III Sustainability of Asian Agriculture

Two approaches can be used to review agricultural sustainability. The conventional, or spatial, approach tends to group the impact of agriculture on the environment into onsite, offsite, and global effects. Under this approach the emphasis is placed on the impact, making it useful for identifying affected groups or areas requiring mitigation and protection. In other words, it investigates where the symptoms are showing. Another approach is to look at the factors leading to unsustainable situations such that the causes of unsustainability can be pinpointed and tackled. The second approach, emphasized here, argues that technology management and government intervention are responsible for the growing symptoms of agricultural unsustainability.

THE RELATIONSHIP BETWEEN AGRICULTURE AND THE ENVIRONMENT

The impact of agriculture on the environment has both onsite and offsite aspects. Onsite, there may be direct negative impact on farm productivity or on the farmers directly involved in production. In this case, the actors bear the burden of their own activities. Offsite effects result in loss or damage that must be borne by those who are not party to production. In other words, offsite effects incur costs that are external to the actors. These external costs however, need not necessarily be physical.

Some empirical evidence seems to suggest that onsite effects are more significant than offsite effects because the loss is generally directly associated with highly productive areas. For example, the annual onsite cost of soil erosion in Java, Indonesia, in terms of losses in agricultural production has been estimated at $324 million, equivalent to 3 percent of the agricultural GDP of that island. The annual offsite costs were estimated at around $25 million to $91 million (Magrath and Arens, 1987).

Onsite Effects

When discussing onsite and offsite effects, it is important to distinguish between intensive and nonintensive agriculture. Onsite effects are largely related to mismanagement of intensive agriculture. These onsite effects were the biggest lessons learned from the green revolution. It was found that the HYV technology package required more complex management than was originally anticipated. Also, as mentioned earlier, the excessive use of agrochemicals created pest resistance and led to the emergence of new, more virulent pests and diseases. This situation has developed into a vicious circle of pest and insecticide overuse, resulting in both health and environmental problems (Box III.1). Other examples include concerns raised at the International Rice Research Institute (IRRI) in the early 1990s over yield declines, salinity buildup, increased incidence of soil toxicity and micronutrient deficiencies, hardpanning, changes in soil nitrogen supplies, and pest-related yield losses (Pingali and Rosegrant, 1993). Nonintensive agriculture, which generally needs relatively little input and which is more likely to be located in rainfed regions, has generated significantly fewer onsite effects. The environmental impact of nonintensified agriculture is related to expansion of agricultural areas or overexploitation of open-access resources, for example overgrazing.

Box III.1 Pesticide Use and its Impact on Human Health

Pesticide exposure can be direct, i.e. through contact on the job, or indirect, through residues in food or contaminated water and soil. Pesticide effects can be acute and immediate, or chronic. Many of those suffering from acute poisoning with such symptoms as headaches, nausea, or diarrhea are not hospitalized and their cases are not reported. Moreover, the effects from pesticides may be long term and cumulative. Not all the chronic effects are well understood. Acute poisoning can also cause health problems in later life. For example, people affected by acute organophosphate poisoning have been found to suffer neurological damage (WRI, 1998, p.44). Other chronic effects include dermatitis, immune system suppression, and male sterility from exposure to dibro-monochloropropane, which is used to control nematodes.

Offsite Effects

The offsite effects related to intensive agriculture are numerous. They tend to be the result of market and government intervention failures. A few examples are given here to illustrate the nature of their impact.

Water pollution in irrigated agriculture is often related to mismanagement and typically the overuse of chemicals. In the case of excessive use of nitrogen-based fertilizers, unused fertilizer may contaminate underground water supplies. Pesticide residues that contaminate agricultural products or the water supply could be harmful to human health, as well as to aquaculture. In the PRC, pesticide use in Zhujian, in the Yangtze basin, is one to three times greater than the national average. Yet only 20 percent of this is actually used by the plants, with the remainder being left in the soil or seeping into water sources (Zhang and Zhang, 1995).

Industrial livestock systems that develop near city centers generally have a high concentration of animals and have the potential to produce substantial organic discharges in excess of the carrying capacity of the surrounding environment. The intensive production of pigs in the PRC has caused animal waste pollution problems that now need close attention. Malaysia is also experiencing environmental problems arising from the pig sector. With proper management, these impacts can be alleviated and the environmental costs internalized and charged to consumers. For example, the Ponggol Pigwaste Plant in Singapore treats wastewater for recycled use at a cost of about 8-9 percent of the production cost of pork (Steinfeld, de Haan, and Blackburn, 1997). In Malaysia, aerobic waste treatment increases the cost of production of pork by 6 percent.

Without proper discharge management, under a high concentration and nutrient-surplus system, the discharges could contain heavy metals that are harmful to animal and human health. Heavy metals such as copper, zinc, and cadmium are used as growth stimulants in some feeds. At present only the Organisation for Economic Co-operation and Development has regulations that aim to reduce the levels of heavy metals in feeds.

The offsite impact of intensive agriculture is not limited to pollution. Intensive aquaculture has considerable offsite impact through the destruction of mangroves as indicated earlier.

In less favorable environments where the green-revolution technology is not suitable, farmers tend to make up for low input use by area expansion. Offsite effects mostly involve the consequences of deforestation. Deforestation in upper watershed areas causes soil erosion and creates such offsite effects as sedimentation, which increases the costs to downstream industries. In the Philippines, the cost to the fishing and tourism sector from sedimentation due to uncontrolled logging in a 1,830-ha watershed was estimated at between $8 and 13 million (measured in terms of net present value) for fisheries and a loss of $9.2 million for tourism (Hodgson and Dixon, 1988, cited in Bann, 1998). Offsite costs resulting from the increased sediment load affecting irrigation systems, reservoirs, and harbors add another $90 million to the total.

Agriculture itself may be affected by pollution from other economic sectors. For example, air pollution from sulfur dioxide emission from electrical utilities may produce acid rain, which damages plants and animals as well as human health. In Thailand, some small-scale impact has been detected in sites near the Mae Moh power plant in Lampang. Industrial, land-based pollution and oil spills often threaten aquaculture. Natural resources and the environment are shared by many stakeholders; thus, multiple-use conflicts and external costs are unavoidable without appropriate intervention.

Climate Change

Global climate change, in the form of atmospheric warming, is occurring due to the release of greenhouse gases that accumulate in the atmosphere and increase the effect of radiation from the sun on the Earth. The changes in greenhouse gas concentrations are projected to lead to regional and global changes in climatic and related parameters such as temperature, precipitation, soil moisture, and sea level. However, the reliability of predictions surrounding the effect of climate change has yet to be proven. There are no hard facts concerning the result of increases in the concentration of greenhouse gases within the atmosphere, and no firm time scales exist.

Agriculture accounts for approximately one fifth of the annual increase in anthropogenic (human-made) greenhouse gas emissions (IPCC, 1996). The agricultural sector contributes to global warming through the emission of carbon dioxide, methane, and nitrous oxide.

Methane and nitrous oxide from agricultural sources contribute about 50 and 70 percent, respectively, of global anthropogenic emissions of these gases. Their main sources are flooded rice cultivation, the use of nitrogen fertilizers, improper soil management, land conversion, biomass burning, and livestock production, including the associated manure management. It has been claimed that the livestock industry contributes between 5 and 10 percent of the overall contribution to global warming.

Deforestation and the burning of agricultural crop wastes or rice stubble remain major sources of carbon emissions. When natural systems are converted into agricultural land, a large proportion of the soil carbon can be lost because plants and dead organic matter are removed. This process contributes approximately one third of total global carbon dioxide emissions. To a lesser extent, carbon dioxide is released from the use of fossil fuels in agricultural production, and from livestock production. High-intensity animal production has become the biggest consumer of fossil fuel energy in modern agriculture (IPPC, 1996).

Within the agricultural sector, methane is the most significant greenhouse gas released. Most of the releases come from rice fields (91 percent), the remainder being from animal husbandry (7 percent), and the burning of agricultural wastes (2 percent). The quantification of emissions from rice fields has proven difficult because the emissions vary with the amount of land in cultivation and also depend on fertilization practice, water management, density of the rice plants, and other agricultural practices. The PRC is a very large source of methane in comparison with other Asian countries (Table III.1).

Livestock and associated manure management contribute 16 percent of the total annual production of methane. These emissions are a direct result of consumption by cattle and buffaloes of large amounts of fibrous grasses that cannot be used as human food or as feed for pigs and poultry. Cattle and buffaloes account for about 80 percent of global annual methane emissions from domestic livestock.

The main source of nitrous oxide released from agriculture arises from the excessive use of nitrogen-based fertilizers, legume cropping, and animal wastes. The flux of nitrogen depends on the microbial activity of the soil. For example, wet rice absorbs only one third of the nitrogen in the fertilizers and upland crops about half. The rest is denitrified and diffused into the atmosphere, contributing to global warming. However,

Table III.1: Methane Emissions from Livestock and Agricultural Sources in Selected Asian Countries, 1990

	Methane (t'000)	
	Livestock	Other Agriculture[a]
Bangladesh	520	473
China, People's Rep. of	8,940	18,400
Indonesia	864	2,039
Japan[b]	520	276
Kazakhstan	939	
Mongolia	301	
Nepal	370	542
Philippines	315	559

[a] including flooded rice fields
[b] 1994

Source: WRI (1998).

the amount of nitrous oxide emitted is much lower in volume than the amount of methane.

The aggregate global effect of climate change on agricultural production is likely to be small to moderate. However, climate change will have significant regional impact on agricultural yields. Crop yields and changes in productivity will vary considerably across regions and probably result in a slight overall decrease in world cereal grain productivity. Decreases in productivity would be most likely in regions that already experience food shortfalls.

The effects of climate change will also differ across Asia. The changing temperature as well as changes in rainfall patterns and the accompanying increase in projected levels of carbon dioxide will have important effects, especially in tropical regions. It is expected that food productivity (especially crop productivity) will alter due to these changes in climate, and due to weather events and changes in distribution of pests and diseases. Land areas suitable for the cultivation of key staple crops could undergo geographic shifts in response to climate change.

Vulnerability to climate change depends not only on physical and biological response but also on socioeconomic characteristics. Low-income populations depending on isolated agricultural systems are particularly vulnerable to hunger and severe hardship. In these areas, where populations are already barely food sufficient, even the slightest decline in yields could be very harmful. The most negative effects foreseen are in dry land areas at lower latitudes, in arid and semi-arid areas, especially those reliant on rainfed agriculture. Many of these at-risk populations are located in South and Southeast Asia.

Impact on rice yields in South and Southeast Asia is likely to vary greatly (Matthews et al., 1994a, 1994b). Several major studies have been conducted of countries in East Asia, including the PRC, the Republic of Korea, the Democratic People's Republic of Korea, and Japan (IPCC, 1996). While large changes were predicted for the PRC, the studies concluded that to a certain extent, warming would be beneficial, with yields increasing due to a diversification of cropping systems. Studies for Japan have shown that the positive effects of carbon dioxide on rice yields would generally more than offset any negative climatic effects.

Climate change could influence food production adversely in three ways: geographical shifts and yield changes in agriculture, reduction in the quantity of water available for irrigation, and loss of land through a rise in sea level, which would also cause salinization of coastal land. Geographic limits and yields of different crops may be altered by changes in precipitation, temperature, cloud cover, and soil moisture as well as by increases in carbon dioxide concentration. High temperatures and diminished rainfall could reduce soil moisture in many areas, particularly in some tropical and midcontinental regions, reducing the water available for irrigation, and impairing crop growth in nonirrigated regions.

Changes in soils, e.g. the loss of soil organic matter, the leaching of soil nutrients, salinization, and erosion, are likely consequences of climate change in some climatic zones. The risk of losses due to weeds, insects, and diseases is likely to increase. The range of many insects will expand or change, and new combinations of pests and diseases may emerge as natural ecosystems respond to altered temperature and precipitation profiles. The effects of climate change on pests may add to the effect of other factors, such as the overuse of pesticides and loss of biodiversity that already contribute to pest and disease outbreaks.

Agriculture in low-lying coastal areas or adjacent to river deltas may be affected by a rise in sea level. Flooding will probably become a significant problem in some already flood-prone regions of Asia such as the PRC and more southern parts of East Asia. The summer monsoon is predicted to become stronger and move northwestward. However, the resulting increased rain could be beneficial to some areas.

Climate change could affect both livestock and dairy production. The pattern of animal husbandry may be affected by alterations in climate and cropping patterns, as may the ranges of disease vectors. In warm regions, higher temperatures would likely result in a decline in dairy production, reduced animal weight gain and reproduction, and lower feed-conversion efficiency. More mixed impacts are predicted for cooler regions. If the length and intensity of cold periods in temperate areas are reduced by warming, feed requirements may be reduced, the survival of young animals enhanced, and energy costs for the heating of animal quarters reduced.

Climate change would also affect livestock through its impact on disease. The incidence of diseases of livestock and other animals is likely to be affected by climate change, since most diseases are transmitted by vectors such as ticks and flies, the development stages of which are often heavily dependent on temperature. Sheep, goat, cattle, and horses are also vulnerable to an extensive range of nematode worm infections, most of which have development stages that are influenced by climatic conditions.

In general, intensely managed livestock systems have a greater potential for adapting to climate change than do crop systems. Adaptation may be more problematic in pastoral systems where production is very sensitive to climate change; technology changes introduce new risks, and the rate of technology adoption is slow. Livestock production may also be affected by changes in grain prices, and rangeland and pasture productivity.

In developing countries, livestock are better able to survive severe weather events such as drought than are crops, and are therefore a better option in terms of income protection and food security (Abel and Levin, 1981).

Various types and levels of technological and socioeconomic adaptations to climate change are possible. The extent of adaptation depends on the affordability of such measures, particularly in developing countries. Recent national studies show that the increased costs of agricultural production under climate change scenarios would be a serious economic burden for some developing countries. Other important factors are access to know-how and technology, the rate of climate change, and biophysical constraints such as water availability, soil characteristics, and crop genetics. Improved land-use practices may help to mitigate greenhouse gas emissions. Some structural changes in agricultural production could also be beneficial and may reduce the necessity for soil disturbances, e.g. switching from rice to other crops such as sugar. However, rice will remain an important food crop in Asia.

Significant decreases in methane emission from agriculture could be achieved through better management of rice fields and by reduced biomass burning. A reduction in methane emission could be achieved by a shift from the use of organic manure to mineral fertilizers (Wasson, Moya, and Lantin, 1998), a shift from traditional to high-yielding crop varieties, the intermittent drying of soils, and zero tillage and mulching. Irrigated rice has been found to produce more methane than deepwater rice (Charoensilp, Promnart, and Charoendham, 1998). The appropriate application of chemical fertilizers, changes in cultivation practices (such as a shift from transplanting to direct seeding), and appropriate water management can also contribute to reducing methane emission. These combined practices could reduce methane emission from agriculture by 15 to 56 percent. Energy use by the agricultural sector has decreased greatly since the 1970s. However, fossil fuel use by agriculture and the resulting carbon dioxide emissions could be further reduced by such actions as minimum tillage, irrigation scheduling, the solar drying of crops, and improved fertilizer management.

Additional methane reduction is possible by improved nutrition for ruminant animals and modifying the treatment and management of animal wastes. The shift to monogastric animals such as pigs and poultry results in a lower level of methane emission because these animals have different feed requirements from cattle. However, opportunities for further reducing methane emission from intensively managed cattle are somewhat limited because the methane production per unit of cattle feed is small and cattle are already being given a high-quality diet. Nitrous oxide emissions could also be decreased through better treatment and management of animal wastes.

It is important to note the role of forests and vegetation as greenhouse gas sources and sinks. The emission of carbon dioxide is only one part of the carbon cycle. The assimilation of carbon dioxide also occurs where vegetation binds carbon into biomass. Carbon storage in the soil is important and dependent on the type of vegetation. Vegetation and soil from unmanaged forests hold 20 to 100 times more carbon per unit area than does agricultural land. Deforestation and land-use changes have diminished the global storage of carbon as well as the land's capacity to bind carbon dioxide.

Although opportunities to reduce the emission of greenhouse gases exist, the problem is that options usually require a trade-off between productivity and emission. It is important to investigate these trade-offs so that appropriate policies and incentives can be designed.

In conclusion, although global warming is expected to have some impact on tropical agriculture, especially in arid and low-lying areas, the specific locations and timing of the projected impact remain uncertain.

FACTORS DETERMINING AGRICULTURAL SUSTAINABILITY

Sustained increases in agricultural production depend on the availability and the quality of natural resources and the way humans interact with nature in the production process. The interaction between humans and nature depends on the availability of resources, crop choice and technology, incentive systems, and the rules and regulations that govern the use of resources. Central to this interaction are two important factors that determine agricultural sustainability: technology management and government intervention.

Technology facilitates the exploitation of nature. It provides the methods used in interacting with and making an impact on nature. It has also been a major instrument in saving natural resources, maintaining and extending nature's carrying capacity, mitigating negative effects, and enhancing positive impact on the environment. Technology designed to meet production or extraction objectives can be environmentally neutral, enhancing, or destructive. Technology can also produce second-generation effects that induce declines in productivity and undermine long-term sustainability. The creation and adoption of technology depend on its profitability, which in turn is influenced by the prevailing incentive system and the rules and regulations related to production decisions.

Generally speaking, developmental and political objectives and policies in Asia have created the incentive systems in the various economies. In order to meet food security and income objectives, maximization of output has often been the overriding goal. In low-income countries and production units, short-term needs tend to take precedence over long-term gains. Governments want to be perceived as givers rather than takers. Therefore, subsidies are readily extended, while taxes or levies are imposed only reluctantly. Technical or engineering solutions such as technological innovation and infrastructure development are easier to administer than rules and regulations. Administrative responsibilities are often sectoralized such that benefits and power can be shared. The status quo is preferred to change as the latter implies winners and losers. For example, using technology that saves land is preferred to land reform. Rewards are bestowed from the top and not determined by the people whom the government machinery is created to serve.

The above modus operandi works well with the green-revolution technology package, at least in the initial phase of technology transfer. The green-revolution technology is scale neutral and does not require institutional reform. It requires investment in irrigation and transportation networks. This genetics-based technology is powerful enough to propel growth in areas where the environment is favorable. However, the same technology will not be able to maintain such miracles in the long term; the mode of operation needs to be adjusted to meet changing needs. Reasons for this are put forward below in terms of technology management and government intervention.

Technology Management Issues

The environmental impact of agriculture varies with the type and the level of intensification. In areas where the environment is favorable, agriculture is usually intensive and high-input technology is often used. Moreover, good water availability makes the use of chemicals more worthwhile. Higher output from the technology in turn encourages the overuse of chemicals, resulting in both onsite and offsite environmental effects that undermine the sustainability of the agricultural sector.

Sustainability of the Intensive Monocropping System

Much of the concern regarding agricultural sustainability is related to yield declines in the intensive monocropping system. The last 20 years have seen the emergence of many site-specific problems in these systems throughout Asia, e.g. boron toxicity and zinc deficiency in rice-rice-rice cropping at IRRI, and boron deficiency in wheat in the rice-wheat cropping system in Bangladesh, PRC, India, and Nepal. The development of such problems is not surprising in cropping systems that have become increasingly intensive. With two and sometimes more crops being grown in succession on the same land and in the same year, major biological, chemical, and physical changes have taken place in the soil.

Boron deficiency occurred in HYV wheat in Bangladesh, northeastern India, and in Nepal because the introduced varieties were not accompanied by screening for boron efficiency. Again, this points to a lack of awareness of site-specific problems. The experience of the PRC shows that many problems related to intensive cropping are site specific and can be managed through strong and responsive R&D in crop management.

Iron toxicity from continuous flooding was identified in Indonesia, Malaysia, Philippines, and Sri Lanka. However, it happened before the widespread adoption of HYVs (Tanaka and Yoshida, 1970). Reported incidences of zinc deficiency in rice also preceded the release and adoption of HYVs. Increased incidence of micronutrient deficiencies could also simply be the result of improved diagnostic capabilities, allowing the identification of previously undetected problems.

Hardpanning or subsoil compaction is a problem that occurs when an upland crop is grown on land previously used to cultivate rice. Recent experiences have demonstrated that there is no difference in yield when the soil is subject to zero tillage or multiple tillage (Hobbs, Sayre, and Ortiz-Monsterio, 1998). In the PRC, reduced soil porosity was solved by tilling the soil once every three years (Wang and Guo, 1994) or by deep ripping.

Changes in supply capacity of the soil were observed during long-term experiments on rice (Cassman, Peng, and Dobermann, 1997), where nitrogen (N) fertilizer levels had to be increased from 140 to 200 kg/ha. Although observed in a research environment, this problem has yet to be encountered in fields under cultivation.

The above complications indicate that genetic improvements alone are not the answer to the food production problem. Second-generation problems do arise, but with good local R&D and crop management with special emphasis on the sustainable management of soil and water, many of these problems can be solved and productivity gains can be maintained. The sustainability of intensive cropping systems will depend on the capacity of the local R&D system for timely identification of the problems and provision of solutions to these problems.

Pest Control

Asia accounts for 16 percent of global pesticide sales (WRI, 1998), and developing countries overall account for about half of all pesticides used (Alexandratos, 1995). The impact of pesticide use on human health is believed to be great. Although the total number of persons affected is uncertain, it is thought to be between 50 and 100 million (WRI, 1998, p.44). Agricultural intensification near the Aral Sea in Uzbekistan has been blamed for pesticide-related illnesses, and impact on farmers' health has been reported in the Philippines (Loevinsohn, 1987; Rola and Pingali, 1993).

Another effect of chemical overuse is the development of pest resistance, leading to an even greater use of chemicals. In this regard, the brown plant-hopper (BPH) epidemics can be singled out as an unexpected side effect of the green revolution. The BPH was a minor rice pest in Asia before the green revolution. The nonselective use of chemicals that accompanied the technology package destroyed the predators of the BHP and transformed it into a major pest. In response to the outbreaks, more pesticides were used. The insect finally evolved into more virulent biotypes that can break down the resistance of some high-yielding rice varieties. Moreover, pesticide overuse also created chemical resistance in the pests.

The BPH epidemics took their heaviest toll in Indonesia, where chemical inputs were subsidized under a food-sufficiency program. In 1977, a BPH epidemic caused Indonesia to lose more than one million t of rice worth more than $100 million. A 1986 BPH recurrence caused even greater damage, estimated at $400 million.

More recently, resistance to the selective herbicide isoproturon, used for controlling little-seed canary grass, in the rice-wheat system in northwestern India, has affected almost one million ha of wheat (Malik and Singh, 1994; Malik, Gill, and Hobbs, 1998).

The collection and accumulation of genes necessary to build up resistance to pests takes a decade or more. Thus, scientists found that a breeding strategy would not be sufficient or timely enough to cope with the problem. Finally, it was decided that integrated pest management (IPM) needed to be adopted. IPM is defined by FAO in the "International Code of Conduct on the Distribution and Use of Pesticides" (Article 2) as "a pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest populations at levels below those causing economically unacceptable damage or loss". It is a holistic approach to pest control where a combination of various control methods are used, including selective chemicals as well as natural predators and parasites. IPM has finally brought BPH under control, particularly in Indonesia (Box III.2).

Indonesia is not the only country that can claim success in reducing pesticide use. The PRC has also been reducing pesticide use since 1982 owing to improved pest management and improved quality of pesticides (Fan, 1997). However, crops not associated with the green revolution, e.g. horticultural crops and cotton, are much more intensive in their use of pesticides. In India, half of all pesticides used are for cotton crops (Paroda and Chadha, 1996), which account for only 4 percent of total crop area.

Nutritional Imbalance

Fertilizer use is often very high under intensive cropping systems such as in the PRC's northern plains, middle and lower Yangtze River valleys, and Sichuan basin, and in Haryana and Punjab, India. In horticulture, annual organic fertilizer use

Box III.2 IPM Farmers

IPM requires some basic knowledge of insect ecology and the toxicology of insecticides. This knowledge was at first considered too difficult for farmers in most Asian countries to learn, because most of them have little formal education. The IPM strategy requires farmers to be para-taxonomists and ecologists. Successful IPM farmers need to recognize and monitor their crops' natural enemies and to take appropriate steps. Rules exist to help determine appropriate actions, but no one single formula for arriving at a remedy exists.

Indonesian farmers were able to prove that when the proper policies were implemented they could overcome the BPH plague and achieve a win-win solution, with both an increase in rice production and a decline in pesticide use. The IPM program was launched in 1986 and by 1989 the necessary associated policy of removing pesticide subsidies was instituted. About $1,200 a year per farm was saved by reduced pesticide use, a total estimated benefit of $1 billion. By 1993, Indonesia had 250,000 IPM farmers.

Large numbers of IPM farmers are also being trained in the PRC, India, and the Philippines, (Oka, 1996). In all countries where IPM has been adopted, rice yields are greater than under conventional methods.

easily exceeds 2,000 kg/ha. Two interrelated problems have arisen as a result of this high input of fertilizer: nutrient imbalance in the soil and offsite effects from the overuse of chemicals.

Nutritional imbalances occur when the amounts of various nutrient elements required by crop plants are not matched by those supplied by the soil and fertilizer. Among the 15 or 16 mineral elements essential to plant growth, those most often deficient in Asian soils, as elsewhere, are nitrogen (N), phosphorus (P), and potassium (K). Fertilizers used in crop production in Asia almost always contain N, and increasingly also P and K.

As most of the fertilizer now applied is N-based, it is inevitable that deficiency of other nutrients will become the next limiting factor to yield growth. About two thirds of agricultural land in the PRC and almost half of the districts of India are considered to be affected by phosphorus deficiency (Stone, 1986; Desai and Ghandhi, 1989). In the PRC, it has been estimated that a yield increase of up to 18 percent (almost equivalent to the gain made by their famous hybrid-rice technology) could be obtained by improving nutrient management (Lin and Shen, 1994). Measurements of plant nutrient status in farmers' fields indicate that the nutritional balance is often poor. Onfarm studies have shown that Asian rice farmers do not often apply N, P, and K fertilizers in amounts that correspond with the soil's capacity to supply these nutrients (Cassman, Peng, and Dobermann, 1997). In addition, new diseases are now increasingly identified as being associated with nutritional imbalances (Cassman, Peng, and Dobermann, 1997). Considerable productivity gains as well as ecological benefits might be expected from improving the nutritional balance in fertilizers. So far, phosphorus, potassium, sulfur, boron, manganese, copper, and zinc deficiencies have been identified as factors that can limit crop yields in various locations in Asia.

While fertilizers are underutilized in most parts of Asia, overfertilization occurs in some favorable environments, especially in intensive vegetable production (Morris, 1997). In addition to the cost, there are ecological and health consequences of excessive fertilization. Very high levels of phosphorus (over 1,000 parts per million (ppm), where a "good" soil contains about 15 ppm), have been found under vegetables in different locations in Asia. This shows a lack of knowledge on nutrient management. Unused nitrogen from fertilizers ends up as nitrates in underground water, or in streams where intensive vegetable crops are grown in the highlands (e.g. the Philippines, Thailand). A survey of 3,000 dug wells in Indian villages showed that about 20 percent of them contained nitrate levels in excess of the WHO limit (Handa, 1983).

The decline in rice yields in IRRI's long-term experiments in the 1970s was found to be due to boron toxicity, resulting from irrigation with well water containing high levels of boron, combined with zinc deficiency (Flinn et al., 1980). Marginal grain-to-nutrient ratios from use of these micronutrients can be expected to be much higher than that currently gained from nitrogen alone. The difficulty lies in determining where and how the gains can actually be achieved on farms. As most of the fertilizers used in Asia are nitrogen based, and 40 to 66 percent of the nitrogen now applied to rice and about half that applied to other crops are actually wasted, some significant gains should also be realized from improving the management of nitrogen.

Waterlogging and Salinity

Waterlogging and salinity, although often topics of discussion in literature related to land degradation, are a result of the mismanagement of water. Waterlogging and salinity problems occur in areas where excessive irrigation induces salt build-up through capillary action.

Global estimates of the significance of the problem differ widely, between 18 million ha (Postel, 1992, cited in Crosson, 1994) and 43.5 million ha (Dregne-Chou, 1992, cited in Crosson, 1994). Some 10 to 15 percent of the irrigated land in developing countries is somewhat degraded through waterlogging and salinization (FAO, 1995a), and “waterlogging and salinization have sapped the productivity of nearly 5 percent of the world’s (250 million ha) irrigated land” (FAO, 1995a). Salinity affects 11 percent of the irrigated land in India, 21 percent in Pakistan, and 23 percent in the PRC (FAO, 1995a).

Using the Postel and FAO estimates, Crosson (1994) calculated the rate of annual increase in salinization to be 2.3 percent, and constructed three supply scenarios based on different assumptions that gave comparative yields from affected and unaffected land. He concluded that the impact on global output by 2030 would be a loss of 3 to 16 percent of production.

It should be noted, however, that it is difficult to differentiate between “intensification-induced” and naturally occurring salinity problems. For example, salinity in the lower Mekong Delta in Viet Nam, caused by the low river flow in the dry season, affects 1.7 million ha of agricultural land as well as other economic activities. The problem is so severe that controls were put on water use for agriculture to maintain a critical flow (Mie Xie, 1996). Without precautionary measures, the total area affected could reach 2.2 million ha.

Waterlogging and salinity problems are another consequence of the singularly crop-centered approach of the green revolution, in that it has neglected aspects of crop management not based on fertilization and irrigation. An integrated approach is needed for salinity-prone areas (Qureshi and Barret-Lennard, 1998), for example the introduction of salt-tolerant wheat, water-table management by planting deep-rooted trees for drawdown, and the planting of halophytes such as salt bushes. These problems indicate the need to intensify crop management research, which has lagged behind breeding research, for example on rice at IRRI.

Some of the region's salt-affected irrigated lands are, however, still not free from the risk of further degradation. This is caused by two basic but related problems: (a) the use of salt-laden irrigation water, and (b) the disposal of the extra salt. Pakistan's irrigation system, for example, adds 60–65 million t of salt as saline water to the underground supply annually, 35–40 million t of salt as canal water, and 20 million t of salt from "fresh" (i.e. better quality) underground water onto irrigated lands. The major saline-effluent disposal projects now under development are expected to carry only a fraction of this salt out to sea (Qureshi and Barrett-Lennard, 1998). Surface soils that were only moderately saline or salt-free have become severely salinized. In addition to increasing the accumulation of salt in the soil profile, using poor quality irrigation water further degrades the soil by destroying its physical structure, making it impermeable to water. Leaching salt from such soils is difficult, and crop growth is then adversely affected by waterlogging as well as by the salt. Some 2–3 million ha in Pakistan have already been reported as having suffered further degradation in this way (Rafiq, 1990).

Genetic Erosion

The loss of genetic diversity following the widespread adoption of HYVs and other MVs in Asia has raised two concerns. The first is related to the fear that traditional varieties will be lost as farmers narrow their crop choice; over three quarters of wet riceland in Asia is now planted with MVs. This concern is currently being addressed by the storage of traditional varieties in international gene banks. The second concern is related to the increased risk of pests and pathogens associated with large-scale production of genetically uniform varieties, a risk that was demonstrated by the 15 percent yield loss in maize in the US in 1970 due to the southern corn leaf blight.

Evidence in Asia tends to suggest that the variability of output, as measured by the coefficient of variation, has decreased. For instance, in India the coefficient of variation of wheat yields between the decade before the green revolution and 1976 to 1986 decreased from 17 to 7 percent (Singh and Byerlee, 1990). Neither maize nor wheat has suffered major outbreaks of pests or pathogens since the green revolution. This remarkable achievement is attributable to the fact that plant breeders have been able to develop new varieties at a rapid pace, especially varieties with a strong resistance to rust pathogens.

The story of rice is quite different, with major outbreaks of disease and pests having occurred in large areas where a single variety is cultivated. Examples of this are the BPH epidemics mentioned earlier and the blight that struck the rice variety RD6 in Thailand.

At present, the coverage of major staple crops by germplasm held in international gene banks provides sufficient guarantee against genetic erosion. In 1992, rice, wheat, maize, and soybean accessions totaled 250,000, 410,000, 100,000, and 100,000, respectively (Chang, 1992, cited in Evenson, 1996). Cultivars of wheat and rice then uncollected constituted about 10 and 5 percent, respectively. There is, however, concern about continuity of international funding to sustain these gene banks and to improve collections from the wild such that more systematic and useful information can be provided.

The lesson to be learned from onsite effects due to the intensive cropping systems, pest control methods, and from offsite effects or externalities, is that for sustainable growth of a crop-centered technology, more emphasis is needed on soil, water, crop, and genetic management. The current capacity of management in these areas lags behind the technology, both at the national and the international level.

Failures in Government Intervention

For the purposes of policy and planning, it is useful to categorize government interventions into those at the project, sectoral-policy, and national-policy levels. In this volume, only failures at the first two levels are discussed because national policies are generally designed to serve much broader economic objectives such as full employment and economic stability. More information on the impact of national policies on rural Asia is available in a companion volume (Rosegrant and Hazell, 1999). However, it is important to note the impact that national policy variables could have on the sustainability of agriculture. For example, the higher the interest rates, the more difficult it may be for economic agents to invest for the long term, including investing for gains from conservation practices. The more undervalued the exchange rate, the greater may be the exploitation of natural resources for exports. For sectoral policies, emphasis is given here on discussion of natural resource sector policies.

Government failures mainly come from one of four sources: intervening in a market that is functioning well, neglecting to correct for market failures, inefficient provision of public goods, and inadequate consideration of trade-offs and opportunity costs (Panayotou, 1993). In the first instance, government policies may distort prices, generally by overpricing output through price supports and guarantees, and by underpricing inputs through subsidies. This has been very prevalent in the agricultural sector. Second, market failures or functions that the market cannot perform, for example to achieve allocation efficiency, are not addressed. Offsite or external effects (such as pollution and deforestation) are not effectively handled. Natural resources are left under an open-access regime and are wastefully exploited. Third, a government may overextend itself by pursuing activities best accomplished by other institutions and agencies. For example, central governments often attempt to provide local public goods directly, rather than create a situation where the provision becomes possible through other agents, in this case local government and communities. Finally, inadequate consideration may be given to trade-offs and opportunity costs, especially when the costs are not readily measurable or not expressed in monetary terms.

Trade-off situations have occurred when there is no win-win solution or when two or more objectives cannot be simultaneously fulfilled. Then there will have to be losers as well as winners. In such cases, the option with the highest benefit is normally selected, provided that the cost-benefit analysis has been thorough and comprehensive. In the area of natural resources and environment, most environmental damage is not immediately obvious, but attempts must be made to quantify the damage.

Trade-offs may occur at the farm, sector, national, or international level. At the farm level, long-term income and sustainability may have to be forfeited for short-term gain owing to resource constraints or immediate hunger. For example, in the uplands, soil conservation may not be adopted because the additional labor required competes for labor to be used in food collection. At the sector level, a new dam that will enhance agricultural productivity may be constructed at the expense of severe biodiversity loss or at the expense of an existing dam that relies on the same inflow. At the national level, trade-offs may be in the form of a choice between accelerated growth in the short run and sustained growth in the longer term.

Project-Level Failures

Project-level failures arise from a lack or neglect of intense and careful information gathering and exchange between the many and diverse stakeholders, especially those at the grassroots level. Projects are frequently designed and undertaken with limited scientific data, without respect for social practices and norms, and without taking advantage of local knowledge and wisdom. Project selection criteria are not based on rigorous and thorough analysis of cost and benefits and often exclude the cost of environmental damage and external effects altogether. Trade-offs and opportunity costs are not given careful consideration and therefore careful accounting is not done for them. In addition, the project time span is often too short for the achievement of project objectives and can indeed influence objectives to be short term.

The establishment of the cattle industry in developing countries is a good example of how the role of information is often underestimated in public investment projects. In Thailand, the Government embarked on a project to promote foreign breeds, which were later dubbed "plastic cows" because farmers were simply not told of the nutritional levels required to achieve full reproductive efficiency. In Nepal, a similar mistake was made with the use of continuous backcrossing with Holstein Friesian cows. In that instance, the situation was even worse because the cow is sacred according to religious tradition and cannot be destroyed even if it does not calve every year and therefore fails to provide milk.

Many failures have occurred with project-level irrigation projects. In northeastern Thailand, the Nam Bor reservoir had to be drained and abandoned after it was completed because it was built on a dome of rock salt and had led to salinity build up. The most classic irrigation failure was the attempt to convert first-class grazing land in Uzbekistan and Kazakhstan in Central Asia into second-class irrigated land. This project resulted in the immense environmental disaster of the drying of the Aral Sea (Turner II and Benjamin, 1994). The Syr Darya and Amu Darya rivers, which flow into the Aral Sea, are heavily drained to irrigate cotton. From the Amu Darya alone, 14 cubic kilometers of water, about 90 percent of all annual renewable water resources in Uzbekistan, are drained into the Kakarum Desert. Despite the desiccation of the sea, the project is overextended and fails to deliver water efficiently, resulting in a loss of up to 70 percent of the water during delivery. Moreover, salinity build up neutralizes much of the benefits of irrigation.

Increasingly, conflicts between stakeholders have delayed and prevented projects because opportunity costs and trade-offs are not well understood and accepted by government agencies and thus are not skillfully handled. Compensation rules allowed under government regulations only compensate for the loss of nonmovable assets such as trees and houses, and not for opportunity costs such as the income forgone from traditional fisheries, or the harvest of nontimber forest products.

Many countries now require an environmental impact assessment (EIA) before granting project approval. This exercise tends to be done in order to meet requirements of international lending agencies rather than being a serious effort to mitigate environmental impact. Environmental impact is summarily appraised although in many cases, year-round observations of potential impact are necessary. In some countries, environmental experts who are invited on a voluntary basis to consider the EIA lack adequate support to investigate the project thoroughly. In other countries, experts within the public sector do not exist. Some consultant agencies do not have adequate skills in handling environmental issues and often mitigation costs are not included in the final cost-benefit calculations of a project. Public participation procedures do not exist in many countries. The procedure of approval and information about projects are not transparent and are sometimes withheld from the public. Public hearings are usually not required (Mingsarn et al., 1998).

Project failures also result from the fact that benefits and costs are narrowly defined without consideration being given to the resource system. For example, investment in water resource development is often project based rather than basin based. Projects are often considered for individual merits without a careful ranking of benefits and costs of related projects in the same resource system. Projects are sometimes implemented despite very low rates of return and high external costs.

Agricultural funding from both internal and external sources has been project oriented. While this may continue, attempts should be made to convince governments to engage in policy and institutional reform. For the next decade, policy and institutional reform would probably release more productive resources and enhance more output than investment. In the future, project-based development should be a component of policy reforms, which are most urgently needed in the areas of natural resource management, R&D, and extension.

Finally, the current management systems that concentrate on legal instruments and command-and-control regimes as the main mechanisms for resource management, have missed out on other management opportunities offered by market-based and fiscal instruments such as taxes, charges, and incentives. The legal instruments also fail to acknowledge specific regional variations and limit the ability of the State to take advantage of local knowledge and initiatives. The devolution of R&D for crop management and for the management of some critical resources is the first step to sustained production increases.

Sectoral Policy Failures

Despite many success stories, price distortions from government support and subsidy programs can still be found in Asia. For example, export taxes on agricultural products and import duties distort the allocation of resources for crops, which in turn has impact on the environment. The impact differs from country to country, depending on the type of crop and also on whether the crop is imported or exported. Such impact is therefore an empirical issue. In Sri Lanka, it has been shown that liberalizing trade could have had a positive effect on the environment (Coxhead and Jayasuriya, 1992). The result has been reduced soil erosion as well as a positive income effect due to the plantation crops (namely tea and rubber that are subject to heavy direct and indirect tax) being more environmentally friendly than food crops (Chisholm, Ekanyake, and Jayasuriya, 1997). In the Philippines, export taxes and an overvalued exchange rate encouraged the production of annual crops such as potato, cabbage, and garlic at the expense of more environmentally friendly export crops like coffee, cocoa, and rubber (Coxhead and Rola, 1998). Agricultural research policy in the Philippines also favors vegetables, legumes, and root crops, which are relatively less environmentally friendly than the woody perennial species. Policies aimed at increasing food security have favored the expansion of corn into the marginal uplands in the watershed in Lantapan.

Food security policy in itself is often a source of agricultural unsustainability. In Bangladesh, many policies have been geared towards rice production and against wheat, although there are some important ecological niches, such as higher elevation and lighter soils, where wheat is more favorable than *boro* rice (winter or dry season rice) (Morris, Singh, and Pal, 1998). Wheat is much less water intensive, making it suitable for areas without access to irrigation. However, the price of wheat is held below import prices owing to food aid and subsidies.

Input subsidies have encouraged excessive chemical use, resulting in pest epidemics and heavy yield losses. There is now an immense literature showing that removing policy distortions will provide win-win solutions. The Indonesian Government, for example, is acclaimed for its action in this direction by removing pesticide subsidies, thus encouraging the use of integrated pest management (Box III.2). Win-win solutions can be expected in India where the removal of fertilizer subsidies would provide greater incentives for the use of manure in soil management, which in turn would raise the demand for labor, especially for women (World Bank, 1996). However, in this particular case in India, the shift in the use of manure as a source of fuel to fertilizer may have to be set against a negative impact on forests.

As food security in Asia has increased, the agricultural policies mentioned above have lost much of the justification for their existence. In addition, the cost of subsidies has become overwhelming. Most of these high-cost policies have been maintained for political, not economic, reasons. Issues related to policy failures today have shifted from agricultural to natural resources policies.

Policy failures concerning natural resources are often the result of open-access policies. A classic example is oceanic fisheries resources: any fisher who is willing to invest in a boat can harvest as much as his boat will carry. The best known example of environmental degradation under an open-access regime was brought to the attention of scientists and the public when Garett Hardin wrote about the "tragedy of the commons". Hardin (1968) depicted a pasture that was open to all. Overgrazing and a degraded pastureland would be the inevitable outcome because each user would tend to raise as many animals as possible in order to maximize private gains. Hardin's "commons" represent an open-access resource, in which each individual tries to maximize private gain by converting public into private property. Consequently, the first-come-first-served situation that exists under open-access regimes tends to encourage the wasteful use of resources.

Land Policy and Institutions

In most countries in Asia, land tenure security, either in the form of ownership or long-term lease, is increasingly recognized as an important incentive for attracting investment in land to improve its productivity. In fact, land is the most privatized natural resource. Efforts are now underway in many countries to define use and ownership rights and to provide the corresponding recognition. The process is often slow, however, and in many instances tarnished with corruption.

The lack of well-defined rights to land use can lead to substantial environmental degradation. According to a detailed analysis of the PRC's pastoral region in the northeastern part of the country (Longworth and Williamson, 1993), the policies of national and local governments are largely to blame for the rangeland degradation that eventually led to irreversible degradation of the whole ecosystem, or desertification.

Rangeland in the PRC is State owned. Since the reforms in 1978, pastoralists have, in principle, occupied rangeland according to a system of contracts and leases. Very often the location of the "leased" land is not specified, meaning that in practice rangeland is treated as common grazing land. Incentives to invest in and improve pastures are minimal. When a piece of land is specified in a lease, the land's use and ownership may still be re-allocated or re-assigned by the Government. Such arbitrariness also discourages sustainable management or private investment and encourages shortsighted exploitative behavior on the part of the lessee. The responsibility for setting the terms and conditions of pastoral leases has been delegated to local governments, with the result that these terms and conditions vary widely from place to place. For example, leases are granted for as little as 5 or as many as 15 years by different local governments. Again, shorter lease periods decrease the incentive for investment in the land and the adoption of sustainable practices. In India, similar problems have occurred. Nationalization of arid rangeland has converted a community-managed "commons" into an open-access system (Steinfeld, de Haan, and Blackburn, 1998). As a result, the common resources were degraded by 30 to 50 percent over a 30-year period, and the number of grazing days was reduced.

The same land tenure problems occur in Central Asia. Crucial to the problem of rangeland degradation are public policies that have led to various uncertainties, and incentives that have induced operators to behave in an exploitative manner. This has, in turn, placed a constraint on finding possible technical solutions that might help to improve the productivity and sustainability of the pastoral system.

A holistic approach to rangeland management would include an evaluation of the influence of public policy, the role of traditional/communal rangeland management, and the potential technical solutions that may be employed. A policy process, at the county or provincial level, that involves participation of pastoralists and communities, as well as governments and technical professionals, would provide a framework from which the management of pastoral systems could be improved.

As far as legal recognition of individual rights to decision making is concerned, Myanmar is a notable exception. Although various legal forms of land tenure including ancestral holdings *(bo bwa bain)* exist, in practice the Government can reallocate land without compensation and designate it for rice production, limiting farmers' ability to make crop choices. In 1994/95, designated paddy land accounted for about 54 percent of the area sown to rice (US Embassy, Yangon, 1996). The Government has also diverted land for bean and pulse production. The areas for this have increased in response to liberalized trade. This system has reduced incentives to increase land productivity. In spite of the abundance of fallow and uncultivated land and of water, it has been estimated that there are 12 million landless laborers in Myanmar (ibid.).

Land tenure systems also affect conservation behavior. It was discovered that the land tenure system in the Philippines of three-year cash leases discouraged soil conservation practices. In the upland areas where land tenure security is absent, farmers lack incentives for the adoption of erosion control practices. Incentives in the form of input subsidies and marketing infrastructure without land security tend to further aggravate land degradation. The types of rights that need to be given are those that harmonize the goals of increased conservation efforts and productivity but minimize area expansion. Increasingly, governments are turning land outside protected and fragile areas over to local inhabitants. The issue now is how to deal with settlements in headwaters and fragile ecosystems. Even in land-abundant countries such as Thailand, the approach of removing settlements from fragile ecosystems is met with strong resistance. This is compounded by the difficulty of locating new sites for resettlement. Other policies, such as nonfarm employment and education for the younger generation in order to create more employment options for them, are needed to complement land policy.

In the more vibrant economies in Asia, where land speculation has been prevalent, especially before the recent financial and economic crisis, the failure to curb windfall gains either through capital gains tax or taxes on unused land encouraged land sales and forest encroachment. Appropriate tax instruments are needed to reduce pressure for opening land frontiers while unused land is still available.

Forest Policies

The state of natural forests in most Asian countries can best be described as critical. Natural forests in the resource-rich countries in Southeast Asia are dwindling rapidly. The PRC and India have already lost most of their natural forests. Much of this poor performance is a result of outdated policies and institutions. Forestry policies in many Asian countries are legacies from colonial administrations of centralized and bureaucratic regimes and are oriented towards production. In many cases they are public land policy rather than forest conservation policy.

Forestry agencies in Asian countries specialize mainly in extraction and production. With changes in the socioeconomic and political environment as a result of population pressure on forests and an increased awareness of ecology and biodiversity, these agencies found themselves without adequate personnel and expertise to cope with people living in the forests and with issues concerning protected forest areas. In some countries, the forestry sector is controlled by some specific interest groups. This leads to a lack of willingness to adopt new responsibilities for conservation. Protection is geared towards protecting State revenues and not sustainable forest functions or the livelihood of those depending on forests. State monopolies over forests have deprived local communities of access to resources for their livelihood.

Sectoral policies that encourage deforestation and overlogging include the underpricing of concessions, promotion of large-scale plantations in tropical rain forests, and forest policies that deprive the surrounding communities of de facto usufruct rights to forest resources and bestow monopoly rights on State forest management. In Cambodia, low royalty rates understate the true economic value of natural resources, leading to revenue losses of $100 million per year (Royal Government of Cambodia, 1997). In India, legal restrictions on the harvest and sale of tree products have reduced the incentive to grow and care for trees. In addition, the policy is deemed to affect soil fertility because manure has to be diverted from farm use to fuel use as fuelwood becomes scarce (Chambers, Saxena, and Shar, 1989).

Although forests in Asia are protected by law, they are de facto under open access owing to a lack of resources and personnel, except where local institutions for forest management exist (Box III. 3). Moreover, a broad range of nonforest sector policies can encourage new social and environmental objectives leading to deforestation, for example policies that support an over-expansion of agriculture either through trade protection or input subsidies.

Box III.3 Forests for the Grass Roots

In West Bengal, 3,000 communities are protecting forests that have a total area of more than 3 million ha. Forest legislation (1989) in West Bengal was amended in 1990 to empower local committees to manage forests. Forest Protection Committees (FPCs) were given the usufruct rights to royalties for fruits, flowers, grass, leaves, and one quarter of the timber (aged over 10 years) produced after 5 years of protection.

A case study of Bhagabatichak in West Midnapur has shown how a small community can design institutions that make both forest and communities more viable. Families in Bhagabatichak are mainly landless farmers and recognize that further degradation will affect their future livelihood. Common property rules are specified and monitored. Occasional raids against illegal activities are also undertaken. Village rules specify harvest schedules for six species of fuelwood. Forest floors are disturbed only in the dry season.

By 1995, the FPCs had replaced official authorities in forest protection. The West Midnapur Forest Division conducted an experiment to compare forests under community protection with open-access forests. It was not surprising to find that the extraction rate was lower in the community-managed forest as the people had gained a more secure supply of fuelwood.

Source: Thapan (1998, p. 262-3).

Protected areas in Asia are not well selected and are poorly demarcated and managed. Conservation staff are inadequately trained and biodiversity knowledge specific to individual parks is scarce. Financing options other than budgetary sources for protected area systems are rarely explored. As a result, protected areas have unduly become a budgetary burden.

The conventional policymaking process has an inherent bias against forest protection. Cost-benefit analyses of development projects that encroach into forests tend to underestimate the value of forests, especially their ecological functions and the future value of their biodiversity (Mingsarn, 1995). Empirical studies suggest that the nontimber value of forests is substantial (Reid et al., 1993; ADB, 1995a; Bann, 1998) and that there is a general willingness to pay to protect forests (Mingsarn et al., 1995). Other studies have indicated that benefits from clear-cutting in natural forests are only one seventh of those from sustainable yields of timber and nontimber products (McNeely, 1998 p.5).

This lack of proper valuation and neglect of the ecological and biodiversity functions of forests leaves their protection as a low priority in government development agendas, which in turn has biased government decisions for public investment for the protection of forests. In Thailand, forest land is considered reserve land for development, tourism, military bases, dam construction, and even garbage disposal. The cost-benefit analysis of a dam construction project in protected areas, for example, often excludes the cost of ecological and biodiversity loss, while timber extracted from the protected area is considered a benefit.

Finally, despite their high biodiversity, developing countries in Asia lack funds, personnel, and knowledge for protecting forest resources, for prospecting, and for establishing a systematic information and knowledge database for future use. A cost-benefit sharing system on a global basis would be needed in order to maintain the global commons (Mingsarn, 1997). Moreover, in the forestry agencies of most developing countries, especially those where extraction activities remain active, R&D personnel tend to lack support and have low morale. In addition, scientific capacity related to forest production in Asia is deteriorating.

Water Policy and Institutions

The principal challenge for a water management strategy is to design institutions that are responsive to changing needs. As the need for water for agriculture increases, most governments concentrate their efforts on the provision of water. Large investments in water resource development have led to the establishment of correspondingly large bureaucracies and industries specializing in water provision. Therefore, water policy and institutions in Asia deal mainly with the provision of water for irrigation, and the agencies are staffed by engineers preoccupied with construction and supply management. It is not surprising to find that irrigation policy in many Asian countries tends to be biased in favor of large-scale infrastructure developments such as dams (Mingsarn and Ammar, 1997; Vyas and Reddy, 1998).

This top-down approach to water resource development has been increasingly countered by public protests organized by NGOs. The increase in social, environmental, and political costs related to dam construction has made large-scale dams a less viable option for water resource management, not only in economic and social terms but also politically. A study of water institutions in 11 countries, including the PRC, India, and Sri Lanka in Asia, indicated a shift of the key issues being addressed from water resource development to water resource allocation and water quality.

Water management in most Asian countries is fragmented and sectoralized. For example, in India, surface irrigation, underground irrigation, drinking water, water supplies, and pollution control are under independent agencies and coordination is often not very effective (Moench, 1994). Another example is Thailand, where water is partially controlled by the Royal Irrigation Department, but there are more than 20 other agencies that also oversee water, under different pieces of legislation. Thus, water conflicts between sectors and between upstream and downstream users are difficult to resolve.

At present, planning for and implementation of water resource development is on a project basis. Increased competition for water, complexities in water-use patterns, inter- and intrabasin water diversion possibilities, and rising conflicts have necessitated “bioregional” planning at the basin level, with wider participation by water users and stakeholders (Mingsarn et al., 1999). The basin development planning process used by the Mekong River Commission, incorporating basin-wide stakeholder participation, is a move in the right direction.

Water institutions and policies in the PRC are relatively advanced in comparison with those in other Asian countries. This has happened for three reasons. First, the PRC is both flood and drought prone. Mitigation of effects of flooding has been a major concern from ancient times. Second, water resources in the PRC are unevenly distributed, although in terms of per capita availability and the percentage of withdrawal, the country cannot be considered water scarce given that its overall water resources per capita are about 2,100 m^3 per year. While most of the irrigated areas and population of the PRC are located in the north, it is in the south where water is most plentiful. For example, in the Hai, Huai, and Huang River basins, where 34 percent of the PRC population and 42 percent of its irrigated land are located, the total per capita water resources are only 310 m^3 per year (Saleth and Dinar, 1999). Third, soil erosion and water pollution in the PRC are particularly severe.

Water policies and institutions in the PRC are geared to solving these problems. In 1988, the Water Law was passed and the Ministry of Water Resources and Power was established. Under the Water Law, water is the property of the people and a clear distinction is made between user rights for people and the allocation rights of the administration. The river basin has been recognized as the basic unit of water management. Water Conservancy Commissions were formed to manage intraprovincial river basins and lakes. In 1997, the

PRC further unified its water resource management policies by enacting the Law of Flood Control and declaring a National Policy on Water Pollution Control.

Throughout Asia, surface water is under an open-access regime. Water resources are free or underpriced, leading to wasteful use. In areas where agricultural intensification is made possible by pumping irrigation, such as in India, overpumping has lowered the water table, such that households with shallow wells are deprived of water. Again, those who suffer tend to be the poorer farmers. In this case, underground water is open access, but the supply and demand imbalance is such that appropriate management of this resource is now a necessity.

When water is abundant, an open-access regime is appropriate. It is also considered an equitable regime. However, as the competition for water intensifies, an open-access regime can no longer produce equitable results. Water-related laws often do not explicitly specify quantitative restrictions on individual or group withdrawals. Water is disproportionately extracted by those who have more money, technology, labor, and power. Those who have access to free water often engage in wasteful uses. In many countries, allocation principles and mechanisms are needed, especially in times of shortages. Water agencies, which are accustomed to simply providing water, have found it difficult to devise allocation methods that are efficient and acceptable to all.

The multiple-use conflicts indicated in Chapter II imply the need for a comprehensive water administration body that can coordinate the needs of different users and establish acceptable and effective allocation principles, provide dispute settlement procedures, and maintain quality control standards while leaving the day-to-day management and dispute settlement to local institutions.

In a number of Asian countries, national guidelines on water use provide directives for pricing that reflect the scarcity value of water. In practice, except in Japan, irrigation water fees are not high enough to influence crop choice or irrigation practices at the field level. In India, surface water irrigation rates only cover operation and maintenance costs. Moreover, electricity charges for pumping irrigation are subsidized. In Pakistan, the establishment costs of irrigation are recovered by the sale of land in the irrigated areas and, as in India, water charges are meant to cover only operation and maintenance costs. In practice, water charges are too low even to maintain the system.

In Thailand, water prices for canal irrigation and underground water bear no relation to their actual cost. In the PRC, pricing has gained an important role in allocating water between and within sectors and also as a means for penalizing polluters (Chen, 1992). A permit system for withdrawing water is expected to be in use by 2010. Reforms are in progress that recognize variations in supply conditions in different regions.

Pricing alone does not guarantee efficient use if prices are tied to the cropping area or even type of crop. Farmers who pay flat rates for water tend to use or hold as much water as possible. In this case, proper pricing and education on water problems related to excessive irrigation will have to be implemented jointly to assure proper use of water resources.

Private water markets are the main feature of Indian tube-well irrigation. Elsewhere, markets for irrigation water have not been developed. In Thailand, where competition for water use is increasing, especially in the northern basins, the development of water markets is not easy. This is due to very small holdings; a mixed tree and annual cropping system, which implies different levels of water commitment; the similarity of crops between deficit and surplus areas; and potential political resistance from landowners (Mingsarn and Ammar, 1997).

In most Asian countries, pricing mechanisms need to be reformed, although water pricing is not a panacea. Rehabilitation, better maintenance, and management of the existing irrigation systems are necessary. Improving irrigation effectiveness is imperative. In many cases, large-scale water resource development projects are not a priority. In Cambodia, the existing "colmatage" systems, which consist of canals dug through the natural levies of the rivers to allow floodwater to inundate and fertilize rice fields naturally with nutrient-rich silt, need to be restored (Benge, 1991). In Viet Nam, the priority in water resource development is rehabilitation of the existing system, and improved drainage and water control against salinity intrusion, rather than new large-scale development. A simulation study by the World Bank suggests that irrigation investment in Viet Nam would have an insignificant effect on poverty and the smallest impact would be in the Mekong Delta. This is due to the peculiar nature of the Delta, which suffers long periods of inundation and seasonal shortages, and contains low-quality acid sulfate soils (Van de Walle and Monhindra, 1995, cited in Litvak, 1995).

Irrigation authorities will need to broaden their perspective and consider other management options and instruments needed to supplement the current command-and-control regimes and supply orientation. An incentive or penalty system needs to be established to encourage the use of water-saving technologies such as drip irrigation. In addition, stakeholder participation and involvement in water resource management could increase both efficiency and equity and could also reduce the budgetary costs of operation and maintenance.

In the mountain areas of many Asian countries, where topography and hydrology permit, irrigation systems have been developed as a common property of communities, and management is generally recognized as being efficient. In Thailand, group- or community-managed irrigation networks have been integrated into public irrigation systems. Increasingly, water-managing communities are being considered as important components in water resource management and need to be recognized, institutionalized, and given greater responsibilities. In India, villager participation helped to rehabilitate and maintain communal water resources (Box III.4). In relation to large-scale water resource planning and management, institutional mechanisms and capacities have yet to be developed for the assessment of social and environmental impact. These capacities need to be developed not only by environmental agencies but also by water agencies and the private consulting sector.

Box III.4 Villager Participation in Water Resource Rehabilitation in Ralegan Siddhi, India

Situated in the State of Maharashtra near the city of Pune, the village of Ralegan Siddhi has undergone an amazing transformation in less than 20 years (AVARD, 1993). By 1976, Ralegan Siddhi's agrarian economy was being ravaged by massive soil erosion, deforestation, recurrent droughts, and land degradation. There was also an acute water shortage. The water table was low, and all water (including that for what irrigation there was) came from wells that went dry in the summer, such that even drinking water had to be brought in. Under these conditions, only 30 percent of the village's food grain requirements could be met. The social consequences were equally devastating. Able-bodied men had little choice but to leave the village to look for work, while locally, illegal liquor establishments were set up. By 1976, Ralegan Siddhi had 40 liquor establishments, for a population of only about 1,200 people. Some 85 percent of the local population became addicted, with the problem even reaching schoolchildren.

The reversal of Ralegan Siddhi's fortunes began with the dedication and work of one individual, Anna Hajare, who had retired from the army in 1976 and returned to help make a difference in his home village. The most pressing issue was the acute water shortage. Water conservation measures were instituted, such as bunding, land shaping, land grading, and the building of water tanks and small check dams for storing rain water. Afforestation and pasture development helped to regenerate the local vegetative cover and the village ecosystem, controlling erosion, minimizing runoff, and permitting the development of previously unusable land. Bore wells were dug for drinking water, eliminating the water-borne diseases common previously. The new dams and water storage facilities helped to raise the water table, allowing new wells to be dug for irrigation. A lift irrigation project was completed in 1986 with the result that by 1993, 447 ha of land could be irrigated,

(continued next page)

Box III.4 (continued)

compared with only 25 ha in 1976. Although water is shared communally, there are various ways by which heavy users compensate those who use less, and this de facto user-pays system serves to enhance responsible water use.

These achievements required the voluntary efforts of the entire community, and the worthiness of their projects enabled government financial assistance on many occasions. As all helped, all have shared in the benefits and now Ralegan Siddhi enjoys not just abundant water and vastly increased crop yields (Ralegan Siddhi is not only self-sufficient but now supplies neighboring villages), but all the liquor establishments have closed down and the social ills are now mostly a memory. The local economy has improved to the point where the men who had previously left have returned. Through its remarkable achievements, Ralegan Siddhi stands out as an example of how the residents of a community can improve their lives through their own actions, and that it can all start at home with the efforts of just one community member.

Source: AVARD (1993).

Coastal and Ocean Resources Policy

Approaches to fisheries development in most Asian countries to date have largely been extraction oriented rather than conservation or sustainability oriented. Thus, as elsewhere, fishery policies have traditionally stressed increasing production goals, especially in marine fisheries, while the conservation and socioeconomic aspects of fisheries have received minor attention. In recent years, there has been “a shift toward conservation and ecosystem based management from traditional exploitation and stock or species based management” (Ahmed, Delgardo, and Svedrup-Jensen, 1997a). Yet for most countries the dilemma between increasing production to meet growing demand and practicing self-restraint and conservation remains a difficult one to resolve. In the absence of adequate information about the status of fishery resources, policies are in most cases ad hoc in nature (Ahmed, Delgardo, and Svedrup-Jensen, 1997a).

Yet resource rehabilitation has been an ongoing process, and many countries have been placing increasing emphasis on conservation, although the efforts are often too little or too late. Given the weak institutions and lax law enforcement in many Asian countries, success has been mixed. Fishers frequently ignore regulations on mesh sizes or gear use, and enforcement is often costly and difficult. A few successful examples have been reported, however. For instance, examples from the Philippines and Cyprus show that seasonal fishing bans can bring about sustainable production increases of 100 percent in less than 18 months (Garcia, 1986, cited in FAO, 1997b).

Often such successful efforts lack consistency. In Thailand, for example, a similar seasonal fishing ban over an area of 26,000 km^2 in 1984 resulted in increased catch rates in just a few years. However, the ban was later lifted for beam trawlers and anchovy purse seiners, purportedly to ease the plight of the fishers using those methods. The ban was really lifted because of a growing export demand for shrimp, which are caught by beam trawlers. Shrimp fishing leads to more bycatch and waste; thus, demersal catches will once again decline rapidly (Boonlert, 1994).

This difficulty is compounded by the fact that the local stakeholders who benefit from the extractive approach to resource management tend to have connections with politicians or administrators in control of policy decisions (Mingsarn and Pednekar, 1998). Therefore, attempts to enforce no-fishing zones or conservation measures stipulated by law are sometimes neutralized by executive decisions. In many Asian countries, political reform has become a prerequisite for economic reform.

Another major issue in aquatic resource management is the management of multiple-use conflicts. In coastal areas, such conflicts pose the greatest challenge. As mentioned earlier, conflicts are increasing between small-scale and commercial fishers, between marine aquaculture and trawling, between shrimp farming and rice farming, between tourism operations and small-scale fishers, etc. These conflicts are not limited to private entities, but occur between public conservation agencies and public production-oriented agencies. This has led to lax law enforcement and situations where outcomes are determined by mob protests and political power plays. This renders the rehabilitation and management of resources difficult.

A major reason for multiple-use conflicts, overfishing, and the resultant stock depletions, is the continuing de facto open-access nature of most of Asia's fisheries, despite growing attention to the worsening situation at both international and national levels in the form of international agreements, conventions, and law reforms. The few notable exceptions include the Japanese system of fishing rights in coastal zones and licenses for offshore fishing (Yamamoto, 1998).

More recently, however, governments in a number of countries have tried to develop various measures to restrict access by giving user rights to local fisher communities or by designating fishing zones. Among these are the ongoing efforts in Bangladesh towards the management of inland fisheries through the involvement of government, NGOs, and local communities (Ahmed, Capistrano, and Hossain, 1997b). Attempts are being made in various countries to define boundaries for coastal fishers. These range from 3 km from the coast in Thailand for fishers with boats smaller than 10 GRT (Ruangrai, 1997, cited in Mingsarn and Pednekar, 1998), to the 15-km zone of the Philippines' municipal fisheries sector for small-scale fishers with boats of 3 GRT or less (Deb, 1997). However, despite these measures, boundary violations and the resultant disputes between small-scale and commercial fishers are common occurrences in most countries, largely due to the lack of proper enforcement and monitoring systems. Moreover, license and registration fees for fishing boats and gear generally bear little relation to their extractive capacities.

Along the lower Mekong River in Lao PDR and northern Cambodia, local fishing rights have been a customary practice. In Tonle Sap, Cambodia, a fishing lot system has been employed for over a century (van Zalinge et al., 1998). Under this system, the fisheries are monitored to protect against theft and to protect wildlife habitats, flood plains, and mangroves; extraction tends to be consistent with maintaining long-term ecological balance. However, the recent influx of migrants due to improved access to the area has created an open-access system and created conflicts between many operators. Institutional reform that takes into account the existing social structure has become an emerging necessity.

Rehabilitation is also important for inland fisheries. Unlike marine fisheries, where rehabilitation usually focuses on reducing fishing effort, the focus in inland fisheries needs to be placed on reducing the pollution of degraded water resources. A number of countries have also launched programs for seeding inland water resources with hatchery-bred juvenile fish, etc. in order to improve production (Coates, 1995).

Owing to the many stakeholders involved, coastal and aquatic resource management needs to be participatory in nature. Fishery management after all is “a balancing act between the requirements for biologically sustainable resource use, economically optimal exploitation patterns and their social acceptability by the involved parties” (van Zalinge et al., 1998, p.9).