rajaputna, and northern Gujarat. Aside from their smaller stature, these forests differ little from their southern counterparts.

3. Tropical Dry Evergreen Forests

Low tropical dry evergreen forests, from 9-12 meters in height with a complete canopy, are found only on the Karnataka coast with the most dominant species being Manilkara (Sapotaceae), Mimusops elengi, and Memecylon edule.

C. Montane Subtropical Forests (groups 8-10)

1. Subtropical Broadleaved Hill Forest

Southern subtropical broadleaved hill forests are native to zones of about 1000 meters and 1,700 meters on the higher hills of southern India, and also above 1,000 meters on the higher hills of central India. Eugenia (Szygium) are characteristic genera and Lauraceae are generally present, while Memcylon and other Melastomaceae usually occur. These forests mostly occur on steep hillsides in south India and the western Ghats; throughout the rest of the peninsula their habitat is mostly hilltops. Northern subtropical broadleaved hill forests occur on the lower slopes of the eastern Himalayas from about 1,000 meters up to 2,000 meters above sea level. This type is characterized by oaks and chestnuts (Quercus and Castanopsis). Other temperate genera are Alnus, Prunus and Betual. A few Dipterocarps occur whereas pines are absent. Subtropical wet hill forests (dense evergreen forests) occur in the upper slopes of the Khasi, Jaintia and adjacent hills in Manipur, Tripura and Assam. Dominant species are oaks (Quercus spp.), Beilschmiedia, Saurauja, and Engeihardtia.

2. Subtropical Pine Forests

Forests of Pinus roxburghii are found throughout the whole length of the western and central Himalayas from the Northwestern Frontier to Sikkim and West Bhutan between 1,000 meters and 1,800 meters extending on ridges down to 600 meters, and up to 2,300 meters on southern hillsides. This pine forest does not occur in the Kashmir. In the Khasi, Nagi, and Manipur hills, forests of Pinus insularis occur at similar altitudes. Pine is the predominant naturally occuring species creating an environment inimical to most broadleaved trees. Quercus is the most typical broadleaved associate along with Rhododendron, Lyonia, and Syzygium cumini.

3. Subtropical Dry Evergreen Forests

These low, practically scrub forests of small-evergreen trees and scrubs occur in Bhabar, the Siwalik hills and the foothills of the western Himalayas, extending up the main valleys to about 1,000 meters above sea level. Predominant species include the olive (Olea cuspidata) and Acacias (Acacia modesta), as well as Dodnaea viscosa.

D. Montane Temperate Forests (groups 11-13)

1. Montane Wet Temperate Forests

Southern montane wet temperate forests of low height occur in the higher hills of Tamil Nadu and Kerala. Important tree growth species include Ternstroemiaceae and Eugeniae, along with Melioosma, Eurya, Symplocos, and Lauraceae. Rhododendron nilagiricum is common and conspicuous. Northern montane wet temperate forests occur in the eastern Himalayas from Eastern Nepal eastwards on the higher hills of Bengal and Assam from 1,800 to 3,000 meters above sea level. Oaks and chestnuts characterize the forest at higher altitudes, while laurels (Lauraceae) are abundant and more numerous than oaks at lower levels. Also present are Magnoliaceae, Engelhardtia, Schima as well as maples (Acer), Prunus and Ulmus.

2. Himalayan Moist Temperate Forest

This forest habitat extends along the whole length of the Himalayas between subtropical pine forests and the sub-alpine formation with a rainfall between about 1,000 and 2,000 mm. The habitat is found in Kashmir, H.P., Punjab, U.P., the Darjeeling district of Bengal, and Sikkim at altitudes from about 1,500 to 3,300 meters. This forest area is characterized by the prevalence of conifers, the chief genera being Abies, Cedrus (Deodar), Picea, Tsuga, and Pinus. Cupressus and Taxus also occur. The confeirous forest tends to be open, with tree heights between 30-50 meters. Among the broadleaved trees, of increasing occurrence in the eastern part of the range, several species of Quercus predominate, while Rhododendron also occur. Temperate deciduous trees, including Acer, are usually of low height (10-20 meters). Dwarf bamboos occur extensively in some areas.

3. Himalayan Dry Temperate Forest

These forests occur in the inner ranges of the Himalayas, where the southwest monsoon is weak and where such precipitation as occurs comes mainly as snow in the winter months. These are essentially open forests, exhibiting closed canopies only in some areas. Coniferous trees are the dominant species; whereas broadleaved trees occur only occassionally, attaining poor heights. Xeropytic shrubs are common. The most characteristic conifers are Cedrus deodora, Pinus gerardiana and Juniperus, but Abies and Pinus wallichiana occur at higher elevations. Broadleaved trees are represented by xerophytic species such as Acer, Fraxinus and Quercus.

2. Alpine Scrub

Several types of alpine scrub associations occur beyond the tree line in the higher reaches of the Himalayas: Birch-Rhododendron scrub forest dominated by the latter and Betula utilis, Dwarf Rhododendron scrub, dry alpine scrub, and Dwarf Juniper scrub.

IV. Land Resource Problems

A. Overgrazing

India's livestock population has grown from 292 million in 1951 tc 416 million in 1982. GOI's Animal Husbandry Department estimates that livestock production accounts for 10 percent of the GNP. Table 1 describes the growth of livestock categories over three decades. The rapid change in the composition of the livestock population during this period reflects the influence of a number of environmental and economic factors. Sheep and goat populations have increased in part due to rising meat prices and because both are relatively better than bovines at making productive use of low quality pasture and fodder.

Table 1: Total Livestock Population 1951-82 (millions)

Year Category	1951	1961	1951-61 % Change	1972	1961-72 % Change	1977	1982	1972-82 % Change
Cattle	155	176	+13	179	+2	180	191	+7
Buffalo	43	51	+18	58	+13	62	69	+19
Sheep	39	40	+3	40	-0	41	48	+20
Goats	47	61	+29	67	+11	76	101	+50

Source: Indian Center for Science and Environment

Table 2 indicates the magnitude of the feed/forage deficit to maintain the current livestock population. The lack of productivity in the current cattle population is reflected by the disparity between available feed/fodder and the minimal level needed for maintenance. Two social factors compound the problem of unproductive cattle. One is the attachment of status to ownership of cattle irrespective of their productivity. The other lies in natural death being the only socially acceptable means of disposal.

Table 2: Feed Requirements and Production, 1985-86 (MMT)

Type of Feed	Estimated Requirement	Estimated Availability	Estimated Deficit
Crop residues	168	142	-26
Grasses	288	283	-5
Green Fodders	290	32	-258
Total Deficit			-289

Source: National Dairy Research Institute, Karnal

Land that is used solely as pasture accounts for only 4 percent of India's total agricultural land area. This plus crop residues from grazing cultivated lands after harvest are still inadequate to maintain the high livestock density in many regions of the country. Much of the above deficit is made up through grazing in forested areas and lopping of trees for livestock feed. As a result, biomass regeneration in the non-cultivated areas is becoming increasingly problematic.

Moreover, soil compaction and removal of plant residues through grazing reduces the productivity of both rangeland and cropland. Overgrazing of clear cut and partially stocked forest areas has exacerbated both soil erosion and land degradation by retarding natural grass and forest regrowth. The reticulated pattern of livestock paths on hillsides is the ubiquitous signature of growing pressure on local land resources throughout most of India.

B. Deforestation

Remote sensing data indicates a loss of 9 million ha. of tree cover between 1972-75 and 1980-82, the equivalent of 1.3 million ha. per year. Since 1982 the estimated annual loss of forest cover has increased to 1.5 million ha. Consequently, only about 36 million ha., roughly 10.9 percent of India's total area, is considered to support good forest cover. This is defined as an area with a continuous canopy greater than 30 percent. The figure on the next page illustrates, according to the latest government statistics, the changing status of forests in India. Little more than half of India's legal forest area is classified as having good forest cover. Failure to make a distinction between legal forests and actual forests limits the utility of official forest statistics for purposes of analysis. The term forest simply does not imply any particular level of stocking with trees.

Figures for the total public forested area differ according to the source. Forest Department records show 74.9 million ha. whereas the NWDB and the World Bank estimate the forested area to be 67 million ha. Table 3 presents land use according to the latter. Part of the discrepancy may be explained by the loss of 4.3 million ha. of forest land to various encroachments since 1950. Only 3 million ha. of land outside of public holdings are covered with tree crops and orchards. Although 1.7 million ha. were afforested in 1986-87, growth of these plantings are not yet sufficient to be picked up by remote sensing devices.

The problem of deforestation is closely linked to the problems of fodder and fuel availability, since trees are exploited by villagers for both fuelwood and dry season fodder for cattle. A survey of all-India fuelwood use in 1979 indicated that 35 percent of wood fuels came from state forests, 36 percent from farmers' fields, and 8 percent from roadsides (Table 4). 1987 World Bank estimates place total present consumption of forest based products at 230 million cubic meters (MCM) out of which 130 MCM comes from bushes and woody matter other than trunks. Industrial demand is estimated to account for 30-35 MCM of the total. The total (sustainable) yield increment of standing forests (trunks) is currently estimated by the GOI at only 35 MCM. The annual shortfall in wood for fuel/industrial purposes is consequently estimated at 65 MCM.

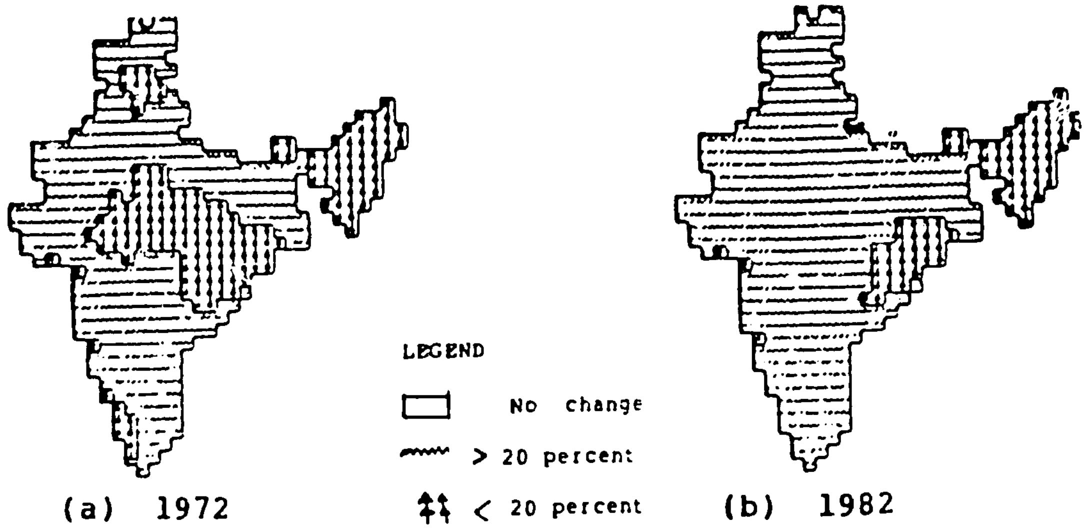


Figure 4. a&b.
Area with more than 20% and less than 20% forest cover for the years 1972 and 1982.

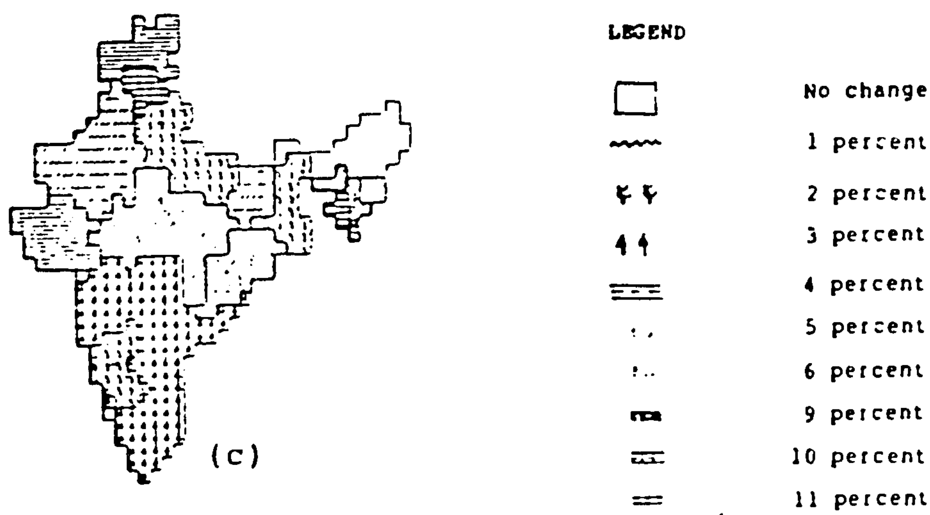


Figure 4 .c.
Statewide breakdown of percent of area of forest cover loss for the years 1972 and 1982.

Table 3: Land Use in 1986 (million hectares)

Land use Category		Total Area	Dryland	Degraded
Total land area		329.0		175.0
Estimated productive land area		266.0	188.0	130.0
Agricultural land		143.0	96.0	40.0
Irrigated	47			
Rainfed	96			
Legal forest (productive)		67.0	37.0	35.0
Closed canopy	36			
Open & degraded	31			
Tree crops/orchards		3.0	3.0	
Culturable wasteland		17.0	17.0	17.0
Fallow land		16.0	16.0	16.0
Pasture land		13.0	13.0	13.0
Alkaline lands		7.0	7.0	7.0
Unculturable wasteland		21.0		21.0
Urban land		18.0		
Unknown (unassessable)		24.0		

Source: NWDB, Ministry of Environmental Forests, 1986

Table 4: All India Fuelwood Use by Source, 1979 (000 MT)

Source	Logs	(%)	Twigs	(%)	Total	% of Grand Total
Own farm	5440	21	19624	78	25064	36
Forest	4827	19	19490	80	24317	35
Roadside	1333	8	14858	92	16191	23
Other	297	9	3134	91	3431	6

Source: Natarajan, 1985.

As India's per capital consumption in paper alone is only 2 kg/annum as compared to 257, 37, 26 and 13 kg/annum for the countries of U.S., Malaysia, Brazil and Turkey, respectively, the estimated industrial shortfall in wood is indicative of a much more substantial shortage. Moreover, as India's economy develops further the industrial share of the total demand for wood is expected to increase significantly. A look at total consumption indicates that overcutting of existing forests and plantations is as high as 300 percent.

Aggregate views of supply and demand for forest products can, however, be quite misleading in terms of developing a strategy to address the problem of deforestation. The use of fast growing species might be expected to alleviate the wood shortage and thereby be both worth of popular support and effective in curbing the rate of national deforestation. Experience in India has shown that such an expectation is naive. India's afforestation strategy must be considered in terms of demand for particular kinds of forest produce, land use and tenure patterns, silvicultural systems and market infrastructures.

15

C. Soil Problems

Soil problems, as occurring with different soil types, affect more than 20 percent of the country's soils. These are erosion, salinity and alkalinity; acidity; waterlogging; and drought resulting in moisture stress.

1. Erosion

Erosion is a major and growing problem as a result of deforestation, increased cropping intensity and rapidly growing animal populations. The worst type, gully erosion, associated with heavy rainfall, swollen rivers and floods occurs with different degrees of severity. At its most extreme it produces deep ravines. This most often occurs during heavy monsoons and is particularly severe in the plains and river valleys of the Jamuna River in U.P. and its tributaries. It is relatively unimportant in the Himalayas and in most of peninsular India. The worst region of gully erosion is along the lower Chambal valley; the other problem areas outside of U.P. are along the Sabarmati and Mahi Rivers of Gujarat.

Sheet erosion is also of widespread occurrence. It occurs during periods of heavy rainfall and particularly affects slopes, being most severe in the steep scarps and deforested hillsides of the peninsular uplands and the Himalayas. The large quantities of sediment carried down into the plains each year by Himalayan rivers is a result of sheet erosion. Wind erosion is a major problem during dry periods when soils are loose and fields are cropless. It is most severe in desert areas of Rajasthan, in the Gujarat Plain, and in the friable and loose alluvial soils of the Indo-Gangetic plain west of the Kosi River. It is also troublesome in the arid tracts of peninsular India, to the lee of the western Ghats. The states most severly affected are Rajasthan, Punjab, U.P., and Bihar. Wind erosion is supposedly inconsequential in the Himalayas, the mountains of the northeast, the Assam valley and the Ganges delta.

2. Salinity and Alkalinity

According to the GOI's Ministry of Environment and Forestry, approximately 8.0 million hectares are affected by salinity and alkalinity, resulting in 20-25 percent reduction in yields for 1.0 million ha. and larger reductions for the remainder. These problems occur chiefly in areas of red, black and alluvial soils. Frequently, the problem is aggravated or brought about by irrigation, which may cause salts accumulated just below the surface to rise. Improperly drained alluvial soils may also experience these problems. On the coast of the Deccan peninsula, salinity is caused by intrusions of seawater. These problems are most severe in Gujarat.

3. Acidity

Acidity occurs chiefly in those high rainfall areas such as the Himalayas, the western Ghats and the Assam valley, where heavy rainfall has led to leaching of bases from the soils. High quantities of available

16

aluminum, manganese, and iron and the absence of calcium and magnesium in these soils adversely affect crop growth. The laterite and red-yellow soil areas of the peninsula are particularly acid.

4. Waterlogging

Waterlogging has many causes: the restriction of the flow of water by construction of roads, railroads, airports, canals and buildings; the obstruction of natural drainage by culverts and bridges; and the rising watertable in canal irrigated areas. At least six million ha. are affected by waterlogging in India. Over half of these are caused by surface flooding (West Bengal, Orissa, A.P., Punjab, U.P., Gujarat, Tamil Nadu, and Kerala), while the remainder results from a high water table affecting the root zone of plants. Canal irrigation affected some 8,000 ha. in Punjab and Haryana alone.

C. Degradation of India's Land Resources

Table 5 compares India's total land, total agricultural land and total forest area to that considered by the GOI as degraded and wasteland. Of the total area, about 130 million ha. (53 percent of the total) are considered as degraded. The table further breaks down degraded land into its major problem areas. Another subset of degraded lands defined by the GOI is wastelands. Wastelands are degraded lands that have been misused to the point that they are no longer productive. As these wastelands (74 percent of the degraded land total) are all part of different watersheds they can be further characterized by the tendency for most precipitation to run off with little percolation into the soil. Often there is no soil of any kind left, only exposed parent material with patches of subsoil in hollows and cracks. Wastelands also include vast expanses of pebble deserts with areas of thin topsoil containing tiny patches of bunchgrass, weeds and prickly bushes and/or scrub trees.

Wastelands fall into three types of ownership patterns: forest, revenue and private. Forest lands account for 28 percent of the total wastelands (or 36 million ha.) which suffer heavily from deforestation and wind/water erosion. Non-forest lands account for the remainder (72 percent or 94 million ha.) of the total. Of these non-forest wastelands, about 75 million ha. is private land and the rest is considered to be revenue land. The Revenue Departments have no institutional capability to manage any of its lands (14 percent of India's total land area), given the increasing pressure of human and animal populations. Recent surveys indicate that only 20-59 percent of the latter is still in the control of State Revenue Departments which gives some idea of the scale of encroachment.

The problems of soil salinity and alkalinity are primarily problems of agricultural land and its use. Although there are non-agricultural lands affected by these problems, their quantity is relatively insignificant. Most of the agricultural lands beset by these two problems will return to production under improved water management (irrigation/drainage), adoption of tolerant plant and tree species, and in the worse cases expensive chemical treatment. Despite existing and any new technologies that may be developed to bring degraded land (including wastelands) back into production, little will come about through their adoption unless the pressures of livestock grazing are alleviated. This is discussed further in another annex.

Table 5: Wastelands in India (millions of ha.)

Category	Area (million ha.)	% of Waste-land Area	% of De-graded Area	% of Total Land Area
Land area	329.0			100.0
Agricultural land	143.0			43.0
Forest lands	67.0			20.0
Degraded lands	175.0		100.0	53.0*
a. Water erosion	90.0		51.4	
b. Wind erosion	60.0		34.3	
c. Water logging	6.0		3.4	
d. Saline/alkaline	8.0		4.6	
e. Shifting cultivation	4.0		2.3	
f. River action, mining, etc.	7.0		4.0	
Wastelands**	130.0	100.0	74.2	40.0*
a. Forest land	37.0	28.0		
b. Non-forest land	94.0	72.0		
i) Private land	75.0	57.6		
ii) Revenue*	19.0	14.6		

Source: Society for the Promotion of Wasteland Development, 1986

* Area and percentage breakdown by category and subcategory do not add up to total because of overlaping classifications on the same land

** The wastelands category is a subset of degraded lands.

V. Water Resources

India's water resources, as summarized in Table 6, can be characterized by, first their enormous size and variety (4000 billion cubic meters annually in torrential Himalayan rivers, in deep Gangetic alluviums, in seasonal deccan streams, and in sodden coastal swamps); and, second by their fundamental irregularity and imbalance. In most of India over 90% of precipitation is within a three-month monsoon period and then, with a mean variability of about 30%.

The variability and brevity of the monsoon and its consequences for the resource base, require major water resource planning, development and management efforts to ensure adequate waste supply for a fast growing agricultural sector, not to mention the smaller but high-value requirements of power, industry, urbanization and water management. To date, India has developed tens of billions of dollars of infrastructure, which utilizes only about 14 percent of this water resource almost entirely for irrigation and power.

Table 6: Water use in India (1978-1979)

Category	Million Ha-M)	
A. Total water resources potential	400.00	
B. Utilizable water resources potential	93.6	25% of (A)
C. Current withdrawal of water	55.0	59% of (B)
D. Current share of irrigation	52.0	95% of (C)
E. Anticipated share of irrigation (2000 AD)	77.8	85% of (B)
F. Ultimate irrigation potential	113.0	63% of (IB)

From Sarma et al. (1980).

A. Northwest Basin Areas

The signigicant characteristics of the hydrology of these relatively arid areas (Punjab, Haryana, Northern Rajasthan and Western Uttar Pradesh) are regular surface flows from Himalayan sources and substantial groundwater in underlying alluvial aquifers. These characteristics are reflected in the level of agricultural development in these areas. Irrigated wheat yields in Punjab, for example, are about 60 percent higher than those achieved in Madhya Pradesh. This is largely due to the relatively more stable and more reliable water supply provided by surface systems supplemented by private groundwater sources.

In the case of groundwater, the reliability is due to the fact that water control rests in the hands of the cultivator. Farmers can access aquifers and usually use groundwater conjunctively with rationed surface supplies. In surface systems, more regular inflows due to snowmelt, a scarce but reasonsably assured supply, and the fairly widespread adoption of rationed, rotational water distribution (Warabundi) provide farmers with a limited but fairly reliable supply of water.

Thus there is a degree of certainty around which cropping and input use decisions can be made. Under these circumstances farmers in this area tend to switch to higher value, but more stress sensitive crops. These water supply systems, along with other input factors, result in over 50 percent of the nation's foodgrain production being supplied by this region.

B. Central and Western Deccan Regions

The central and western Deccan regions (most of Rajasthan, Madhya Pradesh, Andhra Pradesh and Maharashtra) have highly irregular and more limited supplies of both surface and groundwater. Supplies for gravity systems depend on an erratic monsoonal regime. In this area irrigation is still in an expansion phase, often concentrated on new project identification and construction rather than on operations. Groundwater sources are limited and localized. Generally groundwater supply is difficult to predict. Moreover where surface irrigation systems provide a source of recharge, groundwater can be a significant supplemental supply. The more limited and less predictable supply of water, and the increasingly competitive demands for it, coupled with more challenging hydrology, topography and soils, demand careful planning and management of water resources. Given the excellent agro-climatological

14

conditions for higher-value crops and access to regional and international markets, the returns to irrigation can be extremely high.

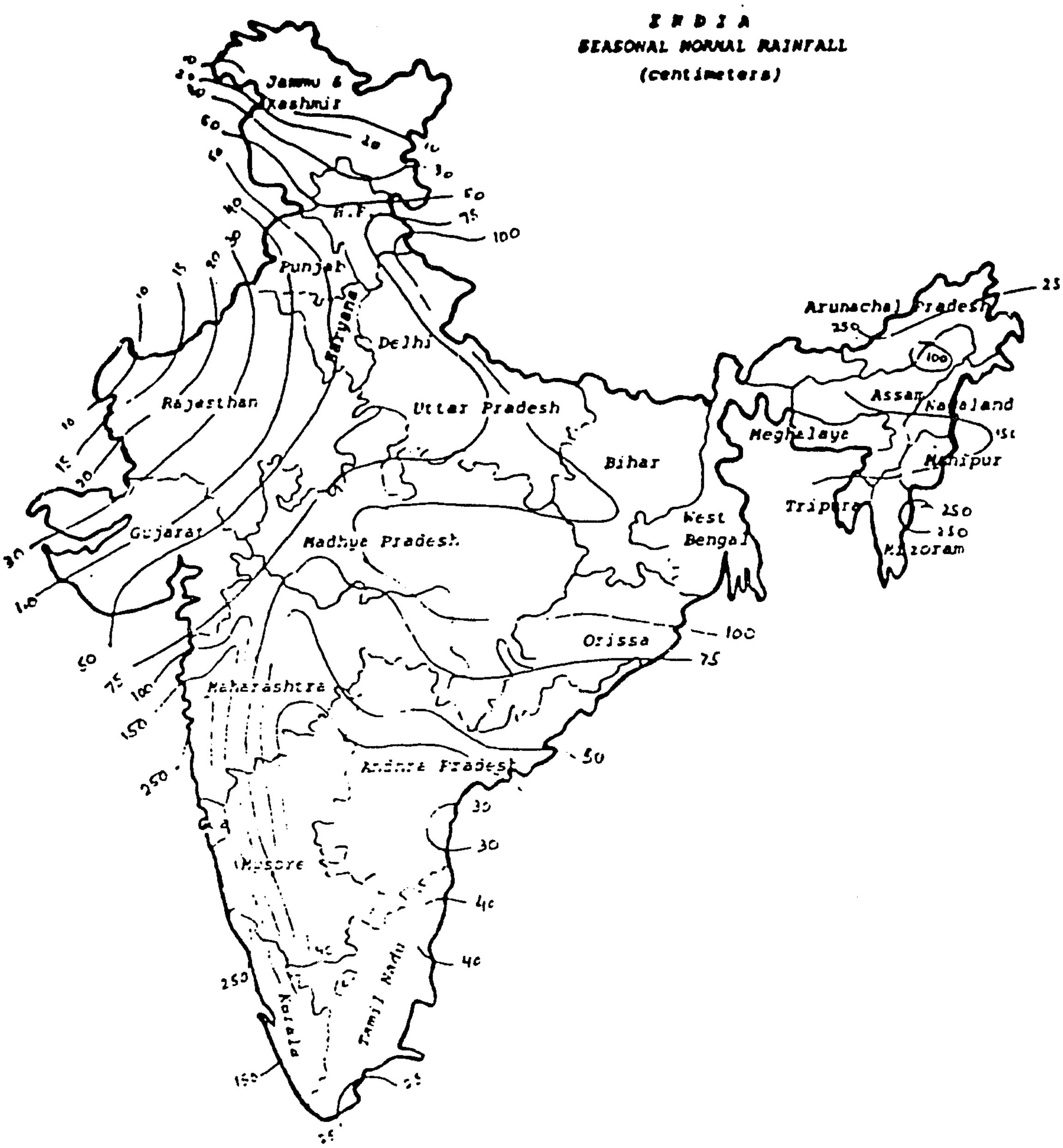
C. South India

The southern areas (Tamil Nadu and Kerala) have largely harnessed the available surface irrigation potentials. These states now face the challenge of managing existing systems better. Despite somewhat higher rainfall than in the Deccan, seasonal water shortages and inter-state competiton for water are important issues in the region. Irrigation development in these areas is in a mature phase with emphasis on rehabilitation and better operation of existing systems as well as comprehensive efforts in water resource systems planning and management.

D. Eastern Gangetic Plains

These fertile plains (eastern Uttar Pradesh, Bihar, West Bengal) contain major alluvial aquifers, both shallow and deep, as well as monsoon fed surface sources. Flooding and drainage are the major physical constraints. The largest exploited irrigation potential lies here - about 12 million hectares. The deep, fertile soils, combined with the large underutilized groundwater potential in this area hold future promise for high payoffs in terms of production, employment and poverty alleviation. However, this potential remains elusive due to the complex socio-economic and institutional constraints, i.e. land tenure, socio-political power structure, input delivery systems, and the under investment in roads and rural electrification.

INDIA
SEASONAL NORMAL RAINFALL
(centimeters)



ANNEX C

Population Growth, Rural Asset Distribution and the Labor Force

I. Population Growth and India's Future (Source: Dr. Warren Robinson, Penn. State, USAID JCC Demographer, 1987)

Concern over the country's rapid population growth goes back to the earliest efforts at planning in India and even before that. India has had an official policy aimed at reducing fertility since 1952 and has made progress towards that goal. Yet the current and likely future pictures remain disturbing. A few points can be noted:

A. Average annual growth is still well over 2.0 percent (the UN's FAO uses 2.3 percent currently) and has declined very little if any over three decades. Slight fertility declines have been matched by mortality declines. India's population will approach the one billion mark by the year 2000 and, shortly thereafter, surpass that of China. At present rates the population will double in some 40 years.

B. The proportion of married, fecund women using some type of contraception has increased but is still only about 30 percent. For reasons that are now clear, recent (last five years) increases in contraceptive prevalence have not been accompanied by corresponding declines in fertility, suggesting other off-setting pronatalist forces at work, such as declines in the incidence of breast feeding. Thus, the end of rapid growth is not yet in sight.

C. These continuing rapid increases in population inevitably mean increases in the labor force of a scale which has saturated rural India. Even with very optimistic assumptions about agricultural growth, agriculture can not supply the amount of new, productive employment opportunities that are needed.

D. There has been a massive upsurge in rural to urban migration. This first showed clearly in the 1971-81 census results but has accelerated since then. Presently most large urban areas are growing at 5 to 6 percent per annum. India presently has 12 cities of over 1 million but soon will have 25 such cities.

E. This rural to urban migration has swamped the cities of India, resulting in deterioration in the availability of public services, of the environment and of the quality of life in general. It also creates growing pressure on urban-industrial labor markets, on public relief agencies, and on the entire political and social fabric of Indian society.

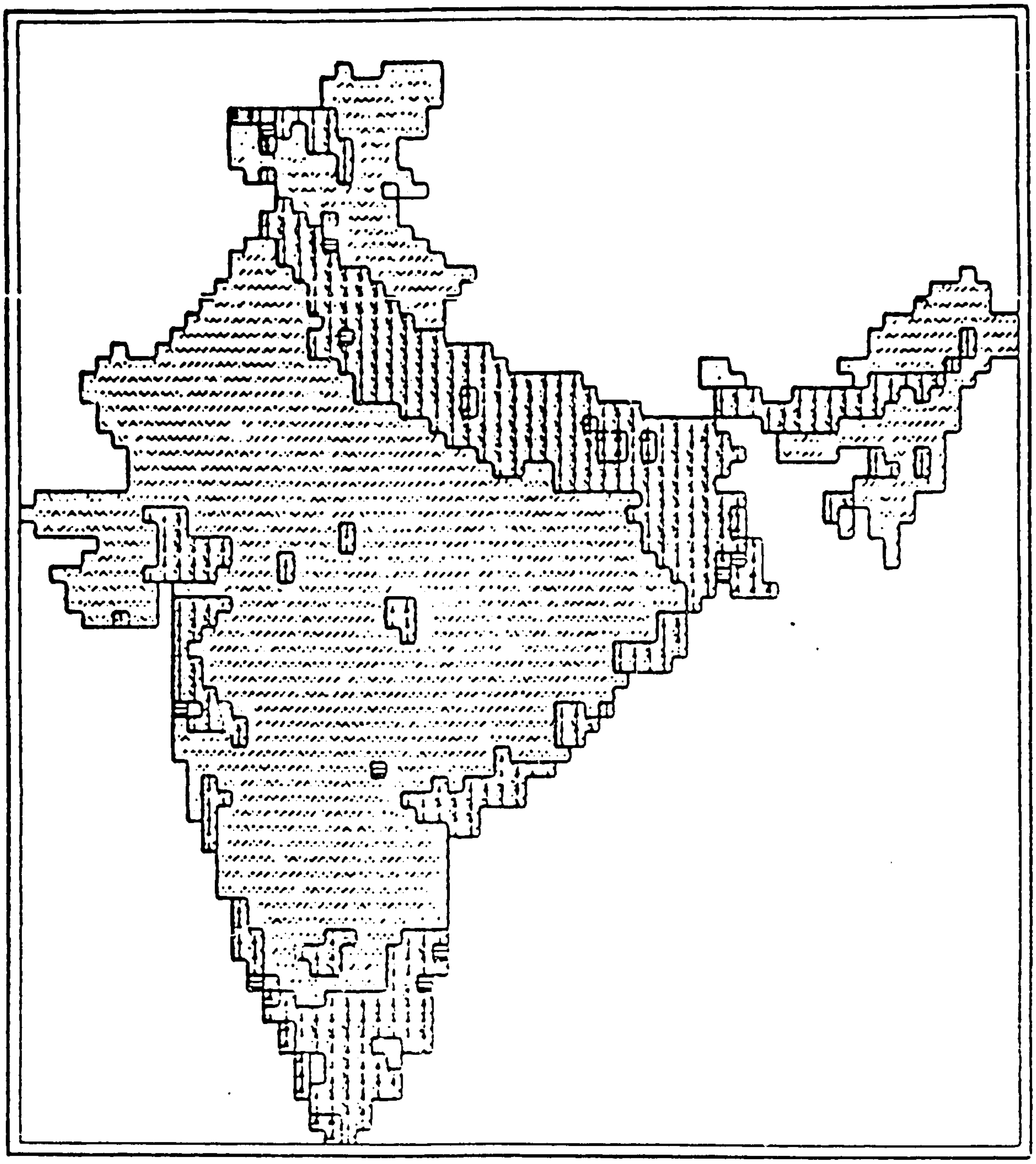
F. These large annual increases (of between 15 to 18 million persons) make the attainment of the economic, social and environmental objectives of India all but impossible. New funds are required each year to avoid losing ground in health education and housing, leaving very little potential for expanding either existing quantity or quality.

In sum, India's basic problems of slow growth in both agriculture and industry underly the nagging poverty problem. Rapid population growth does not cause these problems but it intensifies them and makes dealing with them increasingly difficult. Any favorable economic developments must at once be adjusted for population growth which frequently causes the rather significant progress in absolute terms to vanish in per capita terms.

Table 1: India's Population and the Rate of Growth

Year	Population (millions)	Growth Decade	Decadal rate of growth (%)	Average annual exponential growth (%)	Absolute growth (millions)	
					Decadal	Annual
1. Historical:						
1901	238	-	-	-	-	-
1911	252	1901-11	5.75	0.56	14.0	0.14
1921	251	1911-21	(-)0.31	(-)0.03	(-)1.0	(-)0.10
1931	279	1921-31	11.00	1.04	28.0	2.8
1941	319	1931-41	14.22	1.33	40.0	4.0
1951	361	1941-51	13.31	1.25	42.0	4.2
1961	439	1951-61	21.51	1.96	78.0	7.8
1971	548	1961-71	24.80	2.20	109.0	10.9
1981	685	1971-81	25.00	2.25	137.0	13.7
2. Projections:						
A. Low Series						
1986	758	-	-	-	-	-
1991	833	1981-91	21.60	1.96	148.0	14.8
1996	901	-	-	-	-	-
2001	959	1991-01	15.13	1.41	126.0	12.6
B. Medium Series						
1986	758	-	-	-	-	-
1991	836	1981-91	22.04	1.99	151.0	15.1
1996	915	-	-	-	-	-
2001	991	1991-01	18.66	1.70	155.0	15.5
C. High Series						
1986	758	-	-	-	-	-
1991	843	1981-91	22.04	1.99	151.0	15.1
1996	942	-	-	-	-	-
2001	1,053	1991-01	24.91	2.22	210.0	21.0

Source: V.S. Verma, Registrar General & Census Commissioner, India, Population Projections for India, 1981-2001, New Delhi: March 1984



POPULATION DENSITY IN PERSONS PER SQUARE KILOMETRE
(district level data) (data reflects 1981)

SYMBOL	LABEL
'''''	UP TO 250 PERS SQ KM
¦¦¦	251-750 PERS SQ KM
‡‡‡	751-1250 PERS SQ KM
═	> 1250 PERS SQ KM

84

II. Rural Asset Distribution

In the discussion on the quality of agrarian and rural community structure, prime importance is given to distribution of land ownership and operational holdings. This is as it should be. Land constitutes the single largest component - about 60 per cent - of total rural assets and hence determines all major aspects of social, economic and political life and relations in rural community.

A. Distribution of Land Ownership

Let us briefly revert to land ownership and its distribution before we move to other assets. Between 1970-71 and 1980-81, the number of operational holdings has increased from 70.49 million to 89.35 million. During this period the area operated has increased by a mere 0.67 million hectares, with the result that the average size of operated holding declined from 2.30 ha. to 1.82 ha. Secondly, during this period, the percentage of marginal holdings (below 1 ha.) has gone up from 50.6 to 56.5 and that of large holdings (above 10 ha.) has declined from 4.0 to 2.4 per cent. The area operated under marginal holdings has gone up from 9.0 per cent to 12.2 per cent and that under large holdings has come down from 30.9 per cent to 22.8. Out of 37.13 million hectares operated under large farms, 9.9 million hectares were in Rajasthan, 7.5 million hectares in Madhya Pradesh and 4.4 million hectares in Maharashtra (Agricultural Census: 1980-81).

If data were available (they are not) on the distribution of land in terms of the value of land owned/operated, they would show that the concentration in terms of value is much less than the concentration in terms of area. In other words, the holdings classified as large are not necessarily so large when viewed in terms of their value. The bulk of these are infertile and in unfavorable agro-climatic regions.

B. Composition of Rural Assets

The average value of the total assets per rural household increased by 219 per cent from Rs. 11,311 in 1971 to Rs. 36, 090 in 1981. The increase in the average value of assets per Cultivator Household was 204 per cent and that of Non-cultivator Household was 243 per cent (see Appendix Table 1). "In order to estimate the real growth in total assets over the decade, it is necessary to deflate the value of total assets for the rise in prices." Though it is difficult to make this adjustment in the absence of suitable deflators for each of the assets held by the households, the indicators available in respect of 'construction,' 'livestock,' 'machinery and equipment' and 'final consumption expenditure,' as available in the White Paper on National Accounts Statistics (NAS) have been made use of for this purpose. Accordingly, the real rate of growth in total assets during the decade is estimated to be of the order of 4 per cent per annum. This growth rate is dimensionally comparable with that obtained by using the wholesale price index as a "deflator" (Reserve Bank of India Bulletin, June 1986, p. 438).

95

Over the period 1971-81, no significant change in the composition of assets has taken place. The only phenomenon worth noting was the rather sharp increase in the share of 'durable household assets.' Between 1971 and 1981, the share of these assets in the total assets of cultivator households increased from 4.2 to 6.6 per cent. The increase in the case of non-cultivator households was from 11.5 to 15.8 per cent*. Judging by the insignificant share (0.3 per cent) of non-farm base as equipment in total assets in 1981 (it was 0.2 per cent in 1971), there is indication of diversification of the rural economy by way of growth of non-agricultural enterprises. Even the share of livestock and poultry has come down from 6.5 per cent in 1971 to 5.0 per cent in 1981 for all rural households. The decline is probably due to the reduction in the number of bullocks. The share of agricultural machinery has slightly increased from 1.8 in 1971 to 2.5 per cent in 1981, but is still quite marginal. The share of land has come down during this period from 66.3 to 62.1 per cent, and that of building has increased from 17.9 to 20.7 per cent (Reserve Bank of India Bulletin, June 1986). As these percentages are in terms of value, as mentioned earlier, the differential increase in the price of different assets affects the analysis.

To make sure that the aggregated data at the national level have not averaged out distinct or even contradictory trends at regional levels, changes in the shares of three major categories of assets in the total value of non-land assets of all rural households between 1971 and 1981 were calculated for 16 major states. The study confirmed rather emphatically the findings at the all-India level. The study revealed that in all the 16 major states, there was a decline in the share of livestock. As regards agricultural implements and machinery, only five States registered an increase of over 25 per cent: Punjab (67.3 per cent), Rajasthan (59.8 per cent), Orissa (46.5 per cent), Haryana (32.6 per cent) and Uttar Pradesh (29.7 per cent).

What inference should we draw from this sharp increase in the share of durable household assets in the content of the prevalent view among the academicians that the incidence of poverty has not declined significantly in most regions? The only probable explanation for the sharp increase in the share of durable household assets in the midst of pervasive poverty would be increase in inequality of income distribution. But surprisingly, in the so-called Green Revolution belt - Punjab, Haryana and Uttar Pradesh - where inter-class inequalities are supposed to have increased, the increase in the share of durable household assets was the least - 22 per cent in Punjab, 33.75 per cent in Haryana and 8 per cent in Uttar Pradesh - as against the national average of 37 per cent increase. By the way, these three states along with Rajasthan are the ones in which the share of 'total implements and machinery' has registered the highest increase (Punjab: 67.3 per cent). Tamil Nadu and Kerala are the only states where the share of this asset has declined.

* For the changes in the share of durable household goods in total household consumption expenditure, see Note 2.

Though there are no signs of diversification in the composition of total rural assets, the share of non-cultivator households in the total assets has improved. During the period 1971-81, the ratio of the average value of all assets per cultivator household to that of non-cultivator household has declined in favor of the latter from 5.59 to 4.86. As is to be expected, the only asset whose share in the total assets has gone in favor of cultivator households is agricultural machinery. In the absence of disaggregated data for different categories of non-cultivator households, it is not possible to identify which sub-category has improved its position.

III. Composition of the Labor Force

Assessment of the quality of rural community structure by reference to the composition of workforce will involve an element of subjective judgement. Two criteria may be adopted to judge which type of composition of workforce is better than the other for determining the quality of community structure. One criterion would be obviously the income and entitlements which accrue from a particular type of employment. The other would be the degree of dependence or 'attachment conditions' (loss of freedom and dignity) involved in the type of employment (see Rudra, 1987). Thus bondage is righteously considered as inferior - or more strongly degrading type of employment - even if it yields higher emoluments than that from casual wage employment.

Table 2: Percentage Distribution of All Workers (principal + subsidiary) According to Usual Status by Category of Employment and Sex

Category of Employment	Male Round			Female Round		
	27th	32nd	38th	27th	32nd	38th
Self Employment	65	62	60	64	62	62
Regular Salary/Wage Work	12	13	10	1	2	3
Casual Wage Labor	22	26	28	31	35	35

Source: Sarvekshana, Vol. IX, No. 4, April 1986.

The data reveal many striking features, but the most significant is the persistent increase in the percentage of casual wage labor, particularly for male workers, in the total rural work force and the almost corresponding decline in self-employment. The relative inferiority of casual work is highlighted by the observation that the incidence of unemployment is positively and significantly correlated with the percentage of casual workers in the work force. Commenting on this aspect of employment profile, Minhas observers: "the sustained rise in the proportion of casual laborers among workers over the period of 1972-73 to 1983, has been a disturbing feature (of employment) in India." He also confirms the earlier finding by Visaria regarding positive correlation between unemployment and the proportion of casual workers in the labor force, after extending the earlier analysis to the data from the 32nd and 38th Rounds of the NSS (Minhas and Majumdar, 1987).

A. Sectoral Distribution

Looking at the sectoral (Industrial) distribution of the work force, we find that over the years 1973-83, the percentage of rural workforce (usual status at age 5+) engaged in Agriculture - inclusive of hunting, forestry and fishing - has declined sharply from 83.23 to 76.80 for males and slightly for females from 89.67 to 86.73.

Sectors in which the shares of male workers increased are manufacturing (from 5.73 to 7.21), construction (from 1.56 to 2.75) and wholesale and retail trade, etc. (from 3.06 to 4.43) (Sarveksnana, April 1986). The share of non-agricultural to total workers in the rural area increased from 17 per cent among females.

This may be considered as a favorable turn indicating diversification of the rural economy. But much would depend on whether the phenomenon represents a 'push out' from the agricultural sector or 'pull in' by the non-agricultural sector.

The distribution of workforce within the agricultural sector, however, suggests some deterioration in the quality of employment it provides. The proportion of cultivators in the agricultural workforce has declined from 70.0 in 1961 to 61.4 in 1981 (Population Census). The percentage of rural workers engaged in crop farming has declined from 78.2 in 1972-73 (27th Round) to 73.1 in 1977-78 (32nd Round) (Visaria, 1985).

A more accurate idea of the relative growth in agricultural and non-agricultural employment can be obtained from the analysis of the actual, that is, person-days of employment. Vaidyanathan has done such an exercise and his findings are worth noting. He observes: "This (exercise) gives a slightly different picture in that the share of non-agricultural sector in total employment fell between 1972-73 and 1978 (the fall being more pronounced among females), but had risen substantially thereafter, especially, among males (22 to 27 per cent)" - as indicated by the 1983 data (Vaidyanathan, 1986 .

Vaidyanathan has examined elaborately the causes and consequences of the observed increase in the proportion of non-agricultural employment. Spread of commercialization of agriculture would act as a pull factor for increase in non-agricultural employment. "States with relative prosperous agricultural production tend to have a higher proportion of rural workers engaged in non-agricultural activity." On the other hand, there is a possibility that "rural workers who cannot get adequate work in agriculture spill over into rural non-agricultural activities so that the latter acts as a sponge for excess labor." The non-agricultural sector thus becomes a residual sector. Irrespective of the causal factors, 'there is no doubt about the strong positive association between unemployment rate and non-agricultural employment in rural India." The 'residual sector hypothesis gets some support from the decline in the proportion of 'cultivators' and reduction in the percentage of workers engaged in crop farming. But it is also suggested that the observed pattern of association between unemployment and non-agricultural employment reflects structural changes which go with commercialization and growth of wage labor force (Vaidyanathan, 1986). Growth of wage labor is however common to both sectors. In Punjab & Haryana where commercialization has gained momentum and the proportions of wage labor are high, the incidence of unemployment is also high.

Data from the 32nd round of the NSS show, however, that the percentage of casual labor in the ag. sector is higher than that in the non-agricultural sector. Judging by the difference between the usual status and the current daily status unemployment rates, the incidence of unemployment for casual workers is higher in the former. (Table 3).

Table 3: Percentage Distribution of Male Work Forece in Agriculture and Non-Agriculture According to Usual Status and Current Daily Status

Category	Agriculture			Non-Agriculture		
	Self employment	Regular employment	Casual wage employment	Self employment	Regular employment	Casual wage employment
Usual Status	64.70	6.09	29.20	52.01	30.35	17.64
Current Daily Status	71.41	6.76	22.10	51.53	29.66	18.81

Source: Derived from Sarveksnana, Vol. IV, No. 3 & 4, Jan.-April 1981, p.15

If, as the table shows, the proportion of casual labor is distinctly higher in agriculture than in non-agriculture, what other explanation can there be for the suggested positive relationship between the incidence of unemployment and the proportion of non-agricultural labor in rural workforce?

B. The Emerging Pattern and Future Prospects

The emerging pattern of rural community structure reveals some dominant features.

1. The change over the last three decades in the distribution of operational holdings indicates that while the share of large (above 10 ha.) operators both in the total number of holdings and area operated has been declining, there has been a rapid and sharp increase in the number of marginal holdings. In 1981, they constituted 56 per cent of total holdings.

2. There is no indication of any sharp change in the composition of the total rural assets during the decade 1971-81. The inequality index has remained stable. The share of non-cultivator households vis-a-vis that of cultivator households in the total rural assets has increased. The share of land in the total rural assets has declined, but that of durable household assets has increased sharply. In all states, the share of livestock in the total assets

has declined. The share of non-agricultural productive assets in the total assets remains insignificant, with a marginal increase from 2.1 to 2.5 per cent.* Judging by asset distribution, the rural economy does not appear to be experiencing much diversification by way of non-agricultural development.

3. Viewing the structure from the angle of the composition of work force, it seems that some significant changes are taking place, both in terms of its sectoral and occupational distribution. Sectorally, the percentage share of male workers in agriculture has declined sharply from 83.23 in 1971-72 to 76.83 in 1983, with the reciprocal increase in employment in non-agricultural economy spread between its different sectors. The shift towards non-agricultural employment would suggest diversification in the rural economy. The statement that "there is a significant positve relationship between the rural unemployment rate and the incidence of non-agricultural employment" needs more testing. Occupationally, the share of the cultivators and that of the self-employed has declined. The most disturbing feature, however, is the marked increase in the proportion of casual workers in the labor force. A higher proportion of wage labor is known to be associated with a higher incidence of unemployment.

If we stretch the scenario by 10 to 15 years, it appears that the rural economic structure will deteriorate further. The proportion of marginal holdings will probably go up to 60 to 65 per cent and together with small holdings they will constitute 80 to 85 per cent of operational holdings by the end of the century. The labor force scenario is even more disturbing. According to one estimate, the rural labor force will go up from 242 million in 1981 to 342 million, or by 100 million in the year 2001 (Sundaram, 1984). It is difficult to predict how and where, sectorally and occupationally, the additional labor force will be employed.

There is still some scope for enhanced absorption of labor in agriculture through intensification of cropping, particularly in regions which have lagged behind. Forestry and fisheries also have unemployed potential for development. The declining proportion of agricultural workforce, however, suggests that the agricultural sector's capacity to absorb additional labor force will be serverely limited. Modernization and commercialization of agriculture have given an impetus to non-agricultural employment. It is difficult to understand why growth in non-agricultural employment if stimulated by prosperity in agriculture, as in Punjab and Kheda district of Gujarat, for which case studies are available (Deolalikar, 1984; Rutten, 1986), should result in higher incidence of unemployment. But if the suggested correlation between increase in non-agricultural employment and increase in the incidence of unemployment is true, it would mean that the

* Assets included in this are non-farm business equipment, transport equipment, shares and other financial assets.

quality of employment generated in the non-agricultural sector is not very rewarding. This augers for a strategy that will help augment rather quickly the quantum and quality of non-agricultural employment in the rural areas.

Source: Adapted from article by Dr. M.L. Dantvala in India Journal of Agricultural Economics, Vol. XLII, No. 3, July-September 1987.

Table 4: Percentage Increase in the Value of Assets Per Rural Household Between 1971 and 1981: All-India (Current Prices)

S.No.	Asset	Percent increase in value of assets per house-hold between 1971 and 1981		
		All rural household	Rural cultivators	Rural non-cultivators
(1)	(2)	(3)	(4)	(5)
1.	Land and building	212	198	233
2.	Livestock and poultry	146	133	182
3.	Agricultural machinery	366	347	283
4.	Non-farm business equipment	336	386	251
5.	Transport equipment	275	251	365
6.	Durable household assets	391	381	371
7.	Shares	95	92	100
8.	Other financial assets	300	318	276
9.	Dues receivable	-21	-10.6	-77
	Total Assets	219	204	243

Source: Reserve Bank of India Bulletin, June 1986, Table 4, p.443
Note: The differential price increase of different assets is noted

Table 5: Changes in Shares of Selected Assets in the Total Value of Non-Land Assets of All Rural Households in 1981 over 1971

State	Livestock	Total Implements and Machinery	Durable Household Assets
(1)	(2)	(3)	(4)
Andhra Pradesh	-23.55	6.15	52.80
Assam	- 0.10	11.11	44.29
Bihar	-17.76	31.03	30.59
Gujarat	-26.39	-0.54	46.54
Haryana	-41.14	32.64	33.75
Jammu & Kashmir	-40.27	36.58	34.37
Karnataka	-36.09	15.08	40.35
Kerala	-25.77	-28.68	70.91
Madhya Pradesh	-37.95	58.29	31.80
Maharashtra	-29.43	15.41	52.47
Orissa	-12.63	46.38	44.34
Punjab	-30.85	67.29	21.97
Rajastnan	-43.65	59.81	37.88
Tamil Nadu	-32.18	-27.01	51.58
Uttar Pradesh	-31.60	29.73	7.99
West Bengal	- 3.14	21.50	46.41
All-India	-31.83	22.85	37.29

Source: Reserve Bank of India (1976); Government of India (1985).

91

Table 6: Value in Each Type of Asset with CVs and CRs Over Size Classes of Operational Holdings, 1971-72

Sr. No.	Type of Asset	Value (Rs. Lakh)	Percentage of combined assets	CV	CR
(1)	(2)	(3)	(4)	(5)	(6)
1.	Cattle	33,64,20	45	0.78	0.43
2.	Buffalo	15,62,14	21	0.75	0.35
3.	Other livestock	4,70,82	6	0.61	0.27
4.	Agricultural machinery	13,27,48	18	0.63	0.63
5.	Non-farm business equipment	1,63,20	2	0.99	0.24
6.	Transport equipment	6,33,28	8	0.69	0.44
	Combined	75,21,12	100	0.68	0.42

Source: Kulkarni et al. in Sarvekshana, Vol. VIII, No. 2, October 1984.

Table 7: Total Number and Area of Operational Holdings - Sizewise 1980-81

Size Class	Number ('000)	Percentage	Area ('000)	Percentage
Below 1.0 ha	50,580	56.6	19,727	12.1
1.0-2.0 ha	16,102	18.0	23,010	14.2
2.0-4.0 ha	12,476	14.0	34,533	21.2
4.0-10.0 ha	8,078	9.0	48,314	29.7
Above 10.0 ha	2,157	2.4	37,174	22.8
Total	81,569	100.0	163,344	100.0

Note:

Holding Size (ha)	Category
1. Below 1.0	Marginal
2. 1.0 to 2.0	Small
3. 2.0 to 4.0	Semi-medium
4. 4.0 to 10.0	Medium
5. Above 10.0	Large

Source: - "Indian Agriculture in Brief," 11th Edition and "Agricultural situation in India - August 1985," Directorate of Economics & Statistics, Ministry of Agriculture, New Delhi

92

ANNEX D

Agriculture Sector Performance

I. Macroeconomic Performance

Agriculture is India's second largest economic sector, after services, accounting for about 31 percent of the national GDP in 1985/86, but provides the livelihood for 70 percent of the population. This can be compared to the situation of 30 years ago when agriculture was India's largest sector accounting for approximately 60 percent of the GDP. Table 1 provides historical data for selected economic indicators. During the past 15 years ending 1985-86, the average annual growth rate achieved by the economy was 3.9 percent per annum. In constant prices, net national product (NNP), net farm income and per capita income increased by 86, 30 and 26 percent, respectively, during the same period. Agricultural production is estimated to be growing at a long-term rate of 2.7 percent, slightly higher than the 2.25 percent population growth rate. The average annual growth rate in terms of real national income for agriculture during 1976-86 is 2.8 percent versus 4.9 percent and 6.7 percent for the industrial and service sectors.

Table 1: GNP, NNP, Net Farm Income and Per Capita National Income

	--------------Rs. Billion			----------------		------Rs.------	
Year	GNP	NNP		Net Farm Income		Per Capita Income	
19-	Current Prices	Current Prices	70-71 Prices	Current Prices	70-71 Prices	Current Prices	70-71 Prices
70-71	365	342	325	170	170.8	633	633
75-76	661	621	401	270	188	1023	660
80-81	1139	1058	473	406	196	1559	697
81-82	1306	1208	496	449	204	1741	715
82-83	1449	1335	548	469	198	1882	721
83-84	1717	1583	593	590	221	2186	734
84-85	1894	1740	614	603	219	2335	775
85-86	2136	1957	646	641	221	2596	798

Source: GOI Central Statistical Organization, Quick Estimates of National Income, January 1987.

The sector accounted for approximately 27 percent, 30 percent, 34 percent and 35 percent of India's total exports for 1983-84, 1984-85, 1985-86 and 1986-87 respectively. A breakdown of the value of agricultural exports by major commodity area is provided in Table 2. Leather and leather product exports have risen steadily, virtually trebling in the last seven years. Cotton exports have trended upward due to the strong performance of the ready-made garments industry, which grew 9.6 percent in 1985-86 and accounted for 9.2 percent of total agricultural exports.

Table 2: Major Agricultural Exports (Rs. 10,000,000)

Commodity	83-84	86-87*	% of Total Exports	% Change 83-87
- Leather**	440	931	21	111.5
- Cotton**	421	713	16	69.3
- Tea	515	615	14	19.4
- Marine products	359	461	10	28.4
- Coffee	182	350	8	92.3
- Casnew kernels	151	335	8	121.8
- Spices	117	302	7	258.1
- Jute**	172	275	6	59.8
- Rice	114	180	4	57.8
- Jute**	156	172	4	10.2
- Wheat	2	74	2	3700.0
- Total	2629	4408		67.6

* Estimated ** includes processed products

Source: June 1987 Economic Outlook (Centre for Monitoring Indian Economy)

Exports of coffee, oilcakes, tobacco, casnew kernels, spices, sugar, raw cotton, and rice have increased across the board. In nominal terms the value of agricultural exports increased 67 percent as compared to 27 percent for total value of exports during the period 1983-84 to 1986-87. For the years 1983-84, 1984-85, 1985-86 and 1986-87, agriculture accounted for approximately 9.28 percent, 18.8 percent, 15.8 percent and 11.4 percent respectively of India's total annual import bill (see Table 3). During the last four years the relative share of the major agricultural import commodities, fertilizer and edible oil, have ranged between 71 percent and 84 percent of the total.

Table 3: Major Agricultural Imports (Rs. 10,000,000)

Commodity	83-84	86-87	% of Total Inputs	% Change 1983-87
- Edible oils	846	800	35	-5
- Fertilizers	365	850	37	133
- Pulp & wasted paper	95	240	10	153
- Paper & related products	157	200	9	27
- Sugar	-	212	9	-
- Total	1463	2302	100	57

Source: June 1987 Economic Outlook (Centre for Monitoring Indian Economy)

II. General Trends in Production

India's total production of foodgrains nearly tripled from 50.8 MMT in 1950-51 to 150.5 MMT in 1985-86. This tripling represents a long term growth rate in foodgrain production of about 2.7 percent per year as shown in Table 4 and Figure 1. In addition, India has the largest livestock population (cattle, goats, sheep, and buffaloes) in the world and as of 1985 ranked fourth in milk production.

Table 4: Trends and Fluctuations in India's Agricultural Production

Year 19-	Actual Index of Production	Trend Level of Index of Production	Departure of Actual Production from Trend	Actual Index of Production over Previous year
67-68	99	98	1	23
68-69	97	100	-3	-2
69-70	104	103	1	7
70-71	112	105	6	7
71-72	111	108	3	-0
72-73	103	110	-7	-8
73-74	112	113	-1	10
74-75	109	116	-6	-3
75-76	125	118	6	15
76-77	116	121	-4	-7
77-78	133	124	7	14
78-79	138	127	9	4
79-80	117	130	-10	-15
80-81	135	133	-2	16
81-82	135	135	0	6
82-83	138	145	-7	-4
83-84	156	149	4	14
84-85	154	154	0	-1
85-86	158	159	-1	2
86-87	159	164	-3	1

Actual Trend Rate of Increase (%) between

1967-68 and 1985-86	2.7
1980-81 and 1985-86	3.3
1967-68 and 1980-81	2.4

Source: Centre for Monitoring Indian Economy, Economic Outlook, December 1987.

Table 5 compares the production levels attained by India during the period 1955 to 1985 with those of the world. The Centre for Monitoring Indian Economy estimates that India's overall production is expected to grow about 0.8 percent in 1986/87, compared with a 2.0 percent increase in 1985-86. Despite sub-normal monsoons during 1985-86 and 1986-87, overall production grew about 1.5 percent in the first two years of the Seventh Five-Year Plan as compared to the targeted growth rate of 4 percent per annum.

A. Crops

India's green revolution mainly affected wheat which has emerged as the major single crop helping India approach food security. The introduction of photosensitve, short-statured, and fertilizer responsive varieties over 20 years ago accelerated the acreage planted to wheat, even in non-traditional areas like West Bengal and Karnataka. Approximately 75 percent of the total wheat area is under assured irrigation which is a major factor contributing to the stability of national wheat production. Future increases in wheat

Figure 1: The Underlying Trend in Agricultural Production

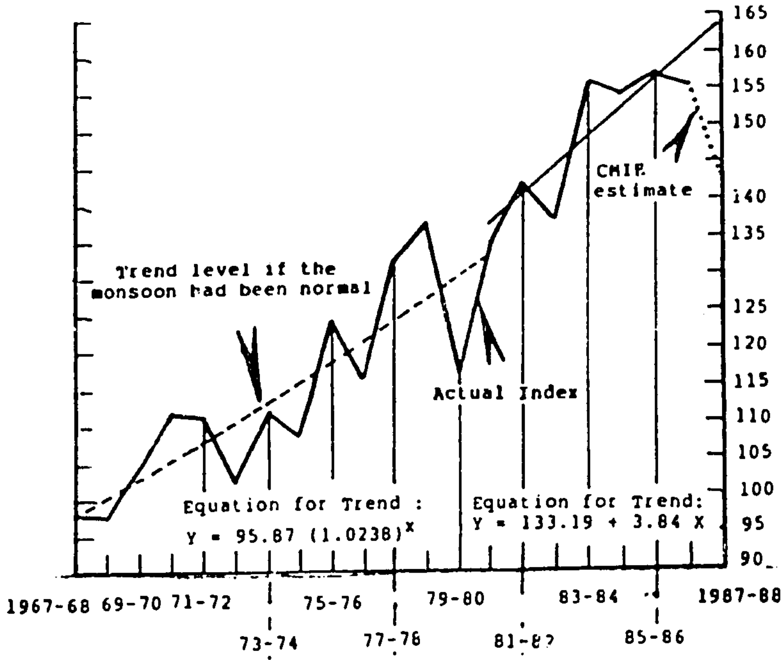


Table 5: India's Agriculture Sector and the World

Category	India		World		% Share of India in the World		India's Rank in the World	
	1955	85	1955	85	1955	85	1955	85
Wheat Production (MMT)	8	44	256	512	3	9	8	4
Wheat yield/ha. (Kg.)	680	1873	1240	2222			63	32
Rice Production (MMT)	46	58	227	463	20	19	2	2
Rice yield/ha. (Kg.)	1400	2181	1940	3201			58	35
Millet Production (MMT)	8	11	13	33	63	33	1	1
Millet yield/ha. (Kg.)	420	618	490	785			25	45
Peanut Production (MMT)	5	6	14	20	35	27	1	2
Peanut Yield/ha. (Kg.)	830	800	940	1096			30	35
Rapeseed Production (MMT)	1	3	4	19	27	16	2	2
Rapeseed Yield/ha. (Kg.)	430	688	570	1249			24	29
Jute Production (000 MT)	1206	1710	2810	4998	43	34	1	1
Jute Yield/ha. (Kg.)	1100	1390	1384	1946			10	7
Cotton lint (MMT)	0.83	1	10	17	8	8	4	4
Sugar cane/beat (MMT)	72	174	537	1224	13	14	1	1
Cattle (mn.)		182		1264		14		1
Buffaloes (mn.)	45	65	93	129	48	50	1	1
Milk Production (mn. MT)	20	40	321	508	6	8	4	4
Milk Production per capita (Kg.)	49	53	114	105				

mn. = million; MMT = million MT; bil. = billion

Source: Centre for Monitoring Indian Economy, World Economy & India's Place In It, October 1986.

production will be primarily dependent on increases in yield rather than expansions in area. U.P., Punjab, Harayana, M.P. and Rajasthan together account for 85 percent of total wheat production. Despite a .5 million acre decline in harvested area, the 1986 wheat harvested set a new record level of 46.88 MMT, reflecting a significant increase in per hectare yield.

Forty percent of India's total foodgrain production is made up of rice which is the staple diet of a major portion of the population. The increase in rice production during the 1970s was not as spectacular as wheat but the growth rate has accelerated since then and production peaked in 1985 at a record level of 64 MMT. Increased coverage of HYV seeds, increased fertilizer and pesticide application, and a special GOI effort to increase rice area in the eastern states generated the recent surge in India's rice production. Most rice production takes place under rainfed conditions and, as a consequence, annual production fluctuates more widely than wheat.

The annual area planted under rice is relatvely independent, unlike wheat, from competition from other crops. The total area under cropped rice increased from 38 million ha. in the mid 1970s to 41 million ha. in the early 1980s and has stablized since then. Most of the increase in area during this period occurred in the states of Haryana, Punjab and western U.P. Table 6 provides statistics on production for 8 major crop categories.

Table 6: Agricultural Production (million MT/Bales)

Crop/Year	81-82	82-83	83-84	84-85	85-86	86-87*
Rice	53	47	60	58	64	62
Wheat	37	43	45	44	47	48
Pulses	11	12	13	12	13	12
Foodgrains	133	129	152	145	150	152
Oilseeds**	12	10	13	13	11	-
Sugarcane	186	189	174	170	172	180
Cotton(bales)	8	8	6	8	9	8
Jute/Mesta	8	7	8	8	13	11

* Estimated
** Groundnut, castorseed, sesamum,rapeseed/mustard, linseed, nigerseed, sunflower, safflower and soyabean.
Sources: a) 1986-87 GOI Economic Survey and b) Centre for Monitoring Indian Economy (June 1987 Economic Outlook)

The total production of oilseeds exceeded 10 MMT for the first time in 1975-76 and has fluctuated between 10 and 15 MMT per annum since 1981-82. Total vegetable oil production in 1986 was 3.3 MMT compared to 3.7 MMT in 1985. Cropped are a under oilseeds over the past eight years has varied between 16.9 and 18.9 million ha.

The compound annual growth rate of area under sugarcane over the past 35 years is 1.98 percent and 80 percent of the total sugarcane area is irrigated. Production rose from 158 MMT of cane in 1976-77 to 171 MMT in 1985-86. However, the growth rate in yield per hecatre has been only 1.13 percent per annum over the same period.

B. Livestock and Livestock Feed

India's livestock population has grown from 292 million in 1951 to 416 million in 1982. Table 7 describes the growth of livestock categories over three decades. The rapid change in the composition of livestock population during this period reflects the influence of a number of environmental and economic factors. Environmental degradation has forced many livestock producers to shift the composition of their herds accordingly. Sheep and goat populations have increased in part due to rising meat prices and because both are relatively better than bovines at making productive use of low quality pasture and fodder.

Table 7: Total Livestock Population 1951-82 (millions)

Year / Category	1951	1961	1951-61 % Change	1972	1961-72 % Change	1977	1982	1972-82 % Change
Cattle	155	176	+13	179	+ 2	180	191	+ 7
Buffalo	43	51	+18	58	+13	62	69	+19
Sheep	39	40	+ 3	40	- 0	41	48	+20
Goats	47	61	+29	67	+11	76	101	+50

Source: Indian Center for Science and Environment

GOI's Animal Husbandary Department estimates that livestock production accounts for almost 10 percent of GNP. Milk and milk products make up 79 percent of livestock's contribution to GNP while meat and meat products account for an additional 11.5 percent. Annual milk production has risen steadily during the last 20 years, reaching 40.2 MMT in 1986-87, making India the World's fourth largest producer. Between 1981-82 and 1986-87, production of eggs increased by 7.9 percent per annum. The per capita availability of eggs also increased from 5 in 1981-82 to 21 in 1986-87. During the same period, the production of broilers increased from 30 million birds to 80 million birds -- a 21.6 percent increase per year.

Table 8 indicates the general magnitude of the feed/forage deficit to support current livestock population levels. These figures are considered to be conservative as they estimate only the minimum feed intake required to maintain productive animals. High livestock density in many regions of the country has put tremendous pressure on the resource base and has made biomass regeneration in the non-cultivated areas increasingly problematic.

Table 8: Feed Requirements and Production, 1985-86 (MMT)

Type of Feed	Estimated Requirement	Estimated Availability	Estimated Deficit
Crop residues	168	142	- 26
Grasses	288	283	- 5
Green Fodders	290	32	-258
Total Deficit			-289

Source: National Dairy Research Institute, Karnal

C. Forests

Under the country's land laws, the original ownership of all forests rests with the GOI. The public sector consequently owns the vast majority of India's total area under forest. Tables 9 and 10 show that in 1979-80 the public sector owned 96.2 percent of the area and in 1983-84 was responsible for 42.2 percent of the annual value of forest produce. The World Bank estimates current consumption of forest based products to be 230 million cubic meters (MCM) per year of which 130 MCM comes from bushes and woody matter other than trunks.

Set against this requirement is the estimate that the total sustained yield of standing forests is only 35 MCM. Assuming that the 130 MCM not coming from trunks must be supplied from other sources than those reflected in the annual increment and leaving aside industrial demands, there will still be a 65 MCM shortfall in fuelwood alone. Forest Department statistics from 1985 estimate fuelwood demands to be as high as 202 MCM plus industrial demands of 30-35 MCM indicating a much more substantial shortfall. Overcutting of existing forests and plantations is estimated to be as high as 300 percent.

Table 9: Ownership Pattern of Forest: 1979-80

Ownership	Area	
	(000,000) Hectares	Percent of Total
A. Public Sector (i + ii)	708	96
i) Forest Department	688	93
ii) Civil Authorities	20	3
B. Private Sector (iii + iv)	28	4
iii) Corpoate Bodies	20	3
iv) Private Individuals	8	1
C. Total (A + B)	736	100

Source: Ministry of Planning, Central Statistical Organization, Department of Statistics, Statistical Abstract: 1984, New Delhi, 1985.

Table 10: Per Hectare Value of Forest Produce: 1983-841

Sector	Area (100,000 ha.)	Value (Rs. 100,000)	Per Hectare Value (Rs.)
Public	708	632	90
Private	28	874	3120
Total	736	1496	3210

Source: Ministry of Planning, Central Statistical Organization, Department of Statistics, Statistical Abstract: 1984, New Delhi, 1985.

III. Inputs

Based on the data presented in Table 11 there is little doubt that an impressive growth rate has been attained in the use of conventional agricultural inputs. Increases in the use of high yielding varieties (HYVs), fertilizer, pumpsets, tractors, and pesticides averaged 3.8, 8.9,

Table 11: Trends in Input Usage (excluding land & irrigation)

Item	1970-71	1986-87*	Avg. Annual % Increase
1. Fertilizer (MMT)	2.26	9.21	8.9
- Nitrogenous	1.48	6.30	8.6
- Phosphate	.54	2.22	10.6
- Potassic	.24	.95	7.1
Consumption of NPK/ha. (kg.)	13.6	52.6	8.9
2. Area under HYVs (mn. ha.)	15.1 (17)**	54.0 (56)	3.8
- Paddy	5.6 (15)	23.5 (58)	4.3
- Wheat	6.5 (36)	19.0 (82)	2.8
- Jowar	0.8 (5)	4.9 (31)	5.8
- Bajra	2.1 (16)	4.7 (44)	4.1
- Maize	0.5 (9)	1.9 (33)	2.9
3. Pumpsets (mn.)	3.18	10.30	6.1
4. Tractors	.14	.95	10.6
5. Power Consumption (bn. kwh.)	4.47	27.55	11.3
6. Power Consumption per 1000 ha. of gross cropped area (kwh.)	27.0	157.4	11.1
7. Pesticide Consumption (1000 MT)	20.0	72.0	8.2
8. Expenditures on Ag. Research & Education (Rs. mn.)	19.4	157.9	11.9

* Estimated ** percent of total area planted

mn. = million, bn. = billion, kwh. = kilowatt hour, MT = metric ton
Source: Centre for Monitoring Indian Economy (June 1987 Economic Outlook)

12.5, 6.2 and 8.2 percent per annum respectively during the period 1970-71 to 1986-87. During the same period, gross irrigated area grew at the annual average rate of 2.4 percent as compared to the average annual increase of 0.2 percent for gross cropped area. Power consumption per 1000 ha. increased 5-fold, from 27 Kwh. in 1970-71 to 157.4 Kwh. in 1986-87. Moreover, the investment in agricultural research and education during the period increased eight-fold, equal to an average annual increase of 11.9 percent.

A. Irrigation

As is well known, the utilization of key inputs such as fertilizers, seeds, HYVs, pesticides, etc. depends to a great extent on the availability and reliability of water supplies (rainfed and/or irrigation). GOI estimates that cumulative irrigation potential as of 1985-87 to be 69.8 million ha. Table 12 illustrates agricultural land utilization (1970-71 to 1986-87) by irrigated and non-irrigated areas.

Table 12: Agricultural Land Utilization (million hectares)

Item	1970-71	1986-87*	Avg. Annual % Rate of Increase
1. Net sown area	140.8	143.0	0.3
2. Gross cropped area	165.8	175.0	0.2
3. Percent net sown area to geographical area	42.8	43.5	-
4. Net irrigated area	31.1	44.0	2.4
5. Gross irrigated area	38.2	57.3	2.4
6. Percent gross Irrigated are to gross cropped area	23.0	32.7	-

* Estimated

Source: Centre for Monitoring Indian Economy (June 1987 Economic Outlook)

As in other countries in Asia, the public sector plays a major role in major and medium irrigation schemes. During the period 1951-1986 public sector investment in medium and major irrigation programmes aggregated to Rs. 165.5 billion, irrigating an additional 21.3 million ha. As indicated in Table 13, the public sector share in the country's physical irrigation infrastructure as of 1980-81 was 45 percent.

Table 13: Share of Public Sector in Irrigation: (million ha.)

Category	Public		Private		Total	
	1950-51	1980-81	1950-51	1980-81	1950-51	1980-81
Canals	7.2	14.3	1.1	0.8	8.3	15.3
Wells	-	-	6.0*	8.2	6.0	8.2
Tubewells	**	**	-	9.5	-	9.5
Tanks	3.6	3.2	-	-	3.6	3.2
Others	-	-	3.0	2.6	3.0	2.6
Total	10.8	17.7	10.1	21.1	20.9	38.8
% Share	52	46	48	54	100	100

Source: Centre for Monitoring Indian Economy, Public Sector in the Indian Economy, November 1986

* Includes tubewells also.

** Some state governments run tubewells but data is unavailable.

Public sector investment in irrigation potential over the seven five year planning periods is found in Table 14. The data in the latter does not tally with the former for reasons unexplained by the GOI. Regarding minor irrigation works, public sector investment was Rs. 48 billion during the 35 year period. This, combined with the institutional finance plus private sector investment of millions of farmers, increased minor irrigation potential by 39.1 million ha. by the end of 1980-81.

The private sector dominates minor irrigation, mainly through wells where water can be obtained exactly when required for the crops (assuming power or diesel is available). However, the public sector irrigation potential remains under-utililized because of shortcomings in planning, implementation and operation of the irrigation facilities.

Table 14: GOI Investment in Irrigation Development, 1951-1986

Period		Expenditure (Rs. billions)			Cumulative Irrigation Potential Created (millions of ha.)			Investment (Rs.) per ha. of additional potential created in major & medium irrigation projects in each five year plan
		Major-medium irrigation	Minor irrigation	Total	Major-medium irrigation	Minor irrigation	Total	
Pre-Plan		NA	NA	NA	10	13	23	NA
1st Plan	51-56	380	76	456	12	14	26	1520
2nd Plan	56-61	380	142	522	14	15	29	1810
3rd Plan	61-66	581	328	909	17	17	34	2526
Yr. Plan	66-69	434	326	760	18	19	37	2893
4th Plan	69-74	1237	513	1750	21	23	44	4758
5th Plan	74-79	3399	868	4267	26	29	54	6587
Yr. Plan	79-80	1079	260	1339	26	30	57	16859
6th Plan	80-85	7531	1802	9333	30	37	68	19310
	85-86	1486	487	2333	31	39	70	30765*
TOTAL	51-86	16507	4802	21309	31	39	70	
7th Plan	85-90	11556	2805	14361	35	46	81	26320**

Sources: GOI, Planning Commission, Seventh Five-Year Plan: 1985-90, New Delhi, October 1985 and Ministry of Water Resources, Performance Budget: 1986-87, New Delhi, March 1986.

* Estimated ** Target

During 1951-56, the average investment for the creation of major and medium irrigation schemes was Rs. 1,520/ha. as compared to the figure for 1985-86 of Rs. 30,765/ha.; an unadjusted 20-fold increase.

As dealt with in the Mission's Irrigation Strategy Paper, the government owned major and medium irrigation works incur massive operating losses every year. A recent report by a GOI financial commission estimated that for 1981-82 the expenditures for irrigation, excluding interest, was Rs. 2.14 billion while revenue receipts from farmers utilizing the irrigation facilities was only Rs. 1.4 billion.

The same commission forecasted for the period 1984-85 to 1988-89 that irrigation expenditures would reach Rs. 26.1 billion and irrigation receipts would only be Rs. 11.1 billion. This differential is further highlighted by the per acre irrigation costs of tubewell water (Rs.500-1000) versus charges for GOI supplied irrigation water (Rs.2.75-Rs.240). For information on the annual trend in losses for the last 25 years please refer to Table 15.

Table 15: Operating Losses of Public Irrigation Works (1960-61 to 1984-85)

Year	Total (Rs. millions)			Per Ha. of Irrig. Area (Rs.)		
	Revenue	Expenditure	Loss	Revenue	Expenditure	Loss
1960-61	200	350	150	13	23	10
1965-66	60	660	600	4	39	35
1969-70	360	1000	640	18	50	32
1974-75	540	1880	1340	25	87	62
1975-76	670	2190	1520	30	97	67
1976-77	830	2480	1650	37	110	73
1977-78	730	3020	2290	30	126	96
1978-79	850	3820	2970	34	152	118
1979-80	860	4250	3390	34	166	132
1980-81	880	4880	4000	39	214	175
1981-82	1130	5650	4520	48	238	190
1982-83	980	6160	5180	41	258	217
1983-84	1480	7500	6020	60	302	242
1984-85	2030	9040	7010	78	348	270
Total	12200	55200	43000			

Source: Reserve Bank of India, Reserve Bank of India Bulletin: Sept. 1985

B. Fertilizer

The average consumption level of chemical fertilizer is 50.6 kg./hectare. Consumption varies by state from 5 kg./ha. in Assam to 160 kg./ ha. in the Punjab. According to the survey conducted on the pattern of fertilizer consumption in India, only 34.4 percent of the gross cropped area was fertilized. Currently, India ranks fourth and eighth in the world in nitrogenous and phosphatic fertilizer production, respectively.

None-the-less, India is the world's biggest importer of chemical fertilizer, importing from Rs. 15 billion to Rs. 18 billion per annum worth of fertilizer. Table 16 provides estimates of fertilizer supply and demand from 1984-85 to 1986-87.

Table 16: Estimates of Fertilizer Demand & Supply (MMT)

Category	1984/85	1985/86	1986/87	1987/88*	% Change
Opening stocks	1.0	1.6	2.0	2.6	30.0
Production	5.2	5.8	7.1	7.4	4.2
Imports	3.6	3.3	2.3	1.1	-52.2
--------------	---	---	---	---	-----
Total availability	9.8	10.7	11.4	11.1	-2.6
Consumption	8.2	8.7	8.8	9.0	2.3
--------------	---	----	----	----	----
Closing stocks	1.6	2.0	2.6	2.1	-19.2

Source: Centre for Monitoring Indian Economy, Monthly Review of the Indian Economy, July 1987.

: Estimated

Fertilizer production reached a record level of 7.1 MMT in 1986/87 which was 23 percent above the production level in 1985/86. This can be compared to total fertilizer offtake of 8.8 MMT for the same period, the difference between domestic production and consumption being met through imports. Capacity levels attained during 1986-87 was 77.8 percent as compared to 66.5 percent and 71.7 percent in the two preceding years. Despite this favorable trend, inappropriate fertilizer policies have led to record stock levels, about 2.6 MMT at the beginning of crop year 1987/88. If next year's production increases by only 5 percent to 7.4 MMT, and no more than 1.1 MMT is imported, then the total availability will be more than 11 MMT. The offtake for the past harvest (under the drought situation) is not expected to exceed 9.0 MMT, indicating carry over stocks of at least 2 MMT.

The GOI response to high carry over stocks and the associated storage costs has been to force the public fertilizer distribution agency not to release lower priced imported fertilizers until the stocks of indigenously produced fertilizer is completely depleted while paradoxically warning the distributors not to discount prices to unload fertilizer. The distributors would prefer to unload stocks even at a loss rather than shoulder the costs of long-term storage and spoilage.

The total fertilizer subsidy rose from Rs. 3.75 billion in 1981/82 to Rs. 193 billion in 1984/85 and is projected to increase to Rs. 50 billion by the end of the Seventh Five-Year Plan. On a more positive note, the GOI announced late July 1987 that it would eliminate the freight subsidy to the fertilizer industry which supposedly amounts to Rs. 2.5 billion. Moreover, GOI has indicated the desire to reduce the fertilizer subsidy even further.

C. Productivity Per Unit of Input

Crop yields in India are low as compared to other Asian countries as illustrated in Table 17. While input usage has increased dramatically, in the aggregate there has not been a corresponding change in outputs. This is demonstrated by the data contained in Table 18 which indicates that all inputs in (real terms) have increased at the average annual compound interest rate of 5.6 percent between the triennia 1972-73 and 1986-87 while real output has only increased at the average annual compound rate of 2.3 percent. Thus the index of productivity graphed in Figure 2 shows a substantial fall in the marginal value product of inputs.

Table 17: Comparative Agricultural Yields, 1983 (Kg. per Hectare)

Country	Wheat	Paddy	Seed Cotton	Sugarcane
India	1,836	2,122	501	56,200
Pakistan	1,678	2,518	728	35,679
Korea	3,348	6,193	897	-
Thailand	-	1,972	1,152	40,600
Turkey	1,855	4,667	2,541	-
Egypt	3,621	5,810	2,883	87,500
Asia Average	2,049	3,134	747	76,500
World Average	2,150	3,048	1,413	71,000

Sources: FAO and USDA/FAS Ag. Attache

104

Table 18: Decline in Productivity of Major Ag. Inputs (1970-71 prices)

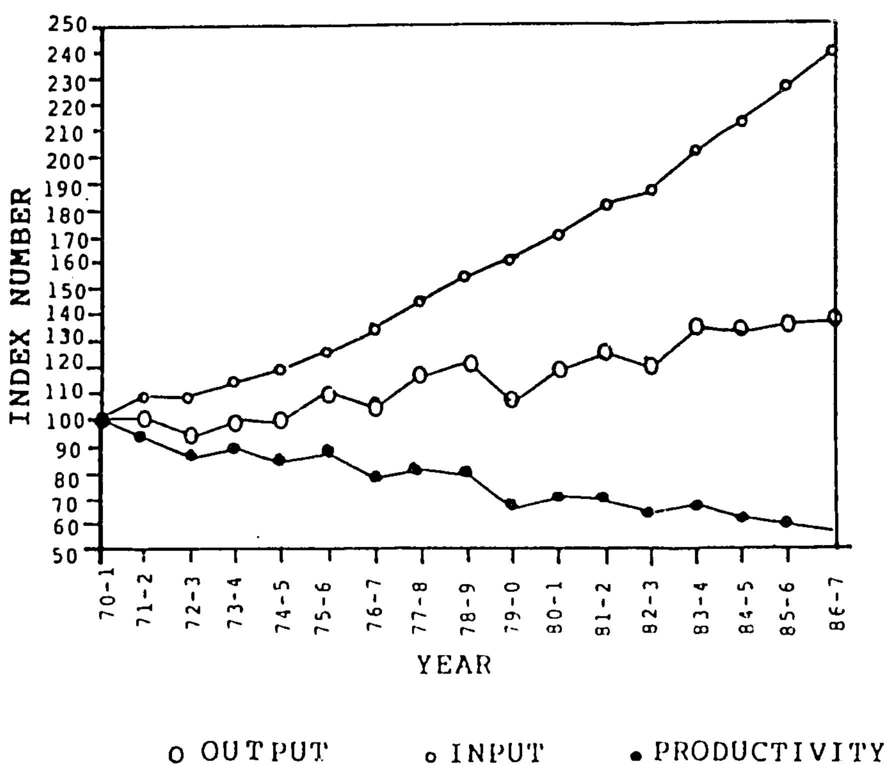
Year	Value of Output		Value of Input		Index of Input Productivity
	Billions of Rs.	% Index	Billions of Rs.	% Index	
1970-71	175.3	100.0	27.7	100.0	100.0
1971-72	175.5	100.0	29.7	107.3	93.0
1972-73	163.1	93.1	30.3	109.2	85.3
1973-74	176.2	100.5	31.5	113.7	88.4
1974-75	172.4	98.4	32.7	118.3	83.2
1975-76	192.9	110.0	35.1	126.6	86.7
1976-77	182.0	103.6	37.0	133.7	77.5
1977-78	202.0	115.5	40.0	144.5	79.9
1978-79	212.0	120.4	42.7	154.3	78.0
1979-80	185.5	105.8	46.0	160.9	65.8
1980-81	207.5	118.4	47.2	170.3	69.3
1981-82	217.5	124.1	50.3	181.3	68.5
1982-83	210.2	119.9	51.7	186.7	64.2
1983-84	234.6	113.8	55.6	200.7	66.7
1984-85	232.3	132.6	59.3	213.9	62.0
1985-86*	237.2	135.3	62.8	226.6	59.7
1986-87*	233.1	136.4	66.6	240.3	56.8

* =Estimated

Note: Inputs include seed, organic/chemical fertilizer, maintenance of fixed assets & operational costs, livestock feed (drought only), irrigation charges (including irrigation losses), market charges, electricity, pesticides and fuel.

Source: Centre for Monitoring Indian Economy (June 1987 Economic Outlook)

Figure 2: Trends in Indices for Value of Outputs, Inputs and Productivity



105

IV. Pricing and Marketing Policies

In 1986 the GOI announced a new policy objective with respect to agricultural pricing policies. This objective is to make the sector "more vibrant, more productive and more cost effective." The attendant GOI policy paper emphasized the role of the price mechanism in removing inefficiencies. Unfortunately, the initiative appears to be only partially implemented. The GOI still exercises an extensive and restrictive system of price and market controls over the sector.

India has a complex set of cross subsidies, offsetting legislation, regulations, etc. that make it extremely difficult to net out the total effect of the set of government interventions. For the farmer it means cheap power and water but expensive fertilizer (perhaps 30 per cent over world prices). Table 19 summarizes GOI support and procurement prices for the major agricultural commodities. On the other hand farm price for wheat and rice are above world prices. And so on. Trends in food and agriculture subsidies are presented in Table 20.

The GOI has repeatedly voiced its intention to reduce subsidies, especially those associated with foodgrains, by raising the issue price to a level higher than the procurement costs. In practice, however, the GOI continues to asborb any increase in costs associated with transportation,

Table 19: Support/Procurement Prices for Major Agricultural Commodities (Rupees per 100 Kg.)

Category	1982-83	1983-84	1984-85	1985-86	1986-87
			Procurement Prices		
1. Paddy (rough rice)	122	132	137	142	146
2. Sorghum/Millet/Corn	118	124	130	130	132
3. Wheat	151	152	157	162	166
			Support Prices		
4. Barley	122	124	130	132	135
5. Gram (chickpea)	230	240	---	260	280
6. Arhar (pigeonpea)	215	245	275	300	320
7. Moong (green gram)	240	250	275	300	320
8. Urad (black gram)	230	240	275	300	320
9. Peanut (in shell)	290	315	340	350	370
10. Rape & Mustard Seed	355	360	385	400	415
11. Soybeans (yellow)	220	230	240	250	255
12. Soybeans (black)	245	255	265	275	290
13. Sunflowerseed	250	275	325	335	350
14. Sugarcane	13	13	14	16	---
15. Raw Jute	185	195	215	225	240

Source: 23 Feb. 87, USDA/FAS Report, INDIA - Agricultural Situation
* No government price etablished

106

Table 20: Trends in Food and Agriculture Subsidies (Rs. billion)

Year	Food Grain	% of Total	Fertil- izer	% of Total	Other *	% of Total	Total
1977-78	4.80	37.3	2.66	20.77	5.41	42.0	12.87
1978-79	5.69	38.6	3.42	23.2	5.64	38.2	14.75
1979-80	5.99	32.9	6.03	33.1	6.19	34.0	18.21
1980-81	6.50	34.0	5.05	26.4	7.57	39.6	19.12
1981-82	7.01	36.0	3.76	19.3	8.69	44.7	19.45
1982-83	7.10	30.8	6.06	26.3	9.88	42.9	23.04
1983-84	8.34	28.9	10.42	36.1	10.10	35.0	28.86
1984-85	11.01	24.9	18.30	41.4	14.90	33.7	44.21
1985-86	16.49	33.5	20.47	41.6	12.25	24.9	49.21
1986-87	17.49	36.9	19.49	41.1	10.43	22.0	47.41

* Others include export promotion, etc.
Source: February 1987, USDA/FAS Report "INDIA - Agricultural Situation"

processing and storage or the exogenous shocks of increasing petroleum prices, imported fertilizer, etc. Similarly, the federal and state governments support farmers through massive indirect subsidies resulting from underpriced irrigation water and power.

The GOI maintains a large Public Distribution System (PDS) which consists of a country wide system of fair price stores (321,000) that release wheat flour, rice, edible oil and sugar at subsidized rates. The subsidy element per MT of wheat and rice distributed through the government in 1986-87 is Rs. 620 and Rs. 717 respectively. For sugar the GOI maintains a dual pricing policy where mills can sell 50 percent of their output at the open market price and the rest to the GOI procurement agency at a below market price. In addition, a large quantity of the country's annual edible imports are supplied through the PDS.

The GOI's export policy is to promote exports in a manner that the national economy is not affected by unregulated exports of essential food items. Based on this rationale, sugar, castor oil, molasses, onions and raw jute are channeled through parastatals. Other commodities not controlled by parastatals but subject to the GOI's minimum export price restrictions or export ceilings include meat of buffalo, sheep and goats, live animals, marine products, pure milk ghee, eggs, fresh fruits and vegetables, most spices, edible oilseed, etc. Regarding imports, the GOI follows a restrictive import policy for most agricultural products to conserve foreign exchange and for protection of domestic producers. The import of most major food items, such as edible oil and grain, is similarly canalized through various government agencies.

V. No Room for Complacency

A. Drought

The seasonal and geographic variations in rainfall largely explain the year to year fluctuations in India's agricultural productivity. A good example of this is the prolonged dry spell experienced by the country during the beginning of the 1987-88 crop year. The delay in the arrival of the South-West monsoon in the Northern foodgrain areas reduced the expected production of the Kharif harvest. As shown in Table 21, 11 meteorological sub-divisions, accounting for 73 percent of the gross cropped area, received less than normal rainfall during July 1987.

In the corresponding period in 1986, only 15 meteorological sub-divisions, accounting for 35 percent of the gross cropped area, received less than normal rainfall.

Table 21: Area Distribution of the 1987 South-West Monsoon (early June to the end of July)

Degree of rainfall	No. of Subdivisions 1986	No. of Subdivisions 1987	% of gross cropped Area 1986	% of gross cropped Area 1987
Excessive	6	-	30.7	-
Normal	13	11	34.0	26.6
Deficient	15	20	35.0	60.0
Scanty	-	4	-	13.2
No Data	1	-	0.3	-
Total	35	35	100.0	100.0

Source: Centre for Monitoring Indian Economy, Monthly Review of the Indian Economy, July 1987.

In the 1987 kharif season, 73 percent of the country's gross cropped area was affected by the drought. Reductions in the harvested area of 10 states resulted: U.P., M.P., A.P., Maharashtra, Tamil Nadu, Rajasthan, Gujarat, Haryana, Jammu & Kashmir and H.P. In previous years these 10 states accounted for approximately 60 percent of India's kharif foodgrain production. The drought conditions also led to a scarcity of drinking water and perhaps most dramatic, an acute shortage of livestock fodder. At the other end of the spectrum, the states of Assam, Bihar, and West Bengal experienced unseasonably heavy rainfall during the same period which lead to widespread flooding.

As a result of this seasonal and geographic variation in rainfall, kharif production of foodgrains is forecasted at 81 MMT during 1987-88, as compared to the target of 90 MMT and the previous year's actual production of 85 MMT. The overall production of foodgrains (kharif + rabi) is estimated at 150 MMT, although some observers say as low as 145 MMT during 1987-88, compared to 152 MMT in 1986-87. The production of oilseeds, cotton, jute and sugarcane are also expected to drop during the same year. As a result, the agricultural production for 1987-88 is expected to drop by at least 1 percent compared to a .8 percent increase in the previous year.

108

B. Unequal Income Distribution and Ineffective Food Demand

Despite the impressive productivity gains made in agriculture over the past 30 years, the vast majority (70 percent) of India's poor resides in the rural areas. Even though food grain demand has increased less rapidly than production over the past decade, at least 40 percent of the population is below the GOI poverty line. The growth of population in relation to gross per capita production of foodgrains (cereals & pulses, which provide 80 percent of the population's caloric intake) for the period 1901-1987 is presented in Table 22. The trend in food grain production and the growth in population is presented in Figure 3. Assuming that the data is correct, the graph indicates that the per capita availability of food grains in the 1920s was more than it is today.

The per capita production of pulses has been declining since 1960-61. The per capita production of edible oilseeds has remained relatively constant during the same period. Despite current record levels of public sector foodgrain stocks (23 MMT), 300 million persons do not consume adequate amounts of food. With India's population expected to double by the year 2000, the agriculture sector will have to increase foodgrain production by 75 MMT just to maintain current levels of per capita availability.

Table 22: Population and Agricultural Production, 1901-1987

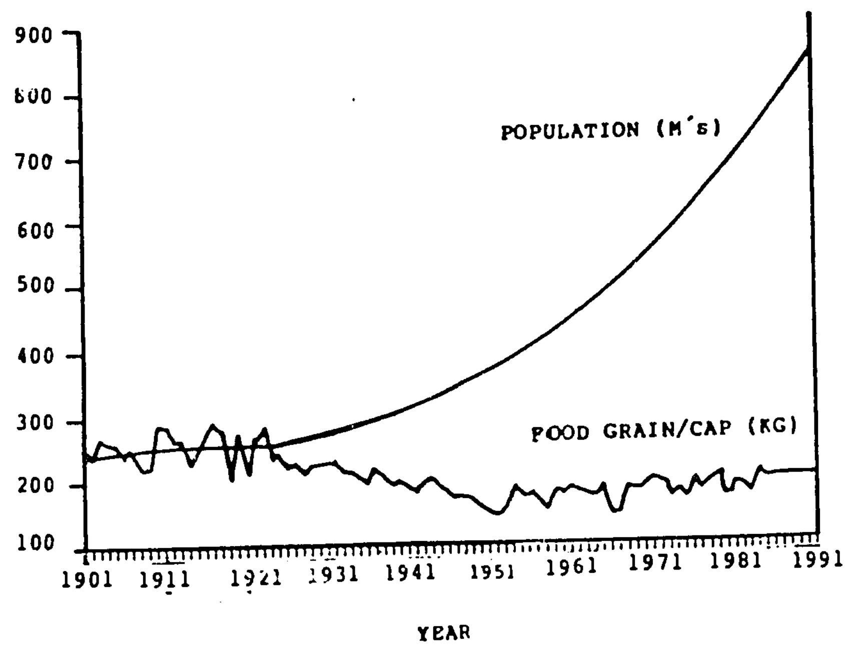
Year	Population (000s)	Foodgrain Production (MMT)	Per Capita Availability (KG)		
			Foodgrain	Pulses	Oilseeds
1901-02	238396	60	233	-	-
1910-11	252093	72	286	-	-
1920-21	251321	53	211	-	-
1930-31	278977	63	226	-	-
1940-41	318661	59	185	-	-
1950-51	361088	51	141	23	13
1960-61	439235	82	187	29	15
1970-71	548160	108	197	21	16
1980-81	685159	130	190	15	13
1981-82	700616	133	190	16	16
1982-83	716421	127	177	16	13
1983-84	732583	152	207	17	16
1984-85	749109	146	195	16	16
1985-86	766008	150	196	17	14
1986-87*	783289	152	194	16	15
1987-88*	800959	130	162	13	12

* Estimated

Sources: David Seckler and R.K. Sampath, Production and Poverty in Indian Agriculture, USAID/India Occasional Report No.2, November 1985, and Centre for Monitoring Indian Economy, Economic Outlook, December 1986.

According to Robert Evenson's report entitled "Food Consumption, Nutrient Intake and Agricultural Production in India," average annual per capita food consumption declined during the 1950s and 1960s and rose in the 1970s and early 1980s in rural areas and improved only slightly in recent years while those in urban areas deteriorated. For the poorest deciles, food consumption in rural areas was roughly constant over the entire period. While the position of the poorest families hasn't changed, the majority of the decline in average per capita food consumption was apparently absorbed by the upper middle income deciles. Similarly, the diets of the rural poor improved slightly while those of their urban counterparts deteriorated during the 1950s and 1960s. In relative and absolute terms, the dietary and consumption status of both groups changed little in the 1970s and 1980s despite GOI efforts to improve their lot.

Figure 3
Population and Per Capita Foodgrain Production
in India 1901 - 1991



India's population and net domestic product (NDP) for the years 1951 and 1985 was estimated to be 363 and 750 million people and Rs. 168 and Rs. 572 billion respectively. As population doubled NDP increased by a factor of 3.4 which translates into a 65 percent increase in per capita NDP. During the same period, non-agriculture NDP increased by 462 percent while agriculture only increased 95 percent thereby reducing the latter's share of NDP from 59 to 38 percent. This disparity is even more striking if the non-agriculture sector is divided into its organized (government & corporate private sector) and unorganized components as illustrated in Table 23.

Per capita NDP of agriculture has remained relatively constant during the past thirty years, whereas per capita NDP for the non-agriculture sector has more than doubled. In the aggregate, India's development efforts have forwarded the non-agricultural sector which still only employs about 30 percent of the labor force. The relative stagnation in the growth of per capita agriculture NDP over the last 30 years largely explains why per capita consumption of foodgrains has not increased and why at least 40 percent of India's population remains poor and undernourished despite impressive agricultural growth.

Table 23: Per Capita NDP at 1986 Prices

Sector	1970-71	1980-81	As a Multiple of Agriculture 1970-71	As a Multiple of Agriculture 1980-81
	Rupees			
Agriculture	426	860	1.0	1.0
Unorganized Non-agriculture	765	1937	1.8	2.3
Organized	1777	4931	4.2	5.7

Source: V.M. Dandekar, Agriculture, Employment and Poverty, Economic and Politicaly Weekly, Vol XXI, NOs. 38-39, 20-27 September 1986.

It should be noted that estimates of per capita foodgrain production or NNP may understate the decline in the condition of the rural poor as it does not account for the declining productivity of pasture/forest lands which has further reduced their access to productive employment opportunities. For example, Table 24 contains data on the distribution of rural population by per capita expenditures for 1983. Assuming the GOI poverty line of Rs.88/month for this period, the additional income needed by the population below the poverty line is Rs.130 million per million population per annum in 1983 prices (146 million in 1986/87 prices). Assuming that 70 percent (546 million) of the total 1987 population is rural based, the additional income to move the rural poor up to the poverty line is approximately Rs.79.7 billion per annum. If the urban poor are included the figure rises to Rs. 94.5 billion per annum which is equal to more than 30 percent of the GOI's net revenues for 1987.

VI. Some Conclusions

Despite admirable increases in agricultural production over the past 30 years, India's food security situation remains tenuous because of dramatic climatic variations, high population growth, income distribution and a deteriorating natural resource base. Food security is defined as the ability of a country's population to obtain adequate amounts of food to live normal healthy and productive lives. This implies domestic production and/or an ability to import necessary foodstuffs, as well as the ability of people to purchase available food. India has serious problems on all three counts.

While overall production has increased at the average annual rate of 2.7 percent, as compared to a 2.2 percent population growth rate, there is some doubt if such growth can be sustained in the future, Dr. Raj Krishna's optimism aside. Most experts knowledgeable with India's situtation would

Table 24: Distribution of 1983 Population by Per Capita Monthly Consumer Expenditure

Per Capita Expenditure Class (Rs.)	% of Rural Population	Avg. Per Capita Monthly Consumer Expenditure (Rs.)	Additional Income Needed Per Year Per Million (Rs. million)
0-30	0.92	25	7.106
30-40	2.47	36	15.780
40-50	5.11	46	26.678
50-60	7.90	55	31.824
60-70	9.69	65	27.328
70-85	15.24	78	20.303
85-100	13.64	92	0.621
100-125	16.99	112	-
125-150	10.00	137	-
150-200	9.78	171	-
200-250	3.96	222	-
250-300	1.81	272	-
300+	2.49	437	-
All Classes	100.0	113	129.640

Source: V.M. Dandekar, Agriculture, Employment and Poverty, Economic and Political Weekly, Vol. XXI, NOs 38-39, Review of Agriculture, September 20-27, 1986.

agree that the next surge in production will be much more dependent on yield increases rather than expansions of the irrigation systems. With this in mind, most doubt that the current and planned schedule of GOI administered prices for inputs and outputs will lead to rapid farmer adoption of improved and more efficient cropping practices and technologies for increased yields.

The price/marketing environment established by the GOI's complex set of cross subsidies, offsetting legislation, regulations, and other policies at the macro, regional and micro level simply does not reflect the opportunity costs of land, labor or capital at either the input or output end of agriculture. By international standards, this has in part led to an inefficient and high cost agriculture sector. The irony of record public sector food grain stocks in 1986-87 while major portions of the population remained under-nourished, despite the fact that the real prices of food remain at their 1920's level, is one manifestation of the failure to use open market mechanisms. Even assuming the proper marketing and pricing policies were adopted, agriculture's ability to respond to the challenge is constrained by lack of inappropriate technological innovations, a deteriorating natural resource base and, perhaps most importantly, widespread climatic variability.

Agricultural Trade, Investment and Rural Financial Markets

I. India's Trade Performance

The foreign trade share of India's GNP has fallen over the first half of the 1980s. During the period 1981-82 and 1984-85 exports and imports accounted for 5.3% and 8.8% of GNP, whereas since 1985-86 both rates declined to 4.6% and 7.6% respectively. Similarly, the share of Indian imports of world exports declined from an average of 0.47% to 0.43% per annum.

The revised export/import figures for 1986-87 contained in Table 1 indicate growth of 14.1% for exports and just 1.6% for imports over 1985-86, which reduced the trade gap by 14% in 1986-87. Nevertheless, India's annual trade deficit is expected to be about Rs.88 billion per in 1987-88. India's overall trade performance during April-October 1987 shows exports increasing by 27.7% and imports increasing by 11.6% over the corresponding period in 1986. In comparison, the export and import growths during April-October 1986 over the same period in 1985 were 15.6% and 1.9% respectively. The impressive export performance was mostly due to the continued good performance of commodities like gems and jewellery, ready-made garments, leather and leather products and cashew kernels. India's total imports in 1987-88 are projected to be around Rs.2,270 billion, a rise of 13%. With projected exports of Rs.1,500 billion the trade deficit in 1987-88 would be around Rs.77 billion.

Unlike some of the other newly industrialized countries, which followed an export led strategy, India has essentially concentrated on production to meet growing domestic demand and on import substitution. As a result, India's share of world trade in total and for most commodity groups has been shrinking, falling from 2.23% in 1948-49 to 0.44% in 1986-87. For instance, the share in tea declined from 33% in 1970 to 13% in 1984, in spices from 21% to 10% and in leather from 13% to 7%. Even for garment exports, which has been growing substantially in the last two years, India commands only 1.5% share of world garment exports, while much smaller countries such as Hong Kong, Taiwan and S. Korea command an export market share of 40%, 25% and 12% respectively. In a time when international trade is steadily increasing this an important feature of India that is counter to world trends.

A significant part of India's trade is concentrated in just a few countries. About 25% of the total trade is with just the USA and Japan. The U.S. share of India's total imports during 1984-85 to 1986-87 decreased from 10.5% to 9.8%. Whereas, the U.S. share of India's total exports steadily increased from 15.0% to 18.8% during the same period.

A. Agriculture's Role in India's Foreign Trade Sector

Exports of agricultural or agriculture related commodities form a relatively important share in India's total exports. The categories of leather & leather products, tea, marine products, cashew kernels, cotton & cotton

Table 1: India's Principal Imports/Exports (Rs. billion)

Year	1983-84	84-85	85-86	86-87	87-88	Avg. Annual Increase
Imports						
Machinery/Transport Equipment	31.7	30.3	35.0	55.0	65.0	10.3
Crude Oil & Pretroleum Products	48.1	53.5	49.6	25.7	44.0	-0.9
Gems & semi-precious Stones	10.0	10.3	11.1	15.3	18.0	2.0
Iron and Steel	10.5	9.4	12.3	13.0	12.0	-0.4
Organic Chemicals	4.2	4.4	4.4	5.0	5.3	0.3
Non-Ferrous Metals	3.9	4.1	4.7	4.3	4.8	0.2
Inorganic Chemicals	2.4	4.1	4.4	4.5	4.8	0.6
Scientific Instruments, etc.	2.2	2.9	3.5	4.0	4.5	0.6
Artifical Resins, Plastics, etc.	2.0	2.2	2.9	3.5	4.0	0.5
Metaliferrous Ores & Scrap	1.9	1.8	2.9	3.0	3.2	0.3
Pharmaceutical/Medicinal Products	1.5	1.4	1.6	2.0	2.3	0.2
Edible Oils	8.5	13.1	8.4	8.0	11.0	0.6
Pulp & Waste Paper	1.0	1.8	2.4	2.4	2.5	0.4
Paper/Paperboard Products	1.6	2.0	2.0	2.0	2.2	0.2
Fertilizers	3.6	14.3	14.1	8.5	2.0	-5.7
Sugar	0.0	1.1	4.5	2.1	1.0	-1.5
Others	24.3	15.0	34.1	42.5	40.4	4.0
Total	158.3	171.2	197.7	200.1	227.0	16.2
Exports						
Gems & Jewellery	13.2	13.1	15.1	21.3	26.0	3.2
Readymade Garments	6.9	10.0	11.0	15.1	19.0	3.0
Crude Oil & Petroleum Products	15.8	18.2	6.5	3.5	5.2	-2.7
Engineering Goods	11.7	11.5	10.0	11.5	12.0	0.1
Iron Ore	4.0	4.6	5.6	6.5	7.0	0.8
Basic Chemicals/Pharmaceuticals	3.0	4.5	4.8	5.6	6.5	0.9
Chemicals & Allied Products	2.4	2.8	3.1	3.3	3.7	0.3
Leather & Leather Products	4.4	5.8	6.7	9.3	12.5	0.5
Tea	5.2	7.7	6.7	6.2	6.5	0.3
Marine Products	3.6	3.8	4.0	4.6	5.3	0.4
Cashew Kernels	1.5	1.8	2.2	3.4	4.5	0.8
Cotton Fabrics/Yarns	4.2	6.1	6.3	7.3	8.5	1.1
Coffee	1.8	2.1	2.8	3.6	4.0	0.6
Spices	1.2	2.1	2.8	3.0	3.0	0.5
Jute Manufacturers	1.7	3.4	2.7	2.8	3.0	0.3
Rice	1.1	1.7	1.7	1.8	2.0	0.5
Tobacco (unmanufactured)	1.6	1.5	1.6	1.7	1.8	0.1
Wheat	0.0	0.1	0.6	0.7	1.0	0.3
Others	14.3	18.5	16.1	14.5	18.5	1.1
Total	98.0	118.5	110.0	125.7	150.0	12.1
Trade Balance						
	-59.8	-52.4	-87.6	-75.1	-77.0	-4.3

Source: December 1987 Economic Outlook (Centre for Monitoring the Indian Economy).

products, coffee, spices, jute, rice, and tobacco accounted for approximately 27%, 30%, 36%, and 35% of India's total exports during the period 1983-84 to 1987-88. Edible oil, pulp & wastepaper, paper & paper products, fertilizers and sugar accounted for 9%, 19%, 16%, 12% and 9% of the nation's total imports during the same period. The main reason the percentage of agricultural imports went down as a share of the total during this period is because of the rapidly increasing indigenous fertilizer production capacity.

The effect of the recent drought on the exports of agricultural commodities, as a class, is expected to be negligible. However, spice exports are likely to decline. Exports of cashew kernels are likely to increase as are leather and leather products. Tea exports which declined in 1986-87 are likely to go up in 1987-88.

Last year's drought has necessitated larger imports of edible oils, oilseeds and pulses. The additional costs associated with this increase is in the range of Rs.50 billion. The drought also reduced fertilizer offtake and, combined with the already existing glut in the domestic market, dramatically reduced fertilizer imports during 1987-88. However, around Rs.20 billion worth of fertilizer are still being imported, mostly from East European countries to meet earlier commitments.

The strong export performers in the agriculture and agribusiness sector during the last several years have been cotton garments and leather & leather products. The performance of readymade garments has been remarkable with exports increasing in 1986-87 by 14.2 percent on top of an increase of 31.4 percent in 1984-85 and 11.9 percent in 1985-86. Readymade garment exports in the last two years have increased from Rs. 95.33 billion to Rs. 121.8 billion in 1986-87. This trend continued in the first half of 1987-88 as cotton garment exports have already reached Rs. 95 billion and expected earnings this year are now expected to be around Rs. 190 billion which is over a 50 percent increase over the previous year.

Leather and leather manufacture exports have increased from Rs. 44.5 billion in 1982-83 to Rs. 78.7 billion in 1986-87. Improved performance was partly due to the GOI improving the access of the private sector to imported inputs. During April - Sept. 1987 exports recorded an impressive 55 percent over the corresponding period in the previous year. It should be noted that the composition of exports has increasingly favored finished leather and leather products. Table 2 shows the export peformance for the sector over a 15 year period ending 1986-87. Table 3 shows the destination of Indian leather and leather products exports for 1985-86 and 1986-87.

However, figures for the above two subsectors of agriculture are mostly due to faster utilization of quotas in the importing countries. Exports of ready made garments remain heavily dependent on bilateral trade agreements with the U.S. and the EEC. Exports of leather & leather products almost trebled in the past seven years. In the first six months of 1987-88, exports were Rs.53 billion, as compared to Rs.40 billion during the same period of the previous year, indicating a growth rate of 31% over the previous year.

115

Table 2: India's Leather Export Performance 1972-87 (Rs. Billions)

Year 19-	Semi-Finished	Finished Leather	Footwear	Footwear Components	Leather Garments	Leather Goods	Total
72-73	153.2	16.6	8.4			8.3	186.4
75-76	134.5	54.7	20.1			18.8	227.9
80-81	56.5	226.8	33.7	45.1		29.7	328.9
81-82	56.9	223.1	21.6	70.4	6.1	36.9	414.9
82-83	54.4	199.9	19.5	79.3	7.4	38.7	399.3
83-84	53.3	195.5	23.5	113.5	10.3	43.3	439.6
84-85	49.2	308.5	26.8	132.8	9.5	57.1	583.8
85-86	49.8	288.2	33.1	190.6	16.7	85.1	662.5
86-87	52.5	400.9	80.4	240.6	62.3	94.0	930.8

Table 3: Imports into 8 Selected Countries of Leather & Leather Products and India's Share Thereof (Millions of Dollars)

Rank	Country	Total Imports	Imports From India 1985-86	Imports From India 1986-87	% Share of India's Total Imports 1985-86
1.	USA*	7694.1	82.0	88.2	8.9
2.	FRG*	3077.9	72.6	135.8	2.4
3.	USSR	N.A.	100.2	138.3	-
4.	GDR	N.A.	28.1	44.9	-
5.	France*	1627.9	30.0	36.7	1.8
6.	UK*	1376.1	45.9	53.7	0.3
7.	Japan*	652.6	12.2	6.7	1.9
8.	Australia	N.A.	15.2	N.A.	-

Note: The countries marked by * accounted for approximately 77 percent of total world imports of leather and leather products.

Another area, or set of subsectors, receiving increased attention in agriculture is processed foods. India's growing middle class is exerting an increasing demand for higher value-added, convenience food products. In response to these changing demands, the nation's agribusiness sector is undergoing a rapid transformation and expansion. As part of this process, the agribusiness sector has become interested in exploiting opportunities in the international market as a way to diversify their markets for fresh/processed foods as well as to earn scarce foreign exchange. While still small the export trade in food is growing rapidly as demonstrated in Tables 4 and 5.

B. Agriculture Import/Export Policy Environment

1. Imports

The GOI follows a restrictive import policy for most agricultural products to conserve foreign exchange reserves and to protect domestic producers. Recent policies have provided greater access to imports of technology, machinery equipment and intermediate inputs to modernize the industrial technological base, foster greater efficiency, and lower costs of domestic producers.

Table 4: Export Trends of Major Agricultural & Processed Foods (Rs. millions)

Item	1980-81	81-82	82-83	83-84	84-85	85-86	86-87*
- Fruit Juices & Other Canned/Bottled Fruits	1415	2946	6432	3849	4986	5734	3913
- Frozen Buffalo Meat	4172	4707	4603	3082	3459	3401	3606
- Fresh/Frozen Sheep & Goat Meat	219	786	1091	1198	1339	1321	937
- Guar Gum	5906	11390	4345	4436	6191	4303	2834
- Walnuts in Shell	142	283	80	45	73	19	30
Walnut Kernals	259	423	339	318	462	352	406
- Fresh Mangos & Other Fresh Fruits	2235	2559	3244	3668	3450	2229	2500
- Fresh Vegetables	1038	2676	2909	3268	3366	2258	2800
- Fresh Onions	19368	16977	18131	18151	27480	6938	26587
Major Items % Share of Total	73	80	85	82	86	89	87

* Estimated
Source: Directorate General of Commercial Intelligence & Statistics, Calcutta

Table 5: Percentage Change in Export Value of Fresh and Processed Food Products

Item	1980-81	81-82	82-83	83-84	84-85	85-86	86-87*	Avg. Annual % Increase
- Fruit Juices & Other Canned/Bottled Fruits	4	7	20	14	15	17	13	13
- Frozen Buffalo Meat	18	15	17	15	14	15	15	16
- Fresh/Frozen Sheep & Goat Meat	2	4	7	10	9	10	8	7
- Guar Gum	25	35	14	10	12	11	11	17
- Walnuts in Shell Walnut Kernals	3	3	4	3	4	3	4	3
- Fresh Mangos & Other Fresh Fruits	5	4	6	8	7	9	8	5
- Fresh Vegetables	2	3	6	8	7	6	6	5
- Fresh Onions	13	9	12	15	18	18	20	26

* Estimated
Source: Directorate General of Commercial Intelligence & Statistics, Calcutta

However, due to foreign exchange problems and local availability, imports of many food products, including processed foods, is banned. To alleviate shortages, the GOI resorts to ad hoc imports of cereals, fertilizers, etc. which is canalized through parastatals.

Under the current three year Trade Policy, there has been a shift toward further liberalization in Indian import policies and procedures. For instance, the GOI has allowed the National Dairy Development Board (NDDB) to import a limited quantity of vegetable oils at competitive prices. In 1987, NDDB bought 25,000 MT of soybean oil from the U.S., availing of the EEP facility, in addition to a similar quantity of rapeseed oil purchased from Canada in 1986. It is also rumored that the State Trade Corporation (STC) is inclined to some imports of oilseeds in place of vegetable oils. Imports of pulses continue to be under OGL, permitting private trade participation. Imports of dry fruits (almonds, raisons, pistachios) are against licenses issued to dealers engaged in this trade.

The import duty on pulses has been recently reduced from the previous 25% to 10%. This is expected to facilitate greater access to U.S. dry pea and lentil exports to India. Unfortunately, restrictive controls on dry fruit imports has limited U.S. and India trade turnover in this area. U.S. almond exports to India have fluctuated between $6.1 and $3.1 million since 1980-81, mainly because of GOI's licensing restrictions. Under present trade policy, any established importer of dry fruit is entitled to import dry fruit (including almonds) at only 20% of the C.I.F. value of the highest import level attained during any of the financial years from 1972-73 (April-March). Because of the high demand for almonds, dried fruit licenses were transacted or sold at 265% of the face value, which resulted in extravagant prices to Indian consumers. Hence, almonds are retailed at about $20 per bag during the festive season. Most recently, the GOI has substantially liberalized import and approval restrictions on plant genetic material for improved seed.

In summary, GOI decision makers are recognizing the importance of liberalization with its peripheral advantage of access to new technology and products. The current three year trade policy (1988-91), announced on 1 April 1988, continues this slow but steady movement towards trade liberalization.

2. Exports

The primary objective of the GOI's policy is to promote exports to the maximum extent, in a manner that the economy of the country is not affected by unregulated exports of essential commodities. For this reason, exports of some agricultural products are channeled through GOI recognized agencies. These items include: sugar, castor oil, molasses, onions, raw jute, etc. Exports of rice and wheat by private trade are permitted. Rice exports are, however, subjected to a minimum export price (MEP) restriction, which is $577 per MT for basmati rice and $231 per MT for other types of rice.

Other commodities whose exports are subject to MEP restriction or export ceiling restrictions include meat of buffalo, sheep and goat, live animals, marine products, pure milk ghee, eggs, fresh fruits and millet, HPS peanuts, sesameseed, nigerseed, sugar, molasses, oilseed meal, semi-processed hides and skins, raw wool, etc. To reduce stocks of raw cotton to an optimal level, the GOI authorized exports of 275,000 bales of cotton for 1986/87 subject to MEP restrictions. As it stands, the agriculture sector is a net earner of foreign exchange, some $1.7 billion in 1984-85.

C. Tariff

A long-term fiscal policy, announced by the GOI's Finance Minister in December 1985, was aimed at rationalization and simplification of the customs and tariff structure for various commodities. This policy will remain in effect till the end of 1990 to coincide with the terminal year of the Seventh

Five-Year Plan. However, most of the commodities affected by this policy were non-agricultural. In the GOI's Budget for IFY 1986-87, the export duty on unmanufactured tobacco was completely abolished. The import duty on raw wool was reduced by 40% ad valorem to 20 percent. As a consequence of deforestation and concern about declining forest resources, the GOI reduced duty on timber and sawn log imports in late 1985. The current rate of duty on coffee is $462 per MT effective 17 July 1987.

D. Export Subsidies and Incentives

The GOI continues to provide subsidies and incentives in the form of cash, duty drawbacks, import replenishment license (REP), etc. on exports of various commodities, including agricultural items. This is aimed at making these goods more price competitive in the international market and to promote exports. Such subsidies and incentives are mostly for value added products. Two years ago the GOI introduced a 10 percent cash subsidy on exports of all oilseed meal.

A scheme of cash compensatory support (cash subsidy) for exports was introduced on 1 April 1986 for a period of three years and broadly covers 10 product groups which include processed food and agricultural items, marine products, textiles, jute goods, and leather goods. Total expenditures incurred by the GOI under the Foreign Trade Export Promotion Program for 1985-86 was about $500 million and is budgeted at $427 million, which represents a very minor share of the total GOI budget.

II. Agricultural Investment

A. General

Trends in investment in the Indian economy as a whole are presented in Table 6. Expressed as a percentage of the respective estimates of gross domestic product (GDP), the rates of gross domestic capital formation for the years 1985-86, 86-87 and 87-88 are estimated to be 24.6%, 25.0% and 24.5%. While the rates for recent years are high, they are still below those of China, South Korea, Indonesia and Malaysia, all of which exhibited (per Table 7) higher average growth rates then India. On the other hand, Thailand and Pakistan have had lower rates of capital formulation than India but have been able to sustain higher rates of growth. This indicates that the higher capital productivity levels in the first group gave higher rates of economic growth, and with higher growth rates a much higher rate of capital formation could be sustained. The performance of the second group of countries also suggests a higher capital productivity than that of India.

As the nation's gross investment rate has increased sharply from 10% of GDP in 1950-51 to around 24.7% in 1980-81, it's clear that India's economy does not suffer from inadequate investment. However, the fact still remains that there has been no corresponding acceleration in the growth rate of national income. Thus, it would appear that too much emphasis may have been placed by the GOI on investment expenditures and not enough on the use of capital assets.

119

Table 6: Trends in Investment In the Indian Economy

Year 19-	Gross Capital Formation Rs. Billions	Gross Capital Formation As % of GDP	GCF in Real Terms Index 70-71 = 100	Agriculture GCF at Current Prices Rs. Billions	% Share in GCF Total
50-51	95.4	10.0			
60-61	254.4	16.9			
70-71	717.7	17.8	100.0		
75-76	1481.1	19.9	117.9		
79-80	2527.8	23.5	153.6		
80-81	3147.6	24.7	170.6	467.0	15.1
81-82	3607.6	24.4	173.8	516.6	14.3
82-83	3994.1	24.2	176.3	570.9	14.3
83-84	4560.7	23.5	183.0	643.1	14.1
84-85	5238.9	24.4	192.9	744.2	14.2
85-86	5991.6	24.6	201.7	790.7	13.2
86-87	6850.0	25.0	226.3	865.1	12.6
87-88*	7550.0*	24.5*	243.5*		
Compound (%) Annual Rate of Increase for Selected Periods-------					
75-80	14.3		16.8		
80-85			4.7		
85-88			8.1		
79-87	15.3				

GCF = Gross Capital Formation * = Estimated
Source: Dec. 1987 Economic Outlook (Centre for Monitoring the Indian Economy)

Table 7: Rates of GCF for Selected LDCs & Annual Real GDP Growth Rates

Countries	GCF as a % of GDP 1965	GCF as a % of GDP 1976	GCF as a % of GDP 1985	Average Annual Growth Rates of GDP 1975-85
---Group One---				
China	25		38	9.6
South Korea	15	25	30	7.6
Indonesia	8	23	30	5.3
Malaysia	20	22	28	6.8
Egypt	18	24	25	7.8
Sri Lanka	12	15	25	4.7
India	18	19	25	4.5
---Group Two---				
Thailand	20	26	23	6.2
Mexico	22	26	21	4.1
Colombia	16	18	18	3.7
Pakistan	21	17	17	6.2
Brazil	25	26	16	3.4
Philippines	21	31	16	2.5
Argentina	19	22	9	-0.1
- Average for the above countries	18	23	23	5.0
- Average for OECD countries	23	24	22	2.4

Source: Dec. 1987 Economic Outlook (Centre for Monitoring the Indian Economy)

128

Only a small part of the problem can be attributed to basic structural changes that normally take place in a developing economy. It appears that the potential gains from the large and laudable increase in the investment rate has been largely negated by a corresponding decline in the efficiency with which the capital assets of the country are built and used (i.e., increase in capital/output ratios). The assertion holds true for the agriculture sector and is further substantiated by the analysis on agricultural productivity per unit of input provided in another section of this paper.

According to the latest data, per Table 8, the national income generated by the public sector in 1983-84 was Rs.2177 billion as compared to the total for the economy of Rs.15880 billion. The public/private share in total national income generated was consequently 23% and 77%. The private sector accounted for 97.5% of national income generated by the agriculture sector. Regarding investment, the public/private share in gross domestic capital formation in 1984-85 was 48% and 52% respectively and remained the same in 1986-87. For agriculture, the private sector accounted for approximately 69% of the sector's 1984-85 investment in capital stock.

Table 8: Activity Wise Share of Public Sector in National Income (NI)

Activity/Year	Rs. Billion			% of income generated by public sector			% of NI Generated by Activity (public & private)		
	60-61	80-81	83-84	60-61	80-81	83-84	60-61	80-81	83-84
Agriculture	7.8	100.6	144.2	5.5	4.7	3.9	1.1	2.4	2.5
Agriculture	3.0	58.3	81.0	2.1	2.7	2.2	0.5	1.5	1.4
Forestry	4.8	42.3	63.2	3.4	2.0	1.7	27.6	41.1	42.2
Fishing	-	-	-	-	-	-	-	-	-
Mining/Manufacturing.	18.6	639.8	1212.6	13.1	29.7	33.1	6.9	25.1	30.6
Communication Transport, & Trade	37.9	327.6	553.5	26.6	15.2	15.1	20.3	15.3	16.6
Banking and Insurance	62.0	286.3	477.2	4.4	13.3	13.0	38.8	85.8	82.4
Community & Personal Services	71.7	797.3	1279.7	50.4	37.1	34.9	51.3	72.6	72.1
Public	142	2152	3667	100.0	100.0	100.0	10.7	20.4	23.1
Private	191	8399	12213				89.3	79.6	76.9
Total	3335	10551	15880				100.0	100.0	100.0

Source: Public Sector in the Indian Economy, November 1986, Report by the Centre for Monitoring the Indian Economy

As indicated in Table 9, agriculture's share of total public gross capital accumulation increased marginally from 11.7% in 1960-61 to 12.6% in 1970-71, declined to 11.2% in 1983-84, and then increased markedly to approximately 19% in 1984-85. The vast majority of public sector capital formation in agriculture during the 25 year period is accounted for by major and medium irrigation works. Private sector investment in the irrigation subsector was almost totally limited to tubewells and low lift pumps which cover about half of the additional irrigated acreage. Beyond irrigation, public participation in agriculture was limited to fertilizer and forestry and to a much lesser degree, the seed subsector.

Table 9: Activity Wise Shares of Public Sector in Gross Capital Formation (GCF)

	GCF in the Public sector Rs. Billions			% of GCF in the public sector			% Share of public sector GCF in the total economy		
Activity/year	60-61	70-71	83-84	60-61	70-71	83-84	60-61	70-71	83-84
Agriculture	13.3	34.8	243.1	11.7	12.6	11.2	32.8	22.5	31.2
Agriculture	12.6	32.9	228.9	11.1	11.9	10.5	31.9	25.3	31.1
Forestry	0.7	1.9	14.2	0.6	0.7	0.7	87.5	79.2	81.1
Fishing	-	-	-	-	-	-	-	-	-
Mining & Manu-Facturing	31.9	52.3	675.6	28.1	18.8	31.0	38.0	24.0	49.9
Communication, Power & transport	35.5	115.1	736.5	31.2	41.5	33.8	76.0	98.6	79.9
Services	33.0	75.1	522.1	29.8	27.1	24.0	40.1	34.6	35.9
Public Sector Activities	113.7	277.3	2177.3	100.0	100.0	100.0	44.7	38.6	48.0

Source: Public Sector in the Indian Economy, November 1986, Report by the Centre for Monitoring the Indian Economy

Government institutions responsible for monitoring the Indian economy have noted in recent years a rapid increase in public and private sector investment in agribusiness which supplies inputs to agriculture and processes and markets the outputs. If this investment could be calculated and included under agriculture, the sector's share in investment and national income would show a steep increase.

B. Foreign Investment In Agriculture

India continues to look upon foreign investment as a vehicle for the transfer of technology required by the country. The GOI regulates the inflow of any private or public investment in various industries and agriculture. In late 1986 and early 1987 the government streamlined some of its complex investment procedures and reduced the number of control points. Proposals involving foreign financial participation are examined by both technical and financial committees.

Favorable consideration is most likely for export-oriented ventures. The GOI allows a flexible approach to the level of foreign equity in joint ventures, but the normal ceiling for foreign investment is 40 percent of the total equity capital. This policy is relaxed for certain high-tech fields, such as electronics and telecommunications, and for joint ventures that are predominantly export-oriented.

A second exception to the general policy is investment by non-resident Indians. There are, in fact, a number of joint ventures in India in which foreign equity varies from 40 to 74 percent. Some export-oriented units are almost wholly foreign owned. The Indo-U.S. collaborative ventures are now active in 21 Indian states and union territories with the greatest concentration in Maharashtra (more than 300), Delhi (nearly 150), and West Bengal (100). More than 50 percent of the collaborations are in high technology products comprising electrical equipment, electronics, industrial machinery and chemicals.

Most investments in agriculture made prior to Indian Independence in 1947, including tea, coffee and rubber plantations, were of British origin. There is not private direct equity investment within the Indian agricultural sector, as narrowly defined by macro-economic statistics. The only known direct American investment in this sector is in areas related to poultry farming. In 1987 a major U.S. grain trading organization entered into a joint collaboration with a private firm in Bombay for production of improved varieties of oilseeds, particularly sunflower. The oilseed sector has drawn the interest of numerous U.S. business enquiries since India needs to develop its capacity to produce HYV seed to help meet the domestic vegetable oil demand.

In 1985 the U.S., with 197 new collaborations, was the leading source of new foreign business approvals in India for the sixth consecutive year. U.S. direct investment in India at the end of 1985 was estimated at about $500 million, and significant new investments are likely to continue. If plans to revise the Foreign Exchange Regulations Act (FERA) come to fruition, the investment climate will be markedly improved. National policy is to promote indigenous industries that will allow the country to become self generating in the future. In view of the number of well-trained engineers and scientists (particularly agricultural scientists) this is a realistic goal in some sectors, although there are obvious disadvantages in restricting foreign competition in the Indian market.

III. Rural Financial Markets (adopted from work by Dr. B. Sen, USAID/India)

In some respects the recent performance of the rural financial market in India has been impressive. The multi-agency approach to rural credit adopted in the late sixties has led to the opening of a large number of new rural and semi - urban branches of nationalized banks. The volumes of crop production credit and investment credit have increased. The share of formal institutional credit in total rural credit has risen from 18.6 percent (in 1981) to about 62.6 percent (in 1981). However, the performance falls short of expectation when judged in terms of growth of credit in real as distinct from nominal terms, the coverage of rural households, the mounting overdues and loan recovery. There are also questions about the viability of the agricultural credit system itself because of increasing politicization of credit, large number of credit-based rural programs which cannot be administered on sound professional lines and the small interest margin allowed to the agencies which is inadequate to cover the transaction costs.

A. Features of the Market

The rural financial market in India consists of both informal (unorganized) and formal (organized) agencies. The informal sector includes professional moneylenders, traders, commission agents, and agriculturist moneylenders. The latter operate outside the provisions of the Indian Banking Companies Act. The organization of this sector is complex; neither the Government of India nor the Reserve Bank of India has any direct control over it. The sector is only multifunctional in the sense that it operates not only in finance but also in land and commodity markets. Little information is available about the number of operators in this sector or about its profitability. There are conflicting views about the nature of profit in this sector's operations. According to one view, profits in informal lending are exploitative and have monopolistic elements. According to another view, high profits in this sector are due to high risks and administrative costs. Therefore, those monopolistic elements, if any, are limited to a few regions.

The formal sector consists of about 92,496 primary agricultural credit societies (PAC), 1968 primary units of land development banks (LDB), 28,504 rural and 10,526 semi-urban branches of commercial banks and 12,836 branches of Regional Rural Banks (RRB). While all these agencies are termed institutional agencies, there are differences among them. First, all commercial banks and the three-tiered cooperative credit agencies dealing with short and intermediate term credit are banking institutions. The cooperative land development banks are not required to maintain cash reserve ratio and the liquidity ratio. Second, the cooperative credit societies receive differential treatment in terms of the banking regulations related to cash reserve and liquidity ratios; they also borrow at an interest rate two percent below the bank rate. Third, the primary cooperatives are supposed to be multi-functional in character, integrating credit and marketing at the village level. In contrast the banks are largely uni-functional.

B. Growth in Institutional Credit

The absolute amount of short-term production credit in nominal terms supplied by all institutional agencies increased from Rs.7.6 billion in 1973-74 to Rs.25.9 billion in 1982-83. In percentage terms this represents a growth rate of 14.5 percent. Growth has been impressive in Orissa (24.6%), Kerala (24.3%) and Haryana (22%); it has been poor in states like Assam (4.2%), Himachal Pradesh (4.1%) and Gujarat (3.4%). (see Table 10)

Table 10: Growth of Short-term Institutional Credit in Nominal and Real Terms (in million Rupees)

State	1973-74	1982-83 (nominal)	Growth Rate (percent)	1982-83 (real)	Growth rate (percent)
Haryana	291	1743	22.0	715	10.5
Himachal	26	38	4.1	16	-5.5
Jammu & Kashmir	22	54	10.6	22	0.0
Punjab	585	2335	16.6	958	5.6
Rajasthan	244	1080	17.9	443	6.8
Assam	15	21	4.2	9	-5.8
Bihar	133	364	11.8	149	1.3
Orissa	130	942	24.6	386	12.8
W.Bengal	153	503	14.1	206	3.4
Madhya Pradesh	522	1450	12.0	595	1.5
Uttar Pradesh	701	2357	14.4	967	3.6
Gujarat	1133	1532	3.4	628	-6.8
Maharashtra	1346	3381	10.8	1387	0.3
Andhra Pradesh	462	2553	20.9	1048	9.5
Karnataka	548	1905	14.8	781	4.0
Kerala	427	3031	24.3	1243	12.6
Tamil Nadu	883	2558	12.5	1049	1.9
Total	7668	25977	14.5	10655	3.7

Source : Adapted from H.V.Gadgil (1986).

Per Table 11, the institutional agencies served about 21.1 million farmers or about 23 percent of all farmers in 1982-83. As a percentage of the production cost of all crops in 1982-83, Rs.25.9 billion represents only 15 percent. Cooperative agencies supplied about 73 percent of the total production credit, while the commercial banks supplied about 22 percent.

The growth in long-term investment credit also appears impressive in nominal terms. Thus, the investment credit flow increased from Rs.4.1 billion in 1973-74 to Rs.17.4 billion in 1982-83, indicating a growth rate of 17.1 percent. Increases have been substantial in Assam (40.5%), Jammu and Kashmir (34.7%) and Himachal Pradesh (30.9%). About 1.7 million farmers benefited from investment credit. Commercial banks' share in the total investment credit supplied was the highest at about 38.6 percent (Table 11).

TABLE 11: Growth of Institutional Investment Credit in Nominal and Real Terms

(in million Rupees)

State	1973-74	1982-83 (nominal)	Growth rate (%)	1982-83 (real)	Growth Rate (%)
Haryana	188.4	797.3	17.4	391.2	8.5
Himachal	36.0	407.5	30.9	200.0	20.1
Jammu & Kashmir	6.0	87.6	34.7	43.0	24.5
Punjab	202.2	1216.5	22.0	596.9	12.8
Rajasthan	162.0	1261.1	25.6	618.8	16.1
Assam	3.2	68.6	40.5	33.7	29.9
Bihar	189.8	760.6	16.7	373.2	7.8
Orissa	69.7	648.1	28.1	318.0	18.4
W.Bengal	63.1	321.7	19.8	157.9	10.7
Madhya Pradesh	279.6	992.2	15.1	486.8	6.3
Uttar Pradesh	498.4	2329.8	18.7	1143.2	9.7
Gujarat	399.6	1472.6	15.6	722.6	6.8
Maharashtra	518.8	1627.3	13.5	798.5	4.9
Andhra Pradesh	390.8	1804.5	18.5	885.4	9.5
Karnataka	481.2	1353.1	12.1	663.9	3.6
Kerala	241.1	1141.1	18.8	559.9	9.8
Tamil Nadu	461.1	NA	NA	518.2	1.3
Total	4195.2	17401.0	17.12	8538.3	8.2

Source : Adapted from M.V.Gadgil (1986)

While the volume of credit has expanded substantially in nominal terms, the growth would seem to be modest in real terms. As against a growth rate of 14.5 percent in short-term production credit in nominal terms, growth in real terms was only 4 percent with large variations among states. As a matter of fact, growth was negative in real terms in three out of seventeen states - in Assam, Gujarat and Himachal Pradesh. Growth in investment credit also was modest in real terms - about 8 percent.

C. Deposit Mobilization

A dominant objective of banking policy in recent years has been to restrict the flow of funds from rural and semi-urban areas to urban and metropolitan areas in the interest of balanced development and reduction of inter-regional disparities. Commercial banks and the Regional Rural Banks are required to achieve a 60 percent credit-deposit ratio. However, the achievement has been unsatisfactory. The stipulated ratio has been achieved only in 197 districts out of 442. Total rural deposits mobilized by institutional agencies - mainly the commercial banks and the Regional Rural banks - were estimated at about Rs.140 billion at the end of 1986.

It appears from some official surveys that only about 12.7 percent of farm households hold deposits with financial institutions despite a large expansion of the rural branches of commercial banks and the Regional Rural Banks in recent years. In fact the proportion of farm households holding voluntary deposits would appear to be much smaller, if the households required to open deposit accounts for purposes of credits are excluded. Furthermore, deposits account for less than one percent of total assets of farm households. Part of the problem of deposit mobilization seems to be the unattractive return on deposits relative to returns on alternative investment on land and even petty bussiness.

D. Interest Rates

The features of the interest rates policy for agricultural loans are the following : (1) the rates are uniform for all institutional credit agencies; (2) the rates for short-term production loans vary with the size of the loans; (3) long term investment loans for minor irrigation and land development carry a smaller interest rate than on other types of long-term loans; and (4) the rate of interest for small farmers on long-term investment loans for purposes other than minor irrigation and land development are lower than for other farmers (Table 12). Compared with commercial loans which carry about 17.5 percent interest rates, interest rates on agricultural loans vary from 10 percent to 16.5 percent, and are highly concessional. In fact, the real interest rate for agricultural loans, considering the rise in wholesale price index, would be negative. Thus, the average interest subsidy in all rural credit supplied would run into billions of rupees. In sum, the borrowers benefited both in terms of concessional interest rates and capital transfer. At the same time, the concessional interest rates have highlighted the question of viability of the institutional agencies.

E. Viability of Agencies

As the interest margin available to institutional agencies is small, their viability would depend upon their transaction costs. These costs vary among the commercial banks, land development banks and the primary cooperative societies. In the case of the commercial banks, the transaction costs of loans are about 2.6 times the minimum interest margin and about 14 percent higher than the maximum interest margin available to them; obviously there is no question of their generating a surplus. Agricultural credit is a losing proposition for these agencies. The transaction cost of Land Development Banks are greater than the minimum interest margin in several states. However, the cooperatives are not so badly off, since the minimum interest margin exceeds their transaction costs in most of the states.

The consequences of the small interest margin are several. First, the agencies cannot generate a comfortable surplus to cover bad debts and expenses to raise efficiency of loan servicing. Second, in order to minimize transaction costs, a minimum of field staff is maintained; staffing is admittedly inadequate and the efficiency is poor because training suffers. All these lead to poor scrutiny, servicing and supervising of loans. Third, the cooperatives particularly have no incentive to mobilize deposits because they cost more than the refinance they get from NABARD.

Table 12: Lending Rates on Agricultural Advances, 1986

Credit Agencies	Interest Rate (% per year)
(A) Primary Agricultural Credit Societies	
(i) Short-term loans	
a) Loans upto Rs.5,000	11.50
b) From Rs.5,000 to Rs.10,000	12.50
c) Over Rs.10,000	14.00
(ii) Medium Term Loans	
a) Minor irrigation and land development	10.25
b) Other purposes	
Small farmers	10.25
Other farmers	12.50
(B) Land Development Banks	
Minor irrigation and land development	10.00
Other Purposes	
Small farmers	10.25
Other farmers	12.50
(C) Commercial Banks and Regional Rural Banks	
(i) Production Credit	
Loans to small farmers upto Rs.5,000	11.50
Loans above Rs.5,000 and upto Rs.10,000	12.50
Loans over Rs.10,000 and upto Rs.25,000	14.00
Above Rs.25,000	16.50
(ii) Investment Credit	
a) Minor irrigation and land development	10.00
b) Other purposes	
Small farmers	10.00
Other farmers	12.50
(iii) Integrated Rural Development Program	10.00
(iv) Self-employment Scheme for Educated Unemployed	
Backward areas	10.00
Other areas	12.00
(v) Differential Rate of Interest Scheme	4.00

Source : P.D.Ojha (1986)

Mounting loan deliquency has been an endemic problem of India's agricultural credit system. It is also the system's Achilles' heel. Defaults can be classified into two types, involuntary and voluntary. Involuntary defaults are due, among other things, to unforseen natural calamities such as crop failure; failure of investments; underfinancing leading to noncompletion of projects on the one hand and borrowing from noninstitutional sector which preempts recovery of formal loans on the other. Voluntary defaults are due to misuse of credit and lack of political support for loan recovery; the complicated recovery procedure through legal action; and the opportunity to earn higher returns from alternative uses. In 1982-83, loan overdues as percentage of demand were as high as 50 percent in the case of land Development Banks, 46.9 percent in the case of Commercial Banks and 40.1 percent for cooperative societies. The ratio was the least (25.4) in the case of Regional Rural Banks. Increasing loan overdues are a serious constraint to the ability of the institutional agencies to recycle funds and to issue fresh loans.

F. Concluding Comments

The environment in which the rural financial market has to function in India is not conducive to growth on a sound basis. Underlying the expansion of institutional agencies and in the size of credit in nominal terms are powerful political forces that can bring about a crisis of serious proportions. Political rather than economic considerations have saddled the agencies, particularly the commercial banks, with a large number of credit-based rural development programs. Political considerations again determine the quantitative targets and the volume of "mass loans." Theoretically, the banks have the responsibility and the accountability for identifying lending potential, preparation of bankable schemes, monitoring and recovery of loans. But in practice, they are unable to perform these functions in the environment they have to operate. Hence, the willful defaults and mounting overdues, high transaction costs and losses have to be covered by incomes from nonagricultural sectors. The system has been designed to serve the objective of growth with equity. It serves neither; it is wasteful of precious resources.

Yet, this system has been given ambitious targets to reach by 1989-90, at the end of the Seventh Plan (see Table 13). Formal credit in agricultural sector is to increase by 151 percent, from Rs.58 billion in 1984-85 to Rs.145.8 billion in 1989-90. Going by past record, perhaps the target will be achieved. Going also by past trend, there will be more defaults, more overdues and more interest subsidy. In short, there is likely to be no change in the overall scenario.

Table 13: Seventh Plan Targets

Credit Agency	Anticipated Achievement in 1984-85 (in Rs.billion)	Seventh Plan target for 1989-90 (in Rs. billion)	Increase in 1989-90 over 1984-85 (Percent)
Cooperatives:			
Production Credit	25.000	55.400	122
Investment Credit	7.500	15.300	104
Total	32.500	70.700	117
Commercial banks: (including RRBs)			
Production credit	11.000	31.550	187
Investment credit	14.600	43.600	199
Total	25,600	75.150	194
All Institutions:			
Production credit	36.000	86.950	142
Investment credit	22.100	58.900	167
Total	58.100	145.850	151

129

Agricultural Education, Research and Extension

I. Agricultural Education

After 1947, when India attained independence, rapid growth took place in all educational fields including agricultural education. Extensive infrastructural facilities were established for higher education in many areas of specialization. The Union as well as the State Governments have legislative power and, therefore, share responsibilities for implementing and coordinating overall educational programs. The Union Government, for example, has assumed responsibility to re-enforce the national and integrative character of education, to maintain quality and standards, and to study and monitor the educational requirements of the country in regard to human resource development.

A. Agricultural Education in India - A Brief History

In 1947, when India became independent, there were 17 institutions providing agricultural and veterinary education. There was a total intake capacity of about 1500 students in agriculture and 250 students in veterinary science. Most of these institutions were established under the State Governments and managed by the respective Departments of Agriculture of the concerned states. These institutions were functioning as affiliated colleges to the general universities which had no special commitment to the farming community. They were previously preoccupied with the development of syllabi and the conduct of examinations instead of providing guidance and leadership to the farmers through direct involvement. Some institutions, however, did maintain high academic standards though they emphasized the teaching principles of crop production rather than their application to field problems.

The pressing need to bring about a rapid increase in agricultural production during the years following independence necessitated a complete overhaul of the agricultural education system. It was soon realized that the goals of increased production could be achieved only through the application of science and technology to agriculture and training personnel for developing a science based agriculture. With the introduction of the first five year plan in 1952, the need for agricultural and veterinary graduates to implement various development programs was openly recognized. In response, a large number of public and private institutions were established throughout the country. The number of agricultural colleges increased about 3 times and veterinary colleges almost doubled during the period from 1951-1961.

In the meantime, the Government of India appointed a number of expert bodies to look into the problem of agricultural education. The University Education Commission headed by the late Dr. S. Radha Krishnan, former President of India, in 1948-49 recommended the establishment of 'Rural

Universities.' This proposal was further studied and examined by various expert bodies. Based on their recommendations, the Government of India came to the conclusion that the Land Grant College System of Education in the USA provided the most promising base for developing a suitable Indian model.

B. State Agricultural Universities

The agricultural university system has been developed and adapted to local conditions, resources and local genius. The model envisages, among other things, statewide responsibility for teaching, research and extension education in agriculture and allied sciences through a network of constituent colleges under a single administration. It also includes the integration of research, education and extension programs with sufficient flexibility for quick response to changes/reforms. It also calls for autonomy in the functioning and adoption of an internal evaluation system. The first ag. university on the land grant pattern was established at Pantnagar, U.P. in 1960. This was followed by the establishment of state agricultural universities in different states. In the initial phase, nine state agricultural universities had entered into a collaborative arrangement with six USA agricultural universities which provided technical assistance, equipment and facilities for the higher education of teachers of agricultural universities in the USA.

The State Agricultural Universities are autonomous institutions established by the concerned State Governments and are governed by an act passed by respective State legislatures. These institutions receive financial assistance from the States for their maintenance and some of their development activities. The Government of India through the Indian Council of Agricultural Research (ICAR) provides the major share of assistance for developmental activities. The universities consist of a number of faculties/colleges such as agriculture, veterinary science, home science, agricultural engineering, etc. Each has both a directorate of extension research under a unified central administration. The faculty-wide administrative responsibility rests with the deans of the respective faculties. The Vice Chancellor is assisted by a Board of Management which is the supreme body concerned with the general administration. Other bodies include the academic council, research council and extension council.

Today, there are 26 State Agricultural Universities offering undergraduate programs in 11 specialized fields with a total intake capacity of about 10,000 students. These institutions also provide postgraduate educational programs in more than 50 disciplines with a total intake capacity of about 3,500 students. The details of these faculties, colleges and their admission capacity are given in Attachment 1.

C. Deemed Universities

Even before the development of an agricultural university system in the country, efforts were made to promote postgraduate education through assisting some of the then existing agricultural and veterinary colleges to establish postgraduate departments. In addition, the Government of India established a postgraduate college of agricultural science at the Indian Agricultural Research Institute, New Delhi, and Post-Graduate College of Animal Science at the Indian Veterinary Research Institute, Izatnagar, Bareilly, in 1956. These institutes were later conferred with the status of 'Deemed to be University' and are offering Master's and Doctoral level programs in different fields of specialization in agriculture and animal sciences respectively.

D. Agricultural Faculties of Central Universities

Over and above the agricultural universities, three Central Universities in the country -- Banaras Hindu University, Varanasi; Vishwa Bharati, Shanti Niketan; and North-East Hill University, Shilong -- have Faculties of Agriculture with facilities for undergraduate and postgraduate education in agriculture.

E. Agricultural Education in General Universities

Though all the major states in the country have been brought under the agricultural university system, about 30 agricultural colleges are still functioning under the private sector as affiliated colleges to general universities. These colleges are responsible for the production of about 45% of the total agriculture undergraduates in the country.

F. Role of ICAR in Agricultural Education

The ICAR is entrusted with the responsibility of coordinating, aiding and promoting agricultural education in the country. It operates a large number of programs for infrastructural development, manpower development and quality improvement. In terms of infrastructure development, the Council provides financial assistance to state agricultural universities to build up necessary facilities for imparting quality education in terms of classrooms, laboratories, and so on. ICAR also provides for the purchase of equipment, development of libraries, students' and staff housing. As a means to promote manpower development, the Council provides various types of scholarships and fellowships to attract talented students towards agricultural education at different levels. To coordinate the educational activities, the Council has set up Deans' Committees from time to time to develop common curricula for various courses in agriculture and allied sciences. The curricula developed by these Committees are being generally adopted by the state agricultural universities with suitable modifications. Examinations/Evaluation System in agricultural universities are also being monitored by ICAR to maintain uniformity in standards. There exists, however, some degree of variation in the entrance qualification, duration of courses, etc. in various undergraduate and postgraduate programs.

As a means of improving the quality of education and research in agriculture, the Council has been operating various schemes. A brief summary of such activities is given below.

G. Centres of Advanced Studies (CAS)

Under this program, developed with the assistance of UNDP in 1969, the ICAR so far established 28 Centres of Advanced Studies in selected agricultural universities and ICAR institutions in various fields of agriculture and animal sciences. These centres not only provide facilities for higher education in specific fields of specialization but also provide facilities for advanced research in these areas. Recently, ICAR has also entered into another agreement with UNDP to strengthen the postgraduate education in Foods & Nutrition and Child Development in five agricultural universities.

The objectives of these programs are to strengthen the postgraduate education and research capabilities of the country in various fields of specialization and to enable training of teachers/researchers to strengthen the faculties of other institutions, generate strategies and tools for intervention in local agricultural problems and disseminate and propagate these improvements to other institutions.

H. Forestry Education

Till recently, there were no facilities for forestry education in the country except the in-service training programs organized by the Forest Research Institute of India, Dehradun. It was realized that trained manpower in forest science is required for the maintenance of forests, which consist of about 23% of the total land area. A massive program of forestry education was launched in the 1985-86 academic session with the establishment of under-graduate programs in forestry in six state agricultural universities. At present, 10 agricultural universities are offering undergraduate degree programs in forestry. Postgraduate programs have been started in 3 institutions.

It's recognized that the most severe limitation in the functioning of the departments of forestry in state agricultural universities is the acute shortage of adequately trained faculty. Therefore, a training program for the development of faculty level manpower has been initiated with the assistance of USAID/British Council and a large number of teachers have been deputed for postgraduate training in different branches of specialization in various international institutions.

I. Summer Institutes

From 1986, the Indian Council of Agricultural Research has been organizing a number of Summer Institutes every year in various fields of specialization with a view to providing continued training to the teachers/scientists of agricultural sciences. Such courses not only give an opportunity to the teachers/scientists of various disciplines to come closer but also to get themselves updated with the latest technologies.

J. Professor of Eminence and National Fellows

To develop education and research around reputed scientists/teachers, the Council created a large number of Professional Chairs and National Fellowships in 1976. Under this program selected teachers/scientists are given additional emoluments as well as financial support to undertake specific research programs independently.

K. Key Issue - Isolation

One of the most significant problems faced by the State Agricultural University system is the relative isolation of their faculties from the international community of scholars, from colleagues in India and from up-to-date journals and references. In the past there were strong ties to the US Land Grant System and many of the leading Indian faculty were educated at premier institutions in the US. US faculty were actively engaged within India and many contacts were maintained for many years but these faculty are now retiring. In more recent years there have been few opportunities for young and mid-career faculty to travel and interact with colleagues to the same extent as in earlier years. Many of these have received all of their degrees from the institution at which they now teach.

Currently, there is a major evaluation of the University system underway and it is clear that there will be strong recommendations to institute new programs to strengthen the linkages of the research faculty in the State Agricultural University system to other scholars in India and abroad.

TABLE 1: Numbers of Colleges, Disciplines and Their Admission Capacity Under Various Programs in Agricultural Universities

Sl. No.	Discipline	No. of Colleges	Admission Capacity: Under Graduate	Admission Capacity: Post Graduate
1.	Agriculture	49	5450	2500*
2.	Vety. Science & A.H.	25	1800	450
3.	Agricultural Engineering	12	560	200
4.	Home Science	11	670	115
5.	Fisheries Science	5	150	55
6.	Dairy Technology	6	160	200
7.	Agriculture Marketing/Banking & Coopn.	2	75	-
8.	Forestry	6	180	12
9.	Horticulture	7	230	-
10.	Sericulture	1	30	-
11.	Food Science & Tech.	1	50	-
		125		

* including Horticulture

134

II. Agricultural Research

A. Background

The National Agricultural Research System in India operates through the Indian Council of Agricultural Research, State Agricultural Universities, the general Universities, and the Federal and the State Development Departments of Agriculture. Around 33,000 scientists are engaged in agricultural research in India. Great strides have been made in agricultural production since the 1960s, following application of science and technology which helped in transforming Indian agriculture from subsistance to an organized, market oriented farming system. The impact is reflected in the achievement of self-sufficiency in food grain production with current buffer stock estimated at 23 million tons.

Promotion of science and technology programs for agricultural research is primarily the concern of the Indian Council of Agricultural Research (ICAR) which is the apex coordinating body at the national level. The organization of the ICAR and the National Agricultural Research System are presented by the figures on the following two pages.

The Minister for Agriculture is President of the ICAR. Its principal executive officer is the Director-General. He is also secretary to the Government of India in the Department of Agricultural Research and Education (DARE) to provide the requisite linkage with the Central and State Government agencies and look after international collaboration. He functions as the Principal Adviser to the Government of India in all matters concerning agriculture, animal husbandry and fisheries research and education. He is assisted by Deputy Director Generals and Assistant Director Generals in dealing with scientific matters in different disciplines. The ICAR receives funds from the Government of India and from the proceeds of the Agricultural Produce Cess. Its total budget for 1986-87 is equivalent to over $140 million.

By the end of 1986 the ICAR had developed a vast network of 41 Institutes, 4 National Bureaux, 5 Project Directorates, 9 National Research Centers, and a National Academy of Agricultural Research and Management (Attachment 1). In addition there are 86 ICAR sponsored All-India Coordinated Research Projects spread over 1,291 co-operating centres in the length and breadth of the country. The total staff working in the Council in different categories is over 30,000, of which over 6,200 are scientists. The state agricultural universities employ about 19,000 scientists for teaching, research and extension education assignments, out of which over 5,000 scientists are employed in the ICAR-supported co-ordinated projects.

ICAR supports over 530 ad-hoc research schemes, implemented by scientists in various colleges, universities and institutes. The programmes of research are need-based and formulated and executed in accordance with the recommendations of scientific panels relating to different crops/disciplines. The country now has a large research and training infrastructure to work on the production and other emerging problems confronting agriculture to meet the growing demand for food, fodder and fibre.

FIGURE 1: ORGANIZATION OF ICAR

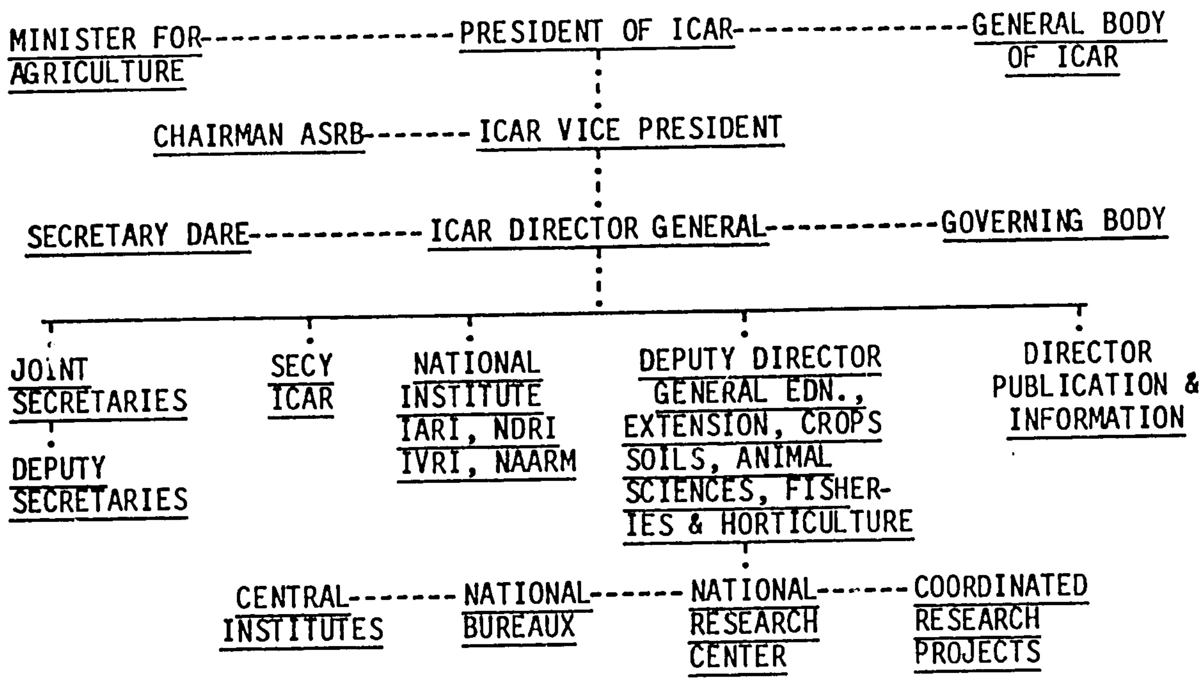
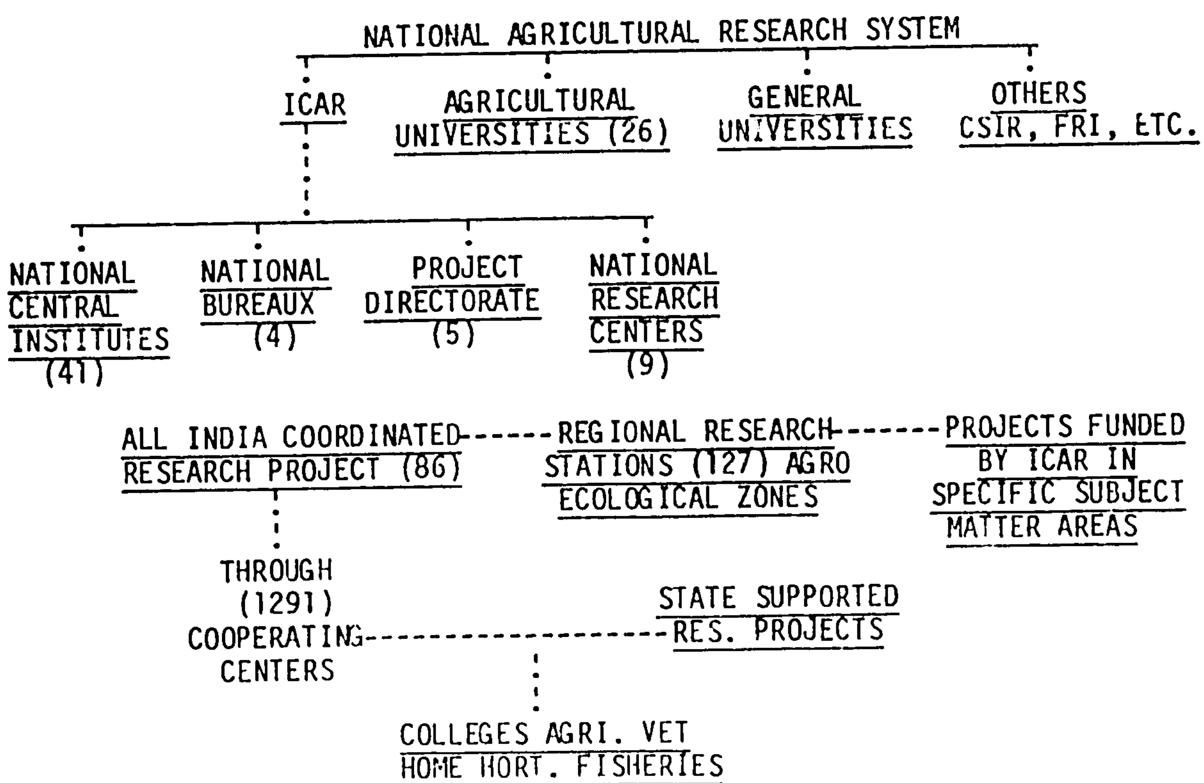


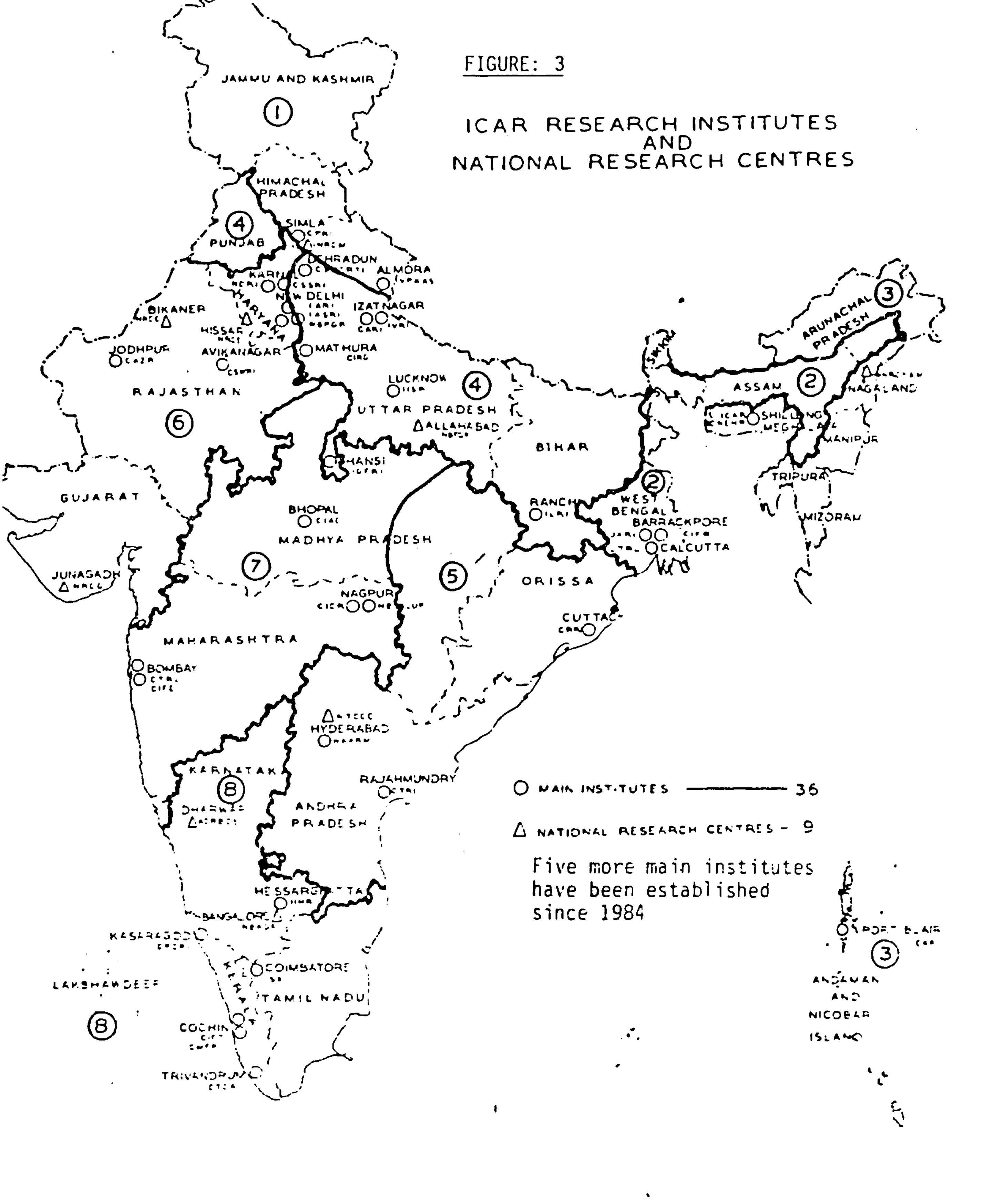
FIGURE 2: ORGANIZATION OF INDIA'S AGRICULTURAL RESEARCH SYSTEM



1984

FIGURE: 3

ICAR RESEARCH INSTITUTES AND NATIONAL RESEARCH CENTRES



Five more main institutes have been established since 1984

(1) Humid western Himalayan region (2) Humid Bengal-Assam basin (3) Humid eastern Himalayan region and bay islands (4) Sub-humid Sutlej Ganga alluvial plains (5) Sub-humid to humid eastern and south eastern uplands (6) Arid western plains (7) Semi arid lava plateaux and central highlands and (8) Humid to semi arid western Ghats and Karnataka plateaux

B. National Agricultural Research Project

The National Agricultural Research Project (NARP) was started in January 1979, with a loan assistance from the World Bank to strengthen the regional research compatibilities of the Agricultural Universities. The number of research projects sanctioned for the establishment and strengthening of regional research stations or for undertaking basic research increased from 67 on 31 March 1984, to 109 on 31 March 1986.

During the implementation of Phase I of the NARP it became clear that the project should be continued for a longer period since it involves a basic change in the structure of the research system in the country. A large number of subprojects are at an early stage of implementation, and additional strengthening is essential in order to cover all components of the farming systems in different agro-climatic zones of the state. Keeping this in view the following components have been included in Phase II of the NARP.

1. Continuous monitoring and financing of the subprojects sanctioned in Phase I which have not completed their 5 year period.

2. Strengthening of research in the remaining agro-climatic zones not covered during Phase I.

3. Additional support is to go to all the 81 agro-climatic zones covered during Phase I. This new support is meant for crop management, animal nutrition, agro-forestry, horticulture, farm implements and facilities for training subject-matter specialists.

Phase II has already been negotiated with the World Bank to meet the above components at a total cost of Rs. 1,310 million (US $110.93 million) over a 7 year period thru 1991. The World Bank has agreed to extend the duration to 7 years from the initial 5 years in Phase I of the NARP. It has also agreed to increase the reimbursement rate from 50% to 60% of the project costs in Phase I.

C. Major Research Achievements

1. Crops

In most of the foodgrain crops, Indian scientists have developed a number of high-yielding, input-responsive, disease and pest-resistant varieties suitable for cultivation in different agro-climates. The impact of research and development efforts is reflected in achievement of foodgrain self-sufficiency, in the production of which has gone up from 51 million tonnes in 1950-51 to a record of 152.4 million tonnes in 1983-84. High yielding, pest-tolerant varieties of rice have given yields up to 7.7 tonnes/ha. on farmers' fields against the national average of only 1.22 tonnes/ha. Similarly, the introduction of new, dwarf, high-yielding wheat varieties has increased the wheat production from 12.3 million tonnes in 1964-65 to 46 million tonnes in 1984-85.

India can be credited with being one of the few countries which has been commercializing cotton hybrids to enhance its capabilities to produce adequate quantities of long staple cottons, not only to reduce cotton imports but also to export the substantial quantities. Another remarkable feature of Indian cotton research is that in 1984-85, the problem of "white fly" as a direct and destructive pest assumed alarming proportions, thereby threatening the scope and prospects of cotton production in several states of India. It is to the credit of the cotton research team that apart from evolving appropriate prophylactic measures to minimize its impact on production and quality, a remarkably white-fly resistant cotton variety has been developed and released under the name 'Kanchana' within a matter of 2-3 years. This variety combines high yielding with pest resistance. From this sustained research over the past two decades, cotton production has virtually doubled with no change in the acreage, if not reduced acreage, and enabled the country to become a net exporter of long and extra long staple cottons today.

A pioneer in the field of sugarcane research, India has evolved a large number of commercial varieties of sugarcane. Some of the short duration high-sucrose varieties are being cultivated in more than 25 countries of the world. India has become the largest sugar producing country with about 8.5 million tons, apart from producing substantial quantities of traditional sweetening agents like jaggery and khandsari to which nearly one third of the cane is diverted annually.

In horticulture, achievements have been made in the development of regular bearing hybrids in mango; high-yielding varieties of ber, apple, pomegranate, coconut, cashew, arecanut, grapes, etc; over 50 improved varieties of different vegetable crops; and about a dozen disease - resistant varieties of potato. Improved propagation techniques including tissue culture in selected crops, seed-plot technique in potato and improved cultivation practices have had a significant impact on the production of these crops. Apple production in the north west hill region has risen from less than 0.1 million tons during 1966-67 to more than 1.0 million tons during 1985-86. Likewise, with improved pineapple production technology yields of 60-70 tons/ha. have been obtained compared to 25-30 tons/ha. in the conventional planting densities. Improved cassava varieties H-226 and H-165 have yielded more than 30 tons/ha. as against the national average of 18 tons/ha. and the world average of 9.6 tons/ha.

2. Integrated Pest Control

An integrated approach to pest/disease surveillance/monitoring, use of biological control and need-based application of pesticides has greatly helped in reducing crop losses and limiting the impact of new pest problems.

3. Soil Science, Agronomy and Agricultural Engineering

The research in the areas of Soil Science, Agronomy and Agricultural Engineering has contributed to the development of improved soil management and crop-production technology for optimizing the benefits from inputs such as fertilizer, irrigation and energy. The soil resources are being systematically surveyed/interpreted for providing land-use maps. Soil conservation measures have been evolved for different land configurations by designing engineering structures and modification of agronomic and cropping practices.

To increase the capability of arid lands to support human and livestock population, techniques have been evolved for efficient water conservation, sand-dune stabilization and desert afforestation. Water-balance analysis in dryland has enabled the identification of suitable growing seasons for different crops and varieties for intercropping and double-cropping. Success has been achieved in the reclamation of saline-alkali soils with chemical and organic amendments, appropriate cropping practices, innovation in subsurface drainage systems, agro-forestry programs and conjunctive use of saline groundwater with fresh canal water. Studies on delineation of nutrient-responsive areas and nutrient substitution through various organic resources have contributed to the judicious use of fertilizers and manures.

Improved agronomic packages of practices have been evolved for various cropping systems. These practices include better seeding, fertilizer application, irrigation, water management, in-situ moisture conservation, water harvesting and recycling, and weed control.

4. Animal Sciences

Through selection and upgrading of indigenous breeds and crossing with superior exotic breeds, two new improved strains, viz. Karan Swiss and Karan Fries, of dairy cattle with lactation yields of 3,200 to 3,500 litres have been developed. This compares to 1,500 litres for indegenious cows. India has nearly 10 million crossbred dairy. Milk production has more than doubled in last 16 years (20 million tons in 1969-70 vs 44 million tons in 1986-87). The development of semen-freezing techniques and management practices for year-round breeding and for reducing calf mortality have led to an improvement in buffalo productivity. Buffalo germplasm has been made available for the development of dairy buffalo stock in Indo-china, Eastern Europe and South America.

Crossbred strains of sheep for fine wool, viz. Avivastra, yielding 2.5 kg. greasy fleece per annum, and for superior carpet wool, viz. Avikalin, yielding 2.0 kg greasy fleece per annum have been evolved. Mutton synthetics, viz. Malpura and Sonadi, and Nellore and Mandya, attaining live weight of 30 kg. at 6 months under intensive feeding have also been developed. Crosses of Karakul with indigenous coarse carpet-wool breeds have produced acceptable quality pelts in different colors, both in hot and cold arid conditions. An Indian Mohair breed has been developed by grading local goats with Angora. Strains of broiler and wool rabbits introduced in temperate areas have also shown excellent performance.

One commercial layer strain of poultry capable of laying 270 eggs per year have been released along with two broiler strain crosses capable of attaining 1.8 kg. live weight at 8 weeks of age. Improved strains of poultry coupled with modern management practices have resulted in an increase of egg and broiler production from 56 and 4 million in 1971-72 to 156 and 85 million respectively in 1986-87. Quail has been successfully introduced and is now being commercially exploited for meat and eggs.

5. Fisheries

Detailed investigations have shown that fisheries of tunas and billfishes, oceanic squids, whitebait, horse-mackerel, perches and a few mesopelagic and bathypelagic resources have great potential for future development. A hatchery technology has been developed for the production of the seed of white prawn and tiger shrimp, which could yield 1,000 kg./ha./year. The success achieved in spat production by breeding Indian pearl-oysters under controlled conditions is leading to the further development of the pearl-culture industry in selected coastal areas. Mussels, edible oysters and clams have shown impressive production rates under culture. A fish seed production and composite fish culture technology has been developed to achieve a fish production of over 10,000 kg./ha./year.

D. Key Issue - Research Relevance and Technology Transfer

There has been substantial dissatisfaction experienced in some quarters with regard to the Indian public sector research system's capability to deliver useful technology from the research system to the user community. This is generally regarded as more of a problem of the relevance of the research isolation from peers (Indian and international), the policy environment in which farmers and agribusinessmen make choices and work linkages to Indian agribusiness firms capable of investing in R&D. This problem is exacerbated as there is no structure to encourage entrepreneurship and creativity within the system.

Several of the most recently designed sub-projects in the USAID supported agricultural research project stress linkages to and participation of the user community. Linkages to other research systems are also important in the continual effort to increase relevance. ICAR, with support from USAID and USDA, hopes to initiate a "Current Research Information System" (CRIS) over the next few years to deal with the isolation issue as well as to more effectively deal with the allocation of research resources.

III. Agricultural Extension in India (by Dr. Surjan Singh, USAID 1987)

Since independence the Government of India (GOI) has given high priority to rural development. There are four extension organizational streams which contribute to the transfer of technology for rural development: the training and visitation (T&V) system is promoted by the Ministry of Agriculture with the assistance of the World Bank; the extention system of the Indian Council for Agricultural Research (ICAR); rural development projects of the Department

141

of Rural Development, Ministry of Agriculture, Government of India; and non-government organizations (NGOs) and voluntary efforts.

A. Main Extension Agency

A nation-wide organized extension program in India started in October, 1952, at the time of the Community Development (C.D.) Program. The Coummunity Development Program is devoted to all round development of rural areas and villages including agriculture. This approach was based on the fact that rural problems are inter-related and inter-woven and therefore they must be taken simultaneously. The C.D. model in India was based on earlier experiences of rural development projects and on the modern extension system of the USA. Ford Foundation was involved from the very beginning in the C.D. movement. As a part of this National Extension Service (NES), in 1953, the Intensive Agricultural Area Program (IAAP) was started in 1963, the High Yielding Varieties Program (1966), and Small Farmers Development Agency were also launched to focus attention on agricultural production.

The C.D. program was well conceived and functioned reasonably well but had several limitations. The Panchayati Raj Movement was also introduced as a part of the C.D. program for stimulating local participation and self-help. Many other programs related to rural development evolved in the early phase of the C.D. program to support its activities, i.e. - National Seeds Program, Nationalized Banks and their rural branches, Village Cooperatives, Training Institutions, and other associated village organizations. In short, as a result of the Community Development Program physical infrastructure for rural development/agricultural extension has been reasonably well developed all over the country. These programs support over 5000 C.D. blocks which are the lowest level units for rural development.

A major limitation of the C.D. program has been relatively limited resources were spread thinly over the country. Also there was not much priority given to economic programs or agricultural development which is the mainstay of the Indian economy. As a result of inadequate experience, limited trained manpower and the lack of committed extension personnel, the performance of the C.D. movement has not produced the results in many areas, particularly agriculture. Given these basic limitations, the C.D. programs have been criticized from many quarters. Instead of improving the C.D. approach the Government found it easier to change to a new model of extension.

In 1977, the Training and Visit System (T&V) assisted by the World Bank was being introduced in 17 major states. Today the two systems (C.D. and T&V) are working side by side. The Community Development Program is developing the non-agricultural sectors in villages and the T&V extension system promotes agricultural development. The T&V system has a single-line of command so to speak. It has large infrastructure in terms of (i) staff, (ii) buildings, (iii) transportation, etc. For instance, in 17 states under the T&V program, there are 16 Additional Directors of Agriculture, 116 Subject-Matter Specialists (at the Headquarters), 178 Deputy Directors of Agriculture, 385 District Agricultural Officers, 1199 Subject-Matter

142

Specialists, 1060 Sub-Divisional Agricultural Officers, 2578 SubDdivisional Subject-Matter Specialists, 11,063 Agricultural Extension Officers, and 78,795 Village Extension Workers. This is a total of 95,390 workers.

B. ICAR Extension System

The ICAR extension education role is mainly that of promoting science and technology in agriculture. This takes place at the agricultural universities (26) and the ICAR research institutes (47) which work together in a partnership. This system aims at (i) promptly demonstrating the latest agricultural technologies to farmers and the extension functionaries of the State Departments of Agriculture. The purpose is to reduce the time-lag between generation of technologies and their adoption by farmers; (ii) verifying and testing the technologies under the socio-economic condition of farmers; (iii) obtaining first-hand scientific feed-back for improving the relevance of research, education and training; and (iv) conducting research on the socio-economic implications of the transfer of technology itself.

In addition to the limited extension program of each agricultural institution, including Agricultural Universities and ICAR Research Institutes, there are four major first-line extension projects launched by the ICAR; namely, (a) National Demonstrations in 48 districts - sites keep on changing every six years; (b) Operational Research Projects in 152 centers; (c) Krishi Vigyan Kendras (Farm Science Centers) in 89 districts; and (d) Lab-to-Land centers in 101 centers in existing institutions and projects.

These projects show the genetic production potential of the improved varieties. They also promote improved management practices and training for farmers and extension functionaries. They also serve as feed-back mechanisms for scientists and institutions. The catalytic role of these projects and the agricultural institutions which support them have been the means for transfer of technology and accelerating agricultural production.

The extension-education role has its root in the U.S. Land Grant Pattern of Education where State Universities have the full responsibility for extension and education in agriculture, and the State Departments of Agriculture which are responsible for input support and supply. The pattern of integrated education, research and extension was introduced in India in 1960 with the establishment of State Agricultural Universities. There are 26 Agricultural Universities and all have strong Directorates of Extension Education and extension programs. Since 1960 they have played a major role in technology generation, manpower development and extension education.

Unlike the USA, in India the total role of extension education is not vested in the agricultural institutions and the research institutes - the major responsibilities lie with the Ministry of Agriculture/State Departments of Agriculture.

C. Rural Development

In order to give added attention to the uplift of the under privileged and economically weaker sectors of the society, a series of special programs were launched under the framework of rural development. The Drought Prone Areas Program (DPAP) was started in 1970-71 for stabilizing the income of the weaker sections and minimising the ill-effect of drought on agricultural production. During the same period Small Farmers Development Agencies (SFDA) were formed to benefit small farmers (holding up 2 hectares), marginal farmers (less than 1 hectare) and agricultural laborers (having a homestead and 50% wage income from agriculture). There were 389 such agencies in 1983. Similarly the Hill Areas Development Program (1975-76), Command Area Development (1974-75), and Voluntary Action Scheme (1974-75) were undertaken, benefiting millions of rural people.

The Department of Rural Development is concerned with building socio-economic infrastructure for the development of rural areas and alleviation of rural poverty. The current Five Year Plan (Sixth Plan) has its major thrust on poverty alleviation. An increase in the productive potential of the rural economy is considered an essential condition for finding solutions to the problems of rural poverty. Gradually more and more pin-pointed and directed rural development programs for reducing incidence of poverty have been taken up for the poorest sections of the rural society, viz. landless laborers, small and marginal farmers, rural artisans, scheduled castes, scheduled tribes and socially and economically backward classes.

While the efforts of the Department of Rural Development, Ministry of Agriculture, Government of India appeared laudable, in actual operation of the projects, the management is reported to be very weak. Often the resources earmarked for the poorest of the poor are not reaching them in full measure.

D. Voluntary Organizations

Presently there are over 1000 NGOs which have roots in rural areas. They are supported by both the center and state governments. Realizing that for rural upliftment, agricultural development is a must, voluntary organizations have given their attention to this sector. This is a very recent development but the severe famine of 1966-67 was an eye-opener for them. The Union Ministry of Agriculture and Rural Development has recognized six national level voluntary organizations for undertaking agricultural development programs. They are: Bharat Krishak Samaj, Young Farmers Association of India, Rashtriya Kisan Sangathan, Bharatiya Grameen Mahila Sang, Confederation of Agricultural Relief Associations and the Farmers Federation of India.

A number of reputed voluntary organizations/autonomous institutions have been associated with some of the first-line transfer of technology projects of the ICAR since 1976. The experience of the ICAR in working with these voluntary organizations has been rewarding. In many cases the NGOs with their dedication and commitment are showing the way to extension agencies for transferring rural technologies to the rural poor. Lately the Government of India has decided to promote them in larger numbers.

E. Some Issues

1. Field observations indicate that the State governments are finding it difficult to sustain the T&V extension system after the funding from the World Bank/IAD is withdrawn.

2. The multiplication of Village Extension Workers (VEWs) in large numbers is perhaps not serving the purpose because of their poor background in agriculture and limited training and education. Farmers today are more progressive and agricultural technologies are more complex. It would be better to have limited, well trained agricultural personnel at the C.D. Block level. Local leadership could be developed to serve as the community change agents.

3. Seventy per cent of the population in India depends on Agriculture and the majority of farmers are illiterate (80 percent). Since they have to grasp the modern technologies which are relatively sophisticated and complex, it is imperative that their technical literacy level be enhanced considerably. The Krishi Vigyan Kendras (Farm Science Centers), sponsored by the ICAR for vocational training of the farmers, farm women, young farmers and school drop-outs, have been serving a useful purpose in this respect. Nevertheless, out of 407 districts in India, KVKs have been only established in 89 districts. Since this model is a down-to-earth way for training Indian farmers, the Government of India has decided to establish KVKs in all remaining districts in the shortest possible time. It is reported, however, that financial constraints are coming in the way of expanding this vital scheme in the country as a whole.

4. General school education is basic to agricultural extension and preparation of the farmer for scientific farming. This is specially important when the school drop-out rate in villages is almost 60 per cent. A strong agricultural program in the school system, especially in rural areas, is needed to create an interest in the application of science to agriculture. The students and school drop-outs who settle in villages could learn more about agriculture and adopt new practices for improving their production, income and employment. Presently basic education in agriculture is very weak in village school systems.

5. Strong functional linkages are needed between the extension education system of the ICAR, the T&V extension system of the Minsitry of Agriculture/State Departments of Agriculture, the Rural Development Programs of the Department of Rural Development, Ministry of Agriculture and the extension programs of the

non-government organizations and voluntary organizations. These development projects and extension systems should be closely linked with the agricultural research system of the ICAR. There is much scope for improvement in this respect for creating synergistic effects and multiplying production gains.

6. The present severe drought crisis in India has refocused attention on agricultural research and extension systems. Relevant technologies have to be generated to meet the varied agro-ecological situations as well as weather aberrations which frequently occur on the Indian sub-continent. The extension likewise has to develop relevant agricultural extension programs to help mitigate such crises. This requires a Crisis Management Institution for developing appropriate contingency plans as well as development stages.

F. Independent Assessment of Agricultural Extension in India (summarized from paper by Prof. George H. Axinn, consultant to GOI)

This statement is a response to the author's terms of reference as given by the Government of India. He was asked to spend up to two months in India, travel extensively, interview relevant individuals, read various documents, and then give a report covering the following areas: "1) the functioning of the extension services in the states, 2) the suitability of the T&V model for the Indian context, 3) comments on the extension sector review mission report, and 4) recommendations on restructuring/reorienting extension services in the country."

The time was small, and the mission very large. What is included in this document is based on observations, interviews, and readings. It is impressionistic and anecdotal. It represents one individual's best professional judgements on many matters.

In considering the "T and V Approach," there is an attempt to separate it from "The Agricultural Extension System," which is always a larger activity in which the T&V Approach is one approach among several others. There is also an attempt to consider each of these separately from the "World Bank Loan Provision," which includes expansion of staff, buildings, and equipments.

1. The Functioning of Extension Services in the States

Many significant contributions are being made by the agricultural extension systems in the several states. They have gone through a series of different approaches, each one perhaps over-emphasized for a time and then discarded. As the system learns from its own experience, it will probably become more sensitive to the voice of farm families, more flexible in its choice of extension communication methods, more able to dovetail contributions of scientists at agricultural colleges with those of agricultural extension officers, and more cost-effective.

- 146

It has also grown in personnel size, and is now the world's largest agricultural extension system - larger than the next biggest nine national agriculturral extension systems combined. This labor-intensive system has overwhelming management problems, and will need to change its approach if it is to become either more efficient or more effective. Some current problems have been identified as:

a. The predominant flow of information tends to be from the top to the bottom, from the center to the field. The system has difficulty fitting its messages to the needs of its clientele, or generating technology specifically to solve farmers' problems.

b. The messages being communicated in the present system tend to be narrow specific suggestions on how to increase productivity of a few particular commodities. Farmers, on the other hand, are interested in profitability more than productivity, and tend to manage mixed farming systems, with many different commodities (including fruits, vegetables, livestock).

c. The program is not gender sensitive.

d. The program is not scale sensitive.

e. The present system is dominated by the T&V Approach, sometimes ignoring and duplicating other approaches now in use, and tends to be relatively costly.

f. The system tends to be "controlled" entirely by its managers and the scientists, and not at all by its ultimate clientele, the farmers.

g. The system is weakened by its underlying assumptions that (a) relevant technical knowledge is available, (b) this technology will "fit" local types of farming systems, and (c) farmers will be better off if they adopt this technology.

The system also suffers from the false and misleading concept that agricultural extension is an input to production, and extension's impact can be judged by the productivity of farmers.

2. The Suitability of T&V in the Indian Context

This approach, introduced along with funds for a significant increase in the personnel of the state departments of agriculture, buildings, and equipments, served as an effective stimulant to the system. The essential contribution was the discipline it brought. Village level staff were pressed to actually visit farms, and the training components gave them simple messages to deliver. But the approach is also fraught with problems, such as: a) lack of two-way communication in the system, b) the problem of appropriate technology, c) the problem of too narrow a narrow focus, d) problems of extension communication methods, e) problems of the contact farmers, f) problems of monitoring and evaluation units, and g) the problem of high cost.

3. Recommendations on Restructuring/Reorienting the Agricultural Extension System

The following recommendations are given in longer form in Chapter 6, and supported by evidence in Chapters 3 and 4, as well as several annexes.

a. Focus on the Agricultural Extension System, not on the T&V Approach, but announce no major change.

b. Emphasize several other approaches gradually, and deemphasize the T&V Approach.

c. Further foreign funding for system expansion is unnecessary, but international idea exchange should be continued and expanded.

d. Gradually broaden the program content.

e. The SMS should be strengthened as a key to broadening the program.

f. Support creative dynamic leadership at the top of each state agricultural extension system.

g. Encourage more "down-up communication" by taking organizational and administrative steps to force more two-way flow.

h. Take women farmers seriously.

i. Diversify extension communication methods and strategies.

j. Encourage local organizational involvement.

k. Modify contact farmer arrangements.

l. Simplify monitoring and evaluation, and emphasize monitoring.

m. Management training is not the solution.

n. Deploy field staff strategically, not by formula.

o. Encourage flexibility among states in staff qualifications.

p. Strengthen the central Directorate of Extension to facilitate communication among the states.

Table 2: List of ICAR Institutes, Project Directorates, National Bureaux and National Research Centers

A. NATIONAL RESEARCH INSTITUTES

1. Indian Agricultural Research Institute, New Delhi-110 012
2. Indian Veterinary Research Institute, Izatnagar(UP) 243 122
3. National Dairy Research Institute, Karnal (Haryana)-132 001

B. CROP SCIENCES INSTITUTES

1. Central Rice Research Institute Cuttack (Orissa) - 753 006
2. Vivekananda Parvatiya Krishi Anusandhan Shala, Almora (Uttar Pradesh) 263 601
3. Indian Grassland and Fodder Research Institute, Jhansi (Uttar Pradesh) 284 003
4. Jute Agricultural Research Institute, Barrackpore (West Bengal) 743 101
5. Central Tobacco Research Institute, Rajahmundry (Andhra Pradesh) 533 105
6. Sugarcane Breeding Institute Coimbatore (Tamil Nadu) 641 007
7. Indian Institute of Sugarcane Research, Lucknow (U.P.)-226 002
8. Central Institute of Cotton Research, Nagpur (Maharashtra)-440 010

C. HORTICULTURE & PLANTATION CROP INSTITUTE

1. Central Potato Research Institute, Simla (HP) 171 001
2. Central Plantation Crop Research, Kasaragod (Kerala)-670 124
3. Central Tuber Crops Research Institute, Trivandrum (Kerala)-695 017
4. Indian Institute of Horticulture Research, Bangalore (Karnataka)-560 080
5. Central Institute of Horticulture for Northern Plains Lucknow (UP)-266 006

D. RESOURCE MANAGEMENT INSTITUTES

1. Central Soil and Water Conservation Research and Training Institute Dehradun (UP)
2. Central Soil Salinity Research Institute, Karnal (Haryana) 132 001
3. Central Arid Zone Research Institute, Jodhpur (Rajasthan)-342 003
4. Central Institute for Dryland Agriculture, Saidabad (Andhra Pradesh)-500 659
5. Research Complex for North-Eastern Hills Region Shillong (Meghalaya)-793 003

149

D. RESOURCE MANAGEMENT INSTITUTES (Cont.)

6. Central Agricultural Research Institute for Andaman and Nicobar Groups of Islands Port Blair (Andamans)-744 101

7. Indian Institute of Soil Sciences, Bhopal (MP)

E. AGRICULTURAL ENGINEERING INSTITUTES

1. Central Institute of Agricultural Engineering, Bhopal (Madhya Pradesh)-462 003

2. Indian Lac Research Institute Nankum, Ranchi(Bihar) 843 010

3. Cotton Technological Research Laboratory, Bombay (Maharashtra)-400 019

4. Jute Technological Research Laboratory, Calcutta-700 040

F. ANIMAL SCIENCES INSTITUTES

1. Central Sheep and Wool Research Institute Avikangar(Rajasthan)-304 501

2. Central Institute for Research on Goat Makhdoom (Uttar Pradesh)

3. Central Avian Research Institute, Izatnagar (Uttar Pradesh)-243 122

4. Central Institute for Research on Buffalo Hissar (Haryana) 125 001

5. Central Institute of Animal Genetics, NDRI Campus Karnal (Haryana) 132 001

G. FISHERIES INSTITUTE

1. Central Inland Fisheries Research Institute Barrackpore (WB) 743 101

G. FISHERIES INSTITUTE (Cont.)

2. Central Marine Fisheries Research Institute Cochin (Kerala) 682 018

3. Central Institute of Fisheries Technology Cochin (Kerala) 682 029

4. Central Institute of Fisheries Education Bombay 400 058

5. Central Institute of Brackishwater Aquaculture Madras (Tamil Nadu)

6. Central Institute of Freshwater Aquaculture Dhauli, Bhubaneshwar(Orissa)

H. ECONOMICS AND STATISTICAL INSTITUTE

1. Indian Agricultural Statistics Research Institute New Delhi-110 012

2. Indian Institute of Agricultural Economics Pusa, New Delhi-110 012

I. RESEARCH MANAGEMENT

1. National Academy of Agricultural Research Mgt. Rajendranagar, Hyderabad (Andhra Pradesh)-500 030

J. PROJECT DIRECTORATES

1. Directorate of Rice Research (ICAR), Rajendranagar Hyderabad (AP) 500 030

2. Directorate of Wheat Research (ICAR), General Research Laboratory, Indian Agricultural Research Institute New Delhi-110 012

J. PROJECT DIRECTORATES

3. Directorate of Pulses Research (ICAR)
Kalyanpur, Kanpur
(Uttar Pradesh) 208 024

4. Directorate of Oilseeds Research (ICAR)
Rajendranagar, Hyderabad
(Andhra Pradesh) 500 030

5. Directorate of Vegetable Research (ICAR)
Indian Agricultural Research Institute
New Delhi-110 012

K. NATIONAL BUREAUX

1. National Bureau of Plant Genetic Resources
Pusa, New Delhi- 110 012

2. National Bureau of Soil Survey and Land-use Planning, Nagpur
(Maharashtra)-440 006

3. National Bureau of Fish Genetic Resources
Allahabad (UP) 211 002

4. National Bureau of Animal Genetic Resources
NDRI Campus, Karnal
(Haryana) - 132 001

L. NATIONAL RESEARCH CENTRES

1. National Research Centre for Groundnut, Junagadh
(Gujurat) - 362 002

2. National Centre for Mushroom Research and Training Solan
(Himachal Pradesh) 173 213

L. NATIONAL RESEARCH CENTRES (Cont.)

3. Advanced Centre for Research on Black Cotton Soils
University of Agricultural Sciences, Dharwad
(Karnataka)-580 007

4. National Research Centre for Camel, Jorbeer, Bikaner
(Rajasthan)-334 001

5. National Research Centre for Equines, Hissar
(Haryana)-125 001

6. National Research Centre for Yak, Nikamadang
(Arunachal Pradesh)

7. National Research Centre for Mithun
Purba (Nagaland)

8. National Research Centre for Soybean
Bhawerkua Farm, Khandwa Road
Indore (MP) 452 001

9. National Research Centre for Spices, Calicut
(Kerala)-673 012

Table 3: List of All India Coordinated Research Projects

i) FOOD CROPS (8)

Rice
Wheat
Barley
Maize
Sorghum
Pearlmillet
Small millets
Pulses

ii) COMMERCIAL CROPS (13)

Sugarcane
Sugarbeet
Cotton
Jute and Allied Fibres
Soybean
Rape Seed Mustard
Castor
Groundnut
Niger and Sesamum
Linseed
Sunflower
Safflower
Tobacco

iii) HORTICULTURE CROPS (110)

Vegetables
Tropical Fruits
Arid Fruits
Subtropical Fruits
Potato
Palms
Cashew
Spices
Tuber Crops
Floriculture
Post Harvest Technology of Horticultural Crops

iv) SOILS, AGRONOMY AND AGRICULTURAL ENGINEERING (22)

Dryland Agriculture
Soil Physical Conditions
Diara Lands
Use of Salt-affected Soils and Saline Water

Agrometeorology
Agricultural Drainage
Cropping Systems
Long term Fertilizer Experiments
Soil Test and Crop Response
Micronutrients
Water Management
Nitrogen Fixation by Blue-green Algae and Azolla
Biological Nitrogen Fixation
Microbiological Decomposition
Power Tillers
Farm Implements and Machinery
Wells and Pumps
Post Harvest Technology
Energy Requirements
Renewable Energy Resources
Agricultural Electronics
Animal Energy

v) PLANT PROTECTION (8)

Seed-borne Diseases
Betelvine Diseases
White Grubs
Nematode Pests
Rodent Control
Biological Control
Pesticide Residues
Economic Ornithology

vi) ANIMAL SCIENCES (12)

Animal Breeding
Cattle Improvement
Buffalo
Sheep
Goat
Pigs
Poultry
Other Animals
Foot and Mouth Disease
Surveillance of Animal Diseases
Haemoprotista Diseases
Byproducts and Waste Materials for Livestock Rations

vii) OTHER (12)

Medicinal and Aromatic Plants
Under Utilized Under Exploited Plants
Honey Bee

Seed Technology
Weed Control
Home Science
Forage Crops
Agroforestry
Tribal Area Research Project
Primary Data Collection
Mushrooms
Agricultural Acarology

The Seventh Five Year Plan for Agriculture Research, Forestry, and Irrigation: A Summary

I. Background

The Seventh Five Year Plan has set high goals for India.

To achieve the stated objectives, the plan lays out the following strategy. Increase cropping intensity, through improved availability of irrigation and extension of new agricultural technologies to low productivity regions and small farmers. Improve the ability of rural development programs to create productive assets. Expand labor intensive construction of housing, urban amenities, roads, and rural infrastructure. Increase the number of primary education and basic health facilities. Change the pattern of industrial growth toward more labor intensive production methods. Emphasize increased production of foodgrains, edible oils, sugar, textiles, cooking fuel, mass consumption items, and housing to meet new demands from higher rural incomes. Improve capacity utilization through efficient project implementation, especially in irrigation power generation, transport, and other industries. Finally, integrate export policies with all productivity policies. In short, the strategy shifts emphasis away from investment in <u>new</u> facilities, to improving capacity utilization and productivity in <u>existing</u> facilities.

Achievement of the above goals by the turn of the century will be a monumental task. Over 130 million new jobs must be created. Population growth must fall to 1.9 percent per year. Domestic savings must rise to 25.8 percent of GDP. Overall, GDP must rise by five percent for each of the next 15 years. Agricultural output must grow at four percent, with domestic fertilizer production growing 11 percent per year. Annual industrial growth will need to be eight percent or higher, requiring the power supply to grow at over 12 percent per year. Large scale improvements in communications and transportation are also needed to approach the desired targets. Thus, sustained levels of unprecedented growth are necessary.

The government will continue to assume a large share of the responsibility for stimulating development. Through public outlays and policies, they will intervene to 1) promote the interests of the poor, 2) reduce income and wealth disparities, 3) curb regional inequalities in the level of development, 4) protect the environment, 5) strengthen the scientific and technological base, and 6) safeguard the interests of future generations (Table 1). Although the plan document gives detailed proposals for all sectors of the economy, the following pages will review the sections on agricultural, with special attention to the research, forestry and irrigation programs.

Table 1: Total Public Outlays in the Seventh Five Year Plan, by Sector

	Amount in Rs. Crores	Percent of Total
Energy	54821.26	30.45
Social Services	29350.46	16.31
Transport	22971.02	12.76
Industry and Minerals	22460.83	12.48
Irrigation and Flood Control	16978.65	9.43
Agriculture	10573.62	5.87
Rural Development	9074.22	5.04
Communications	6472.46	3.60
Special Area Programs	3144.69	9.43
Science and Technology	2466.00	5.87
Other	1686.79	5.04
Total	180000.00	100.00

Source: Seventh Five Year Plan, 1985-90. Government of India Planning Commission. New Delhi, October 1985.

II. Agriculture

The planning commission has identified five major program thrusts for agriculture during the Seventh Plan period. The first, the Special Rice Production Program in the Eastern Region (Assam, Bihar, Orissa, West Bengal, eastern Uttar Pradesh, and eastern Madhya Pradesh), is aimed at removing the infrastructural constraints to higher rice production. Through the development of irrigation, exploitation of ground water resources, improved drainage, development of credit and marketing institutions, and improved land tenure, the government hopes to close the gap between actual and potential yields. They also expect to introduce new varieties and cropping systems that are adapted for the relevant agro-climatic zones.

The second major thrust for agriculture is the National Oilseeds Development Project. Through this program, special efforts will ensure price and marketing support, as well as extending the use of available technology. Reducing yield variability will be important. Vertical integration will be encouraged and state level Oilseeds Growers' Federations will be strengthened.

The National Watershed Development Program for Rainfed Agriculture represents the third major thrust. The intentions of this project are to harvest water, conserve soil moisture, and extend farming practices and systems which increase production by minimizing yield risks.

Increasing the capacity of farmers to invest and bear risks, assisting in irrigation investment, and providing inputs are the main goals of the Scheme for Assistance to Small and Marginal Farmers. Measures to improve access to credit and extension will supplement the program. Rent regulation and tenure security will also increase the incentives for small and marginal farmers to intensify their use of inputs. Furthermore, the government recommends consolidation of holdings.

The last major thrust for agricultural development during the Seventh plan period is the Social forestry program. Through afforestation, the program will generate employment, and produce fodder and fuelwood. The National Wastelands Development Board will be responsible for designing management and development projects. Also, the Rural Firewood Plantations scheme will be extended to cover all fuelwood deficient regions in India. Research efforts will be strongly encouraged by the Council for Forest Research and Education.

To achieve the goals of the five major thrusts, special attention will be directed to areas which affect all of the programs simultaneously. Water management, including improved utilization of existing irrigation potential, increased use of ground water, and better drainage, will receive high priority. Research and extension, particularly on intercropping and multi-cropping systems, biological nitrogen fixation, fertilizer use efficiency, and stress resistant varieties, will also be promoted. Next, credit instititions must be improved by measures such as restoration of the cooperative movement, extension of crop insurance, and disbursement of adequate funds to the Eastern region, small and marginal farmers, as well as for oilseeds and dryland farming. Agricultural price policies should be examined to ensure appropirate relative prices and to improve procurement. Finally, the government will make special efforts to ensure farmers' participation, especially in water management and pest control programs, growers' cooperatives, and decentralized planning.

III. Agricultural Research and Education

The Planning Commission has identified several research areas which will receive priority during the Seventh plan period. First, new varieties should be developed which incorporate resistance to pests, diseases, saline and alkaline soils, droughts, and floods; these strains will help reduce the gap between actual and potential yields. Also, research will be undertaken to improve rice production and productivity.

Table 2: Total Public Outlays in the Seventh Five Year Plan for Agriculture

	Amount in Rs. Crores	Percent of Total
Crop Husbandry	3311.80	31.32
Forestry	1859.10	17.58
Cooperatives	1400.58	13.25
Animal Husbandry and Dairying	1076.68	10.18
Soil and Water Conservation	740.39	7.00
Agricultural Res. and Education	704.60	6.66
Fisheries	499.19	4.72
Agricultural Finance Institutions	353.66	3.34
Storage and Food Processing	307.08	2.90
Plantations	150.00	1.42
Marketing	149.44	1.41
Management of Natural Disasters	21.10	0.20
Total	10573.62	99.98

Source: Seventh Five Year Plan, 1985-90. Government of India Planning Commission. New Delhi, October 1985.

Dryland technology should be further refined. Breeding programs will be directed to develop new strains of oilseeds and pulses. Conservation and exploitation of germplasm for animals and plants will broaden the possibilities for new varietal development. Programs to improve human resource development will be funded. Biotechnology will also receive priority. Finally, greater research support will be directed to agro-meteorology.

The overall program in research and education will be further divided into sectors: crops, natural resources, inputs, agricultural engineering, animal sciences, fisheries, transfer of technology, agricultural education, the National Agricultural Research Project (NAARP), and biotechnology.

The GOI has selected a group of crops toward which research during the Seventh plan will be specifically directed. These include upland and lowland rice (especially for the Eastern region); non-irrigated wheat; rabi season maize and sorghum; resistant varieties of fruits, such as mango, apple, citrus, and guava; and improved oilseeds and pulses.

Throughout the Seventh Five Year Plan document, the Commission has stressed the need to pay more attention to the resource base. This is being done through the agricultural research program. Priority will be given to preparing resource inventories, perfecting intercropping and multi-cropping systems, developing alternative land use patterns to replace shifting cultivation, and applied research in water management and agrometeorology.

Research to improve input use by farmers will be undertaken. Particular attention will be paid to improving fertilizer use efficiency, especially by reducing the nitrogen loss due to leaching and denitrification. Studies will also be undertaken to examine biological nitrogen fixation and micronutrient deficiencies under intensive agriculture. Finally, the planning commission expects to increase the number of crops which can utilize atmospheric nitrogen.

Research in agricultural engineering will be focused on improving and developing appropriate equipment and machinery for cropping systems. Also, systems are to be created for the safe and economic collection, handling, processing, and transport of animal wastes, so that they can be utilized in a program of integrated nutrient use.

Animal sciences research will be intensified during 1985-90. The plan document recommends that priority be given to improving the productivity of indigenous livestock, developing new breeds which will be adapted to tropical environments, and increasing poultry production through improved strains of broilers and layers. In addition, research should be directed toward creating higher levels of carpet wool production and quality. Finally, a host of animal health issues will be studied.

Both inland and marine fisheries will be researched. For the former, attention will be directed toward capture and cold water fisheries, brackish water fish culture, genetic improvement of carp, and control of fish diseases. For the latter, researchers will study fish resources in the Exclusive Economic Zones, open sea culture, harvest technology, and technology for the diversification of marine products, as well as fuel saving devices for mechanized fishing boats.

The Indian Council for Agricultural Research (ICAR) will be responsible for the program of technology transfer through four major projects, 1) National Demonstrations, 2) Operational Research Projects, 3) Krishi Vigyan Kendras, and 4) Lab-to-Land programs. Emphasis will be given to the dissemination of information about improved production technology for pulses and oilseeds under rainfed conditions, and identification of cultural, economic, and institutional constraints which limit productivity.

Institutional development, qualitative improvement of education and research, and manpower development will be the foci for agricultural education programs during the Seventh plan period. Courses in agricultural management will be introduced, along with the creation of advanced centers for post-graduate research and education. Attempts will be made to cover more disciplines.

The National Agricultural Research Project (NARP) has been expanded in both size and scope. Additional universities and training facilities have been proposed. Each research station would be further strengthened by promoting research on horticulture, animal nutrition, animal health, and technology transfer.

The final aspect of the agriculture research and education strategy addresses biotechnology. Topics such as molecular biology, plant tissue culture, biological nitrogen fixation, protoplast fusion, recombinant DNA technology, immunological bio-techniques in reproduction and fertility improvement of cattle, embryo transfer, and genetic engineering in viruses will be studied. The research will be carried out at selected agricultural universities and the three National Research Centers, one for each of the following: crop production, animal production, and animal health.

IV. Forestry

The Planning Commission has designated more than 17 percent of the total agriculture budget during the Seventh Five-Year Plan period to the forestry sector; this amount is second only to crop husbandry. To utilize these resources there are seven specific programs proposed.

Conservation of the fragile ecosystem and preservation of bilogical diversity is the first goal of the program. Other objectives include substantially increasing the vegetative cover by massive afforestation projects; meeting the basic needs for fuelwood, fodder, minor forest products, and small timber; ensuring close linkages between the forestry programs and the welfare of tribal and other communities traditionally dependent of forests; emphasizing forestry research, education, training, and extension; implementing wildlife conservation; and creating a popular movement for achieving the above objectives.

The first of the specific programs that are discussed in the Seventh plan is conservation forestry. It will extend the centrally sponsored scheme of social forestry to cover all fuelwood deficit regions. Also, it will continue the state sector schemes, with external aid where possible. In addition, the program will identify suitable indigenous species, introduce cost-effective measures for raising seedlings and nursery management, develop sustained public interest through tree grants, improve institutional arrangements to give tree rights to those who plant, intensify forest extension by use of mass media, ensure the distribution of benefits by creating special incentives for small and marginal farmers, and improve wood based technology such as smokeless chullans, gasifiers, and charcoal. Also, intercropping relationships between fueldwood and crops should be studied. Finally, the research effort will be directed toward fuelwoods, biomass, fodder trees, agro-forestry, and genetic engineering.

The plan also presents a program for production forestry. Estimates suggest that an additional two million hectares must be planted during the Seventh plan period to fill the gap between supply of and demand for industrial wood. It will be necessary, therefore, to strengthen state forest corporations to obtain institutional finance for increasing plantations. Degraded and waste lands will be made available on a trial basis to forest based industries. In addition, forest produce prices must be rationalized.

Special attention will be devoted to a program for the welfare of tribals and rural poor as part of the forestry strategy. Attempts will be made to associate tribals with the process of protection, regeneration, and development of forest resources. Projects will be examined for consistency with socio-economic values of the particular region. In addition, training will be organized to improve the skills and outputs of forest based cottage industries.

The fourth program for the plan period relates to minor forest produce. The objectives here are to introduce systematic and scientific methods of development, harvesting, collection, processing, and grading for these outputs, and to stimulate meaningful participation of tribals.

The forest research and education program has an ambitious agenda. It will cover all aspects necessary to ensure sustainable biomass production, utilization, and quality improvement, while safeguarding the ecosystem. Studies will be undertaken on issues such as problems in the production of improved planting materials, seed production areas, standardized techniques for clonal propagation, reproduction biology, genetic engineering, tissue culture, physiological properties, the impact on soil properties, and the utilization of forest produce. This research program will be accomplished by linking the ICAR and universities with the Forest Research Institutes. The program also aims to educate and train forest managers, and to begin graduate level programs in forestry.

Any strategy for improving the utilization of forest resources requires an upgraded data base system. This necessitates a scientific survey of forest resources, and timely regular collection and publication of reliable data. The final program for forestry that is presented by the Planning Commission is people's participation. This project aims to involve local people and organizations in the formulation and implementation of schemes based on local needs, potential, and availability of inputs. Programs like social fencing will help create awareness and an exchange of views.

The Planning Commission also recommends three overall thrusts. The newly created National Wastelands Development Boards will formulate plans and programs which promote, encourage, and finance wastelands development. The Indian Council of Forestry Research and Education will be reorganized so that its structure is similar to that of the ICAR. This will enable the intensification of efforts by the Forest Research Institutes, and will guide and promote problem oriented research by state government research units. In addition, remote sensing techniques will be developed and applied to forest management.

V. Irrigation and Command Area Development

Six major objectives are defined for the irrigation and command area development program during 1985-90. First, and foremost, is the rapid completion of unfinished projects. Second, new starts will be restricted to medium projects in drought prone, tribal, and backward areas, and minor projects which can be quickly completed. Third, existing potential should be better utilized by constructing field channels, land levelling, and introducing warabandi systems. Also, priority will go to drainage schemes for completed projects and new projects which solve salinity and water logging problems. Exploration and exploitation of ground water, especially in the Eastern and northeast region, will be accelerated. Finally, maintenance of canals and distribution systems will be improved by new financial allocations.

Towards achieving increased water productivity, the GOI will earmark outlays from year to year to specific projects, monitor and evaluate projects periodically, develop an evaluation system to assess the actual benefits of completed projects, and review the functioning of the Command Area Development organizations. Moreover, the government will integrate the various authorities that have responsibility for water projects, review water rates so that they meet maintenance and operations expenses, as well as providing a return on investment, and involve farmers in day to day management and distribution. In addition, efforts will be made to reduce regional imbalances and define a national perspective on inter-basin transfers.

The Planning Commission has presented a strict order of priority for the funding of irrigation projects. Externally aided projects that are already under construction will receive first priority. Next, completion of on-going medium projects will be undertaken. Then, major projects that were begun prior to and during the Fifth plan period should be finished. Interstate and multi-purpose projects have the next priority. Major projects begun during the annual plans (1978-1980) will then be funded. After that, major projects which are in advanced stages of construction should be finished. Finally, money will be allocated for modernizing existing works.

Several institutions will perform research or irrigation issues during the Seventh plan years. The Central Water and Power Research Station (CWPRS) in Pune will continue model testing, basic research, and evaluation of economic designs for ensuring safety and operating efficiency. The Central Soil and Materials Research Station (CSMRS) in New Delhi will execute basic and applied research, providing information about geomechanics and construction materials. The National Institute of Hydrology (NIH) in Roorkee will focus their attention on reviews of the relevant literature, testing computer programs, data collection, training of scientists, implementation of ground water modeling studies, and Narmada Basin flood studies.

Research in hydrology, hydraulics, irrigation, drainage and reclamation, flood control and river training, coastal engineering, and tidal hydraulics will be undertaken by the Central Board of Irrigation and Power (CBIP). They will also coordinate research and disseminate results. The Central Water Commission (CWC) in conjunction with the National Remote Sensing Agency (NRSA) will become involved in research projects on the application of space technology to water resources development. Additional efforts will be directed to improved training. A National Water Management Training Institute has been proposed.

Minor irrigation projects will receive more attention during this plan period. Stepped up ground water development is called for. In addition, resources will be mobilized to accelerate systemaic hydrogeological surveys, to complete on-going surface water schemes, to allocate adequate funds for externally aided projects, to ensure the timely availability of power, to increase the use of diesel pumpsets, to provide subsidies to small and marginal farmers for private irrigation development, and to encourage conjunctive use of water to expand the benefits from major and medium scale projects.

A large number of recommendations are included in the plan for command area development. The following proposals will help modernize and improve the efficiency of irrigation and drainage systems: construct and line field channels and water courses, promote conjunctive use of water, adopt and enforce suitable cropping patterns, increase the use of warabandi systems, plan input supply availability, strengthen extension services, accelerate road construction, develop marketing and processing operations, expedite credit dispersal and review institutional finance, and integrate irrigation, forestry, and farming systems efforts. In addition, encourage the use of

162

sprinklers and drip irrigation through demonstrations and education. The combination of these programs can greatly increase the value of irrigation systems.

VI. Conclusion

The Seventh Five Year Plan outlines a broad list of objectives and strategies for development of agriculture, forestry, and irrigation during 1985-90. More attention will be directed to areas to improve the efficiency and productivity of existing investments. Much attention is given to a "balanced" set of objectives and investments. On the whole the GOI has fostered a focus on completing existing irrigation projects. The need for cost reducing technological innovations is recognized by the support and emphasis given to agricultural research. The private sector, while some lip service is rendered, is not actively looked upon as a vehicle to accelerate the development process. Fortunately, Indias' private sector is alive, albeit constrained, and playing a more significant role than anticipated. Agro-forestry, the food processing industry and the drip/sprinkle irrigation industry are only a few examples of active private sector participation in the nation's agriculture development.

Current Portfolio, Emergent Themes and Other Donor Activities

I. Current Programs

The current portfolio consists of three separate programs with projects in irrigation, forestry and agricultural research which address the critical issues of water resource variability, land and biomass degradation, and system's productivity.

A. Irrigation

USAID's largest program is in irrigation and water resources. Water is critical to the growth and stability of Indian agriculture. This combined with the capital intensive nature of water resource development and current national objectives all lead to the existing dominance, in dollar terms, of this effort in the portfolio.

Water resources development is centrally important to India due to the highly imbalanced, variable nature of the subcontinent's climatology and hydrology. About 80 percent of total annual precipitation falls in only three months in most of India, with a variability in many areas as high as 50 percent. The capriciousness of last year's monsoon is indicative: many parts of Northern and Central India suffered from a 100 year drought while a month later Eastern India was inundated with destructive flooding. The situation is further exacerbated by the increasing competitive use pressures on water resources. Although India's total water resources are approximately the same as U.S. (equivalent to 1.6 billion hectare-meters), India's population is about three and a half times larger and its hydrology is twice as the variable due to the monsoonal climate. This variability under increasing competitive pressures for irrigation, power generation and flood protection to sustain growth, and the spreading hazards of salinization "mined" aquifers, and waterlogging due to poor management argue for continued more-effectively focused effort in the water resources sector.

India has historically made huge efforts to store and utilize its water resources through massive dams, hydroelectric facilities and diversion and canal networks on a scale unparalled in the world outside of China. To attain and sustain the maximum productivity from existing and potential water resource developments, tremendous scope exists to improve and sustain performance (i.e. conservation and dependability) through better systems analysis and operations. Increased reliability and conservation practices would rapidly double water productivity and alleviate much of the water-related land degradation. The GOI's current 5-year Plan alone calls for $13 billion water resource investment (60% of total Plan budget), a pace of development which outstrips the present national capacity for water resources analysis and planning, and local ability to design and manage irrigation systems to optimize and safeguard productivity.

164

USAID, although a minor player in this area, has the potential to make significant contributions to the development/management of this vital resource for two important reasons. First, the U.S. was an early, major professional collaborator in the development of India's water resources in the 1950-60s. U.S. agencies provided early models for, and assistance to, India's water resource institutions. U.S. universities trained many of the current senior professionals. U.S. credibility and reputation in water resource development is high. Secondly, there are striking similarities between the Indian water resources sector and that of the U.S.: highly imbalanced arid and humid hydrological regions, contentious States' water rights issues, and a highly politicized water resource development process. The U.S. institutional and technological experience is highly relevant to India due to its semi-arid hydrology, its watershed management and basin planning development and its recent institutional transformations in water resources.

The current irrigation project portfolio (LOP funding $220 million) was an initial response to regional droughts in the 1970s. USAID provided financial support for construction of large, surface irrigation schemes in the arid areas of Gujarat and Rajasthan, the former co-financed with the World Bank. Construction of irrigation works to expand irrigated area was the primary project objective. Approximately 100,000 hectares have come under irrigation with USAID assistance, although little technical, managerial or policy improvement was initially included.

USAID's program expanded soon after with the development of projects in the under-irrigated Deccan States of Maharashtra and Madhya Pradesh. Although physical, loan-financed outputs were again stressed, these projects established efficiency and institutional objectives via "design criteria" for improved planning, construction and operations, and shifted to more-quickly implemented "minor" irrigation schemes. With experience gained in the development of these projects an institutional focus started to evolve, and a large training requirement was identified. The IM&T project was designed primarily as a human resource development effort directed at improving irrigation and agricultural cadres' abilities to plan, design and manage public irrigation systems. The current project portfolio follows:

1. <u>The Maharashtra Irrigation Technology and Management Project</u> -- supports the development of 12 prototype medium irrigation schemes to increase hectarage and test and demonstrate improvements in design and operations with related training and institutional development activities such as computerization, pilots and studies. The total project cost is $104 million of which USAID funds $44 million. PACD: 9/88.

2. <u>The Madhya Pradesh Minor Irrigation Project</u> -- assists the design and construction and initial operations of 50 minor irrigation schemes to increase hectarage and to improve the performance of minor irrigation by testing and demonstrating higher quality and innovations in systems planning, design and operation with involvement of farmers. This project was recently redesigned to link disbursement directly to

165

objectives. Total project cost is $98 million of which USAID funds $48 million. PACD: 9/91.

3. The Maharashtra Minor Irrigation Project -- supports planning, design and construction/rehabilitation of approximately 100 minor irrigation schemes to expand irrigated area and improve the systems planning, design and management with farmers' involvement and strengthening of the Irrigation Department and associated institutions with training, computerization, management systems and special studies. Total project cost is $102 million of which USAID funds $51 million. PACD: 9/90.

4. The Hill Areas Land & Water Development Project -- supports the development of thousands of minor and micro irrigation schemes including "upstream" catchment treatment, lift and gravity supply infrastructure, distribution channels, selected on-farm works and associated agricultural extension, introduces new approaches to water management through training and studies with emphasis on farmer community involvement and interdepartmental collaboration. The project is currently being redesigned to redefine objectives and disbursement methodology. Total project cost is $109 million of which $54 million is USAID assistance. PACD: 9/91.

5. The Irrigation Management and Training Project -- provides funding, training and technical assistance to center organizations and an 11 state network of water resource management study, information and in-service training institutes (WALMIs) in various aspects of the planning, design, distribution, and operations of irrigation systems based on modern concepts and technology. The project is currently being restructured to simplify administrative arrangements and clarify objectives. Total project cost is $101 million of which USAID funds $51 million. PACD: 9/90.

Last year, the Mission undertook an intensive review and re-thinking of the irrigation program in order to consolidate a strategy focused on specific opportunities in the sector which had a comparative advantage for USAID, and offered high economic returns. The major conclusions follow:

1. The design "criteria" established for the various projects were in large part effective in improving irrigation. However, three fundamental prerequisites of system performance are a priority:

   - Hyrological analysis and planning: Qualification of water source above and below ground and the optimization, cost-effectiveness and maintenance of its supply;

   - Systems operations: The workings of the entire system, including cropping requirements, rainfall interactions, conjunctive groundwater use, flow measurement and controls, communications and management information and feedback; and

- Beneficiary participation: The establishment of clear rules, rights and responsibilities in systems planning, operations and costs.

2. There are high returns, in terms of increased and higher-value production to reliable, scheduled systems operations. The primary constraint to higher-yielding and value cropping patterns in public surface irrigation systems is the uncertainty over the timely and adequate delivery of water.

3. The scope of most public surface irrigation systems are increasing and evolving toward broader water resource systems serving domestic and industrial consumption needs, fisheries and livestock expansion, private lift irrigation development, and flood control and aquifer recharge as well as being affected by watershed use. Yet, the Irrigation Department's planning, analysis, design and implementation have not expanded to account for these broader objectives and potential costs, risks and benefits.

4. USAID has had a significant role in the public dialogue on farmers and their participation in systems design operations as well as linkages to water resource systems planning. The degrees and forms of beneficiary rights and responsibilities, particularly costs, is a major policy issue which will have substantial effect on the economic efficiency of the sector.

5. With increasing competitive pressures on the resource base the current level of surface/ground water resource analysis and management is inadequate to provide informed alternatives to planners & managers. The full range of India's technological and socioeconomic capabilities have not been applied in the interdisciplinary analysis of increasingly critical water resource problems.

These conclusions have enabled the program to define a clear set of assistance targets which can yield high returns as well as have broad impacts in areas of comparative AID advantage: a systems "technology package" focused on improved, scientific water resource analysis, systems operations and beneficiary participation; an institutional goal of the modernization and reorientation of Irrigation Departments and of support to relevant change-inducing organizations, and; an emphasis on optimized management of the sources of water in upstream watershed and downstream aquifers. Infrastructure investments will be limited to those systems and institutional developments necessary to test, teach or demonstrate these changes.

B. Forestry

Current and anticipated pressure from rapidly increasing human and animal populations highlights the urgency of addressing sustainability issues affecting India's natural resource base. Ironically, the very programs and policies which have led to impressive growth of agriculture have in fact contributed to the rapid degradation of India's land resources. The resultant devegetation, soil erosion and desertification is seriously undermining the natural resource base upon which future increases in agriculture production and income generation will depend.

The problem has manifested itself most strongly in deforestation. Most experts agree that afforestation has a large multiplier effects on preserving watersheds, generating rural income/employment, and general maintenance of the rural environment. As a result, the GOI has steadily increased its expenditures for afforestation. Planned expenditures in the Seventh Five Year (1985-90) Plan, are approximately $2 billion, which is 3.5 times the level of the Sixth Five Year (1980-85) Plan and 43 times that of the Fifth Five Year (1974-79) Plan.

USAID, followed by other foreign donors, supported forestry projects in 14 States. These programs have made substantial progress. For example, nearly 700 million tree seedlings will have been producted and planted on more than a million acres in just six states. Nevertheless, the current rate of tree planting and survival rates still falls well short of requirements. Moreover, the institutions, policies and technologies required for rapid afforestation and sound forestry resource management are still evolving and/or yet to be put into place.

The initial response to the GOI request for AID to engage itself in problems affecting the forestry sector took the form of three projects with USAID funding of $150 million. These projects work with six major Indian states to test alternative social forestry interventions, evaluate their effectiveness and develop supportive policies and future initiatives. The GOI is now in the process of approving two additional activities to develop the forestry research and education capabilities in the country's state agricultural university system. The forestry portfolio follows:

1. The Maharashtra Social Forestry Project -- supports expansion and strengthening of the forestry extension organization and reforestation program in Maharashtra. Approximately 4,300 village woodlots will be established and a million seedlings distributed to increase the supply of firewood, fodder, timber and other forest products, with a goal of 81,000 hectares of mixed plantations adjacent to rural villages. Total project cost is $60 million of which $30 million is USAID assistance. PACD: 9/90.

2. The National Social Forestry Project -- co-financed with the World Bank, strengthens the capacity of five states and the Central Government to implement, monitor and evaluate social forestry programs to increase production of small timber, fuelwood, fodder and other forest products and to arrest erosion. 700,000 hectares will be reforested through alternative tree planting programs and monitoring & evaluation offices established in each state. A joint

USAID/World Bank mid-term review of this project will begin in late 1987. Total project cost is $328 million of which USAID contributes $80 million. PACD: 3/90.

In addition to these social forestry projects, USAID, under its Agricultural Research Project, is currently working with the Ministry of Agriculture on two supplementary activities to strengthen the forestry research, education and training capabilities.

3. The Faculty Training in Forestry/Forestry Education Subproject -- develops the forestry and agroforestry university faculty through fellowships and short courses. Faculty members from Indian state agricultural universities will be assigned as visiting faculty in the Forestry Departments of nine U.S. universities and return as core university staff. Total sub-project cost is $3.5 million of which USAID contributes $2.7 million.

4. The Agro-Forestry Research Subproject -- will begin in FY 1988 to support agro-forestry research at state agricultural universities and Indian Council for Agricultural Research (ICAR) centers. Total subproject cost is $4 million of which USAID contributes $1.9 million.

The current projects were developed around two basic thrusts: the direct afforestation of community lands and support of tree crops on private lands. The objective of the former was to develop the village capabilities to manage plantations of trees for their own benefit. The latter supported farmers' efforts to meet their own sustenance and income needs. Because it is complex and site specific, community forestry has not been as successful as the farm forestry element which has far exceeded initial targets and continues to expand rapidly.

During the rapid growth and development of India's social forestry programs, the donors and the GOI have all been on a steep learning curve: initial assumptions are being questioned, program objectives being modified, and institutional arrangements being changed. While information continues to emerge from on-going evaluation and the active public discussion by NGOs, GOI, donors and private citizens, the paucity of empirical data and analysis combined with the long growth periods of trees and of the new social institutions have left many pressing questions unanswered. However, some overall lessons have become evident:

1. Resource management strategies and technologies must build upon the needs of farmers and other rural dwellers as perceived at the household level. The primary need at this level is income generation and fodder. Fuelwood is of secondary importance.

2. Soil and water conservation, forest protection and revegetation can only be accomplished through situation-specific prescriptive analysis based on local physiography and land use patterns.

3. The distinction between traditional production forestry and forestry focused on local needs is critical. It is only through technological development in vegetation management for satisfying local needs that protection and management of outlying forests and watersheds is possible.

4. Indian institutions engaged in natural resource management generally lack an analytical orientation. Afforestation and reforestation activities, forage production, and improved natural resource management in general must be supported by an active and rigorous analytical program and by strong programs in education, research and extension.

5. Private sector investment by both farmers and industry is critical to improved natural resource management. Market structures, legal mechanisms and public policies that promote investment must be developed and directed toward sustained private sector income generation.

Knowledgeable observers agree that afforestation and reforestation, in its private and community sector dimensions, have entered an intermediate stage of development in India. Today it is virtually impossible to find anyone living in India who does not know about the massive afforestation efforts going on across the country. Early on AID provided inputs in the form of funds and new ideas for field programs and made a critical contribution toward the subsequent marshalling of substantial GOI and donor attention and resources in this area. Moreover, the level of support is expected to increase substantially in the future. It is plain that the job of enlisting the aid and support of scientists, the bureaucracy and the general population for afforestation is largely done.

Social forestry has brought forth new questions and demands from those who practice it and/or benefit from its products. Farmers want better models for agroforestry, access to genetically improved tree species, and improved market channels to sell to. Villagers want better community woodlot models that will provide a continuing supply of fodder, fuel and income. Foresters want more information on mixes of trees, shrubs, and grasses to grow on degraded lands and how to manage forests/watersheds to satisfy a diverse range of social, economic and environmental needs. Finally, scientists and the general population want to safeguard India's plant and animal wildlife to provide a rich genetic pool for future biological research and for the enjoyment of future generations.

Social forestry has heightened both the GOI and the general public's awareness of other related environmental problems. It's now recognized that afforestation is simply one element in India's environmental rehabilitation and that many of the remaining problems cannot be solved through tree planting. As a result, new opportunities now exist for AID to address the broader issue of sustainable land use management in the agricultural context.

Sustainability herein is defined as the ability of an agricultural system to meet evolving human needs without destroying and, where possible, improving the resource base on which it depends. In addition to deforestation, this issue includes loss of biodiversity, habitat destruction, soil erosion, ground water contamination, and so on.

Given the lessons learned to date, trajectories of GOI and donor expenditures for afforestation, and the spectre of declining USG-assistance levels to India, the Mission concludes that financing of large-scale plantation (tree planting) activities is no longer an appropriate use of AID resources. Rather, future AID resources should be oriented towards addressing the broader issues of natural resource sustainability of which forestry is only a single but important part. Given this broader view, we believe the program outlined in the text of the agricultural strategy has great potential for changing India's land management regime. It is furthermore consistent with the Mission's overall modernizing India theme and reduced funding levels.

C. Agricultural Research

India has an enormous cadre of professional human capital, trained in the sciences and engineering, in its large research establishment, public institutions and private sector. This has largely been responsible for the present strength of India's agricultural sector, and is the envy of most developing nations. However, Indian agriculture continues to be characterized as highly inefficient. Increasing factor productivity is a prerequisite for sustainable agriculture growth and modernization. So far, however, overall crop yields, patterns and diversification and its costs have not attained proven standards of performance. For example, overall yields in India are about one-third of China, a country considered to be less well endowed agriculturally. The cost-reducing, productivity-enhancing, technological innovations from the application of science and technology to Indian agriculture have yet to be fully developed or applied.

India's impressive research network provides the basis to develop the necessary technological and management innovations. For example, rainfall in thirty percent of India's dryland agricultural area is normally adequate for good crop production (above 1200 mm.). In principal, yields can be substantially increased through better moisture management, cultural practices, soil fertility and varieties. Physiologically at least, the yields of crops like maize, wheat, rice, peanuts, oilseeds, pulses, coarse grains, etc. can be increased several-fold over those currently realized. Even in dryer regions, productivity increases through new practices, trees or grasses, and livestock options can be achieved to support the population living there.

The GOI and USAID agreed that agricultural research was to be a principal area of U.S. Indian collaboration when USAID re-established a program in India in 1978. In 1980, the U.S. and Indian governments established the Indo-U.S. Subcommission on Agriculture. By 1982, the current project had crystallized into a broad umbrella effort. The Agricultural Research Project provides a direct and flexible response to individual agricultural research activities of a mutual interest. The total project cost is $28 million of which USAID contributes $20 million. PACD: 6/92. Despite approval of the umbrella project three additional years were required to adequately design the first subprojects for implementation within the USAID and ICAR management structures. Now, after two years of implementation and subproject design, the management and monitoring modalities have been worked out, the project disbursements are accelerating with training, post-doctoral exchanges, research equipment procurement and the arrival of special consultants. In fact, the project is now more or less fully subscribed even though all of the originally proposed subprojects have yet to be approved. The subproject portfolio follows:

1. The Soybean Processing and Utilization Subproject -- develops simple processes and equipment to make soybeans into low-cost food products and processing technologies suitable for home, village and small industry level operations. Activities are being undertaken by the Central Institute of Agricultural Engineering in Madhya Pradesh. Also included is a supportive training program in oilseed processing and utilization at G.B. Pant University in Uttar Pradesh. Total subproject cost is $3.4 million of which USAID funds $2.8 million.

2. The Post Harvest Fruits and Vegetables Technology Subproject -- focuses on harvesting, handling, storage, and marketing to decrease the loss rates of seven crops. Research activities are conducted through the all India Coordinated Program on Post-Harvest Technology of Horticultural Crops and located at four different locations throughout India. The total subproject cost is $6.9 million of which USAID funds $5.0 million.

3. The Intracellular Blood Protista Subproject -- develops and implements immunoprophylactic and diagnostic measures for three major tick transmissible protistan blood diseases of animals, including utilization of bio-technology advances involving antigen/antibody work to develop methods of control as well as the production and testing of vaccines. Scientists at five different locations throughout India are collaborating in this research activity. Total subproject cost is $2.6 million of which USAID funds $1.6 million.

4. The Conversion of Bio-degradable Animal Wastes Subproject -- develops biotechnology for the conversion of wastes of animal feeds using micro-organisms in concert with physical and chemical processes including screening of micro-organisms, evaluating nutritional value of fermented feeds and transfering viable technologies to farms and industry. The research will be conducted at five locations throughout India. Total subproject cost is $2.8 million of which USAID funds $1.3 million.

5. The Embryo Transfer and Bio-Engineering in Livestock Subproject -- develops the embryo transfer technology to enhance the genetic manipulation of specific animal production traits. Techniques

\172

include superovulation and synchronization of donor and recipient animals, in-vitro fertilization, embryo culture, cryopreservation, sexing, cloning, engineering and embryo transfer technology. Six Indian institutions are participating under the coordination of the ICAR. Total subproject cost is $3.3 million of which USAID funds $2.2 million.

6. The Agrometeorology Subproject -- strengthens research within the all India Coordinated Research Project on Agrometeorology by introducing latest technologies and procedures in agrometeorological modeling and analysis including "forecast farming". A total of twelve institutions throughout India are involved in the subproject. The total subproject cost is $1.4 million of which USAID funds $0.5 million.

Several major conclusions can be drawn from the ARP-I experience:

- One of India's principal strategic challenges is excellence, entrepreneurship and agility in the application of science and technology to the problems and opportunities of agriculture and resource management. This project's goal is to increase the research capacity of the ICAR which is essentially an institutional strengthening objective. Increasing the agricultural research capacity of India was the right objective, yet the subprojects in the main were aimed at obtaining specific solutions to specific problems by the actual transfer of technologies from the U.S. to India. Although building institutional capability in agricultural science and technology does involve direct transfers, it is not sufficient to deal with the systematic constraints in agricultural research and education in India.

- Project implementation has shown that, while technology transfer between countries can be "procured" on a contractual basis, the most effective transfers of technology occur through collaborative research arrangements where both parties are involved because of self-interest. The process of technology development is fraught with risk, and requires time and flexible responses. USAID-developed contracting and sub-contracting procedures have tended to place narrow restrictions on a process which needs to be dynamic and collaborative.

- As the development process and problems become more sophisticated, so too does the site specificity of plant/species development. India did well borrowing and adopting green revolution varieties of wheat and rice; however, today India has to deal with site-specific problems. For example, the origin of Karnal bunt in wheat is in India, where the resistant geno-types are also found and must be preserved. There are many other examples, particularly indigenous grasses and trees. India's plant genetic resources are critical to sustainable productivity of all of agriculture.

In summary, the Mission has now had eight years of experience since re-establishing the program in India. All of the projects developed were too optimistic in the time and efforts needed to become operational within the huge Indian development administration. In short, "their rules, our regulations" is the essence of the slow pace of implementation. It is not a problem of substantive quality or the strategic interface between the challenges facing India and USAID's developmental agenda. USAID's AGRM portfolio of about $380 million leverages a total program valued at nearly a billion dollars. The Mission has learned a lot about the development process in India as well as its own constraints since 1978. Yet, these initial programs in water, forestry and agricultural research have stood a test of time in relevancy and of developmental impact.

II. Emergent Themes

The AGRM program focuses on assisting the creation of new ideas knowledge and management skills, as such assists in the enhancement and building of India's human capital. The recent experience clearly indicates that the promotion of excellence and entrepreneurship in the application of science, technology, and management skills to new opportunities and old problems is essential. Linking U.S. and Indian scientists, analysts and technical managers to collaborate on problems shared by both societies has proven to be an important means to address these issues. Similarly, supporting efforts must link Indian and U.S. professionals or institutions working on broader issues of national importance, e.g. breeders' rights, fertilizer market regulations, services' cost recovery, water resource optimization, etc., which raise the level of public debate and understanding on important policy choices.

Professional linkages to international and U.S. centers of excellence (research institutions such as IFPRI, IIMT, ICIMOD, WRI and selected U.S. agencies and universities) are one of the means to this end. Modern computerization, telecommunications and informatics to improve the transmission and networking of ideas and knowledge is another necessity of modernization with which the U.S. has applicable experience and technology. Also, modern methods (and supporting technologies) of management in key public sector organizations in research and resource management (forestry and water) are solely needed.

Finally, contemporary India, particularly its top leadership, is shifting its view of its burgeoning business community. This is driven by a larger but less visible disenchantment with GOI's inability to deliver goods and services efficiently. Loud/vocal political groups conclude that even more government management is required, but the sheer size of the economy and the democratic processes must inevitably lead to greater private sector participation in agricultural development. Over a third of the irrigation in India is privately developed. Pioneer and Cargill are involved in the seed industry. Western India Match Company (WIMCO), with Swedish equity and U.S. technical expertise, is an example in the forest products sector. The U.S. agribusiness community, that a few years ago was not welcomed in India, now provides an important new resource to USAID in linking professionals and institutions.

Moreover, within these three distinct programs several surprisingly clear themes have emerged which are common to each:

- Research and Education -- will provide the knowledge necessary to meet the critical challenges in agricultural resources management. It is rooted in USAID's historical involvement with agricultural research and education institutions in India, and more recently from the Mission's substantial involvement with ICAR through numerous research subprojects. More recently new activities have been initiated in forestry education and biotechnologies. The larger forestry and irrigation "field" projects also obtain important research and educational support from various State Agricultural Universities and ICAR activities such as the National Water Management Program and various Universitys' Adaptive Research Projects. The creation and dissemination of new knowledge are the heart of a modernizing India and are at the center of the AGRM's strategy.

- Natural Resources Management -- is necessary to ensure prudent husbandry if a limited resource base is under stress. Its theme stems from the Mission's intensive experience with State Irrigation and Forestry Departments through USAID's irrigation management and social forestry field projects. As these projects have matured the program has focused on the manpower, managerial and procedural constraints of these large public institutions themselves. Both the irrigation and forestry programs have become increasingly concerned with in-service and "action" training, manpower and management assessment, interdisciplin- ary planning/evaluation, and modern computerization and information systems for these old line institutions. The U.S. has considerable relevant agencies and India's institutions can benefit from their experience in the transition from resource developers to resource managers. Modernization and reorientation of these institutions are necessary to meet the changing circumstances of managing a resource base placed under stress by burgeoning rural populations and an expanding economy. The intelligence and responsiveness of these public "guardians" of India's natural resources influence both growth and its sustainability. These institutions are the public arbiters between modernizing India and the rural resource base.

- Finally, Policy and Enterprise provides the incentives which drive a maturing program and modernizing economy. The policy environment has been a major if understated concern throughout the program. Tree tenure in social forestry, cost recovery in irrigation and commercialization rights in agricultural research are policies which the AGRM program is targeting indirectly through support to various interest groups. As USAID's experience and familiarity with Indian personalities and institutions grows, more emphasis will be given to increasing the level of public debate on desirable policy changes. Individual enterprise also plays an increasing role in the AGRM program as experience shows the productivity of entrepreneurism in water marketing, agro-forestry, and technology development. U.S.

entrepreneurism and technology commercialization can provide ample models and ideas for India's private sector. Incentives are the dynamic of a modernizing India and is the leading edge of the AGRM Strategy.

The Mission's Agriculture Resource Management Program builds upon its existing projects in research, forestry and water by concentrating on potentially self-sustaining academic, professional and business linkages between relevant Indian institutions and U.S. and international centers of excellence. The strategy can be represented as a "triad" of objectives: Science, Technology and Education, Resource Systems Management, and Policies and Enterprise.

III. Other Donor Activities

The AID Consortium has been maintaining its pledged assistance at about $4 billion for the last three years. Consortium members are Austria, Belgium, Denmark, Norway, France, Germany, Italy, Netherlands, Sweden, the U.K. and the United States. There are strong complementarities between donor programs. The GOI discourages "coordination" but at the working level frequent informal working arrangements exist to further cooperative efforts, e.g. USAID and the World Bank in agricultural research and the State Agricultural Universities.

India continued to be the single largest recipient of World Bank and IDA assistance and the Bank group remained India's largest single source of foreign borrowing. Through June, 1986, the World Bank contributed about $2,366 million in aid including 1.743 in IBRD loans and .625 in IDA, very close to the previous year's levels. Close to a billion of this was for agriculture related projects. There were two new programs in irrigation last year, one in research and another for agricultural credit. This year's level looks a bit higher at about $2.5 billion. New agricultural projects have begun in Tamil Nadu and Bihar.

India has the largest Title II Food for Peace Program in the world but it, too, is facing large budget reductions and the level is expected to fall from $94 million in FY 86 to $80 million in FY 87 and still further in FY 88. The total number of recipients, however, is expected to remain about the same for this year, due to shifts in commodiites and lower commodity prices. By category, mother and child health programs, administered by C.A.R.E. and the Catholic Relief Services, receive the bulk of the funding ($53.5 million), followed by school feeding (10.4 million) and food for work program (.234 million). Commodities for the above include bulgur, CSM and vegetable oil. Working closely with the Cooperative League of the USA (CLUSA), the National Dairy Development Board (NDDB) is receiving a final tranche of 10,700 tons of soybean oil ($6.7 million) for its Oilseeds Growers Cooperative Project (OGCP).

The Far Eastern Regional Research program between Indian institutions and the USDA/ERS began in 1960. Out of total 599 research grants since the program's inception there are now 82 active and about 40 proposed grants which have already been approved by both FERRO and the GOI's Indian Council of

Agricultural Research. Funding for this program has been provided from excess rupee accounts and is being continued under the rupee endowment fund.

India continued to receive development assistance donations through the World Food Program in the irrigation, forestry, nutrition and social welfare sectors. As of January, 1986, 13 programs were underway with a total budget of $206.3 million and three new programs were planned ($45.48 million). New programs during 1986 were developed in integrated watershed management, irrigation, forestry and a pilot project developed for inland fisheries. WFP programmed commodities for India include vegetable oil, dried skim milk, pulses, and soy-fortified bulgur. In some cases, food is distributed directly to the recipients and in others, the food is sold to generate proceeds for development projects.

Most of the member states of the European Community have a long history of bilateral cooperation with India. India is also the largest single recipient of EC grants which are mostly in the rural and agricultural development sector. 1986 commitment and disbursement levels were ECU 65.9 and 42.7 million respectively, compared to 45.0 and 45.9 million in the previous year. Food AID levels (CIF) were estimated at ECU 25.3 million in 1986, in milk powder, butter oil and skim milk for the National Diary Development Board program. The EC is currently reappraising its assistance to the Operation Flood program to determine what donations should be granted this year and next. Other new programs in 1986 included a fertilizer supply project (ECU 45.6 million) and a rural storage program for Bihar through the NCDC ($21.1 million). Planned 1987 programs include irrigation technology transfer, sheep development in Tamil Nadu, a fertilizer program and Kerala coconut development.

The Canadians appear to be entering phase two of their commodity assistance program with the NDDB's OGCP. Levels as high as $88 million worth of rapeseed oil have been reported for the 1988-93 period.

Source: Attache's <u>Agricultural Situation</u> Report, February 1987.

IWR Strategy, Maharashtra Assessment and HALWD Evaluation Summary

I. IWR Strategy

The rationale for USAID/India's involvement in irrigation and water resources is substantial and compelling. In monsoonal regimes such as India's, year-round access to a reliable supply of water through irrigation infrastructure is central to agricultural growth and consequent generation of rural income. India's public investment in irrigation is huge and continuing, yet most systems perform below potential, leading to low production, a waste of water and financial resources and, at worst, deterioration of the resource base. The U.S. has considerable relevant technological and institutional experience which can be brought to bear on the cost effectiveness and systems management constraints in irrigation and water resources development in India.

Irrigation as well as other water resource activities can be broadly conceptualized as the interrelation of three physical and socio-economic systems and their related technical and institutional issues: a water resource macrosystem, a water transfer hydraulic system, and a production or on-farm microsystem. Two dimensions cut across these: The interacting hydrologies of suface water and groundwater and the various forms of public and private ownership and control. Productivity and performance depend on the management of these systems, particularly their interfaces.

The USAID irrigation/water resource program currently consists of four State-specific and one National support project totalling approximately $270 million (U.S. assistance: $ ___ million), focused primarily on small surface irrigation systems. Until recently, USAID's program rhetoric has generally been directed at the on-farm issues related to agricultural water management and its interface with the water supply system. Meanwhile, USAID's loans for the most part finance main system infrastructure. Hence, although the projects included comprehensive technology packages, a dichotomy existed between what USAID talked about and what it was funding. Construction also dominated much of the USAID-GOI dialogue.

The experience of the past four years clearly indicates that reliable main system supply is a major constraint to sustainability and performance, and is prerequisite to downstream, on-farm development. Our analyses indicate high returns to main system improvements and operations which ensure reliable supply. On the other hand, initial returns to on-farm investments have been disappointing. In new systems, efforts in initial planning and operations can also yield high marginal returns. Benificiary participation in costs and distribution ensure sustained productivity and performance over the long-term.

With these lessons learned, and the evidence of sustained productivity from predictable water, USAID is shifting attention towards the planning, operations, and performance of the larger water resource/irrigation systems.

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This strategy focuses on the fundamental technical, economic and institutional aspects of surface and ground water supply which are prerequisite to cropping shifts for more productive use of a resource under stress.

The program is currently focused on technical and institutional improvements in public surface systems in the Indian Deccan due to initial project investments and the potential for employment generation from high-value crops in these resource-poor areas. This involves improved planning, design and operations of specific irrigation schemes, and concomitant professional development and studies. Institutionally, the program assists the reorientation of Irrigation Departments (the primary controllers of water) from public works to public service and to broader planning and productivity issues, including resource conservation, groundwater use, and non-public sector possibilities. Indo-U.S. professional exchange and training, studies and pilots are key to this thrust.

USAID will also be looking further upstream and underground. Activities have been initiated in the larger water resources environment, both at regional and site-specific subproject levels. These consist of: training and study of analytical methodologies applied to basic-wide resource allocation; professional exchange among resource management institutions; collaboration with USAID forestry activities; and improved planning criteria, hydrological monitoring and watershed management in subproject development. Groundwater will figure prominently in this effort.

The on-farm production system will receive limited attention. There will be some efforts in water conservation through discrete technical and institutional studies and demonstrations necessary to complement the water resource and supply strategic thrusts. Possible joint-programs and agrotechnology initiatives with USAID forestry and agricultural research activities are being considered.

To implement this strategy, USAID is restructuring and consolidating its irrigation projects to better target assistance. Disbursements are being directly linked to systems performance indicators, rather than to construction. State projects are being consolidated into "programs" to encompass broader issues within their water resource sector. Staff is being shifted from construction and on-farm works towards planning, operations and institutional issues. Grant-funded activities are being streamlined to promote studies and technical exchange. Public and private institutions concerned with irrigation issues are being assisted in analysis of performance and management questions.

In sum, to build on past experience and investments and effectively concentrate current staff and funding levels, the Mission's strategy emphasizes program-tied assistance focused on the technical and institutional improvements necessary to ensure reliable water supply. The strategy targets systems management and institutional performance in water resource planning, supply and distribution primarily, for irrigation.

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II. Evaluation Summary of Maharashtra Irrigation

Overall, the assessment team was greatly impressed by the level of professionalism of the Maharashtra State Irrigation Department (ID), as well as the complexity of its management responsibilities under existing irrigation policies and water resource limitations. The team was also impressed by the responsiveness of the USAID program to the needs and opportunities of the Irrigation Department, but feels that it should establish a clearer focus, consistent with the new USAID/India Irrigation Strategy.

There is universal agreement that the physical objective, or goal, of an irrigation system is to deliver a timely, reliable and equitable share of water to all farm units within its command area. Most public irrigation systems in Maharashtra are designed to store water and supply it to upland crops. We wish to focus attention on the primary set of system features/conditions which are currently limiting the performance of these systems. In our view, these primary features are:

- Inaccurate hydrologic predictions
- Unknown and faulty main system hydraulic performance
- Inadequate control of outlet flows/discharges serving the chaks
- Faulty chak-level distribution and farm turnout systems
- A water allocation and delivery system (Shejpali) that is difficult to manage
- Unknown relationships between system losses and potential/actual conjunctive use

A. Priority Areas

Priorities and specific recommendations are identified briefly by topical area.

1. Design and Implementation

Hydrologic analysis of many schemes appears to be faulty. With data from over 4,000 minor and medium tanks, and numerous rainfall and stream flow data, there is scope for making quick and greatly improved hydrologic predictions based on sophisticated computer-assisted modeling. This should be made a disbursement point for USAID.

Completed systems rarely meet design standards. Performance Testing should be established from headgate to farmgate. This means verifying flows/discharges from the dam to the boundary of each farm unit to provide a basis for:

- Commissioning systems, and triggering USAID disbursements;
- Pinpointing economically corrective measures, as well as establishing a basis for upgrading design and construction procedures for future projects; and
- Designing a realistic operational model for the system as built.

The Team strongly endorses USAID's "performance disbursement" program and suggests that disbursement provisions be modified to require Performance Testing down to the farmgate level, to assure the physical and operational capability to distribute water equitably throughout each system.

Existing control of system discharges is cumbersome and unreliable. Fixed discharge outlets with on/off gates should be installed at the public outlet serving each chak. The outlets should be reliable, durable and well-protected against tampering.

Chak development is currently completed as quickly as possible, without making provisions for calibrating or modifying inoperable structures. Chak development should be divided into two phases, each tied to a disbursement step.

- Initial stage -- construct channels and permanent structures (such as division boxes, channel crossings, drops and farm turnouts) sufficient to guarantee allocated flow from the fixed public outlet to each farmgate. Essential erosion protection must be provided in the channels.
- Final stage -- after at least one year of operation (and not more than two), in consultation with farmers, inspect each channel and make necessary adjustments and corrections in accordance with the intent of the existing chak development program. This constitutes the chak level portion of the Performance Test.

This procedure will improve the cost-effectiveness and physical efficiency of delivery systems and establish more meaningful dialogue between the ID and farmers.

Conjunctive use of groundwater and lift irrigation in, and adjacent to, command areas is extremely important, having implications for system design and operation, as well as more general water resource planning. However, the team feels that current knowledge is too limited. Therefore, a study is recommended which will result in an economic optimization model for conjunctive use and lift irrigation in (and adjacent to) command areas.

2. Management and Operations

The ID has accepted the notion of incorporating operational planning into the design process, but provisions are not made to up-date operational plans/rules on the basis of monitoring flows. Three steps should be taken:

- Plans should be modified after Performance Testing to adjust them to fit actual system characteristics;
- Flows should be monitored throughout the system at least every 3 to 5 years, economic repairs/improvements made, and plans adjusted accordingly;
- In early stages of operation of systems which require 2 or more years to complete, discharges and releases should be carefully

controlled so that initial users develop the expectations and discipline which will be required after the planned full development;
- One way to establish appropriate expectations right from the start is to limit discharges to full development levels, regardless of the amount of water actually available.

The Shejpali water allocation system has many good features, but it is not really working. Modifications such as Rotational Water Supply (RWS) or "rigid Shejpali" are being tried, but results are not monitored well. The team endorses retaining the "slab system," whereby every farmer is guaranteed a water allocation for a minimum cropping area but, when water is scarce, larger units receive only a fraction of requests above that amount. However, we suggest that the following modifications of the RWS be tried:

- Provide rotational water deliveries to each chak every 8 to 12 days, rather than 15 or 21 days, to allow for more flexible cropping programs;
- Base water allocation on holding size and the "slab system," regardless of crop being grown; and
- Regularly monitor calibrated measurement points at the end of each distributary and minor to assure dependable releases.

The ID has adopted a policy which calls for the creation of outlet associations (OAs) and the eventual transfer of responsibility for minors to the OAs, but the policy is more rhetoric than substance. USAID supports the policy and requires OAs to be formed in MMI sub-projects, but very little has been done about this. NGOs and other external agencies should be invited to experiment with different methods of forming OAs and different water allocation systems. The efforts should be monitored carefully and results compared to enable the ID to establish viable operational guidelines.

Also, the ID should experiment with different types of working relationships between itself and outlet associations (OAs) and monitor them carefully to determine appropriate policies regarding ways to devolve authority, share responsibility, and maintain accountability, while assuring reliable and equitable water supplies.

The ID currently gathers much information, and much is available when demanded, but the system is rapidly getting over-loaded. The ID should develop a computerized management information system. First, it should identify information needs at different management levels and then develop an appropriate computerized management information system to provide reliable information on a timely basis and to reduce time and labor commitments for demand aggregation, scheduling, billing and accounting.

In conjunction with the computerized management information system, for canals serving over 1,000 hectares the ID should introduce main system hydraulic modeling in the management system, enabling managers to improve their operational decisions.

3. Economic and Social Soundness

Project economic analysis should be re-computed, based on subsequent experience. To optimize the economic value of sub-projects, economic analysis should be integrated in the design process, rather than added after designs are completed.

The team strongly supports USAID's policy of making the satisfactory completion of resettlement of people from submerged areas a disbursement point. However, the resettlers should be monitored periodically to determine the viability of policies and quality of implementation.

Traditional water use should be investigated as part of the sub-project appraisal process. Provisions should be made to assure either that traditional water supplies are not interrupted by the construction or operation of irrigation systems or, if the traditional supplies need to be disrupted, that they are replaced or otherwise compensated for. To utilize dead storage, pipes should be installed in reservoir bottoms, with intakes that can be adjusted to sediment levels.

4. Professional Development

The Maharashtra ID is a leader in India in the professional development of irrigation staff. The current program lacks individualized programs for synchronizing training programs with career development, as well as a coordinated, comprehensive training strategy. The ID should undertake a comprehensive training needs assessment to identify relevant current and future training needs and develop an appropriate strategy. The team offers these additional recommendations:

- Establish a course in "main system management," perhaps at the WALMI, Aurangabad, to complement the existing WALMI course efforts in lower system (minor and below) management;
- Reduce in-breeding at the MESC by providing opportunities for training staff to gain new ideas, and by attracting new staff;
- Introduce management science and economics at the MESC;
- Reconsider establishing the graduate program in irrigation and water management being developed at Mahatma Phule;
- Meanwhile, reduce the number of elective courses offered in the inter-departmental irrigation/water management field.

5. Future Issues and Needs

The Maharashtra ID experiences increasing competition from alternative users for water resources. This will increase the pressure to increase water use efficiency, perhaps leading to more stringent distribution arrangements. Furthermore, sugarcane will continue to play an important role in complicating scheduling and water allocation.

- Crop diversification incentives and disincentives should be studied to permit formulation of useful policies.

The ID needs to develop the capacity to identify information needs, commission studies, oversee them, and then interpret results into viable policy alternatives. Accordingly, the team very strongly recommends that the ID:

- Establish a "think tank" at DIRD charged with providing senior level policy-makers with the information they need to permit informed judgments.

A. Recommended Studies

The Team acknowledges the high value the ID places on the special studies components of the USAID projects, and feels that the studies would benefit from some judicious technical assistance, which could be arranged either through the MMI or IM&T project. We also trust that the completed studies will be presented to seminars, as originally intended, in order for authors to receive professional feedback. As part of an institutional strengthening exercise, the team recommends that the ID undertake three studies mentioned above, to prepare for procedural changes:

- A sophisticated computerized model to improve hydrologic prediction for system designs which utilizes a compilation of the existing hydrologic data;
- A detailed review of information needs, to be used as the basis for designing and implementing a computerized management information system;
- A comprehensive training needs assessment, to be used to identify gaps and to develop an appropriate training strategy.

The Team also identified a number of empirical studies which should be undertaken:

- A study of conjunctive use of groundwater and lift irrigation within and adjacent to irrigation command areas;
- The study on Rotational Water Supply, already identified but not yet undertaken;
- Experiments with different ways to form OAs, carefully monitored;
- Studies to develop appropriate main system hydraulic operations models;
- A re-calculation of the economic analysis of the projects and sub-projects;
- A study of the incidence and causes of irrigation underutilization; and
- A study of the impact of resettlement on people moved from submerged areas.

III. Evaluation Summary of the Hill Areas Land/Water Development Project

Source: Dr. Michael F. Walter, Cornell University
Dr. Ralph J. Edwards, Development Alternatives Inc.

The Hill Areas Land and Water Development (HALWD) Project has had a major positive impact on irrigation development in the State of Himachal Pradesh and has considerable potential to resolve specific water and land use problems. Several critical actions are required to improve its technical quality and economic viability. The pace of scheme development should not increase and new schemes should be selected with greater emphasis on technical considerations and include watershed planning. Special training and research programs are needed in water management techniques appropriate to hill area conditions and requirements. Successful project implementation and management require the support of a substantial contract team of appropriate technical specialists.

A. Achievement and Impact:

Although implementation has been slow at the start there is clear evidence of significant impact and progress toward realization of the project's potential. The project has had a major impact on irrigation design in the state. Evaluation of scheme investments, scientific determination of water requirements, distribution system planning, working relationships with users, and establishment of irrigation as a profession are significant changes in the state which have been introduced by the project. The potential also exists for broader, high impact efforts in related watershed forestry and conservation interventions. However, there is little institutionalization of these changes due to very slow progress in technical training, socio-economic analysis, technology adaption and system research activities.

B. Economic Viability:

Although there are indications of high returns to irrigation in Himachal Pradesh, the internal rate of returns (IRR's) of many of the surface water high lift schemes appear questionable due to high capital and recurrent costs (particularly for the increasing numbers of high-lift pump systems). Furthermore, given the low charges for water and particularly high operating costs, the recurrent costs to the State of the project investments will become increasingly burdensome. Three steps may resolve the economic questions: (1) technical selection of more optimal, less difficult sites, (2) increased community/farmer control and responsibility, and (3) ex-post analysis of actual benefit streams.

C. Funding Requirements:

All projections indicate that the project is substantially over-funded given its timeframe and the size and experience of the implementing departments' cadre. Options for the remainder of the Project range from completing as pilots only those schemes already committed (approx. $20 million) to continuing with more schemes in an extended timeframe with concentration on watershed protection and the addition of the development of a major institution (approx. $45 million). The current commitment to the state and the obvious impacts and potential argue strongly for an option which strengthens and extends the project's activities. At the same time, the large number of schemes planned should be reduced and a necessary emphasis placed on the critical elements of training, analyses, applied research and feedback monitoring.

D. Implementation Capacities:

The substantial management demands of the project are due less to its apparent complexity than to the very limited staffing, technical and institutional resources in the state in relation to the project's size and objectives. Successful project implementation will require considerable assistance and support to the State's field staff, Project Cell and Universities from a multi-disciplinary team of both U.S. and Indian specialists experienced in hydrology, hydraulics, soil conservation, water resources engineering, monitoring/evaluation, in-service training, and rural organizations. Institutional development with these inputs is important. With this supplemental assistance the project can be managed by the current Irrigation Water Resources and Resource Management staffs.

In summary, the HALWD Project has had a major positive impact on irrigation development in the State and has considerable potential to resolve specific water and land use problems in the State. Several critical actions are required to improve its technical quality and economic viability. The pace of scheme development should not increase and new schemes should be selected based upon and including watershed planning. Special training and research programs are needed in water management techniques applicable to hilly area conditions and requirements. Successful Project implementation and management require the support of a substantial contract team of appropriate technical specialists.

ANNEX J

Evaluation Summary of the National Social Forestry Project

I. Purpose of Activities Evaluated

The overall objectives of the project are to: (a) increase the production of forestry products (fuelwood, small timber, poles and fodder) to help meet national and local deficits; (b) increase rural incomes, employment and equity, particularly opportunities for the poor and landless; and (c) reduce soil erosion and improve the environment. To meet these objectives in a sustainable way, the project was designed in collaboration with the World Bank to strengthen the capacity of public and private institutions in four States and the GOI to carry out a variety of tree production programs and develop viable methods for addressing natural resource shortages and degradation on both private and public lands.

II. Purpose of Evaluation and Methodology Used:

As scheduled in project documents, a mid term review of the project was conducted in order to: (a) evaluate the degree to which the project is meeting its objectives and (b) to identify needed mid-course changes. Since two of the states have carried out social forestry for over eight years and there is currently considerable debate on the subject as well as GOI and donor reappraisal of social forestry, an additional purpose was added to: (c) re-examine social forestry with the present context and chart future directions.

The methodology was based on a team planning process whereby specialists from different disciplines and institutions carried out rapid appraisal field visits to each state, held a variety of group meetings with villagers, field technicians, state officials and fellow team members. These visits were based on a review of background materials and documents prepared by each state, including the most recent monitoring and evaluation studies carried out, and individually designed observational and interview schedules. Considerable emphasis was placed on producing Action Plans for post-evaluation follow-up, each of which were discussed in detail with State and GOI officials, and agreed upon in a wrap-up meeting called by the GOI and attended by each State, the World Bank, and USAID.

The final report consists of three sets of documents: Part I contains the overall report, a summary action plan, and accompanying tables; Part II consists of detailed State Subproject Aide Memoires and Action Plans; and Part III contains the annexes on technical, institutional, and socio-economic issues, including women, NGOs, and an elaboration of the methodology used.

III. Findings and Conclusions:

A. Findings:

The project has reported significant progress in achieving physical planting targets. Approximately half a billion seedlings have been distributed for planting, representing 118% of the target set for the project as a whole. However, most project components have averaged 80% achievement, due in part to a 25% budgetary shortfall related to the continuing drought affecting most states. Monitoring reports show reasonable survival rates (50-60% for farm forestry and 60-70% for public forestry); however, few independent surveys have yet been conducted. Budgets for the remaining project years are expected to increase, allowing most physical targets (as revised by this review) to be achieved if the project is extended to the end of 1991.

Project objectives are being met to different extents by the various planting programs. Increases in the total production of wood products is most efficiently and spectacularly being accomplished by farmers planting trees on their own land. These include block plantations on both good and degraded lands, and, increasingly, agroforestry boundary plantations and intercropping models. Total production from farm forestry through the project alone could be approaching 10% of India's current commercial and industrial needs -- providing considerable potential relief to existing forests.

Rural incomes are being augmented both through private farm forestry and through the massive employment benefits of community and government wasteland planting. Employment benefits are entirely obtained by the poor through self-selection and increasingly smaller farmers are taking up tree farming, although around half of the participating farmers are either medium or large landowners. Equity objectives are also addressed through the collection of fuel and fodder from public land plantations and the targeting of special pilot programs such as tree tenure initiatives. On public lands, the amount of returns received by poor users is primarily a function of the type of plantation model used: most currently used models provide less than anticipated benefits. Implementation of the targeted pilot programs have proved to be more problematic than anticipated, resulting in a limited number of beneficiaries to date.

Although most of the planting programs provide some positive environmental benefits, this aspect of the project was neglected during project design and achievements are considerably less than they could be. In addition, over-reliance on traditional timber production models and methods without regard to site variations and the need for continuous ground cover sometimes produce negative or merely neutral results.

Important, if insufficient, incremental gains have been made in strengthening the technical and managerial capacity of the concerned Forest

Departments and private farmers to carry out social forestry planting programs. While training, monitoring and evaluation, and microplanning have demonstrated noteworthy progress, needed extension and research have lagged behind. The capacity for GOI support to the states through a Central Support Unit has been less than anticipated.

B. Conclusions:

The objectives and activities of social forestry need to be realigned to reflect the actual achievements and lessons learned in the last decade of social forestry projects in India. Naive expectations regarding farmer motivations and the strength of local panchayat institutions need to be laid to rest along with previous macro analyses of the supply and demand for forest products which overemphasized the fuelwood gap and failed to place social forestry within an overall land use and resource production context. A new strategy -- based on those elements of the NSFP which are succeeding -- is required which incorporates the objectives of production, incomes and equity, and environmental rehabilitation in a holistic perspective.

As set out in the report, such a strategy would allocate the responsibility for producing short rotation wood for the industrial and commercial requirements of the country largely to private farmers. This would allow the reserve forest estate to confine itself to long term wood production with limited local usage and increased environmental benefits. The subsistence requirements of poor rural residents could then be accommodated within the public wasteland plantation program on community, revenue, and degraded government forest lands by using technologies which would be environmentally sustainable.

Action plans for each State have been developed to implement this strategy in the remaining project period. These plans call for :

- Placing private farm forestry on a self-sustaining basis through continuing privatization of seedling production, removal of subsidies (particularly for larger farmers), removal of legislative constraints to tree harvesting and marketing, diversification of agroforestry technologies, and increase of agroforestry research, extension, and marketing support;

- introducing new technologies for public forestry on community and wasteland plantations which incorporate environmental and socio-economic concerns by using wider spacing, increased sowing of trees and shrubs for low cost continuous fuelwood supply, contour furrow planting and increased grass and legume production to provide fodder and increase soil and moisture conservation;

- focusing experimental programs such as tree tenure for the poor, community management and private wasteland planting into pilot projects which explore alternate land use arrangements, and reducing or eliminating experiments which show little promise;

- greatly expanding technical research and planning capabilities through contractual arrangements with State Agricultural Universities, increased training, workshops and technical assistance; and

- increasing women's involvement through increased recruitment of women forestry staff and greater coordination with Non-Government Organizations through GOI and State initiatives.

IV. Principal recommendations :

It is recommended that the Mission support the effective implementation of the strategic and operational changes identified by the evaluation and outlined in the State Action Plans through: (a) revising the logical framework; (b) issuance of a PIL containing the modifications in targets and unit costs; (c) providing additional technical assistance to support the increased emphasis on introducing new technologies, planning and monitoring, and involvement of women and NGOs; (d) collaborating with the NWDB (GOI) to strengthen central level support; (e) extending the PACD by six months to coincide with the IDA Credit and allow time for States to make up initial budgetary shortfalls; and (f) maintaining close monitoring of the GOI and states' progress in fulfilling the operational and policy recommendations contained in the Action Plans.

In accordance with the Mission's new CDSS, possible follow on activities should build on the existing collaborative relationships with the State Forest Departments, Agricultural Universities, Ministry of Forest and Environment of GOI, and the World Bank to identify programatic modes for sustained technical cooperation, software support, and policy dialogue.

V. Lessons Learned :

This evaluation has shown how it is important to identify how different project components need to be linked to the different objectives they serve. Counterproductive controversy and some confusion in the field has been generated by failing to clearly distinguish between those components primarily directed to production (i.e. farm forestry) from those directed towards poverty alleviation and environmental concerns (i.e. public forestry). By focusing on overall objectives as well as the project purpose, the evaluation was able to redefine the project's framework and more clearly chart a future strategy.

ANNEX K

Agricultural Research Project Evaluation Summary

I. Purpose of the Activity Evaluated

The purpose of the Agricultural Research Project (ARP) is to strengthen the capability of the Indian agricultural research system to conduct research on priority problems in certain key functional scientific areas.

The ARP was developed at a time when Indo-U.S. cooperation was being reestablished following a number of years of limited contact. It is one of three efforts which began in the 1980s under the Indo-U.S. Sub-Commission on Agriculture: joint research by senior Indian and U.S. scientists on biological nitrogen fixation and nitrogen fertilizer efficiency, now under the Presidential Science and Technology Initiative (STI); the USIF rupee-funded collaborative agricultural research program of USDA's Far East Regional Research Office (FERRO); and the AID-funded ARP, which focuses on training and the transfer of advanced technology to Indian agricultural research institutions and scientists.

The ARP umbrella project was designed to respond to the priority needs for research identified by the Subcommission. Individual sub-projects are developed within the selected areas and agreed upon by USAID/India and the Indian Council on Agricultural Research (ICAR), the Government of India (GOI) agency responsible for implementing this project. Fourteen subproject areas have been agreed. Ten of these are operational: soya bean processing; post harvest technology; project implementation unit; embryo transfer; biodegradable waste for animal feeds, intra-cellular blood protista; forestry training; plant genetic resources; agro forestry and agro-meteorology. Three have been designed but not yet approved, and one has not been designed.

II. Purpose of the Evaluation and Methodology Used

This is an interim evaluation, conducted at the end of the fourth year of a nine-year project (amended PACD). The review team was requested to: (a) assess the project's progress and impact to date; (b) determine what, if any, changes need to be made to improve project performance; and (c) identify important principles and procedures for the ARP operation that could lead to a long-range program for Indo-U.S. collaboration in agricultural research. The evaluation was carried out by a team composed of four U.S. scientists provided by Chemonics and two Indian scientists contracted directly by USAID/India.

The evaluation team reviewed project documentation in detail in the U.S. and India. In the U.S., site visits were made to three cooperating U.S. institutions providing staff training and consultation, where trainees and consultants were interviewed. Consultations in Washington were held with officials of AID, USDA, the State Department, Winrock International and others.

In India, the team accumulated and reviewed other documents, and made site visits to the ICAR as well as the centers conducting subproject research. Team members held discussions with senior GOI research administrators, project leaders, and midlevel investigators, many of whom have received U.S. training under ARP. Discussions of some depth were also held with staff of USAID/India, the Science Advisor's Office of the U.S. Embassy, USDA/FERRO, the World Bank and UNDP/FAO.

III. Findings and Conclusions

A. Conceptual: The fundamental proposition of the project is that concentrated support over a limited period of time can strengthen selected elements of the Indian agriculture research system. An "umbrella" design permitted subsequent selection and design of subprojects in areas identified by the Indo-U.S. Subcommission on Agriculture (the Subcommission). The Sub-Commission has provided an appropriate forum, to date, to determine issues of mutual interest in agricultural research.

The team concluded that the original project design and concept are sound, particularly to initiate reestablishment of cooperative agricultural science relationships after a ten year hiatus. The Project's purposes are appropriate and should be achievable to a large extent, provided that appropriate mid-course corrections are made.

Under the project, management teams involved in the design serve to promote the initiative and leadership for productive subproject implementation. The management team concept can be strengthened in two ways. First, the management team formed for subproject design should include three representatives of the subproject research centers and one from the coordinating committee. Second, the management team should have an oversight function in implementation. With these modifications, the team believes that the innovation and leadership functions envisioned in project design can be met.

Truly collaborative research has not been designed into the ARP subprojects, which are primarily engaged in transfer to Indian institutions of U.S. technology and research methods. Joint research is thus one step removed, pending this transfer. It is suggested that the Subcommission expand its focus from the selection of priority research topics, giving greater attention to existing cooperation and to mechanisms for planning truly collaborative projects. The team also notes that representation on the Subcommission currently emphasizes the federal research agencies and underrepresents the university research establishment.

At the present time there does not appear to be any clear relationship between the objectives of the ARP, STI and FERRO programs and the selection process for each is separate. However, a closer relationship among STI, FERRO and ARP activities, including joint/swap funding, would be desirable.

B. Organizational: The overall umbrella organization provides for flexibility, assured funding and a basis for design and implementation of subprojects. However, the approval and implementation procedures are complex and time consuming and involve an excessive number of GOI units. The Project Implementation Unit (PIU) is understaffed. If the PIU cannot be strengthened, an alternative might be to centralize, within ICAR, coordination and monitoring of all international research projects. As an interim measure the USAID Mission may wish to expand its contract with Winrock International to supplement the ICAR/PIU functions.

A study of the project by National Academy of Agricultural Research Management (NAARM) at ICAR's request correctly identified the organizational issues and problem areas in implementation, and did a real service in sequencing the steps involved. However, few positive steps have been taken to implement the NAARM recommendations. USAID and ICAR should give high priority to resolve the very serious operational issues raised by the NAARM study.

The flexibility of the umbrella design can obscure the need for hard analysis of subprojects. The team was unable to find in the subproject design documents a clear description of previous work carried out in the subject matter area. Neither was a clear baseline established for measurement of progress.

The Management Support Services (MSS) being provided by Winrock International are essential and must be continued. The MSS is the only place where information from both USAID and ICAR are documented on a regular basis. Even with a well-functioning PIU, a MSS is needed to service the project outside India. The team recommends that funding for the MSS for the LOP be assured. It also recommends that an annual Delivery Order (DO), based on subproject annual work plans, replace the multiple limited scope DOs.

C. Operational

(1) Selection. The selection process for subprojects can be improved by better preparation for the Subcommission's deliberations and by assuring full subproject analysis.

(2) Design. The Team strongly supports the recommendations made by NAARM and others to reduce the number of steps in the approval process. An operational chart (LOP work plan) should be prepared at the time of subproject approval, to be modified as necessary through the monitoring process. Subprojects should be designed by joint design teams in which Indian scientists are full and equal participants in the design process. The design should include a thorough review of previous research work carried out in the areas concerned in order to help establish an adequate project baseline and to identify the most appropriate project implementation centers.

(3) Appraisal. An independent appraisal is highly desirable, provided it be limited to a desk study by knowledgeable individuals within one month following design.

(4) Implementation and Monitoring. The major implementation problem is the ineffectiveness of the PIU. Lack of monitoring by the PIU allows problems and delays to accumulate. The time consuming procedures for procurement from the U.S. dollar fund are responsible for much of the delays. Some of the subprojects have encountered initial implementation difficulties; USAID and ICAR should meet to follow up on evaluation recommendations to improve the performance of the subprojects.

(5) Financial. Disbursements are expanding rapidly but remain considerably below projections, the result of (1) unrealistic projections, (2) the umbrella project design, with only two subprojects included in the original PP, and (3) delay in establishing both PIU and MSS.

D. Impact

There is no evidence of impact by the project on Indian agriculture to date, nor should it be expected. It is much too early and such impact is beyond project control. At this point, the team must concentrate on inputs and implementation, rather than impact.

Training programs appear to be both appropriate and successful. The transfer of technology appears to be just starting, in part because of lags in training and procurement, the completion of which was awaited before calling forward consultants. The team strongly recommends increased use of consultants, if necessary before equipment arrives in order to orient Indian investigators and help them prepare work plans.

IV. Principal Recommendations and Implications for the Future

The most important recommendations for a mid-project correction are:

- There should be discussion at a very early date between USAID/India staff and the Director General of ICAR to assure that ICAR takes the necessary action to bring the Project Implementation Unit (PIU) into more effective operation, as agreed at the time of project negotiation, or in accordance with an agreed upon alternative.

- USAID and ICAR should meet to agree on actions to improve the implementation of subprojects. This should include a review of the evaluation findings and recommendations about the subprojects as well as a review of pertinent recommendations of the NAARM study.

- There should be a joint USAID/ICAR review of the LOP financial needs of existing sub-projects and a corresponding reallocation of subproject budgets. USAID & ICAR should also decide what additional subprojects are to be included in the ARP for the remaining LOP.

- USAID and ICAR should agree on actions to improve the project design and appraisal process for future subprojects as per the evaluation recommendations. Of particular importance are the organization of joint design teams with full participation by Indian scientists and brief, independent appraisal of subproject proposals.

- USAID and ICAR should agree on steps to improve the monitoring and evaluation of subprojects, particularly the formulation of LOP and annual workplans for all existing and new subprojects.

- USAID should assure continued funding for the Management Support Services (MSS) for the LOP.

Recommendations and implications for the future include:

- Greater collaboration and interaction among the ARP, STI and FERRO programs would be beneficial and should be encouraged. Specifically, a U.S. dollar grant should be made to FERRO to support U.S. training for Indian scientists and to provide opportunities for more international exchange by U.S. and Indian scientists. At the same time USAID should attempt to attract additional rupee support for the ARP and other projects.

- The Indo-U.S. Sub-Commission on Agriculture should be encouraged to continue, but it should consider extending its function to give more attention to existing cooperative efforts and to plan how to develop truly collaborative projects. Representation on the Sub-Commission should also be broadened, to include more participation by the universities and others, to give agricultural research the attention that is required.

- The ARP has the potential to build a long term collaborative relationship if the effort is sustained.

- Prospects for post project sustainability are good, largely because subprojects are already included in ICAR Plans.

- A follow-up of the ARP, or a similar umbrella-type project, could well be a significant component of future strategy for Indo-U.S. collaboration in agricultural research, but not the exclusive approach. In certain fields, larger stand-alone projects are already evolving, which provide the basis for longer-term benefits and more truly collaborative research than was possible at the early stages of the ARP subprojects. The experience to date should help USAID and ARP to identify a limited list of topics with a sharper focus, to which they can provide sufficient resources to make a more lasting contribution and build scientist-to-scientist and institution-to-institution collaborative research.

- It is realistic to plan for long-range Indo-U.S. cooperative research programs in a few selected areas. However, this plan will require a financial commitment on both sides for a minimum of 10 to 15 years.

V. <u>Lessons Learned</u>

- Umbrella projects, which involve the design, review, and approval of multiple subprojects require more start up time than other kinds of projects.

- The flexibility of an umbrella design does not reduce the need for detailed subproject analysis.

- Simplification of design and implementation procedures and realistic projections would have improved the ARP reputation.

- For effective implementation of complex umbrella projects of this kind there is a need for efficient project coordination and support units in both USAID and GOI.

ANNEX L

Tropical Forestry and Biological Diversity in India: Continuing Crisis with Prospects for Progress

I. Introduction

By necessity this assessment takes the form of an overview. One of the points of emphasis is the dearth of detailed current data needed not only for a more thorough assessment, but also for program planning and implementation. This assessment draws heavily on two sources. One of these is an AID internship report prepared by Jeffrey Y. Campbell during the summer of 1987 expressly for this purpose. The other is the excellent Insight Guide on Indian Wildlife released by APA Productions in 1987. The list of contributors to the latter volume reads like a roster of important figures in contemporary Indian conservation. Notwithstanding the lack of detailed data, the problems facing India are painfully apparent. The same cannot, however, be said for solutions. Nevertheless, experience with recent programmatic efforts on the part of GOI (Government of India) and international donors provides some insight relative to potential effectiveness of different developmental strategies and opportunities for USAID inputs. In any case, degeneration of biodiversity is so intimately linked with tropical forestry through habitat destruction that it would be pointless to discuss either of the two topics in isolation. An integrated view of biodiversity and tropical forestry is, therefore, presented in this first level assessment. Toward this end, the first step will be to review briefly the biogeographical regions of the subcontinent.

II. Biogeographical Background

The Indian region is one of the world's 12 centers of genetic diversity, encompassing two biogeographical realms -- the Paleartic and the Indo-Malayan. With it's southern tip lying 8 degrees north of the equator and stretching northward over 30 degrees of latitude, India embraces an array of habitat types ranging from hot/dry and seasonally wet/saline deserts in Rajasthan and Gujarat to freezing alpine mountaintops in the Himalayas to tropical evergreen rain forests of Arunachal Pradesh and Assam to the swamp forests of the Sunderbans. This kaleidoscope of habitat types arises from the combination of geologic discontinuities with latitudinal and altitudinal gradients coupled with coastal influences and a monsoonal precipitation pattern. Geologic influences and landforms provide a point of beginning for understanding this biogeographic melange.

In considering the geology and landforms of India within which internal diversity is expressed through gradients of latitude and altitude interacting with meteorological phenomena, it is convenient to begin with the vast Deccan plateau, comprising much of peninsular India including the states of Tamil Nadu, Andra Pradesh, a large part of Karnataka, Madhya Pradesh, Orissa, and parts of Maharastra and Gujarat. The Deccan is characterized in general by hilly terrain formed of fractured basaltic rock that is resistant to weathering, but the thin soil formed thereon is easily erodable. Rainfall is variable on an annual basis over the interior of the region, averaging 35 to 55 inches in a seasonally concentrated monsoonal pattern giving rise to dry deciduous natural forests of teak (Tectona), mahogany (Swietenia), Indian rosewood (Dalbergia), Terminalia, Chikrassia, sandalwood (Santalum), Bauhinia, Lagerstroemia, Cassia, Butea, Acacia, Dillenia, Pterocarpus, Odina, Grewia, Buchanania, bamboo and others.

In extensive areas of the north central Deccan natural forest is sal (Shorea robusta). Scrub forests occur in the drier zones of the Deccan with Zizyphus, Acacia, Capparis, Balanites, Flacourtia, Prosopis, and other associates. Where adequate areas of sufficiently undisturbed habitat occur, the large mammal complement includes elephant (Elephas maximus), gaur (Bos gaurus), nilgai (Boselaphus tragocamelus), sambar (Cervus unicolor), chital (Axis axis), muntjac or barking deer (Muntiacus muntjak), mouse deer (Tragulus meminna), four-horned antelope (Tetracerus quadricornis), barasingha (Cervus duvauceli branderi), wild pig (Sus scrofa), sloth bear (Melursus ursinus), tiger (Panthera tigris), leopard (Panthera pardus), jungle cat (Felis chaus), leopard cat (Felis bengalensis), rusty spotted cat (Felis rubiginosa), small Indian civit (Viverricula indica), palm civit (Paradoxurus hermaphroditus), dhole (Cuon alpinus), jackal (Canis aureus), striped hyena (Hyaena hyaena), langurs and macaques. Listing of small mammals, avifauna, and reptiles will not even be attempted.

The Deccan plateau is flanked along the west and east by the coastal ranges (Ghats). Orographic effects produce moist zones along the coasts with rapid decrease of moisture inland due to rainshadow effects of the Ghats. The wet coastal ranges give rise to moist evergreen broadleaf forests comprised of diverse species with a well-developed vertical structure providing habitat for abundant avifauna. Typical woody components are rubber (Hevea), Ficus, Dyosyros, Cedrela, Dipterocarpus, Artocarpus, Santalum, Pterocarpus, Myristica, Calophyllum, Michelia, Ternstroemia, Mimusops, Hopea, and Stericula. Along with moist evergreen forests, the coastal plains support palms and various fruit trees. Swampy mangrove forests also occur along the coasts. Tropical moist deciduous forests are found in coastal Kerala and Malabar. Impressive coral reef formations are found around the offshore islands and along certain portions of the coast.

Although aridity is by no means confined to this sector, Gujarat and Rajasthan in the northwest are the primary desert states. Desert conditions here in the plains of the Indus basin are due to salinity as well as aridity. The Rann's of Kutch provide unique seasonally wet saline desert habitats that are critical breeding grounds for a variety of migratory birds such as flamingoes. Major portions of Rajasthan are occupied by the shifting dunes of the dry saline Thar desert. Woody growth in the arid plains is largely confined to Salvadora, Acacia, Albizzia, Caparis, Tamarix, Prosopis, and other thorny shrubs. Morus and Dalbergia sissoo occur where moisture is sufficient.

The Indian desert areas support an amazing variety of avifauna, reptiles, and mammals. Notable among the avifauna are the great Indian bustard (Chriotus nigricaps), peafowl (Pavo cristatus), sandgrouse, houbara, and quail along with migrants such as flamingoes and cranes. Representative mammals include gazelle or chinkara (Gazella gazella), blackbuck (Antelope cervicapra), nilgai, wild ass (Asinus hemionus khur), wolf (Canis lupus), jackal, and foxes. The desert inhabitants include 43 species of reptiles, mostly snakes and lizards. The Gir Forest National Park and Sanctuary in the Saurashtra peninsula of Gujarat contains the only surviving population of the Asiatic lion (Panthera leo persica).

The vast area of fertile alluvial soils in the basin of the gangetic system comprises the central and eastern portion of the north Indian plains, within which rainfall increases generally from west to east. Now largely devoted to agriculture and constituting the granery of the green revolution, the forests, grasslands, and floodplains of this region once provided primary habitat for elephant, tiger, and rhinoceros. The natural ecological character of the central gangetic plain encompassed monsoon forests and savannas ideal for large herbivores and correspondingly large predators such as the tiger and leopard. Remnants of the sal forests, savannah grasslands, and wetlands are still observable in national parks such as Keoladeo Ghana and Dudhwa.

The wildlife complement in such parks includes elephants, large cats and canids, wild boar, sloth bear, chital, sambar, blackbuck, nilgai, and even reintroduced one-horned rhinoceros. Keoladeo Ghana is particularly impressive for its wetland avifauna. The tidal swamp forests of the Ganga delta known as Sunderbans harbor more than thirty species of mangrove trees with corresponding richness of other marshland flora and associated fauna.

The Himalayas occupy the extreme northern portions of India, encompassing a mosaic of habitats arising from altitudinal temperature gradients and orographic effects as well as variations in geologic materials. The Himalayan spectrum of biotypes encompasses snowfields, tundra, coniferous forests, temperate evergreen forests, mixed forests and grasslands of the terai, and even virtual deserts. The Himalayas are a focus of international environmental concern both because they contain more endangered species of mammals than any other region of India and because of the instability of the geologic materials in the outer Himalaya and Siwalik ranges.

The rich flora of the Himalayas ranges from the stately deodar cedar and hardy chir pine to an array of species of colorful rhododendrons and orchids. The Himalayan region has more species of mountain sheep and goats than any other range in the world. It is home to such highly endangered species as the snow leopard (Panthera unica), Himalayan brown bear (Ursus arctos isabellinus), Sikkim stag (Cervus elephas wallichi), and Kashmir stag (Cervus elephas hangul). Other species such as the musk deer are also under heavy pressure from poachers.

In concluding this biogeographical brief it is appropriate to review the faunal biodiversity of the subcontinent. Over 50,000 species of insects are present. There are 4,000 species of molluscs, 6,500 species of other invertebrates, 2,000 species of fishes, 140 species of amphibians, 420 species of reptiles, 1,200 species of birds, and 340 species of mammals: totalling 65,000 in all. Some 253 species and sub-species of mammals, birds, reptiles, amphibians, and invertebrates are listed in Schedule I of the Wildlife (Protection) Act of 1972, meaning that they are highly endangered, and should be given total protection (Singh, 1986; Agarwal, 1985). These include large high profile animals like the tiger, leopard, rhinoceros, bears, Indian wolf, several deer species, crocodiles, turtles, and many others.

III. History and Policies

A relatively small population, lack of markets and transportation facilities, subsistence agricultural systems, and an indigenous religious reverence for non-human life forms ensured the preservation of large tracts of forests in India into the 19th century. With the establishment of the British Raj, railways, and industry and the reduction of health constraints to population growth and expansion of agriculture and animal husbandry, many of these tracts were increasingly destroyed. Large scale commercial exploitation for shipbuilding, railway sleepers, and export coupled with agricultural land clearing, overgrazing and fuelwood collection by the local population vastly increased the pace of natural resource degradation.

These destructive trends were further accelerated following Independence and the rapid industrial and population growth that took place in the transition to modern India. Areas which had been conserved as hunting preserves of the Maharajas and British colonialists were exploited for timber and pulp or encroached for land. Growing villages and nomadic herds of livestock intensified their foraging for fuel, fodder, and minor forest products. Tribals living in forest areas continued shifting cultivation, but found themselves in increasing competition for forests with the State and timber contractors. Large scale projects were initiated to convert natural forests into monoculture plantations by the State or under industrial leases.

Despite these destructive forces, India has always been in the forefront in establishing policies and institutions designed to conserve her natural resources. During the colonial period, one of the oldest forest departments in the world was legally consituted by the Indian Forest Act of 1865. Although responsible for much of the exploitation, the forest departments in Indian States have also been responsible for conserving those forests which are left today and introduced a number of policies providing usefruct rights to local people which still serve as a model for new social forestry programs.

This legacy of early legislation and practices continues to provide the basis for present policies. In fact, the National Forest Policy of 1952 is only now being presented to the parliament for revisions which have been the subject of considerable controversy between environmentalists and the forest department since the mid-1970s.

IV. Policies and Politics

Despite their economic aggressiveness, the British had a propensity for regularity. Consequently, India has one of the oldest forest departments in the world, legally constituted by the Indian Forest Act of 1865 during the colonial period. This legacy of early legislation and practices continues to layer present policies. In fact the National Forest Policy of 1952 is only now being presented to the parliament for revisions which have been the subject of considerable controversy between environmentalists and the forest department since the mid-1970s.

Critics lay much of the blame for India's current deforestation on the revenue oriented slant of the earlier document, claiming that the state forest departments overexploited standing forests either directly or through contractors, neglecting regeneration (Guha, 1987; Gadgil, 1983; Chattrapati Singh, 1986 and others). The earlier documents also maintained strict penal clauses to allow foresters to protect and 'police' state forests. This proprietary attitude is considered responsible for alienating local forest dwellers and adjacent farmers, leading them to 'plunder' their surrounding forests over which they no longer had community control (Guha, 1987; Singh, 1986). Forest department officials maintain that forest dwellers and local people have traditionally had extensive rights and privileges to forests and their products and that the forest department has in effect been the only real protector of these common property resources.

Growing concern is being expressed for the ecological role of forests in catchment areas and on degraded soils and for the need to preserve genetic and biological diversity in wild species of plants and animals. In response to widespread criticism the new forest policy under consideration by parliament intends to put a complete halt to clearfelling of natural forest for plantation work. No felling will be allowed in ecologically sensitive areas, in moist evergreen forests, and in areas of high genetic diversity. Further directives will have the intent of insuring that no areas of forest will be worked without a management plan, that all areas cut should be fully regenerated, and that areas of submarginal production should be improved. Under the revised policy, revenues in certain forest areas where villagers hold many customary rights and privileges to forest products will be shared with the villagers. The role of forests as part of the services sector will be emphasized over the more traditional role of revenue generation.

A. Forest Conservation Act, 1980

The second major piece of legislation currently under review by parliament is the Forest Conservation Act of 1980. This act restricts the use or transfer of forest department land for any purpose other than forestry in all states without approval of the central government. New revisions will make the Act even more specific by clarifying what constitutes uses other than forestry. It will, for instance, disqualify plantations of tea, coffee, or rubber on forest lands and will include a penal clause to ensure enforcement.

There are mixed feelings about the Forest Conservation Act in the development community. Environmentalists feel it puts further restrictions on possible people's participation in forestry by strictly limiting alternate legal arrangements for tree tenure on forest lands. In many instances where community lands are scarce, these degraded forest lands provide the only opportunity for community forestry and sustained benefit flow to the poor.

B. Five-Year Plans

The national planning process is enunciated in the form of Five-Year Plans. The current Seventh Five-Year Plan covers the years 1985-1990 and indicates the considerable leap in the importance given to the forestry sector over previous plans. With the broad objectives of forest conservation and development the Plan includes the following components:

i) conservation of ecologically fragile ecosystems and preservation of biological diversity in terms of fauna and flora;

ii) increasing substantially the vegetative cover by massive afforestation through social forestry, farm forestry, and other plantation programs;

iii) meeting the basic needs of the people in respect of fuelwood, fodder, minor forest products, and small timber;

iv) ensuring close linkages between forestry programs and welf re of the tribal and other communities traditionally dependent upon forests;

v) special emphasis on forestry research, education, training, and extension;

vi) creating a massive people's movement for achieving the above objectives (Planning Commission, 1985).

The Seventh Plan allocates Rs. 18 billion for forestry of which Rs. 13 billion is earmarked for reforestation in keeping with Prime Minister Rajiv Gandhi's call for the afforestation of 5 million hectares annually. This represents a threefold increase over the forestry budget of Rs. 6.9 billion in the last plan, bringing the percentage of total public sector expense set aside for forestry to 2% (Shivaramakrishnan, 1987). With the responsibility for reforestation currently included in the objectives of a number of other plans, such as the National Rural Employment Programme (NREP) which has earmarked 25% of its funds for the purpose, the grand total allocated for reforestation is as much as Rs. 25 billion.

Five-year plan policy takes several years to formulate with the result that changes can only come slowly, and need to be instigated well before the next plan period. Many forest officials feel that 'plan' targets for afforestation and/or expected revenue often supplant long range forest working plans and short term compliance to 'the plan' can detract from implementation of more sustainable management practices.

210

C. Institutional Framework

Both the Center and the State Governments share responsibilities for and control over forest lands. Previously under the Ministry of Agriculture, forestry now shares a separate ministry with the environment called Ministry of Environment and Forests (MOEF). Within the ministry a Department of Forests and Wildlife headed by an Inspector General of Forests (IGF) and assisted by several Deputy Inspector Generals (DIGFs) sets policy, coordinates activities with state forest departments and other central ministries or departments, and oversees national forest research, education, and training. With the creation of the National Wastelands Development Board (NWDB) and the extension of afforestation responsibility to a number of other agencies and departments, the monopoly of the state forest departments over forestry activities has been diminished considerably. Table 1 shows some of the institutions at the national and state levels involved in forestry activities.

For nearly 80 years the Forest Research Institute and Colleges in Dehra Dun have dominated India's forestry research and training. For most of that period it was the only major institution involved in forestry education in the whole of South Asia. It is one of the oldest institutes of its kind in the world. Almost every forester in India was trained at Dehra Dun or one of FRI's regional colleges, and the sprawling campus at the foothills of the Himalayas was the main center for scientific forestry research. In recent years, however, the institution has come under attack. Critics question whether the traditional courses of instruction, relatively unchanged since colonial times, and the industrial/commerical orientation of the research remain relevant to the changing world of forestry in India today. With the massive increase in all forestry activities called for in the Seventh Plan, the grip of the FRI/C is being broken and the structure of forest research and training institutions is in the process of rapid change. Some states have started their own Forest Rangers Colleges and research institutes, a notable example being the Kerala Forest Research Institute in Peechi. Four new institutes of specialization have emerged in the last few years, with one of these being the Wildlife Institute of India. State Agricultural Universities (SAUs) are assuming a major role relative to agroforestry and plantation forestry.

D. National Wildlife Policy

India's constitution, as adopted in 1950, specifically mentions the need for protecting the natural environment and promoting ecological security in Articles 48 and 51. Until 1972, however, there was no legal framework to insure this protection other than the Indian Forest Act and Forest Policy. With the enactment of the Wildlife (Protection) Act in 1972 legal protection was proclaimed for wildlife in national parks and sanctuaries. In 1976 both forests and protection of wild animals and birds were transferred from the State List to the Concurrent List which helped insure that the previous act was effective in all states. The Forest Act of 1980 discussed previously gave further protection to natural habitats in forested areas. There is currently an effort underway to revise the Wildlife Act to increase its scope and the likelihood of enforcement, with greater central government support.

E. Policy Versus Political Practicality

Promulgation of policy, preparation of plans, and passing of legislation are prerequisite to progress, but do not necessarily imply implementation in the Indian context. India has a long tradition of official privilege and political patronage that introduces inertial resistance to implementation of land reforms, especially if those reforms run counter to the short-term economic interests of bureaucratic officials or the constituents of powerful politicians. Private encroachment on public lands is so widespread that many of the parcels targetted for afforestation are unavailable in practice.

Efforts at eviction of encroachers bring appeals to local politicians, who in turn are often successful in seeking special exemption that may even transfer the land in question permanently to those encroaching. The complex budget process often results in ostensibly available funds not being utilized as projected because all funds must first be officially allocated before they can actually be used. Likewise, corruption constitutes a drain on the energy of the system at many levels. It should therefore not be surprising that policy and practice may stand in stark contrast.

V. Forest and Fodder Famine

Rapidly increasing human and livestock populations and drastically diminished forest and grazing lands have combined to produce acute shortages in fuelwood, industrial wood, and fodder all over India. If present trends continue, the population of the country is expected to top one billion people by the year 2000. Remote sensing data indicates that there has been a loss of 9 million ha of tree cover between 1972-1975 and 1980-82; the equivalent of 1.3 million ha per year. Since 1982 the annual loss of forest cover has increased to 1.5 million ha. Only 36 million ha, or roughly 14% of India's total area, is considered to support adequately stocked forest.

In this context, adequately stocked forest is liberally defined to have more than 30% canopy cover. This represents only a little more than half of India's legal forest area. Figures for the total legal area differ according to the source. Old forest department records show 75.3 million ha; whereas more recent (post 1984) publications of the FRI/C, the NWDB, and the World Bank agree on 67 million ha. Part of the discrepancy may be explained by the loss of 4.3 million ha (150,000 ha/year) of forest land to various types of encroachment since 1950. Table 1 provides a overview of forest land.

Table 1: Composition of forest land in India.

Legal forest area	74.9 million ha
Adequately stocked forest	36.0 million ha
Open forest*	28.2 million ha
Mangroves	0.4 million ha
Desert/snow-capped mountains	10.3 million ha

* NWDB shows this as scrub forest of 10 million ha and forest without tree cover of 'nearly 30 million ha.'

Source: Ministry of Environments & Forests, 1987.

204

Only 3 million ha of land outside of the forest departments holdings are covered with tree crops and orchards. Although 1.7 million ha have been planted in 1986-1987 under the various social forestry programs, most of this planting is too young or on areas too small to be picked up by remote sensing devices of the type used for analysis.

Statistics on fuelwood requirements represent a vast gray area because of the extremely wide range of products burned as fuel in the country, which vary in accordance with many site-specific factors. A survey of all-India fuelwood use in 1979 (Natarajan, 1985) indicated that 45% of fuels came from state forests, 45% from farmers' own fields, and 8% were collected from roadsides. Table 2 shows the breakdown according to source and to the type of fuel.

Table 2. All-India Fuel Use by Source, 1979 (thousand Mts)

Source	Logs	(%)	Small	(%)	Total	% of total
Own farm	5,440	21	19,624	78	25,064	36
Forest	4,827	19	19,490	81	24,317	35
Roadside	1,333	8	14,858	92	16,191	23
Other	297	9	3,134	91	3,431	6

Source: Natarajan, 1985.

World Bank estimates place total present consumption of forest-based products at about 230 million cubic meters, of which it is admitted that 130 million cubic meters come from bushes and small material other than trunks of trees. Set against this requirement is the estimate that the total sustained yield increment of standing forests is only 35 million cubic meters. Assuming that the 130 million cubic meters not from trunks must be supplied from sources other than those reflected in the annual increment and leaving aside industrial demands, there would still be a 65 million cubic meter shortfall in fuelwood alone.

Forest Department statistics from 1984 estimate 1985 fuelwood demands to be as high as 202 cubic meters (with industrial demand totals between 30-35 million cubic meters) which indicate a much more substantial shortage. Data on total consumption suggest that overcutting of existing forests and plantations is as high as 300%. By the year 2000, total consumption of forest products is expected to reach 290-300 million cubic meters of which 230 million cubic meters will be for fuelwood alone.

Since a substantial portion of fodder for livestock comes from forest land including considerable tree fodder, the problems of forest and fodder in India are inseparable. India has 15% of the world's livestock population on only 2% of the world's land. NWDB estimated the total livestock population at 414 million with a breakdown as shown in Table 3.

Table 3. India's Livestock in 1982

Animal	Number (millions)	Increase from 1977
Cattle	190	6 %
Buffaloes	69	11 %
Sheep	48	17 %
Goats	94	25 %
Camels, horses, & other	13	
Total	414	

Source: NWDB & World Bank, 1982.

There are no reliable statistics on fodder production in India because the majority of the livestock graze freely on community and public lands. NWDB estimates that fodder demands may be 700 million tons as against a supposed supply of 540 million tons. NDRI (the National Dairy Research Institute) estimated the fodder needed to satisfactorily feed all livestock in 1985 as shown in Table 4.

Table 4: Fodder Requirements (million Mts)

Fodder type	Optimum requirement	Availability	Deficit
Straws	168	142	-26
Green fodder	290	32	-258
Grazing (green grass)	288	283	-5
Total	746	457	-289

The extent of fodder deficits gives an indication of the low economic productivity of livestock in India. A point of great importance is that most of this fodder must come from dry and/or rapidly degrading lands.

VI. Water and Wastelands

Despite the fact that forests, fodder, wildlife, and biodiversity are the calling cards of environmental programs both internationally and inside India,the natural resources most in need of conservation are soil and water. The real disasters of deforestation in India's monsoonal climate and extensive area of sloping terrain are accelerated erosion and disruption of hydrologic cycles. Water in India makes the difference between abundant production and spectre of famine. As irrigation waters become available brown landscapes turn to verdant green.

Exposure of soil surfaces to intense monsoonal rainfall as a result of deforestation and overgrazing is causing rapid erosion of soil and decreased reservoir capacity that India's agriculturally based economy can ill afford. Concern for soil conservation is expressed primarily as attempts to control gully erosion through earthwork, but the far more serious sheet erosion often goes virtually unnoticed as evidenced by the fact that farmers continue to plow their furrows in the downslope direction and foresters feel satisfied that soil stabilization has occurred as soon as tree seedlings are planted.

The companion problems to soil erosion are drought and flood. Reduced porosity of the exposed surface coupled with rapid runoff from bare slopes carry the intense rainfall of the monsoons quickly into the valleys, causing flood damage to farmlands and villages, then on to the sea from which it cannot be retrieved for use in the long dry season that follows the inherently variable monsoon period. India's approach to the water problem has been one of brute force engineering on a massive scale.

Inattention to stabilization of catchment areas is causing irreversible loss of reservoir potential on an order of magnitude more rapid than the rate projected by engineers. The simplistic attitude of relatively uneducated farmers that 'if some is good, then more is better' has led to waterlogging and salinization of some of the most fertile farmland. Even the awakening

206

public perception of a link between forests and water takes a misguided form. There is a growing false public opinion that vegetation controls the pattern of the monsoon itself. This leads to the defeatist feeling that the community can do little to control its own destiny relative to water.

Instead of going about improving the water capture capacity of local watersheds through low cost vegetative methods, there is instead a hue and cry that the government should come to their aid. In an attempt to alleviate water shortages and increase agricultural production quickly, the government subsidizes distribution of small pumps for drawing irrigation water from shallow wells. This, in turn, lowers the near surface water table still further, thus causing dug wells to go dry and depriving villagers of water for human and livestock consumption. The whole unfortunate scenario raises the prospect of a near future tragedy of major proportions.

VII. Progress in Protection

India's indigenous environmental advocates such as the Bombay Natural History Society, bolstered by the weight of world opinion, have achieved a major reorientation of public opinion and governmental action toward support of national parks and sanctuaries. The tiger is the symbol of conservation efforts in India, and Project Tiger has provided the major impetus in this direction.

To make up for shortcomings in earlier legislation, the National Wildlife Action Plan was formulated and adopted in 1983 by the Indian Board for Wildlife (IBW) which is the central policy-making organ for wildlife and habitat conservation in the country. The Action Plan has the following major elements:

- Establishment of a representative network of protected areas.
- Management of protected areas and habitat restoration.
- Wildlife protection in multiple use areas.
- Rehabilitation of endangered and threatened species.
- Captive breeding programs.
- Wildlife education and interpretation.
- Research and monitoring.
- Domestic legislation and international conventions.
- National conservation strategy.
- Collaboration with voluntary bodies and non-governmental organizations (Singh, 1986).

The immediate result of this new momentun was an increase in the number of protected areas. In the period between 1980-1984, the number of national parks increased from 19 to 53 while wildlife sanctuaries rose from just over 100 to 247. Now the total area protected by this system is approximately 9 million ha, or roughly 3% of India's total land area.

The creation of these national parks and sanctuaries has in many instances, however, been somewhat haphazard without attention to covering representative habitats and areas of high genetic diversity. Instead, attention tended to focus on the conservation of high profile mammal species like the tiger. In order to rectify this, India is presently investigating the establishment of Man and Biosphere Reserves based on systematic selection of natural ecosystems. Each biosphere reserve is intended to include one or more of the following:

a) representative examples of natural biomes;
b) unique communities or areas of unusual natural features;
c) examples of harmonious landscapes resulting from traditional patterns of land use;
d) examples of modified or degraded ecosystems capable of being restored to more natural conditions (Singh, 1986).

Table 5 shows the 12 sites that have been identified as potential biosphere reserves by the Man And Biosphere committee. The central government is to assume full responsibility for the costs of establishing these biosphere reserves while individual state governments will be charged with managing them. Here a major problem emerges, particularly for the Nilgiri reserve which spans three states. The complexities of shared administrative and bureaucratic responsibilities are holding up the establishment of this reserve which will protect crucial wet tropical rainforests in the Western Ghats. It is not clear when the Man And Biosphere reserves are intended to begin functioning officially.

Table 5. Potential Man And Biosphere Reserves and Locations.

Biosphere reserve	State
1. Nilgiri	Tamil Nadu, Karnataka, Kerala
2. Namdapha	Arunachal Pradesh
3. Nanda Devi	Uttar Pradesh
4. Uttarakhand (Valley of Flowers)	Uttar Pradesh
5. North Islands of Andamands	Andamans & Nicobar
6. Gulf of Mannar	Tamil Nadu
7. Kaziranga	Assam
8. Sunderbans	West Bengal
9. Thar Desert	Rajasthan
10. Manas	Assam
11. Kanha	Madhya Pradesh
12. Nokrek (Tura range)	Meghalaya

Source: Singh, 1986.

The optimistic tone relative to parks, sanctuaries, and reserves should not, however, lead to the impression that these efforts are proceeding without problems. In some areas where complete protection is sought, tensions between the forest department and local inhabitants have been particularly violent. On several occasions the police have had to resort to firing on crowds of local livestock owners demanding grazing rights within protected areas. Even within national parks/sanctuaries, human populations may number into the tens of thousands (A. Kothan et al., 1987). While many of these inhabitants have encroached illegally into park areas, the majority are tribals whose traditional rights to these forest areas have been long established.

Merely declaring an area protected without carefully balancing the need of local forest residents can lead to disasterous results. Increasing incidents of man-eating by tigers, crop damage by pigs and deer, and uncertainty over rights to grazing and collection of forest produce are all alienating villagers and forest dwellers from the conservation effort. Some social scientists and 'progressive' critics have opposed these programs as an escalation of the traditional policing attitudes of the government. The concept of preserving a forest for the tiger when millions of surrounding villagers are directly dependent on it's resources is perceived as elistist, pandering to the international community and camera toting tourists.

Only 62 of the declared national parks and sanctuaries have their own special management staff, and many of these workers do not have adequate or appropriate training in habitat or wildlife management. The Wildlife Institute of India offers two kinds of courses for foresters working in protected areas. One is a 10-month course for forest officers above the rank of Rangers, while the other is a 3-month orientation for junior foresters. At present neither course is required. The decision whether to send forest officers is left entirely to the individual state forest departments. The WII also sponsors research in wildlife ecology and management, though the majority of their researchers seem to be focusing strictly on biological topics.

VIII. Biological Banks

About 45,000 species of plants are said to occur in the country, of which 30,000 are nonvascular plants like algae and fungi. More than 60% of the 15,000 species of vascular plants are endemic to the region. These only represent discovered plants. Recent surveys in the 9,000 ha Silent Valley in the wet tropical evergreen forests of Kerala uncovered 9 new species and a new genus of vascular plants (CSE, 1985). A preliminary inventory by the Botanical Survey of India (BSI) has produced a list of 135 threatened species and sub-species of rare and endangered plants. Many more are likely to fall within this category when extensive surveys now underway are completed. India has over 1,250 species of orchids alone, of which 300 are found in the single state of Meghalaya. Many of these are becoming scarce and 20 species are now extremely rare.

Wild varieties of domesticated crop plants still flourish in India's forests and thousands of cultivars of field crops grow in farmers' fields where the single strains of the green revolution have not penetrated. India is recognized as an important center for the collection and preservation of rice varieties. One variety, Oryza nivara collected in Uttar Pradesh in 1963, was responsible for introducing a resistance to the gray stunt virus which destroyed more than 116,000 ha of rice in Southeast Asia in the early 1970s. Other varieties with salt tolerance have been introduced around the world. India is also a center of diversity for vegetables. A wild melon variety from India saved the melon crop in California by providing resistance to a form of mildew. Some of the important vegetables whose genetic diversity center is in India are shown in the following table.

Table 6: Vegetables having India as Their Genetic Center

egg plant	wax gourd	cucumber	watermelon
loofah	melon	bitter gourd	pigeon pea
hyacinth bean	mung bean	yardlong bean	kangkang
okra	roselle	crumstick tree	amaranth

Source: CSE, 1985 taken from International Bureau of Plant Genetic Resources, Rome.

In addition to the above, India has a rich genetic wealth of bamboo, fruit trees, sugarcane, jute, and spices like pepper, cardamom, ginger, and turmeric. There are well over 150 economically important plants scattered throughout the country, many of which are very important medicinally.

India's forests represent a storehouse of tree species with multiple uses. Specific trees whose economic value has suddenly increased are particularly endangered, especially in arid and semi-arid tracts where vegetation was already sparse. Kadad (Garuga pinnata) used for pulp and packing cases, tanch (Ougeinia oojeinensis) used for agricultural implements, and haldu (Adina cordifolia) used for making bobbins and furniture are all becoming scarce in certain parts of western India.

The FRI/C lists about 20 species of trees in danger of extinction or serious depletion as well as several bamboo species (CSE, 1985). A very important function of India's national parks, sanctuaries, and other protected areas is that of perserving the floral complex that provides habitat for the resident fauna. In this role, such protected areas serve as biological banks containing potential raw material for biotechnology.

The need to preserve plant genetic resources has led to the creation of the National Bureau of Plant Genetic Resources (NBPGR) and has spurred a number of Indian and international research institutions in the country to develop large gene banks of economically important species. Major gene banks in India include the following:

a) Rice (Oryza sativa) at the Indian Agricultural Research Institute in New Delhi and the Central Rice Research Institute in Cuttack;

b) Sorghum (Sorghum bicolor) at the International Crops Research Institute for Semi-Arid Tropics (ICRISAT) in Hyderabad;

c) Peal Millet (Pennisetum typhoides) at ICRISAT and the All India Coordinated Millet Improvement Programme (AICMIP) in Pune;

d) Foxtail Millet (Setaria italica) at AICMIP and ICRISAT;

e) Finger Millet (Eleusine coracana) at AICMIP and ICRISAT;

f) Kodo Millet (Paspalum scrobiculatum) at AICMIP;

g) Cassava (Manihot) at the Central Tuber Crops Research Institute in Kerala;

h) Mungbean (Phaseolus aureus) at Punjab Agricultural University in Ludhiana and the Indian Agricultural Research Institute in New Delhi;

i) Chickpea (Cicer arietinum) at ICRISAT;

j) Pigeonpea (Cajanus cajan) at ICRISAT;

k) Groundnut or peanut (Arachis hypogaea) at ICRISAT;

l) Winged Bean (Psophocarpus tetragonolobus) at the National Bureau of Plant Genetic Resources in New Delhi (Source: CSE, 1985).

IX. Productive Private Plantations

In order to help alleviate the wood shortage and promote income generation, GOI in cooperation with international donors has launched a massive tree planting program under the name of 'Social Forestry.' This term reflects the focus on farm forestry and plantations in populated areas where forest products will become available in places of high demand. Initially a number of states began to add a social forestry component to their programs with the emphasis on distributing seedlings to farmers, planting roadside, railside, and canalside plantations, and beginning some community woodlot plantations with village Panchayat (i.e., ruling council) cooperation. As fuelwood statistics and estimates of demand became public along with remote sensing data on forest cover, the government tripled spending in the forestry sector, and social forestry in particular, in the Sixth Five-Year Plan of 1980. Forestry spending was then dramatically raised in the Seventh Five-Year Plan to ten times the level for the Sixth Plan.

This led to the creation of the Ministry of Environment and Forests (MOEF) to separate forestry from the agriculture ministry, and the National Wastelands Development Board (NWDB) to supervise and coordinate the ambitious national afforestation campaign. Nearly all states and union territories now have a large social forestry component in their overall forestry programs. Because of the input of central and donor derived funds, in fact, afforestation under social forestry has begun to dominate the forestry program in many states. Staffing problems in the state forestry departments are arising as a consequence of being the implementing agency for a wide range of social forestry activities such as establishing nursersies, planting community woodlots, reclaiming desert and degraded revenue department land, planting roadsides, and providing technical assistance.

While social forestry programs differ widely from state to state, there are several fundamental components which most of them share. These include:

a) Farm forestry -- the distribution of seedlings to private farmers for planting on their own lands as block plantations, shelterbelts, or in an agroforestry combination;

b) Decentralized nurseries -- the establishment of small private or communally run nurseries to supply seedlings for the other components of the program;

c) Community woodlot plantations -- fuelwood and fodder plantations on community land or on government revenue land which are intended to supply sustained alternate sources for these products;

d) Tree pattas -- leasing arrangements which allocate tree tenure to local communities, either on revenue lands or strip plantations;

e) Roadside, railside, and canalside strip plantations -- to be established by the concerned department for the benefit of local communities;

f) Reclamation of degraded areas -- this includes afforestation and planting of forage grasses on degraded forest and public lands, stabilizing sand dunes, and protecting watersheds or eroding catchments.

In addition, efforts are being made to encourage the formation of village level cooperatives to manage and share the produce from local forest sources, particularly in the case of tribal adivasis and other forest dwellers who depend directly on the sale and collection of minor forest products (MFP). Private industries are also being encouraged to make efforts to meet their own demands, either by leasing government revenue lands or organizing farmers and village communities to grow the products they require.

The private components of social forestry programs (i.e., farm forestry and decentralized nurseries) have proven to be a resounding success relative to their primary goals of wood production and income generation. Seedling distributions to farmers have far exceeded expectations. A drive through farmlands in Punjab, Harayana, western Uttar Pradesh, and parts of Karnataka reveals a landscape transformed in the last few years by the presence of trees in windbreaks, block plantations of fast growing species, trees on field margins, newly planted orchards, multipurpose trees intercropped in fields, and rows of trees along roadsides and canals. Proliferation of small sawmills and pole/fuelwood depots attests to the impact on the agricultural economy. In those areas where such private plantations have matured, prices of wood products are even beginning to decline as reflection of price elasticity under increasing supply. Thus consumers benefit as well as producers.

As with the progress in protection, however, the optimistic tone does not imply an absence of problems. The distribution system for raw materials from farm forestry has often not kept pace with production. Therefore, the farmers may find themselves at harvest time without ready access to the major urban markets. An ecological concern surrounds the proliferation of monoculture plantations, particularly those of Eucalyptus. Fortunately, the declining prices for Eucalyptus are gradually motivating farmers toward species diversification in new plantations.

The public components of social forestry have proven much more problematic, and have largely failed to achieve their goals of providing forest products needed for local use and thereby relieving pressure on outlying forests. Much of this failure is due to inappropriate types of plantations, and can be rectified by better planning and research on silvipastoral plantation models. By farmers' choice, farm forestry mostly provides alternative cash crops rather than fuelwood and fodder for local use. The latter continue to be procured from surrounding public lands. Unfortunately, plantations on public land have differed little from those on private lands, being directed toward the production of roundwood at the end of a fixed rotation.

The only real intermediate product for local use has been handcut grass for the first few years of the rotation prior to crown closure. Perversely, then, the villagers are driven to bypass these protected plantations and go even farther afield to exploit forests. As discussed in the next section, the real need is for a very different kind silvipastoral plantation that produces a continuous flow of fodder, fuelwood, and minor forest produce while maintaining a relatively intact ground cover for soil stabilization and moisture retention.

X. Fodder, Fuel, and Forests in Successional Series

As noted in the foregoing section, the orientation of farm forestry is essentially economic. In contrast, fuel and fodder have traditionally been largely non-economic entities in rural India that are obtained by foraging on public lands. However, the public lands have not been managed in any systematic manner for fodder and fuel production. As a result, vast expanses of public lands are in a highly degraded and essentially unproductive state with exposed soil undergoing rapid erosion and whole regions experiencing aridification. Social forestry has provided an opportunity for introducing effective public land management, but the timber oriented plantations established on such lands have been inappropriate for generating these products of local need.

A point to be noted as preface to the following is that fuel as used by rural villagers is mostly stick and twig size material, thus making shrubs as appropriate as trees or perhaps even more so. In this context, the successional stage of vegetation has a direct bearing on its utility for different human purposes. Early successional stages are most productive of fodder. Middle successional stages (shrub/brush) are more productive of small diameter fuels. Later successional stages dominated by forest trees produce little fodder and fuel procurement mostly requires climbing or felling trees.

Closed canopy high forests produce primarily bolewood and limbwood in conjunction with felling operations. Furthermore, tall trees are not particularly effective at controlling sheet erosion, especially when intense rainfall follows a long deciduous dry season. Litter layers which could be of help in this regard are seldom allowed to accumulate in rural India. Leaf and twig litter is either swept up for local use or removed by burning, whether intentional or unintentional. From a human perspective, then, conventional closely spaced plantations of fast growing forest trees are one of the least appropriate forms of vegetative cover on public lands in India.

In order to be effective in reducing village abuse of the land, social forestry operations on non-private lands must be conducted with the objective of maintaining an intermediate successional stage containing a mixture of herbaceous and shrub species. The new approach will require strategic planning and a very different vegetative model from that of traditional forestry. It will be necessary to do an initial map-based analysis of habitation, land ownership, and land use in each locality considered for such operations.

The purpose of this analysis will be to identify paths of movement used by villagers for exploitation of forest lands and the location of developable parcels along these routes or close to the villages. Demarcated forests, revenue land (not encroached), panchayat lands, and rights-of-way are candidates for development. Demarcated forest lands are perhaps the most appropriate by virtue of legal jurisdiction already residing with the forestry department. Roadsides are advantageous by virtue of lying along paths of movement.

Proceeding with development should be contingent on identifying enough land available for development that an appreciable amount of local needs can be provided thereon. Where there is not enough land available to achieve this minimal level of effect, social forestry operations should be limited to provision of rural roadside hacking strips as outlined below. Beyond this, developmental costs would be better allocated to other localities where an appreciable impact is possible.

Where developable blocks of land are available, they should have low growing indigenous coppicing shrubs (preferably fruit bearing) planted in contour strips with widely spaced trees chosen for fodder value planted between the shrub strips. The tree density should be planned with a degree of openness that will permit growth of grass and herbaceous fodder species as a ground cover between the shrub strips. Total protection should be given to the area only long enough for establishment of grass/herbaceous cover. Thereafter, handcutting of grasses should be permitted but protection otherwise continued until the shrubs are well established and trees grow above browse level.

At this stage, the area should be turned over for community management by rotating coppice of the shrubs for fuelwood and similar regularized pollarding of trees for fodder. Pollarding should be sufficiently heavy to prevent crown closure of the degree that would suppress understory growth. The one practice that must be avoided is that of uprooting plants. There should be no roundwood rotation as such. Trees can be salvaged when mortality occurs. At such time as the overstory may become overly sparse, portions of the area can be closed to livestock for replanting of trees. Such replanting should not involve destruction of other cover components. Understory components should not require replanting, and hand harvesting can continue while the trees are becoming established. Areas with badly abused ground cover should likewise be closed periodically to livestock in a rotational grazing pattern. Forage management entirely by handcutting and stall feeding should be encouraged wherever possible.

Although the result will not be particularly aesthetic, plantings along rural rights-of-way should take the form of densely planted very hardy coppicing shrub species on which hacking by headloaders is not only permitted after initial establishment but even encouraged. The strategy here is to provide readily available, if not the most desirable, sources of fuelwood. Observational evidence indicates that the villagers will hack supposedly nonpreferred species such as Ipomea in preference to walking additional kilometers for other materials. In this case, the expedient approach is to forget about systematic management and take advantage of existing patterns of exploitation to avoid the need for continuing attention. If the strip becomes so badly abused as to be unproductive, it can be fenced temporarily for re-establishment.

XI. A Setting for Science and Technology

USAID has played an active and influential role relative to forestry, land management, and biodiversity in India. Much of this support to date has taken the form of direct cofinancing of field work. USAID has supported past forestry projects in Madhya Pradesh and Maharastra, and is presently combining forces with the World Bank in supporting the multi-state National Social Forestry Project. Likewise, USAID has been instrumental in numerous irrigation development projects. However, India has now largely taken control of its own destiny for conducting development operations, and other donors overshadow USAID in terms of finance.

USAID already has several programs directed toward scientific and technological support of biodiversity and sustainable resource development underway or in the planning stages. Programs originating from the Asia and Near East Bureau include collaborative research agreements between the US Fish & Wildlife Service, the National Park Service, and some universities in the US with MOEF and WII in India to improve the capabilities of the latter. The Fish and Wildlife Service with Syracuse University of New York are involved with a program to develop environmental education through the MOEF and the Centre for Environment Education, an Indian NGO. The US Embassy Office of the Counselor for Scientific and Technological Affairs is also administering some wildlife oriented programs. The Indo-US Scientific Collaboration in Environment and Ecology provides $1.5 million for collaborative environmental research and ecological research on preservation and management of endangered habitat and species. The same office is also in the process of finalizing a $5.4 million project to develop the institutional capacity of WII.

The Plant Genetic Resources Project (PGR) addresses the goal of achieving the preservation of India's rich and diverse genetic resources, particularly for use in sustaining advances in agriculture through biotechnology. The project will concentrate on building within India a greatly strengthened system for collecting, preserving, and using indigenous and exotic plant genetic resources. It will foster the maturity of the National Bureau of Plant Genetic Resources (NBPGR) which will provide well maintained collections of germplasm that can be drawn upon by scientists for future research work.

The NBPGR will provide key resources for building sustainable agricultural systems which can also increase agricultural efficiency and production. If India is to keep pace with its growing population, it is essential for its research system to develop this potential to the maximum extent. Project implementation will be to assist India's efforts to develop fully the physical, administrative, technical, and financial resources of NBPGR so that it and the institutions it supports can manage professionally a national germplasm system which fully sustains all aspects of exploration, preservation, and exchange (nationally and internationally, public and private) of plant germplasm.

The Agroforestry Subproject of the Agricultural Research Project will also focus on germplasm and biotechnology. As part of the germplasm program, regional centers are expected to perform lead functions in a nationally coordinated agroforestry germplasm collection and screening program. A workshop is slated to produce a detailed design for the program. As a minimum, this will include:

a) major and most promising species by region;

b) directions for collecting, depositing, verifying, preserving, multiplying, and distributing seed and vegetative propagules;

c) identification of special collection and collaboration needs;

d) identification of priorities for research in propagation, nursery operations, seeding, and planting; and

e) development of species selection systems.

Also as part of this subproject, scientists working in agroforestry are receiving special training at selected US universities. This training will be considerably expanded under the proposed U/FRED project.

Development of irrigation systems has received more attention in India than their management and sustainability. The catchment area above a dam site is an integral part of an irrigation project, and should be accorded equal attention with the storage and distribution components. The size and nature of the catchment determine water yield to be available for irrigation. Land cover, soils, and other characteristics of the catchments determine the rapidity of runoff, the degree of soil erosion, and the resulting sediment load to be absorbed by the reservoir.

The AD/Soil Conservation section has developed a number of engineering and biological treatments to control soil erosion in catchment areas. These include contour bunding, nalla plugs or check dams, and planting of grasses, shrubs, and tree crops. Under the Maharastra Minor Irrigation Project the AD/SC in cooperation with the Forestry Department will design and implement an appropriate treatment program for the catchments of up to two existing and three new minor irrigation schemes which are included in the pilot program. These should provide models for widespread replication throughout the extensive irrigated lands of India.

216

In virtually all phases of its development, a lack of current information on terrain characteristics, land use, vegetative cover, infrastructure, etc. hinders the planning and implementation efforts. Although national level surveys typically run afoul of bureaucratic entanglements and concerns for intelligence or political implications, local and regional surveys could be accomplished by adaptation and application of the remote sensing and geographic informations systems (GIS) that have attained a high level of sophistication in the United States. It should be recognized, however, that Indian conditions are not supportive of acquisition and maintenance of the specialized computer hardware associated with such systems in the United States and other advanced technology countries.

USAID has an opportunity to mediate the transfer of GIS technology in forms appropriate for operation on generic microcomputers, and to support India's movement in the field of remote sensing. Likewise, other statistical and analytical technologies have similar potential for helping to insure that development is done in a cost/effective and sustainable manner.

India makes a promising partner for cooperative science in many regards. Indian conditions provide extremes of the ecological spectrum not found in the United States which offer opportunities to test the extensibility of the model based research that characterizes modern American science. Indian scientists are typically well versed in theory, but often lack access to sophisticated facilities. Cooperative research provides an opportunity to obtain such access. It is of utmost importance, however, that US scientists contemplating such cooperation should familiarize themselves with the machinations of the bureaucratic interface between the two countries. Failure to do so will result both in attempts to transfer technology inappropriately and in supreme frustration and delusionment on the part of US associates.

In like manner, the Indian efforts at maintaining a semblance of natural conditions in parks, sanctuaries, and reserves could undoubtedly benefit from assistance by foreign donors. However, uninformed attempts at assistance often amount to unwelcome intervention and may even provide ammunition to pressure groups opposing the protection work. Background work on assessment of the situation by indigenous entities having international linkages must set the stage for assistance. An obvious course of action is for USAID to commission such background work through third-party contract arrangements.

ANNEX M

INDO-U.S. SUBCOMMISSION ON AGRICULTURE

I. Mandate

The Subcommission's mandate is to develop and coordinate government programs in agriculture between India and the United States. At present the subcommission encompasses AID research development and assistance programs; Special Foreign Currency research projects; U.S.-India Fund projects; and scientific exchange programs developed by USDA and other agencies. University scientists also participate in these activities. Trade issues have not been a part of the Subcommission's agenda, and private organizations have not participated in the Subcommission sessions.

II. Background

The Indo-U.S. Subcommission on Agriculture was established in April 1979, by the India-United States Joint Commission on Economic, Commercial, Scientific, Technological, Educational and Cultural Cooperation. It is one of four Subcommissions -- the others being Science and Technology, Economic and Commercial, and Educational and Cultural -- which implement bilateral programs in specific areas. The Subcommissions are major official channels for bilateral programs between the United States and India.

III. Meetings

The Agricultural Subcommission first met on New Delhi in September 23 - 25, 1980. The major substantive areas of concern for each of the four Working Groups and the scope of the Subcommission were identified at this first session. The second meeting was held in Washington, D.C. at USDA on June 3 - 9, 1982; the third in New Delhi on January 24 - 30, 1984; the fourth meeting was held in Washington, D.C., September 23 - 27, 1985; and the fifth meeting was held in New Delhi, December 7 - 11, 1987.

IV. Scope of the Subcommission

The Subcommission operates as a Government-to-Government body, administrative in function, providing a forum for discussion of cooperative activities. Meeting every 18 months approximately, the Subcommission sanctions broad priority areas identified by the four Working Groups -- Research and Education, Natural Resource Management, Inputs and Allied Technology, and Extension and Training.

The Subcommission outlines guidelines for joint activities, resolves problems, approves priorities agreed to at joint Working Group meetings, endorses previously identified priorities, and explores new areas for future collaboration. Its deliberations, however, do not necessarily imply commitment; it cannot make judgements for implementing agencies, nor does it have any funds at its disposal. Obligations are made only after established

U8

review and approval processes have been completed by the respective Governments. The scope and limits of the Subcommission are outlined in the Scope Paper (Attachment 1) agreed to at the Subcommission's First Meeting in 1980.

V. Working Groups

The four Working Groups provide a second forum to define in greater detail priority areas. They bring together a wide array of technical specialists from each side for substantive discussions. Agreements may be reached on research, training and other priority areas, and on procedural guidelines for their implementation. As with the Subcommission, they do not necessarily have authority to approve projects and programs outside of established U.S. Government and Government of India channels.

VI. Funding

USAID/New Delhi authorized the $20 million Agriculture Research Project in 1983 in part to respond to priority research areas identified by the Indo-U.S. Subcommission on Agriculture. The project currently is supporting research activities identified by the Subcommission. The Department of State and GOI signed the agreement in January 1987, establishing the U.S. - India Fund (Endowment) using the rest of the PL-480 U.S.-owned rupees ($110 million). In 1986 and 1987, USDA received approximately $2 million in rupees. This amount is expected to increase in each of the next few years until a peak of approximately $4 to 5 million/year is reached in about 4 years. There is also a possibility that USAID/New Delhi and USDA will cooperate in supporting certain research projects in the near future.

VII. Political Relationship

The Subcommission on Agriculture is a useful mechanism and an important channel for cooperation between two major powers. The Subcommission's mandate is in a field both critical and non-controversial. Agricultural cooperation is endorsed by both President Ronald Reagan and Prime Minister Rajiv Gandhi. The Subcommission has strong support in the State Department and in the U.S. Embassy in New Delhi. Its activities were last endorsed by its parent body in the 6th session of the India-United States Joint Commission held in Washington on February 6, 1986, under the Co-Chairmanship of Mr. George Shultz, Secretary of State, and Mr. Bali Ram Bhagat, Minister of External Affairs.

VIII. Past Progress and Recommendations for Future Activities

The Working Groups on Research and Education and on Natural Resources Management of the Fifth and most recent Indo-U.S. Subcommission on Agriculture made the observations concerning past progress and recommendations for future activities which are summarized in Attachment 2.

Attachment 1
to Annex M

Scope of U.S. Indo Subcommission, Working Groups, and Executive Secretaries

I. Subcommission

A. Purposes:

1. Enhance Indo-American relations.
2. Promote cooperation through development and the sharing of technology.
3. Encourage cooperative research and scientific exchange programs.

B. Scope of Responsibility:

1. Government-to-Government body, administrative in function, and providing a forum for discussion in agriculture.
2. Identify priority areas for cooperation in agriculture, to include research, training, assistance programs, and scientific exchanges.
3. Assess work accomplished since the previous Subcommission meeting.
4. Resolve administrative and procedural problems.
5. Approve annual meetings in alternate sites in the United States and India.
6. Explore new areas and means for expanding agricultural cooperation.
7. Make recommendations and develop guidelines for joint project activities. Details of implementation and funding to be worked out between participating U.S. and Indian agencies.
8. Utilize existing mechanisms for funding agricultural activities and explore new opportunities for funding.

II. Working Groups

A. Purpose: To define specific priorities and work out concrete activities for collaboration in accordance with guidelines set out by the Subcommission.

B. Scope of Responsibility:

1. Working Groups headed by co-chairmen from each side to provide continuity for specific and on-going Subcommission activities.
2. Co-chairmen or their designees serve as official members of the Subcommission.
3. At individual Working Group option, a Secretary will be designated to coordinate each Working Group's activities.

4. Meet as agreed in alternate sites concurrently with the Subcommission. They may also meet between sessions of the Subcommission as necessary to assure smooth operations of cooperative venture.

220

III. Executive Secretaries

A. Purpose: To coordinate all activities between sessions of the Subcommission.

B. Scope of Responsibility:

1. Serve as focal point for implementation of activities under the Subcommission.
2. Prepare for all meetings of the Subcommission and assist with preparations for Working Group meetings.
3. Maintain official correspondence on Subcommission activities.
4. Responsible for administrative functions of the Subcommission and assist with administration of Working Group functions.

Attachment 2
To Annex M

REPORT OF THE RESEARCH AND EDUCATION WORKING GROUP

I. New Thrust Areas:

The Working Group emphasized the necessity of strengthening collaborative research areas for enhancement of productivity in dryland agriculture and water resources management, identified for cooperation in the recent meeting of the Indian Prime Minister and the U.S. President. The Group identified the priority areas for new as well as continued scientific cooperation. These are:

A. Agricultural Research

1. Dryland Agriculture

   (a) Characterization of Dryland Soils
   (b) Agro-meteorology
   (c) Integrated Soil and Water Conservation Practices
   (d) Germplasm Screening Development and Evaluation
   (e) Cropping Systems
   (f) Integrated Nutrient Management
   (g) Dryland Mechanization
   (h) Integrated Pest Management
   (i) Economics

2. Water Management in the Command Areas

3. Ground Water Exploration & Management

4. Improvement of Oilseeds and By-Products for Yield, Quality and Safety

5. Improvement of Horticultural Crops for Multiple Resistance to Biotic and Abiotic Factors

6. Animal Disease Diagnosis and Control

7. Conservation of Animal and Fish Genetic Resources

8. Aquaculture:

   (a) Fish and Shellfish Genetics and Breeding
   (b) Fish and Shellfish Diseases and Parasites
   (c) Post-harvest Technology
   (d) Dynamics of Impounded Aquatic Ecosystems

9. Integrated Pest Management

10. Plant Genetic Resources

11. Plastics in Agriculture

222

B. Agricultural Education

Collaboration in Agricultural Education between Indian and U.S. Institutions.

II. Statement of Progress

Considerable progress has been made in implementing work in high priority areas identified in previous meetings of the Sub-Commission on Agriculture. The following eight sub-projects under the umbrella of the Indo-US Agricultural Research Project are under implementation:

- Soybean Processing and Utilization
- Post-Harvest Technology of Fruits & Vegetables
- Project Implementation Unit
- Faculty Training in Forestry
- Studies on Embryo Transfer Technology and Bio-Engineering in Livestock Species and their Patho-biological Implication
- Conversion of Biodegradable Farm and Animal Wastes for Livestock Feed
- Agro-Meteorology Research

The following sub-project is in the final stage of sanction:

- Agro-Forestry Research

The details of the following four sub-projects are being worked out and it is expected that these would become operational in the near future:

- Integrated Nutrient Supply and Management in Multiple Cropping Systems
- On-Farm Water Management
- Preservation of Plant Genetic Resources
- Farm Equipment Manufacturing Technology

The scope of work for the following sub-project has been identified for the guidance of a Design Team:

- Tissue Culture for Crop Improvement and Micropropagation

It was satisfying to note the progress of five on-going Science and Technology Initiative (STI) areas in the fields of Biological Nitrogen Fixation and Nitrogen Fertilizer Efficiency. In addition, eighty on-going projects under PL-480/USIF are coming up very well. The Working Group endorses the continuation of work in these areas.

III. Specifics of Future Research:

The Co-Chairpersons, in consultation with members of the working group, identified the following areas for collaboration:

- Dryland Agriculture
- Groundwater Exploration and Management
- Improvement of Oilseeds and By-Products for Yield, Quality and Safety
- Improvement of Horticultural Crops for Multiple Resistance to Biotic and Abiotic Factors
- Animal Disease Diagnosis and Control
- Conservation of Animal and Fish Genetic Resources
- Aquaculture
- Collaboration in Agricultural Education between Indian and U.S. Institutions
- Integrated Pest Management
- Plant Genetic Resources
- Plastics in Agriculture

The minutes and specific priority research topics in each of the above outlined areas appear in Appendix I and the list of participants in Appendix II.

IV. Report of the Natural Resources Management Working Group

A. Background

Mr. G.S. Jakhade, Member (Water Planning), Central Water Commission, Ministry of Water Resources, Government of India, and Dr. J.M. Safley, Assistant Director, Ecological Sciences Division, Soil Conservation Service, U.S., were the Co-Chairs of the Working Group.

At the outset, Mr. Jakhade gave a brief introduction of programmes taken up so far under this Working Group. While suggesting that the gains

224

made so far are important, he highlighted that in the light of recent discussions between the Prime Minister of India and the President of the United States, there should be additional emphasis on enhancement of productivity in arid zone agriculture, water management and evaluation of ground water resources.

Mr. Jakhade further pointed out that in view of recurring drought in the country, schemes for drought management are needed. Further, for creating jobs in the sector, poultry development is also important, particularly for landless labour. Then he presented new areas of thrust that have been identified for collaboration. They are:

1. Water Resources Development & Management
2. Evaluation of Ground Water Resources
3. Catchment Treatment
4. Conservation Farming
5. Grassland Management and Development
6. Land Reclamation
7. Poultry Development

The first two programmes are primarily for water resources development and management for optimal utilization of the important input vis water in crop production. The next four relate to resource conservation and bio-mass production. Poultry development has been included for seeking better marketing, quality improvement in feed and broiler and overall genetic improvement.

Dr. Safley pointed out that conjunctive use of water is practised in dryland farming in the U.S. He indicated that restoration of degraded land resources in the U.S. is actively pursued in relation to strip mines and overgrazed lands, as well as wind and water-eroded areas. He pointed out that highly erodible land is being taken out of cultivation and inducements to that effect are being provided to farmers.

He also felt that suitable plant materials can be identified for effective erosion control. The importance of conservation tillage technology and modifications thereof were also highlighted. He also felt that trainers from the U.S. could be sent to India for specific training programmes.

This was followed by presentations from individual technical specialists who elaborated on the points already presented by Mr. Jakhade.

Mr. D.C. Das stated that catchment treatment, both for control of reservoir siltation as well as moderating plans, started in the late 1950s. The programme was organized on a priority watershed basis in 1974-75. Out of 1150 watersheds, work in 320 watersheds has been completed.

Watershed degradation continues to affect land productivity in two ways: by eroding soil and nutrients from the catchment areas; and by siltation and damage to land productivity through flooding. An evaluation showed the project to be effective. However, the project now needs improved planning and design norms to make the programnme more cost-effective, both for investment decisions and to promote greater awareness and participation by the people.

Dr. J. Venkateswarlu presented three themes on resouces conservation and managment leading to improved bio-mass projection:

- Conservation farming is a practice in America used for increasing productivity in drylands while conserving soil and water. This practice needs to be adapted to suit the Indian conditions.

- For grassland management and development, the quality improvement in pastures, combined with top feed provided by tree components, requires attention. Further, water harvesting to provide drinking water for animals in arid areas (as practised in Arizona) needs to be adapted to the arid regions of India.

- To improve the productivity of degraded lands, efforts are being made in the country and the experiences from the U.S. would be helpful in restoration or reclamation of such lands.

Mr. S.S. Iyer narrated the progress on projects under the Indo-US Sub-Commission. He also gave details of new projects formulated in this sector. The necessity of continuing the programme in the field of water management and providing required funds for taking up such work were emphasized.

Dr. D.K. Dutt narrated the present position of underground water development and the future programmes. Seven areas were identified for cooperation in the field of ground water development.

Dr. B.S. Rao identified the need for improved marketing facilities, increased awareness of broiler quality, and feed quality. The need for improved genetic resources in the development of the egg and poultry industry in India was also discussed. He felt the experience of the U.S. in this sector would be helpful to Indian farmers.

Co-Chairman Safley and his group from the U.S. felt that the programmes developed for consideration in the Working Group are of importance. They suggested that these programmes be prioritized and projectized for further consideration. They also felt that training should be given in the appropriate country as need dictates. In areas where specific technology is needed, U.S. trainers could be sent to India to assist in developing courses and training programmes in existing institutions. Indian experts would also receive training in specific subjects available in institutions and universities in the U.S.

Mr. H.S. Daulay pointed out that arid land ecosystems continue to degrade because of ever-increasing human and livestock population growth. Technologies for the rehabilitation of this fragile land are available. They

226

include dryland farming for optimal bio-mass production, identification of plant types of economic importance, use of models for climatological forecasts, resource inventory, and management of grassland afforestation in arid areas. Technologies are also available in the use of limited water and/or brackish ground water for growing crops. Exchange of notes through a seminar on such issues with the U.S. would be useful for development of arid zone agriculture.

Further discussions regarding prioritization and format of the working group report were held.

B. Areas of Priority Consideration:

Within the overall framework of priority areas (created by the Working Group at the 4th Subcommission meeting) there are several important issues which the 5th session group feels are important.

The thrust for new areas is basically guided by the Joint Communique issued by the Prime Minister of India and the President of the United States of America. They are: efficient water management; ground water management; and improved rainfed farming in arid and semi-arid areas. There are many interdependent resource issues which must be addressed in the spirit of collaboration. As a means to carry out collaboration in these areas, the Working Group set forth the following vehicles for consideration:

1. Water Management Studies:

These studies would continue to build on studies underway by placing specific emphasis on the testing and evaluation of:

a. Remote sensing technologies
b. Methods to improve quality and quantity of surface water
c. The role of drainage in the agricultural systems
d. Methodologies to improve water retention in the soil (such as conservation tillage, mulches, soil amendments and/or crop management)
e. Conjunctive water use
f. Irrigation system methodologies (such as drip irrigation) more suited for drought conditions
g. Methods in a total system to more effectively manage the effects of drought.

2. Ground Water Utilization Studies

These studies would continue to build on and supplement the survey currently underway. These studies, using model watersheds and other areas, would serve to test and develop:

a. Mathematical models of quality, quantity, and use of the resource

221

b. Means to improve recharge of aquifers
c. Use of remote sensing and other techniques to evaluate status of the resource and timing of use
d. New uses for ground waters such as use of brackish water for fishery development, etc.

3. <u>Model Watershed Project</u>:

Catchments of less that 10000HA would serve as outdoor laboratories to test and evaluate the specific resource concerns enumerated by the Sub-Commission on Agriculture. These catchments would serve to help develop and promote:

a. Water management practices (especially in rainfed areas)
b. Conservation systems
c. New plant introductions
d. Data gathering, monitoring and evaluation processes such as mathematical models
e. Geographic information systems
f. Ground water utilization
g. Subsistence and livelihood issues
h. Reforestation and agroforestry
i. Animal husbandry and fisheries development
j. Development of grazing resources and their utilization for livestock production
k. Interagency policy and implementation procedure coordination

4. <u>Workshop on Aquaculture in Dryland Agriculture</u>:

The Working Group believes that additional follow-through is needed to the report of the USDA Aquaculture Team. It is proposed that a workshop be planned and convened to address the role of fishery development in a dryland setting on a micro-planning scale.

5. <u>Resource Management System Workshops</u>:

The Working Group observed that more collaboration is needed in the areas of plant species exchange and in plant and plant-animal management systems. Examples of these systems include those used in reforestation, agroforestry, and in general agricultural systems.

The Group proposes that exchange of material and data in these areas be carried out and that one or more workshops be developed and conducted to address establishment and management of these systems.

Workshops would be developed by specialists from both sides and specific to the broad resource and planning concerns of the Indian government.

6. Watershed Planning Workshops:

The Working Group proposes the development of a series of workshops to present process and procedure training to resource planners at both the meso and micro-planning levels.

7. Issues Referred to Other Groups:

Resource management concerns related to poultry systems were referred to the working group for Extension and Training for their evaluation and support.

ANNEX N

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230

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232

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