

SUSTAINABLE FOOD PRODUCTION IN THAILAND

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INTRODUCTION

Agriculture is the major source of employment, national income and foreign exchange in Thailand. Although industry has been growing at a rapid rate over the past decade, most of Thailand's population is located in the countryside. The agricultural population accounts for 62% of the country's total population, and approximately 67% of its total labor force.

In recent decades, Thailand has increased the efficiency of its agriculture, using economic concepts such as investment benefits and opportunity costs as the basis for production increases. Imported agricultural inputs such as chemical fertilizer, and other chemicals such as insecticides, fungicides and herbicides, plus fuel, farm machinery and hybrid seeds, have been introduced to increase production. These have replaced locally produced farm inputs such as compost, manure, herbs and power from draft animals. Obviously, higher yields have resulted from this increase in agricultural inputs. For example, rice yields of 9.4 mt/ha have been obtained using high-yielding cultivars and chemical fertilizers, and corn yields of 6.2 mt/ha when hybrid corn was planted. From this point of view, the increase in farm inputs has given Thailand a considerable profit.

However, since the early 1960s, agricultural development has been having a harmful effect on the environment, in the form of widespread deforestation, desertification, land degradation, salinity, all kinds of pollution and a huge loss of genetic resources. Indirectly but significantly, the growth in agricultural output and international trade has caused numerous social problems in both rural and urban areas.

Degradation of the physical resources needed for agricultural production is a cause of great concern all over the world. In general, this ecological, economic and social imbalance will not affect the agricultural activities of the present generation, but will affect the capability of many countries to produce food for future generations. Sustainability in agriculture has to be considered. Agriculture has to

meet this challenge mainly by increasing production on a more or less fixed land resource base, utilizing the environment in such a way that careful maintenance and conservation of resources are emphasized at all times.

CONSTRAINTS TO AGRICULTURAL SUSTAINABILITY

FAO estimates indicated that by the year 2000, the global population will be 25% higher than that of the mid 1980s (FAO 1991a). It is also estimated that 90% of this population increase will be in developing countries, including Thailand. There will be a demand for food and agricultural products for this increased population, and yet the use of modern agricultural technology also means greater exploitation of natural resources and damage to the environment.

Deforestation

The rapid loss of forest cover is possibly the most serious environmental threat in Thailand. Over the past three decades, Thailand's once abundant forests have been decimated by logging and shifting agriculture. In 1961, forest (mostly tropical rain forest) covered 53% of Thailand's total land area.

By 1989, only 28% of the land area was in forest (i.e. 143,417 ha). Table 1 shows the reduction in forested area in some Asian and Pacific countries between 1976 and 1980. The main cause of deforestation has been shifting cultivation. The fact that cropping cycles are shorter than in the traditional system, and the spontaneous encroachment into forest areas by lowlanders, reflect the increasing demand for cultivable land among the landless and unemployed rural poor. In Thailand, deforestation has resulted in a reduction of rainfall, and is probably the main reason for the severe drought of 1994.

Land Degradation

One of the most important ingredients of sustainable agriculture is an adequate soil resource base to provide the nutrients and moisture essential to plant growth. Over vast areas of Thailand, population pressure is forcing farmers to cultivate marginal land, exposing this fragile resource to degradation. It was reported by Dent (1989) that while in 1981 the area of arable and permanently cropped land was 20 million ha (approximately 39% of Thailand's total land), the amount of degraded land was 17.2 million ha (33.7%).

In relation to erosion, Table 2 shows the nutrients removed by erosion from cultivated land with a slope of 33-55% in Northern Thailand.

Pest Problems

Up to 35% of the losses in annual crop production in Thailand are due to pests. When these are combined with postharvest losses, they probably account for almost one-half of the country's potential food supply. The advances in agricultural technology that make possible higher production, such as changes in cropping practices, shorter fallow periods, less varied crop rotations, and replacement of mixed cropping by the large-scale monoculture of genetically uniform varieties, have resulted in the escalation of pest problems for a number of crops (Gaston 1989).

One intractable pest problem in Thailand is weed control. Much of the field preparation and subsequent cultivation work is to reduce weed infestation, and most of the manual labor during the cropping season is aimed at keeping weeds at a low level (FAO 1991a). As a result of periodic labor shortages, manual weed control is sometimes late and inadequate, and herbicides are used instead.

At the initial stage of their use, pesticides and weedicides were regarded as an excellent way of abolishing famine and eradicating vector-borne diseases. However, the gradual development of resistant pest species, plus the undesirable effect of chemical pesticides on non-target species and their adverse effect on human beings and the ecosystem

Table 1. Average total deforestation between 1976 and 1980

Country	Area in hectares
Bangladesh	8,000
Bhutan	2,000
Brunei	7,000
India	147,000
Indonesia	550,000
Cambodia	15,000
Laos	125,000
Malaysia	230,000
Myanmar	95,000
Nepal	54,000
Pakistan	7,000
Papua New Guinea	21,000
Philippines	101,000
Sri Lanka	25,000
Thailand	333,000
Vietnam	65,000
Tropical Asia (16 countries)	1,815,000

Source: Rao 1989

Table 2. Removal of soil and soil nutrients by erosion each year from cultivated land situated on a 33-55% slope in Northern Thailand

Component	Average soil property		Removed in soil with an average erosion rate of 60 mt/ha + runoff
	Concentration	Quantity in top 20 cm/ha	
Organic matter	4.00	96,000 kg	2,952 kg
N (total)	0.17	4,080 kg	112 kg
N (available)	*	326 kg	7.5 kg
P (total)	400 ppm	960 kg	28.3 kg
P (available)	6 ppm	14.4 kg	1.1 kg
K (extractable)	190 ppm	456 kg	17.0 kg
Ca (extractable)	420 ppm	1,008 kg	38.0 kg
Mg (extractable)	120 ppm	288 kg	9.0 kg
Total soil loss (kg/ha)		216,890	
Total runoff (m ³ /ha)		2,252	

Source: Turkelboom *et al.* 1991

generally, has given rise to widespread concern.

The main type of pesticide used in Thailand is herbicides (44%), followed by insecticides (32%) and fungicides (18%). It is alarming to see that the total amount of pesticides used in Thai agriculture is increasing, from 12,000 mt/year in 1973 to 27,000 mt/year in 1981, and 48,003 mt/ha in 1988.

Socio-Economic Problems

Farmers in Thailand are facing enormous problems when they try to increase agricultural production. The cost of inputs such as seeds, fertilizers and pesticides is increasing, and there are widespread problems of land ownership and tenure, especially in upland areas. Other problems include price fluctuations and uncertainty in marketing, a farm labor shortage, and poor infrastructure for transporting produce to market.

This situation has resulted in widespread rural poverty. The income gap between farmers and non-farmers has increased, and farmers do not want to continue farming if they can choose something else. Whereas in 1961 the ratio between farmers' incomes and those of other workers was 1:6.2, by 1987 the ratio was 1:9.1 (i.e. non-farm incomes were more than nine times higher than farmers' incomes). Poverty forces farmers to overexploit the environment, even if they are aware of the destructive consequences. Their immediate needs take precedence over their concern about the future. The alarming rate at which natural resources are being degraded is the consequence of environmentally destructive farming practices. The outcome is a vicious circle that makes alleviation of poverty and

conservation of resources much more difficult to achieve.

SUSTAINABLE CROP PRODUCTION

We in Thailand realize that to achieve sustainable crop production at a national level requires interdisciplinary work by various institutions working in cooperation. It involves the recognition of problems in agriculture, analysis of which can lead to appropriate technologies, and implementation which fits in with physical and socio-economic determinants, while aiming at environmental conservation at all times.

There are a number of ways in which sustainable crop production can be achieved.

Mixed Cropping Systems

Any type of cropping system which has a higher degree of biodiversity is considered important. There are vast areas of Thailand where sufficient rainfall is available and soil structure is adequate to allow for a multiple cropping system. A grain-legume-grain crop rotation, particularly rice-legume double cropping, can be readily established (Table 3).

Subsistence agriculture is still practiced over large areas of Thailand, and is dependent upon the slash-and-burn method for food production. Alley cropping (growing an annual crop between rows of perennial trees) is an attractive alternative to the slash-and-burn procedure, especially in northern and southern Thailand where chemical fertilizers are not readily available. The recycling of nutrients,

the addition of organic nitrogen when the alley crop is a legume, and the incorporation of organic matter, are the primary resources derived from the alley crop that benefits the companion crop. This system is also attractive in areas where firewood is in short supply, since the woody tissue from the alley crop can be used for this purpose (Table 4).

Agro-forestry can also be used to prevent land degradation. Trees may be grown in large plantations, but they can also be grown in a mixed cropping system. Perennial tree crops form a production system which is in harmony with sustainable agriculture, since they replace the previous forest vegetation and protect soil against erosion.

Restoration of Soil Fertility

Thailand has begun a strong program to restore and replenish soil fertility. The use of leguminous cash crops in a rice-based cropping system is emphasized, providing nitrogen for the subsequent crop. Green manure crops such as sesbania are being grown before rice in areas such as the Northeast where soil organic matter is particularly low. Azolla is being used to increase rice yield, and also microorganisms such as mycorrhiza, including Ectomycorrhiza and Endomycorrhiza, both of which are phosphate solubilizing microorganisms. Other approaches include the use of farm by-products such as rice straw and livestock manure to increase soil organic matter.

Reduced Tillage or No-Tillage

Crop production based on reduced tillage is becoming increasingly popular in Thailand as a

means of controlling soil erosion. No-tillage techniques can significantly reduce soil loss and improve soil structure by maintaining a higher level of organic matter. However, there are some drawbacks. Weed control at planting is done by chemicals rather than mechanical tillage, involving as great an environmental risk as normal tillage and high costs of sometimes more than \$100/ha. Since fertilizers must be applied on the surface, there are higher losses from leaching and volatilization, and a risk that fertilizer in run-off will contaminate water resources. Finally, the mechanical equipment, particularly the large tractors, required for no-tillage limits the technique to larger farms.

Water Management

Water use efficiency has long been neglected, due principally to the fact that water has seldom been treated as a resource. Adequate water management, especially in large irrigation schemes, is an important factor in sustainable agriculture.

The fundamental problem in irrigation water management lies in the separation between management and users. Farmers receive water according to decisions made by organizations not involved in the crop production process. Thailand is now attempting to develop better water management procedures, the end result being much greater water use efficiency.

Integrated and Biological Pest Control

In Thailand, integrated pest management is being developed based on a combination of cultural practices, host plant resistance, and natural enemies. There is also an emphasis on the need for safe

Table 3. Net income from different rice-based cropping systems when compared to one crop of rice each year

Unit: US\$ per hectare

Cropping system	Net income	Income increase compared to rice only	% income increase
Rice only	325	0	0
Peanut-rice	631	306	94
Sweetcorn-rice-mungbean	1869	1544	475
Stickycorn-rice-mungbean	1487	1162	357
Sweet potato-rice-peanut	1369	1044	321

Source: Department of Agriculture, Thailand, 1991

Table 4. Soil loss rate, as measured on field trials in northern Thailand

Treatment	Soil loss (mt/ha/year)	
	Median	Minimum-maximum soil loss
Traditional slash-and-burn	60	25 - 125
Terraces	0.12	0.05 - 1.0
Grass strips	0.13	0.03 - 5.0
Alley cropping ¹	0.20	0.06 - 2.5

1. Perennial trees were *Leucaena leucocephala*, *Cajanus cajan*, *Gliricidia sepium*
 Source: Turkelboom *et al.* 1991

pesticides and better pesticide management. Development of novel products such as growth regulators seem to be easily integrated with non-chemical control methods. Implementation of integrated pest management in Thailand has been particularly successful for rice and soybean. However, many crops still need urgent attention, especially those for which misuse and overuse of pesticides are common, including vegetables, fruit crops, and cash crops such as cotton.

Biodiversity, Genetic Resources and Plant Improvement

Biodiversity is a fundamental element in sustainable development. The conservation of a wide base of plant genetic resources has direct implications for the future development and enhancement of crops.

Plant breeding in Thailand aims at selecting crops and genotypes adapted to environmental constraints. Crops should be adapted to local conditions, including climatic factors, mineral stress and soil toxicity, and should have durable resistance to most important pests.

Another plant breeding objective is efficiency of nutrient use, and where appropriate, of nitrogen fixation. Furthermore, breeding programs should emphasize the adaptation of crops to the entire production system.

Biotechnology is a tool which may bring advances that were considered difficult or impossible through conventional plant breeding, as individual characteristics can now be transferred from one variety or species to another. Biotechnology is also important in the production of disease-free germ plasma and for disease diagnosis.

Adoption of Technology by Farmers

Once technology has been developed, the main objective for development is to introduce it to farmers. A huge amount of technology generated by research has not been accepted by farmers, simply because farmers feel that it is impractical. Recently, farming systems research has been introduced, so that researchers have an understanding of the farmer's situation before technology is developed. It is important that technology should be tested under farm conditions, and recommendations should be made only in consultation with farmers. There is an urgent need to develop and promote technology that increases or sustains productivity at a lower cost and does not harm the environment. There is also a need for technology which is less labor intensive.

Soil and water conservation measures to achieve sustainable development should be designed to benefit farmers in their application, otherwise they are unlikely to be widely adopted. Simple water harvesting methods can match this requirement, as well as certain forms of minimum tillage. Emphasis should be placed on low external input farming system, to reduce residue problems from fertilizers and pesticides, and the cost of production inputs.

Emphasis of Agricultural Development in the Next Decade

In the next decade, resources for agricultural production will be limited, including land, water and socio-economic resources. Competition will be greater among the countries of the Asian and Pacific region. Therefore, agricultural development should

emphasize self-sufficiency, and the possibility of using agricultural products as raw material for agroindustry. There should be an emphasis on value added products, especially for export, and on quality.

REFERENCES

- Dent, F.J. 1989. Land degradation in Asia and the Pacific. In: *Environment and Agriculture*. FAO Publication, Bangkok.
- Ratanavaraha C. (ed.). 1991. *Sustainable Agriculture*. Ministry of Agriculture and Cooperatives, Thailand. 153 pp.
- Department of Agriculture. 1993. Sustainable agriculture: The future of Thai farmers. In: *Annual Technical Bulletin for 1993*. Ministry of Agriculture and Cooperatives, Thailand. 336 pp.
- FAO 1991a. Sustainable agriculture and rural development in Asia and the Pacific. Regional Document No. 2, FAO/Netherlands conference on Agriculture and the Environment. Hertogenbosch, the Netherlands, 15 - 19 April. (Unpublished mimeo).

DISCUSSION

Dr. Mutert asked whether Thailand's program of crop diversification was likely to lead to an increased use of pesticides. Dr. Aphi Phan thought this was likely in the case of fruit and vegetable crops, for which there is often an overuse of pesticides, and also of crops harvested at an early stage such as baby corn. He pointed out that many farmers in Thailand are not well informed about pesticide use, and apply chemicals only a few days before harvest in order to improve the appearance of the produce. Dr. Saleem Ahmed had been interested to see a commercial preparation extracted from the neem tree on sale in Thailand, and asked whether regulations had been relaxed to allow the manufacture of such products. Dr. Aphi Phan replied that there had been a lot of research in Thailand into neem tree extract, which had been found to be a good insect repellent.

Dr. Mutert raised the point that the situation in Thailand concerning the disposal of livestock wastes was fairly typical of the whole region. Most of the intensive pig raising carried out in Thailand is found in the central plain near large urban markets, where it produces large quantities of organic wastes. On the other hand, it is in northeast Thailand that soils are particularly in need of organic matter. He asked whether there was any way of solving the problem of this spatial separation between areas with a high concentration of organic wastes, and areas with a high demand for them. Dr. Aphi Phan replied that no study has yet been made of the feasibility of moving wastes from the central plain to northeast Thailand, but suggested that it might be better to think in terms of crop-livestock integration, and the development of livestock production in the northeast. Director Koh of FFTC pointed out that illegal logging was in the long term a disaster for the whole of Thailand, and asked whether the Thai government had programs to stop it. Dr. Aphi Phan replied that government policies had imposed a ban on all logging in Thailand, but that some illegal logging was still being carried out.