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Harvard Institute for International Development
One Eliot Street
Cambridge, Massachusetts 02138

NATURAL RESOURCE MANAGEMENT:

STRATEGIES FOR SUSTAINABLE ASIAN AGRICULTURE IN THE 1990S

Theodore Panayotou

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CONTENTS

The Past 20 Years: Sources of Growth 5

Land Expansion 5

Multiple Cropping 7

Increase in Yields: New Varieties, Irrigation and Agrochemicals 8

Changing Resource Environment and Emerging Problems 11

Land-Related Issues 15

Watershed Degradation and Soil Erosion 20

Irrigation-related Issues 24

Loss of Genetic Resources and Biological Diversity 28

Excessive Pesticide Use 33

Soil and Fertilizer Related Issues 36

Asian Agriculture in the 1990s: Critical Choices for Natural Resources 38

Natural Resource Management: How Much Will It Cost? 41

The Need for Policy Reform 43

The Role of USAID 45

ABSTRACT

During the past two decades the performance of Asian agriculture has been remarkable. Agricultural production in Asia grew at an average of 3.6% per year compared to only 2.2% in Latin America and 1.5% in Africa. The sources of this growth have been the opening of new land area for cultivation, multiple cropping, the expansion of the irrigated area and the adoption of biological and chemical technologies.

These "easy" sources of growth are no longer available. The land frontier is all but exhausted. The most suitable irrigation sites have already been taken up; further expansion of irrigation systems faces a steeply rising curve. High-yielding varieties have already been widely adopted (with some exceptions); where they are not, this is mostly due to resource constraints and environmental problems. Few technological breakthroughs are expected in the next few years, and given the adoption lag they can not become a major source of growth during the 1990s. Heavier use of pesticides is probably counterproductive and environmentally imprudent.

The major issues facing Asian agriculture in the 1990s in relation to natural resources are: 1) How to sustain the rapid agricultural growth of the past two decades in the phase of demand shifts arising from past successes, and supply constraints arising from resource scarcities and the environmental side-effects of past growth? 2) How to minimize the impact of agriculture growth in the 1990s on future growth and on environmental quality? These two issues boil down to one: What could and should be the sources of agricultural growth in the 1990s?

The opportunities for the future are to be found in the failures of the past: insecurity of land tenure, degradation of watersheds, mismanagement of irrigation systems, excessive use of pesticides, inefficient use of fertilizers, and inadequate soil conservation. While these past failures have created problems and constraints for Asian agriculture, if remedied can become the sources of growth in the 1990s. Increasing security of land tenure can release powerful forces for land improvement, soil conservation, investments in tree crops and diversification, all sources of productivity growth.

Rehabilitation of watersheds can reduce soil erosion and flooding that damages or renders unproductive millions of hectares of prime agricultural land as well as slow down the sedimentation and consequent loss of capacity of hundreds of major dams in Asia. Increased cost recovery, maintenance and management of irrigation will reduce loss and waste of water, improve application efficiency, increase water control and reliability of supply and expand the irrigable area.

Efforts to conserve genetic resources and reduce the current losses in biological diversity combined with agricultural research and extension can be a major source of sustainable agricultural growth for the late 1990s and beyond.

Reduction in pesticide use and widespread adoption of

integrated pest management (IPM) also hold great potential as sources of growth for the 1990s. IPM is not only more effetive in controlling pests over the long-run, it is also less costly for the farmer, and the government, less damaging to the environment and more suited to Asia's relative factor endowment. Finally, practice of more soil conservation, increased use of organic fertilizers and more efficient and effective application of chemical fertilizers will contribute to both more sustainable agricultural production and reduction in off-site pollution.

A long-term policy reform program that is both necessary and sufficient to ensure the sustainability of agricultural development in the 1990s without increasing the level of government intervention would include: 1) elimination or at least reduction of policy distortions (such as pesticide subsidies) that favor environmentally unsound practices while, at the same time, they discriminate against the poor, reduce economic efficiency and waste budgetary resources; and 2) correction or at least mitigation of market failures (such as downstream environmental effects, insecurity of land ownership, and unpriced irrigation water) that result in overexploitation of resources, through a system of institutions, incentives, regulations, and fiscal measures.

NATURAL RESOURCE MANAGEMENT: STRATEGIES FOR SUSTAINABLE ASIAN AGRICULTURE IN THE 1990s

Theodore Panayotou

During the past two decades the performance of Asian agriculture has been remarkable. Agricultural production in Asia grew at an average of 3.6% per year compared to only 2.2% in Latin America and 1.5% in Africa. India, Indonesia and the Philippines, three large food deficit countries, all attained self-sufficiency in their main staples, while Thailand and Malaysia have increased their agricultural exports significantly. Burma, Sri Lanka, Pakistan and Bangladesh all have had high rates of food and cereal production growth. The rapid growth of the agricultural sector, especially in Southeast Asia has helped sustained high rates of overall economic growth by providing food and raw materials, savings for capital formation, domestic markets and foreign exchange to the non-agricultural sectors.

To sustain the rates of economic growth and structural change that are necessary for long-term economic development, Asian agriculture must continue to grow in the 1990s at least as rapidly as it has in the 1970s and 1980s. However, for agricultural growth itself to be sustainable it must accommodate the new circumstances of changed market conditions and more stringent resource constraints. In the past, governments have invested heavily in the attainment of, self-sufficiency in cereals and increased exports of traditional agricultural commodities. The attainment of self-sufficiency and the emergence of surpluses call for diversification of

agriculture but agricultural systems are inflexible because of past investments. Can diversification proceed fast enough to sustain the high agricultural growth rates of the past decade?

The sources of past agricultural growth have been the opening of new land area for cultivation, the expansion of the irrigated area and the adoption of biological and chemical technologies. The land frontier is now all but exhausted and the expansion of irrigable area can only be obtained at significantly higher costs because the best sites for irrigation systems have already been used up. Major technological breakthroughs are not yet in sight and serious environmental constraints are emerging partly because of the pace and pattern of past agricultural growth. Can sufficient new sources of growth be found to sustain high rates of agricultural development throughout the 1990s without further damage to the resource base and the environment? Environmental deterioration does not only threaten the sustainability of agricultural sector; it may also undermine the growth of other sectors, as well as lower the quality of life, the ultimate objective of development.

The purpose of this paper is to try to answer these questions by (a) analyzing the sources of past growth, (b) identifying emerging resource and environmental constraints ; and (c) investigating alternative sources of growth for the 1990s. The emphasis is on critical issues affecting the sustainability of Asian agriculture and the strategic choices that are available for dealing with them.

The Past 20 years : Sources of Growth

The major sources of agricultural output growth in Asia during the past two decades have been land opening, yield increase and multiple cropping. According to FAO (1979) about 25% of the increase in crop production in the developing countries of Asia between 1961-76 can be attributed to the expansion of the cultivated area and 75% to yield increase and multiple cropping.

Land Expansion

The relative scarcity of agricultural land, the prevalence of small-scale farm and the high density of rural population are distinguishing features of Asian agriculture. The average agricultural land per capita is less than one-fifth of a hectare and the rural population density is twice as high as in Latin America.

Land expansion in South Asia during the past two decades has been minimal, about 4%, compared to 21% increase in the agricultural labor force. In Southeast Asia, the agricultural area expanded faster than population growth, 25% vs 21%, but if Thailand, is excluded the reverse is true. With the exception of Thailand which accounts for over 50% of the opening of new land in Southeast Asia, the average land holding declined throughout the developing Asia.

In Thailand, the arable land almost doubled during 1960-80 through encroachment of public forests and clearing of new land for cultivation of mainly upland crops such as cassava and corn. This land was found to be very productive in the first few years following the slush-and-burn of the forest but its productivity declined sharply in later years as the original nutrients were used up or leached by erosion. Most of this newly opened up land is held without a formal title in a climate of uncertainty that discourages investments in land improvements and soil conservation. While Thailand is an extreme case, similar forest encroachment in search of arable land has taken place in many other parts of Asia, including the Philippines, Indonesia, Burma and Nepal. In Indonesia there have been both government resettlement programs and spontaneous migration to the outer islands in search of arable land.

The scope for further increasing the area of land under cultivation through land clearing during the 1990s is minimal throughout Asia, with the possible exception of Indonesia's Outer Islands and Sabah and Sarawak. Not only is the land frontier almost exhausted, even in countries such as Thailand, Sri Lanka, Burma, Nepal and the Philippines, but agriculture is already suffering from the consequence of past uncontrolled expansion into critical watersheds and fragile lands. Any remaining forest areas are either in watersheds or on marginal lands unsuitable for agriculture. Even in Indonesia and East Malaysia the remaining land is more suitable for the cultivation of tree crops, livestock and agroforestry than cereals. According to FAO only 10% of the output growth projected for the years 1980-2000 can come from land expansion, and most of this has already taken

place during the 1980s. This means that the burden of agricultural growth in the 1990s has to fall on more intensive and efficient use of existing land through multiple cropping and increase in yields.

Multiple cropping

Multiple cropping is the product of the last 25 years and is most prevalent in land-scarce Asia. The growing of more than one crop a year on the same land was made possible by irrigation investments that made available water during the dry season and by technological advancements that developed high yielding, early maturing varieties as well as by efficient planting and harvesting equipment. Cropping intensity is measured by the multiple cropping index (MCI) which is the ratio harvested to the planted area multiplied by 100. By this measure, and based on the limited information available, East Asia has the highest cropping intensity (MCI between 150-200) followed by Southeast Asia around 150. India and Pakistan have the lowest cropping intensities, under 120, while Nepal and Bangladesh have MCIs comparable to those of East Asia. According to Warr (1980:16) Indonesia's rapid growth of rice production in the last decade largely came from the second and third crops that were made possible by the adoption of early maturing, disease-resistant varieties and the development of irrigation.

Obviously, there is considerable scope for increasing cropping intensity in the 1990s especially in countries such as Thailand, Pakistan, India, Sri Lanka and the Philippines. However, the extent to which this

potential would be realized depends on irrigation efficiency, land development, pest management and technological advancements in non-cereal crops. Areas prone to severe flooding and droughts are not likely to be put under multiple cropping unless either water control and availability are improved or flood and draught-resistant varieties are developed. Moreover, multiple cropping often requires on-farm investments that are not likely to be undertaken without secure title to the land and access to credit.

Increase in Yields: New Varieties, Irrigation and Agrochemicals

Yield increases have been the single most important source of agricultural growth during the past decade. Between 1966 and 1981 rice yields have increased by almost 50% in Southeast Asia and about 30% in South Asia. By 1980 rice yields in Southeast Asia were 16% higher than those in South Asia. Indonesia, Philippines, Burma and Pakistan have experienced the highest yield increases (over 50%) and Thailand the lowest (8%) while in Nepal yields fell by 3%. The stagnation of yields in Thailand is understandable because of the tremendous land expansion. According to Barker, Herdt and Rose (1985) only 14% of the Thai agricultural growth in the seventies is attributable to yield increases. For the region as a whole yield increases have contributed almost three quarters of the gains in rice production, and a lower but rising proportion in other cereals such as wheat and maize. (Currently rice accounts for over 50%, wheat for 20% and maize for 10% of the total area planted to cereals).

The rapid increase in agricultural yields was made possible by a

combination of irrigation investments and biological and chemical innovations. Between the mid-1960s and the early 1980s, 22 million ha of irrigated area were added bringing the proportion of arable land under irrigation from 20% in the mid-1960s to about 30% in the mid 1980's. Irrigation has not only made dry season cultivation possible; it has also made possible the adoption of biological and chemical innovations introduced in the mid-1960s. New high yielding varieties of rice, wheat and maize were successively introduced and rapidly adopted by farmers throughout Asia with the notable exception of Thailand. By the early 1980s modern varieties were planted to over three-quarters of the rice area in the Philippines, over 70% in Sri Lanka, over 60% in Indonesia and over 50% in Pakistan. Equally rapid was the adoption of modern wheat varieties which in seven years spread to over two-thirds of the Indian wheat growing area. The responsiveness of the modern varieties to fertilizer, which was subsidized, and the availability of irrigation which was also subsidized have encouraged the increased use of fertilizers to the order of 400% in South Asia and 500% in Southeast Asia. Malaysia and Sri Lanka are the biggest users with rates around 100 kg/ha, while Thailand, Burma and Nepal are the lowest users with rates around 10 kg/ha. These are also the countries that have been the slowest in adopting modern varieties.

Along with the modern varieties, fertilizer, and irrigation came a vast array of pesticides, insecticides and herbicides that helped controlled the enemies of the more vulnerable new varieties. Initially, and at modest doses these chemicals appeared to contribute significantly to yields and soon they became past and parcel of the new package of inputs, that was

subsidized by governments throughout the region. Subsidies encouraged pesticide use beyond its economic optimal level. With increased pesticide use the natural enemies of pests have been decimated while pesticide-resistant strains of pests begun to appear requiring ever increasing doses of more lethal pesticides. While there is no question that pesticides have contributed to increase yields during the past two decades it is also true that this have been accomplished at considerable economic and environmental cost, that cast doubts on the sustainability of this source of growth, as we will see below.

The combination of a 50% increase in irrigated area, the rapid adoption of modern varieties and a 4-5 times increase in the use of agricultural chemicals resulted in a 3% annual increase in cereal yields since the mid 1960s. The critical question for the 1990s is whether this yield increase can be sustained and further increased to take up the growth deficit being left by the approaching end to the land frontier? Technically, the answer is yes since the cereal yields in developing Asia are only half those of developed Asia. In the case of rice, actual farm yields in Asia are only half of the potential farm yields (Barker, Herdt and Rose 1985, p. 222). Economically and environmentally the answer is no. To quote Timmer (1988) "The prospects for further sharp increases in domestic production of rice are limited. The high rates of growth since the 1970s are unlikely to be sustained because of the scarcity of additional arable land, the lack of new technological breakthroughs, the expected moderation of government support for increased rice production and the already widespread adoption of high yielding varieties and intensive cultivation techniques."

Changing Resource Environment and Emerging Problems

The sources of agricultural growth of the past 20 years cannot be relied upon to sustain the historically high growth rates of Asian agriculture in the 1990s, for several fundamental reasons. First, the success of traditional cereal importers in achieving self-sufficiency removes a relatively "easy" source of agricultural growth for both the importers and exporters of cereals. Diversification into non-cereal crops requires structural changes and more intensive resource management. Among the constraints are the inflexibility of past investments, such as irrigation and marketing infrastructure, and institutional ambiguities such as insecure land tenure that discourages investments and the planting of perennials and tree crops.

Second, the scope for continuing the past extensive pattern of growth is severely limited by resource constraints. Not only, has part of past growth taken place at the extensive margin (opening up of new land) but even growth taking place at the intensive margin has been extensive in its intensity and hence natural-resource-using rather than natural-resource-saving. For example, irrigation was expanded in area rather than in intensity and efficiency; new irrigation investments were directed at constructing new dams rather than in improving, maintaining and operating efficiently existing irrigation systems, which still lack proper distribution and drainage system. Similarly, with fertilizer and pesticides, the emphasis has been on increasing their use rather than in

improving the efficiency of use.

These "easy" sources of growth are no longer available. The land frontier is all but exhausted; in fact, some retreat of agriculture from encroached watersheds and fragile lands may become necessary in order to contain emerging environmental problems that threaten the agricultural resource base (see below). The most suitable irrigation sites have already been taken up; further expansion of irrigation systems faces a steeply rising supply curve. ADB reports that the cost of new irrigation investments doubled between 1978 and 1983, from $2,453 per ha to $5,000 per ha (ADB, 1979). High-yielding varieties have already been widely adopted (with some exceptions) ; where they are not, this is mostly due to resource constraints and environmental problems. Few technological breakthroughs are expected in the next few years, and given the adoption lag they can not become a major source of growth during the 1990s. Heavier use of pesticides is probably counterproductive and environmentally imprudent.

What about forestry and fisheries? These two subsectors which are more important to some countries than others, have made their growth contribution solely on the extensive margin in a production process that resembles more mining than fishing or harvesting. Thailand had its big export boom in forest products in the 1950s and the 1960s, the Philippines in the 1960s and 1970s, and Malaysia and Indonesia are currently the world's largest exporters of tropical landwoods. In all cases, the forest industry has practiced unsustainable forest management or rather no management al all leading to wasteful harvesting and extensive deforestation and forest land

degradation.

In the late 1970s, as Thailand's forest resources dwindled to about half their 1960 area the government banned log exports. Indonesia introduced an export ban on unprocessed log exports in 1985 while promoting inefficient plywood processing to the degree that more forest is being logged today than before the export ban. Stock depletion and environmental and social pressures are expected to slow down the growth of forestry production in the 1990s in both Indonesia and Malaysia although, at present, they are under pressure from low oil prices to increase their non-oil exports. South Asia having depleted its forest resources long ago runs no risk of loosing this source of growth. Burma has still some potential for growth in the forestry subsector because of its long isolation, although log smuggling into Thailand has been going on for years.

While fisheries are important to all coastal developing Asian countries only Thailand can claim a major contribution by this subsector to its economic growth. Between the mid 1960's and the mid 1970's fisheries production grew at the rate of 10% a year. The heavy depletion of fish resources in the Gulf of Thailand did not stop the growth of the industry as Thai fishermen move into international waters and deep sea fishing. More recently, the declaration of exclusive economic zones (EEZ's) by other Asian countries, including Thailand's neighbors, has gradually slowed down the growth of the industry.

Coastal fisheries are overfished throughout Asia but with the

declaration of EEZs there is scope for some growth of offshore fisheries in all coastal states, except Thailand, but countries have been slow in building up their offshore fishing capability. Joint fishing ventures, or fee-fishing arrangements between countries with underfished stocks such as Bangladesh, India and Indonesia, on the one hand, and countries with excess fleet such as Thailand, Taiwan and Korea, on the other, hold some promise for the 1990s.

Fish prices are expected to continue to rise and aquaculture technology to advance rapidly during the 1990s. Thailand, Philippines and Taiwan have already made significant progress in fish farming and other Asian countries are following closely. Shrimp is becoming Indonesia's fastest growing export commodity. The potential for development of aquaculture in the context of diversification of agriculture is substantial but environmental problems threaten this subsector more than any other.

We have already alluded to the emerging environmental problems. These are problems that are related to, but go beyond, the changes in resource availability and sources of growth. Many of these problems have their origin in the pattern of past agricultural growth and the economic policies such as irrigation, fertilizer and pesticide subsidies that were introduced to bring about this growth. Others are related to physical, institutional and technological factors, they involve mismanagement of the resource base and as such they have a baring on the pace and sustainability of future growth.

The resource base of crop agriculture consists of the factors of production necessary for the production of crops, that is, land and soil resources, water resources, genetic resources natural predators of agricultural pests and the climate (see figure 1). Forest resources, though part of the agricultural base in the broad sense, are not a factor of production that directly enters the production of crops. Yet, forest resources may have indirect but pronounced effects on crop agriculture through their effect on water, soil, genetic resources and climate.

Land-Related Issues

Land-related issues include (a) land fragmentation, (b) land taxation, (c) land ownership concentration, and (d) tenure security. Land fragmentation is most serious in Asia and the Near East where farms have become "fragmented into myriads of small scattered plots. This implies a lot of time, energy and money spent in transport, and it prevents farmers from modernizing and mechanizing their farms" (Falloux 1987). Concentration of land ownership, tenancy and landlessness are most severe in the Philippines where land reform has been an important national issue for decades; despite several land reform programs introduced over the years little redistribution of land has been achieved. Land reform programs have also been introduced in Thailand and elsewhere in Asia with little success. Since much of the wealth in Asia is held in the form of land and land value benefits from rural infrastructure, such as roads and irrigation, it is both possible and appropriate to use land taxation as the principal source of financing of operation and maintenance of rural infrastructure. At present,

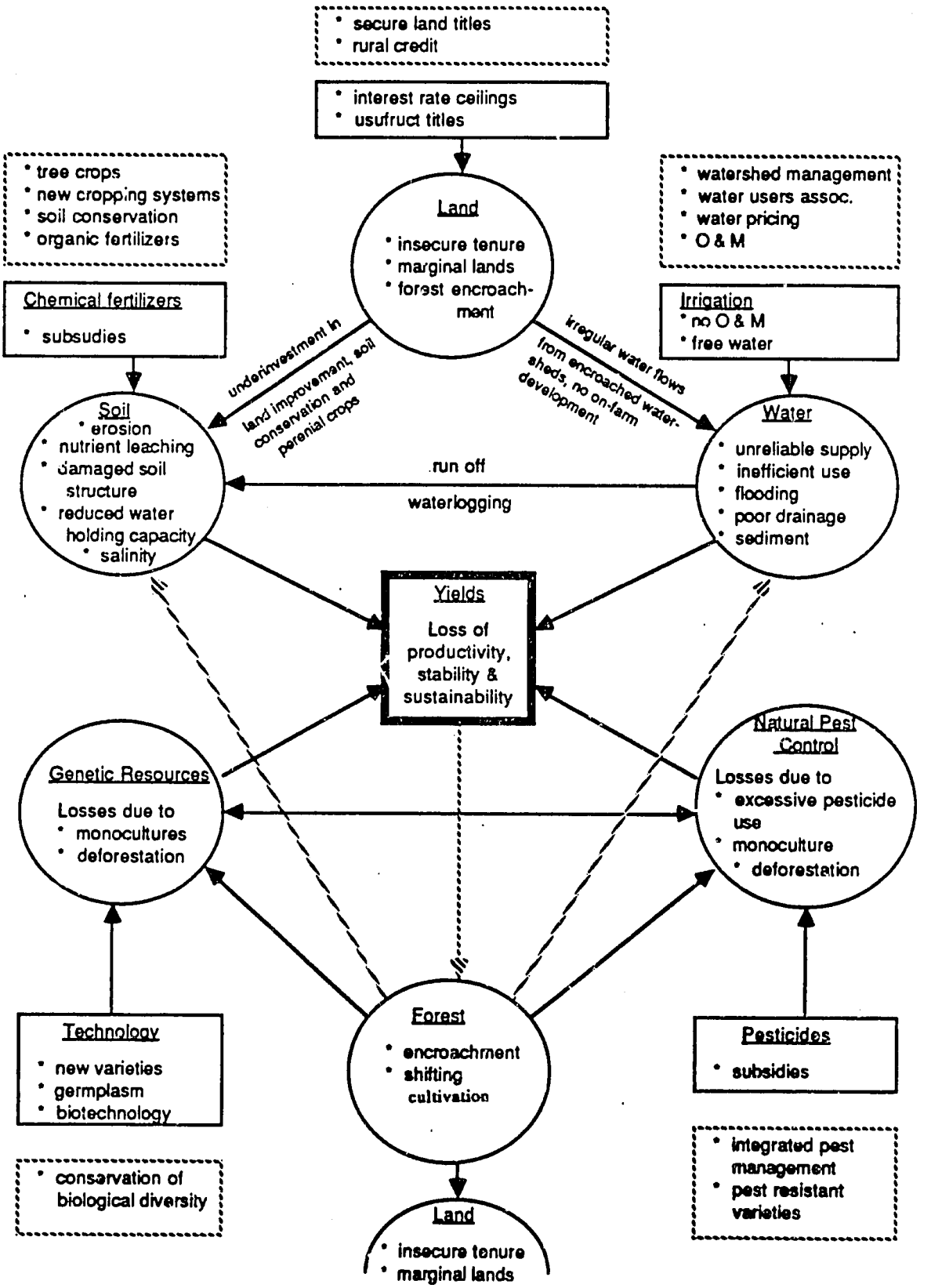

Figure 1: Loss of agricultural growth due to mismanagement of the agricultural resource base. Entries in the solid line rectangles indicate inferior or inadequate management policies. Entries in broken-line rectangles indicate superior or supplementary policies for improved resource management.

land taxes are nominal and little or no tax revenue is derived from land, partly because of the lack or inadequacy of land cadastre, lack of enforcement and very low tax rates.

Insecurity of land ownership takes many forms: (a) totally untitled land, the result of forest encroachment and squatting; (b) land under unclear, disputed or multiple ownership; and (c) land under short-term lease or tenancy. Thailand offers the most striking example of untitled or insecurely titled land. As a result of massive forest encroachment and land opening over the past two decades, 37% of the agricultural land in Thailand is undocumented and untitled while another 47% is covered by certificates of utilization (Nor Sor 3) which are not accepted as collateral for long-term credit. A classic example of multiple or unclear ownership is provided by some 500,000 tanks and ponds covering 70,000 ha in land-scarce Bangladesh that remain largely unused despite an apparent high potential for fish culture (Khan, 1989). Widespread multiple ownership aggravated further by inheritance, is suspected to be a major constraint (FAO/UNDP 1977).

Untitled or insecurely held land is commonly found in the Philippines (the result of swidden cultivation), in Indonesia (the result of spontaneous migration), in Burma (in areas outside the control of the central government) and in Nepal (as a result of migration from the hills to the Terrai). However, the quantitatively most significant form of insecurity of tenure in the Philippines and South Asia is tenancy. While owners and tenants with reasonable security do not seem to differ in their willingness to adopt innovations, such as new varieties, fertilizers and pesticides for

annual crops, they may have different attitudes towards long-term investments to enhance land productivity and sustainality over the long-run such as irrigation and drainage structures, land terracing, investment in livestock pastures, tree crops etc. (World Bank 1985 p. 98).

The lack of security of ownership over land constitutes a serious obstacle to farm investments necessary for diversification, intensification, and increased productivity. Untitled land is not accepted by financial institutions as collateral for credit forcing farmers into the high-interest-rate informal credit market, which makes farm investments unprofitable (Feder et al 1988). The risk of eviction, however small, adds an element of uncertainty that further discourages investments in land improvements and soil conservation. Uncertainty, lack of access to institutional credit, and easy access to public forest land combine to bias agricultural development against intensification on existing lands and in favor of expansion into new lands. This leads to encroachment of forest reserves thereby depleting forest resources and increasing the amount of land under cultivation. Moreover, insecurity of land tenure and the consequent lack of access to credit biases the cropping system in favor of annual crops such as corn and cassava that generate a quick return even at the expense of long-term productivity. Tree crops which may be more profitable over the long run and are certainly more protective of the soil and, therefore, more sustainable are discouraged by insecurity of ownership, uncertainty and lack of credit because of their long gestation.

There is empirical evidence that insecurity of ownership has been a

serious impediment to production growth in Thailand. According to Feder, et. al. (1986), "large numbers of farmers do not have legal ownership of the land which they operate even though they are perceived as de facto owners within the farming community." Through extensive surveys and rigorous econometric analysis, Feder et.al. (1988) found that (1) the value of insecurely held land was only one-half to two-thirds the value of securely-owned comparable land; (2) the capital-land ratio in securely-owned lands was 60-250% higher than that of insecurely titled land. Finally, the authors found that the social benefits from providing land ownership security range between 25% and 80% of the market value of the squatters' land, and that the private benefits to the farmers were even higher (Feder et al 1988). These are enormous benefits, if one considers that almost 40% of the agricultural land in Thailand is untitled. They amount to roughly 10-30% growth in Thailand's total agricultural productivity as well as to substantial soil and forest conservation. It is believed that 14% of the encroached forest in Northern Thailand is used to replace land that is seriously eroded and degraded (Attaviroj 1986).

The importance of security of ownership for investment, long-term productivity, and conservation cannot be overemphasized. The World Bank (1985) based on its 40 years of experience in lending for agricultural development around the world has concluded that:

> "How farmers use land is greatly affected by the degree of security of land-tenure -- with respect to such matters as duration of user rights, clarity of land rights, ability to sell these rights or to pass them on to succeeding generations, and ability to obtain compensation for investments. A farmer with unclear, insecure, or short-term tenure is more likely to "mine" the land, that is, to seek maximum short-run production gains through crop rotations and other practices that may degrade the biological and physical qualities of the soil."

The large percentage of agricultural land under insecure tenure in Thailand, the Philippines, Indonesia and parts of South Asia is partly due to the open access status of public forest lands, as discussed below. In the absence of enforcement of state ownership, forest land has been effectively made available for agricultural expansion free of charge. As an unpriced resource, forest land for agricultural expansion is in high demand and increasingly short supply as the limits of the land frontier are being approached. Yet in the absence of secure and transferable titles, an efficient land market for encroached land failed to develop and consequently increasing land scarcity did not lead to higher prices and increased land conservation. Thus, we have a dual failure of the market to bring about efficient allocation and use of land resources. First, an excessive acreage of forest land is being cleared even when its best use is in forestry rather than in agriculture. Second, cleared land is not used efficiently because of the insecurity of ownership discussed earlier. Moreover, the availability of free land discourages land investment even on securely owned lands because it biases relative prices in favor of extensification and against intensification.

While insecure ownership is certain to lead to mismanagement and waste, secure ownership is no guarantee that land would be put to its best possible use or that it will be conserved and properly managed if other conditions are not met. The most scarce resource for farmers is not land but the capital necessary to invest in land improvements and to purchase the inputs necessary for putting their land to its best use. Ecology and long-term economics favor perennials and tree crops for fragile tropical soils. Such

crops require a relatively large initial investment and long gestation periods. Small farmers, who are the overwhelming majority of farmers in Asia, can afford neither the initial investment nor the long waiting time unless they have access to credit. In many areas, institutional credit is not available, or poor people are not eligible while non-institutional credit is too costly. The result is that many farmers are unable to put their land to its best possible use even if they know how and have the incentive to do so. At very low levels of income, risk aversion and heavy discounting of the future may also prevent farmers from putting their land to its best possible use, thereby limiting productivity growth.

Insecurity of land tenure and lack of access to credit have both on-farm and off-farm environmental consequences that result in further reduction of productivity. The on-farm environmental effects are soil erosion, nutrient leaching and waterlogging resulting from inadequate incentives (and funds) to invest in drainage and soil conservation practices. The off-farm effects are further encroachment of marginal lands and watersheds because of inability to maintain yields on existing agricultural lands. This results, as we see below, not only in loss of valuable forests resources but also in soil erosion and sedimentation of downstream irrigation systems (see fig. 1).

Watershed Degradation and Soil Erosion

A combination of logging, swidden cultivation and opening of new land for sedentary agriculture have resulted in an estimated 160 million ha of

degraded watersheds in tropical developing countries worldwide (World Resources Institute, 1985). The average rates of soil erosion in entire watersheds are estimated to range between 30-60 tons per hectare per year while severely eroding watersheds lose as much as 100 tons per ha per year (Repetto, 1987). The same source reports that erosion in Indonesia has rendered unproductive one million hectares of arable land and adds yearly an additional loss of 200,000 ha. According to USAID (1987) 36 of Indonesia's 125 river basins require "urgent rehabilitation, conservation and development". On the island of Java, which retains only 15% of its original forest cover, croplands loose so much soil that an estimated amount of rice sufficient to feed 11-15 million people is lost annually (Daryadi 1981, Seemawoto 1979, and Myers 1984). Preventing the conversion of certain key forests to other uses is sometimes the best possible support for Agriculture (Rockefeller Foundation 1981, cited in World Bank 1987). According to FAO erosion, if remained unchecked, may result in a 20% loss of potential agricultural production by the end of the century (cited in Repetto 1987).

Soil erosion and consequent fall in yields is only one of the consequences of watershed destruction others include flooding of downstream areas and sedimentation of irrigation systems. In the Ganges River Plain of India and Nepal, home to 500 million people, estimated flood damages have risen from $120 million for year in the early 1970s to $1 to $2 billion (Center for Science and Environment 1982.) While India spends between $100 and $250 million a year on embankments, dykes and large dams, only negligible amounts are spent on the conservation of the forest in the upper catchment areas (Spears 1982) which has been reduced by 40 percent in the

past 30 years. Considering the loss of crop production and soil nutrients due to flooding, and soil erosion from deforestation, one researcher has estimated the annual value of India's watersheds at $72 billion. He further estimated that it would cost nearly $48 billion to construct even earthwork reservoir to store the same volume of water which the forests soak up and release gradually each year (Ranganathan, 1978, cited Grainger, 1980).

Sedimentation from deforestation in upper watersheds have reduced the capacity of India's Niznamsagar Reservoir from 900 million cubic meters to 340 million cubic meters (a 60% loss of storage capacity) resulting in inadequate water for irrigating the 1100 square kilometers of rice and sugarcane for which the reservoir was built, and considerable underutilization of the sugar factories (IUCN 1980, cited in World Bank 1987). The actual rate of sedimentation turned out to be 25 times the originally assumed rate. The expected lifespan of India's Tehri Dam and Pakistan's Mangla Reservoir has been reduced from the planned 100 to 40-50 years due to deforestation of the watershed (Repetto, 1987). Examples from Southeast Asia include the Upper Solo Watershed and Karanglates and Cacaban reservoirs in Indonesia, the lower Agno River watershed in the Philippines and the Nam Pong reservoir in Northeast Thailand.

Destruction of upper watersheds may have profound effects on the behavior of farmers downstream. Even if they have legally secure ownership of their land they may still be unable to put their land into its best possible use. Their life may be a constant struggle against droughts and floods, siltation and erosion, totally outside their control but well within

the control of other (upstream) and of the government. Logging and shifting cultivation in upstream watersheds affect and may even determine the productivity and profitability and, hence, the pattern of land use downstream. While the damage caused by upland deforestation to downstream agriculture may far exceed the benefits from logging and shifting cultivation upstream, there is no mechanism whereby the lowlanders can induce (compensate) the uplanders to reduce deforestation and hence the damage to their lands. The transactions cost for the establishment of a market are enormous. This is a prime area for government intervention to establish such a mechanism. One possibility is for the government to tax the lowlanders and use the proceeds to create more attractive and less damaging employment opportunities for the uplanders. For example, shifting cultivators may be given incentives for reforesting and protecting rather than destroying critical watersheds.

However, as long as irrigation systems are designed and managed as substitutes rather than as supplements to natural watersheds, as it is the case with most Asian irrigation dams, not only are watersheds not protected but they are often destroyed by displaced communities that relocate further up the watershed and engage in shifting cultivation. This process accelerates the sedimentation of the irrigation system reducing its efficiency and economic life necessitating new dams in a vicious circle of unsustainable development. This is why many reservoirs throughout developing Asia are filling up 2-3 times faster than anticipated when the investments were made.

A counterexample of sustainable irrigation development comes from Sulawesi, Indonesia, where a World Bank assisted irrigated rice project funds the protection and management of the 3,200 square kilometer Dumaga National Park located in the watershed of the Dumaga irrigation system. Here, a positive externality between the National Park and rice production has been recognized and subsidized, generating benefits for both the generators and the recipients of the externality and for the society at large. The irrigation project derives benefits from reduced maintenance costs, increased water availability, reliability of supply, and water control. The park preserves its forest and endangered species. The free market would have not brought about this result because of the prohibitive transaction costs of bringing together thousands of farmers to reach an agreement, and enforce it. Government intervention has produced two public goods, watershed protection and biological conservation, neither of which could have been produced by a free market, because of inability to exclude free riders. Moreover, the changes that would have taken place in the absence of government intervention would have been irreversible either biologically (species extinction) or economically (sedimentation of the irrigation system). This brings us to the discussion of irrigation-related issues.

Irrigation-related issues

Two major irrigation-related issues have emerged during the 1980's and are expected to assume increasing significance during the 1990's: (a) poor system maintenance and inefficient water use; and (b) waterlogging and salinization due to overirrigation and poor drainage.

According to the UN Water Conference about half of Asia's irrigation systems require improvements half of which are described as major. Research in Pakistan has found that water losses in watercourses ranged between 33% and 67% with an average loss rate of 47%, while losses within the farmers' field ranged between 20% and 36%. The study also found overirrigation coexisting with underirrigation in the same system with 73% of the sampled farmers complaining of insufficient supplies of irrigation water while farmers close to the water source were overirrigating causing salinity and drainage problems (Loudermilk et. al. 1978).

Irrigation efficiency in Thailand is estimated at 15% of the potential, (ADB, 1984), in the Philippines 20-25%, and in Malaysia 40%, compared with 60% in Taiwan (Levine 1977). The difference between Taiwan and the other Asian countries is accounted for by different management practices. Taiwan practices rotational irrigation according to a strict plan, uses control gates and measuring devices and has an extensive network of farm ditches. The Philippines, Thailand, and Malaysia practice continuous irrigation, there are few effective controls in the channels and turnouts, channels are not well maintained, and there exist only few farm ditches and hardly any measuring devices. In Taiwan water management is decentralized with irrigation associations utilizing systems of incentives for managers of the systems and for farmers. In the Philippines and Thailand farmer cooperation and involvement in irrigation is minimal. Levine (1977) concludes that the difference between Taiwan and the other countries is that water in Taiwan has long been recognized as a socially scarce commodity, while other

countries continue to regard water as a free good. With no water rights, and no effective water user associations or other mechanisms to allocate water efficiently, water scarcity does not register, "many farmers continue to think of water as free, virtually unlimited resource whereas the facts increasingly suggest otherwise" (TDRI, 1987, p. 67).

Irrigation policy in the developing countries of Asia has been biased in favor of new construction rather than rehabilitation and management of the existing system despite the cost advantage of the latter. The economic rents inherent in the subsidized irrigation systems create excess demand for new systems by those who benefit. According to ADB (1979, p. 38) "in 1978 new ADB irrigation projects cost $2,435 per hectare on average compared to only $690 per hectare for rehabilitation of the existing systems. By 1983 estimated costs had risen to almost $5,000 per ha in new large scale gravity systems." With a policy bias against O&M and no effective cost recovery mechanisms[1] it is no wonder that so many of Asia's irrigation systems are in need of major repairs. To make matters worse farmers intentionally damage irrigation structures as a protest against the inability of the systems to deliver water in times of need (TDRI, 1987). The farmers expect the irrigation authorities to operate and maintain the irrigation systems while the authorities "have erroneously assumed that the complementary investments in maintenance and distribution would be undertaken by other authorities or the farmers themselves" (World Bank 1985, p. 103).

1. Only a fraction of the costs of operating and maintaining the Asian irrigation systems, even at the current low level of maintenance, is covered by the revenues collected by water users. This fraction is 20% for Bangladesh, 27% for Thailand and 60% in Nepal (Reppeto 1986).

Overirrigation, inadequate drainage, and poor water quality resulting form lack of maintenance and management of irrigation result in salinization and waterlogging, two serious environmental problems affecting soils throughout Asia. One of the lessons from World Bank experience in irrigation projects has been that "unless the irrigation water is removed soils eventually become waterlogged or salts toxic to plants accumulate. If soils are allowed to reach this state before something is done, restoration may be very costly... In some cases the damage is irreversible (World Bank 1985, p. 101). FAO estimates that 50% of all irrigated lands have been damaged from salinization, alcanization and waterlogging and 1-1.5 million hectares of irrigated land is added every year. "Past neglect of drainage, in conjunction with irrigation, has reduced productivity of millions of hectares, which must now be reclaimed if at all possible. In some cases, large areas of irrigated land have had to be abandoned as a result of soil salinization." (FAO 1980) drainage is required for 42 million ha of irrigated area in Asia and 7 million ha in the Near East. In Pakistan about 12 million hectares, or half the command area of the Indus Basin canal system is waterlogged or saline or both. In India waterlogging has forced farmers to abandoned 10 million ha and salinization is currently threatening another 25 million ha. In Northeast Thailand 17% of the arable land suffer from saline soils due to poor drainage. In the Near East 50% of Irag's lower Rafactain Euphrates Valley suffer from salinity and waterlogging while in Egypt and Iran 30% and 15% of the irrigated lands are affected (FAO 1980).

The waterlogging and salinization problems being experienced currently throughout Asia and the Near East are far more serious than anticipated. The consequences are reduced crop yields[2], loss of irrigated lands, increase salt loadings of return flows and aquifers, and generally poor water quality, detrimental to other uses such as fish culture and industry. Pelts (1984) also reports disturbance to river hydrology downstream resulting in erosion and siltation of estuaries and river deltas. Overirrigation and poor drainage is a critical constraint in any efforts to diversify agriculture from rice to other crops. While rice thrives in high moisture conditions, most other crops are sensitive to poor drainage and continuous high moisture.

Other environmental problems of poor irrigation management include breeding and transmission of diseases such as schistosomiasis malaria, river blindness and bilharziasis. Lockeretz reports that careless irrigation practices can create conditions highly favorable for disease". With excessive irrigation, the humidity in the soil and around the plant can be high for long periods, producing optimum conditions for the germination and spread of many fungus diseases.

Loss of Genetic Resources and Biological Diversity

A good part of agricultural growth in Asia during the past two decades was made possible by the introduction of new high yielding varieties, which

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2. Waterlogging reduces the yields not only of those who overirrigate but also of those who use the return flows.

have been derived through selection and cross-breeding from traditional varieties or wild strains of plants. Studies have estimated that half of all increases in grain crops have come from genetic improvement (CGIAR 1985; Fehr 1984). According to Pino and Straus (1987, p.257) "Plant breeders have drawn extensively on the genetic diversity of crop germplasm to achieve the tremendous gains seen in the past two decades. Further gains, however, will require continued availability of such materials and the expansion of existing collections". In fact, the need for genetic improvements and genetic diversity is as great as ever. First, there is a need to develop drought and flood-resistant varieties for the rainfed and flooding areas, respectively, which are more heterogeneous than the areas currently under modern varieties.

Second, the mismanagement of irrigation systems, the spread of monocultures and the explosion of new strains of pesticide-resistant-pests (resulting from pesticide overuse) necessitate development of new varieties with increased resistance to pests and fungus diseases and increased tolerence to saline and water logged soils. Third, the need for crop diversification necessitates development of improved varieties for an array of new crops and animals. Relatives of domestic crop plants can increase yields, improve quality, provide resistance to pests and diseases, extend growing ranges, and provide "genetic bridges" between crop species and distantly related wild species.

Unfortunately, as the need for genetic improvements rises overtime, the genetic resources from which such improvements can be derived are dwindling

at an alarming rate for reasons that range from deforestation to the spread of monocultures and the use of agrochemicals. According to Pino and Straus (1987, p.257) "Since the beginning of scientific plant-breeding there has been a decline in both the number of crop species and the genetic variation within species. In fact, the range of genetic diversity of the world's major crops may well be declining rapidly". They attribute this genetic loss to the displacement of the genetically diverse traditional landraces by the spread of improved varieties which increased uniformity with two potentially serious consequences: (a) increased risk of vulnerability to disease and of pest losses; and, (b) the loss of the diversity and broad genetic base for continued crop improvement (Chang 1985a; Pluckett and Smith 1986, cited by Pino and Straus 1987). This is another way in which past agricultural growth has been attained at the expense of future growth: monocultures have increased production but they reduced the genetic base for future production raising the spectrum of unsustainality.

Genetic resources, both plants and animals, provide the necessary means for the improvement of existing crops as well as for the development of new crops in the future, as demand changes and technology progresses making necessary continuous diversification. Since demand shifts and technological changes are expected to continue so is the need for genetic diversity. Raven (1981) estimated that two-thirds to three-quarters of all biological diversity resides in tropical evergreen forests. Certainly, the major reserve of genetic diversity necessary for development (and biological protection) of future agricultural plantations and forestry crops for the humid tropics is the natural forest. When the indigenous forest is cleared

and converted to agriculture or to forest plantations and the soil, biomass and microclimate are modified through fertilization, drainage and application of pesticides, the genetic resources are eliminated.

The tropical forests should be perceived as large "gene banks" or depositories of biological diversity which refers to three elements: (a) the variety and number of different ecosystems found in a country or region; (b) the number of different species and their relative frequencies; and (c) the genetic variation within each species. The economic justification for preserving biological diversity is threefold: (1) to sustain and improve agriculture; (2) to provide opportunities for medical discoveries and industrial innovations; and (3) to preserve choices for addressing as yet unforseen problems and opportunities for future generations (OTA, 1987). Another way of putting it is that conservation of genetic diversity is an investment for the future and an insurance against future agricultural catastrophe. And, like any investment it has a cost and like any insurance policy it involves payment of a premium. Preserving biological diversity involves a high opportunity cost in terms of (a) the forgone value of timber and crops that could have been produced in the absence of the biological reserve, and (b) the costs of establishing, managing and protecting the reserve. Any reduction in natural forests inevitably leads to some extinction, some attrition of genetic diversity. The aim of conservation must, therefore, be to optimize rather than to preserve everything, which is prohibitively costly if not impossible. However, judging from past experience it is more likely to err in the direction of not conserving enough, because of short-term economic pressures, myopia or simple lack of

imagination.

The evolution of the rubber industry illustrates a number of points. The industrialized world did not even utilize rubber until the mid-eighteen hundreds; in 1986, exports of natural rubber earned US$3 billion for the tropical countries (IMF, 1987). The natural rubber industry literally grew from a mere 22 seeds collected from a single area (Carpenter, ed, 1983:20). Diffusion of tree breeding and selection technologies have resulted in enormous productivity increases in recent years and will continue to do so. However, it was recognized that reliance on such a narrow genetic range was resulting in "genetic erosion" and loss of available germplasm. Consequently, the industry has been experimenting with other wild rubber germplasms which may again increase productivity and provide resistance to the South American leaf blight (Prescott-Allen and Prescott-Allen, 1986). Similarly, cacao, coffee, sugar cane, and pineapples, among other crops, stand to benefit from current research and use of new germplasm collected from the wild. Crop genetic resources were responsible for about 50% of productivity increase worth about $1 billion in annual contributions to US agriculture (OTA, 1987). The foreign exchange value of oil palm in Malaysia increased US$57 million in the first year after introduction of its pollinator, an African weevil, taken from the wild forests of Cameroon (World Bank, 1987). The establishment of germplasm collections, and the progress of biotechnologies such as in-vitro cell and tissue culture and promising recombinant DNA technologies will certainly enhance the maintenance and use of germplasm but, in no way, will they remove the need for preservation of wild species and land-races in their natural environment

(in situ). Firstly, biotechnologies at present apply to only a few species and their genetic stability is yet known. Secondly, crops such as banana and coconut and some animals important to developing Asian countries cannot be preserved for long through germplasm storage. Thirdly, germplasm storage is static and prevents evolution and dynamic interaction with wild relatives in varied natural ecosystems. Fourthly, germplasm banks cannot preserve entire ecosystems which are part of the genetic diversity, nor can they preserve germplasm for thousands of plants and animals of potential future value. The optimal strategy would certainly involve some combination of germplasm collection (extended to biological or nature reserves, and environmentally more sound agricultural and forestry practices and policies.

Excessive Pesticide Use

Pest attacks have always been a major constraint to the growth of agricultural production. FAO estimate the losses from pest attacks between 20-40% of agricultural production worldwide (FAO 1985). The danger of pest attacks has further increased in recent years as a result of changes associated with the agricultural intensification such as the spread of monocultures, increased fertilizer use, multiple cropping, irrigation with poor drainage, reduced tillage and use of a smaller number of crop varieties. To maintain the gains from adoption of high yielding varieties and irrigation the farmers had to use increasing quantities of pesticides. The use of pesticides was further encouraged by generous government subsidies. For example, Indonesia until recently has been subsidizing 85% of the retail price of pesticides and so did Egypt in the Near East. In

contrast, Pakistan and Thailand pesticide subsidies are insignificant. The median pesticide subsidy for Asia has been around 50%.

The heavy pesticide use, encouraged by the generous pesticide subsidies, has indispensable negative environmental effects and doubtful economic benefits over the long-run. While humans, animals and fish are poisoned, the pest populations which are the targets of pesticides resurge with the elimination of their natural predictors and become resistant to pesticides, necessitating the use of larger quantities of a wide spectrum of more lethal chemicals in a vicious circle of unsustainable struggle to maintain productivity growth. Dover and Croft (1984) report that 400 pests have become resistant to one or more chemicals. Many of these are major pests of major crops such as rice stem borer and brown planthopper, the cotton bollworm, the boll weevil and the leafworm of cotton, and the cutworms and weevils of cereals. FAO surveys shows a large increase in the number of resistant anthropod and insect pests between 1965 and 1975 and attribute it to the repeated applications of pesticides. Similarly FAO reports that over 35 species of plant pathogens have become resistant with the increased use of fungicides.

The experience of Indonesia with the rice brown planthopper is a case in point. During 1975-79 millions of tons of rice were lost to the rice brown hopper, an insect that was not considered a pest five years earlier. Research between 1977 and 1985 has now shown that the rice brown planthopper became a pest because of unnecessary insecticide applications. Insecticides were applied uniformly, 4-5 times per season, in generous quantities across

millions of hectares of rice as an insurance regardless of the need of the individual fields. Following economic analysis that showed negative returns from insecticides, agroecological research that confirmed the link between insecticide use, and the surge of brown planthopper and a second outbreak in 1985 which threaten 70 percent of Java's rice, a Presidential degree (INPRES 3/1986) banned 57 registered brands of broad spectrum insecticides, 20 of which were heavily subsidized by the government. The same degree declared integrated pest management as the national pet control strategy for rice. Subsequent research has confirmed that untreated fields had 75% lower planthopper populations, higher yields and lower costs (FAO, 1988).

Integrated pest management (IPM) is today judged by experts to be the best alternative pest control method over the long-run agronomically, environmentally and economically. Yet pesticide subsidies and indiscriminate use of pesticides are still widespread in Asia. Thailand, which in the past avoided the temptation of subsidizing pesticides, has begun to do so as a politically attractive form of helping the farmers. Pesticide subsidies distort incentives in favor of chemical pesticides and against alternatives such as integrated pest management which is more productive and less damaging.

Integrated pest management is a combination of five alternative approaches to chemical control: (1) environmental control, (2) genetic and sterile-male technique, (3) biological control, (4) behavioral control, and (5) resistance breeding. IPM, while not precluding selective and judicious use of a narrow spectrum of pesticides relies more on cultural practices,

resistant crop varieties, the pest's natural enemies, changes in cropping patterns and careful timing of irrigation and limited pesticide application if such is indicated.

IPM is less capital-intensive and more labor-intensive than heavy pesticide use and as such it is more suitable to the relative factor scarcities of labor-abundant developing Asia and the Near East. Egypt experience with cotton makes the point. A program for cotton began right by planting late to avoid the peak pest season, monitored pest breeding patterns, employed labor to pick egg masses from young cotton plants by hand and burned infested bolls at the end of the season (Brader, 1979).

Soil and Fertilizer Related Issues

There is no question that the use of fertilizers as nutrient supplement to deficient or intensively used soils have contributed tremendously to the rapid agricultural growth of the past two decades. Fertilizer has been critical to high yielding varieties and multiple cropping. Barker, Herdt and Rose (1985) have estimated that fertilizer use has been responsible for 2.9% growth of rice production in Indonesia, 1.0% in Burma, Thailand and the Philippines 3.0% in India, 1.8% in Pakistan, 0.6 in Bangladesh and Sri Lanka. Overall fertilizer has been the single largest contributor to the growth of rice production in Asia. The prospect for further contribution in the 1990s in the developing countries of Asia are good considering that fertilizer is responsible for a 4.4% growth of rice production in Taiwan

(Barker, Herdt and Rose 1985).

However, it should be recognized that (a) heavy use at chemical fertilizers has significant environmental effects, and (b) that chemical fertilizers are not the only means for maintaining soil fertility. Excessive use of chemical fertilizers, without proper soil conservation, causes water pollution that poisons fish and promotes aquatic weeds that inhibit free water flow increasing the cost of maintenance of irrigation systems and waterways. Whatever the argument in favor of fertilizer subsidies their environmental costs and available alternatives should be part of the calculus. There is no good justification for discriminating against soil conservation and the use of organic fertilizers, both of which help restore soil structure and stability, reduce nutrient leaching and therefore increase the effectiveness of chemical fertilizers and reduce runoff and water pollution.

Organic manuring increases the water retention and reduces nutrient leaching in sandy soils; it increases the porosity and reduces runoff and erosion in clayey soils; it moderates the toxicity, alkalinity and acidity of soils; it prevents baking and hardening of soils; and it promotes biological activity in the soil that is essential to plant growth (Repetto 1987). Studies have shown that organic fertilizers can be as effective as chemical fertilizers in improving yields, and can further improve yields when combined with chemical fertilizers "offsetting the sharp declines in marginal returns to chemical fertilizers that most South and Southeast Asian countries have experienced" (Repetto, 1987). Seen in this light, chemical

fertilizer subsidies of 50-60% of the retail price that are common in Asia seem overly excessive and biased. First, they induce farmers to use more fertilizer and less labor for weeding and be careless about the timing of application and the use of irrigation water. Repetto (1986) attributes the low application efficiencies (under 50%) of nitrogen fertilizers to the effect of the subsidies. Second, fertilizer subsidies seem to persist long after their original justification has expired. If the purpose of these subsidies is to induce adoption or to reduce subjective risk aversion, 13 years (the result of a 1984 survey of 17 developing countries) is a long time (Harris 1984). Third, regardless of their economic justification, generous fertilizer subsidies make soil conservation and use of organic fertilizers appear less necessary and relatively more costly than chemical fertilizers. Fourth, while the environmental costs of chemical fertilizers are significantly lower than those of pesticides, a diversified economy with a sizable aquaculture and inland fisheries sector cannot ignore agricultural pollution. Reduction and restricting of fertilizer subsidies in correspondence with social costs should improve the economics and ecology of Asian agriculture as well as conserve fiscal resources.

Asian Agriculture in the 1990s: Critical Choices for Natural Resources

To summarize, the major issues for Asian agriculture in the 1990s in relation to natural resources are: 1) How to sustain the rapid agricultural growth of the past two decades in the phase of demand shifts arising from past successes, and supply constraints arising from resource scarcities and

the environmental side-effects of past growth? 2) How to minimize the impact of agricultural growth in the 1990s on future growth and on environmental quality? These two issues boil down to one: What could and should be the sources of agricultural growth in the 1990's?

The opportunities for the future are to be found in the failures of the past: insecurity of land tenure, degradation of watersheds, mismanagement of irrigation systems, excessive use of pesticides, inefficient use of fertilizers, and inadequate soil conservation. While these past failures have created problems and constraints for Asian agriculture, if remedied can become the sources of growth in the 1990s. Increasing security of land tenure can release powerful forces for land improvement, soil conservation, investments in tree crops and diversification, all sources of productivity growth. The findings of Feder et. al. from Thailand point to a 10-30% productivity growth as well as substantial soil and forest conservation resulting from land titling.

Rehabilitation of watersheds can reduce soil erosion and flooding that damages or renders unproductive millions of hectares of prime agricultural land as well as slow down the sedimentation and consequent loss of capacity of hundreds of major dams in Asia. Increased cost recovery, maintenance and management of irrigation will reduce loss and waste of water, improve application efficiency, increase water control and reliability of supply and expand the irrigable area. ADB (1984) estimates that only 25% of the irrigable area in Thailand is actually irrigated in the dry season. There should be no difficulty in doubling this percentage with more efficient

water management. Moreover, improved water control and drainage will facilitate crop diversification and shift to high-value crops that demand less water. While some additional investments are needed the main task is to develop more effective institutions for reducing distortions and market failures that make farmers treat water as an abundant resource when is in fact scarce and becomes increasingly so over time.

Technology is also expected to make a contribution to agricultural growth in the 1990s. According to Farrell (1984) "Scientists suggest that yields for major crops could be increased 40 to 50 percent by 2000, by using either current technologies or those available "on the shelf". Impressive gains in livestock productivity also are possible within the next ten to twenty years." However, because of the greater vulnerability of crops to disease and pests in the tropics, the emergence of new pest and the ability of these pests to breakdown the pest- resistance in new varieties there is a continuous need for research and experimentation to develop new varieties with more or different genes of resistance to pest and disease. Moreover, diversification of agriculture calls for high-yielding pest-resistant varieties of new crops, and this in turn requires availability of traditional varieties of crops and their wild relatives. Efforts to conserve genetic resources and reduce the current losses in biological diversity combined with agricultural research and extension can be a major source of sustainable agricultural growth for the late 1990s and beyond.

Reduction in pesticide use and widespread adoption of integrated pest management (IPM) also holds great potential as a source of growth for the

1990s. IPM is not only more effective in controlling pests over the long-run, it is also less costly for the farmer, and the government, less damaging to the environment and more suited to Asia's relative factor endowment (i.e. low-cost abundant labor and high-cost scarce capital). Finally, practice of more soil conservation, increase use of organic fertilizers and more efficient and effective application of chemical fertilizers will contribute to both more sustainable agricultural production and reduction in off-site pollution.

Improved management of two related resources, forests and fisheries, will contribute to overall agricultural growth since they are considered part of agriculture. Forests could also make an indirect contribution through watershed protection. However, in both these resources things may have to become a bit worse before they can become any better. Slowing down deforestation and reducing fishing effort (in overexploited fisheries) is bound to slow down further the growth of these sectors but incentives for reforestation and the recovery of the fish stocks will bring about higher growth towards the latter part of the 1990s. For many developing countries in Asia there is also scope for expanding their offshore fisheries, through increased fishing capacity or joint ventures, but appropriate management systems must first be developed to prevent overfishing.

Natural Resource Management: How Much Will it Cost?

These is a misconception that resource conservation and management is too costly and developing countries too poor to afford it. Environmental

conservation is seen as anti-growth while developing countries need growth to feed and improve the living standards of their growing populations. Conservation is seen as deprivation of the poor from their access to resources while countries are struggling to reduce poverty and improve income distribution. Finally, conservation and resource management are seen as a luxury item and a dispensable drain on the scarce fiscal and financial resources needed to service mounting foreign debts and carry out much needed development projects.

While there may be some truth to these arguments in relation to preservation of wilderness or air pollution control the opposite is true with regard to conservation and resource management necessary to sustain Asia's agricultural growth. The proposed policy changes would promote economic efficiency and growth, improve income distribution, save fiscal resources and conserve natural resources and the environment. Elimination, or at least reduction, of pesticide and fertilizer subsides, water pricing and cost recovery for irrigation systems, and effective land and forest taxation all promise to raise efficiency and growth while generating or saving substantial amounts of government revenues. It is true that certain policy changes require additional investments. For example, rehabilitation of watershed, improvement of distribution and drainage infrastructure of irrigation systems, preservation of genetic resources, land titling and reforestation incentives require new investment or expenditure outlays but the growth benefits and future tax revenues are well worth the costs of these investments. The benefits from improved resource management are not as limited and distant or difficult to measure as it is widely believed, and

the costs are not as large and unrecoverable as the cost of replacing the lost assets or suffering the damage. For example, in 1978 the average cost of irrigating one additional ha of land in Asia was $690 by rehabilitating existing systems, compared to $2,500 by constructing new systems.

The Need for Policy Reform

The first priority is to eliminate, reduce, or cushion policies that have significant environmental costs or create perverse incentives that encourage the expansion of resource depletion and environmental degradation beyond the level that even a free market would produce. Reforming policies that distort incentives for efficient resource use is a priority because unless perverse incentives are removed project investments aiming at improved utilization and conservation of natural resources are unlikely to succeed, and, when they do, their impact would be unsustainable-lasting for as long as the projects last.

Reforming policies that are detrimental to both the economy and the environment are an easier point to start because no difficult development-environment tradeoffs or budget outlays are involved. Eliminating policy distortions usually reduces government expenditures and may even generate additional budget revenues. The distributional implications are also in the right direction since many of these distortions are not only sources of inefficiency and resource depletion but also sources of inequality. Finally, eliminating policy distortions can be done by adjusting prices, taxes, and subsidies which is easier than introducing new instruments or

developing new institutions to deal with market failures. Therefore, eliminating policy distortions is the place to start but not the place to finish because without correction or at least mitigation of market failures, efficient use and conservation of resources cannot be secured.

A comprehensive long-term policy reform program that is both necessary and sufficient to ensure the sustainability of the development process would include five components:

1) elimination or at least reduction of policy distortions that favor environmentally unsound practices while, at the same time, they discriminate against the poor, reduce economic efficiency and waste budgetary resources;

2) correction or at least mitigation of market failures such as externalities, insecurity of ownership, and absent or imperfect markets that result in overexploitation of resources, through a system of institutions, incentives, regulations, and fiscal measures;

3) investment in human resource development, rural industry and resource rehabilitation to provide alternative employment to disadvantaged groups such as shifting cultivators, landless farmers, coastal fishermen and underemployed workers to lessen the pressure on natural resources;

4) application of a broad social benefit-cost analysis to all public projects by: (a) casting them in the overall sectoral and macropolicy context; (b) by taking into account all benefits and costs, whether near or distant, whether economic, social, or environmental, and whether quantitative or qualitative; and (c) by avoiding projects that lead to irreversible changes of the environment or foreclosure of options,

5) development of indigenous analytical capability and institutional

capacity for analyzing, formulating and implementing policies and projects that have environmental dimensions.

The Role of USAID

The most acceptable, and in the long run, the most effective role for AID to play in effecting policy changes in developing Asia is that of a catalyst and facilitator that helps to create a conducive environment for change and assists the process of change. This can be done with limited resources in a few targeted areas where AID has a comparative advantage based on prior experience: (1) human resource development in environmental management and policy sciences with a focus on agricultural resource management in Asia; (2) support of research and policy analyses in natural resource management through research grants and institutional development assistance to government agencies, universities and NGO's concerned with agricultural development and resource management; (3) strategically targeted projects on genetic resource conservation and agricultural research for crops relevant to agricultural diversification in Asia; (4) technical assistance in natural resource management and (5) dissemination of factual information and knowledge on the state, management and potential of natural resources in Asia, and their role in agricultural development, to increase awareness and promote acceptance of the need for change in private behavior and public policy.

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