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FARMING SYSTEMS DEVELOPMENT FOR SMALL FARMS: RESOURCE USE, PRODUCTIVITY AND INCOME CHANGES

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1. Introduction

1.1 Importance of Farming Systems Development

The continued high rates of population growth ranging from 1.6 to 2.8 per cent in the developing countries of Asia like Sri Lanka, Indonesia, Nepal, the Philippines and Thailand are accompanied by increases in the demand for food. In many instances, however, the land area available for agricultural expansion either has already reached its limit or the available lands are considered marginal for agricultural purposes (Table 1). In addition, urban growth continues to exert pressures on agricultural lands for conversion to industrial and residential purposes.

In view of these conditions, there has been a shift from land area expansion to increasing land productivity as a source of output growth. Consequently, there arises the need to develop technology and ways for increasing land productivity as well as the income of small farmers. During the past few years, a methodology for developing new production systems of farming has been evolving which has contributed to the development of a relatively new research program on farming systems.

The concept of farming systems takes into consideration all farming attributes which are evaluated as to how best they can be used. This systems approach may advocate the raising of two or more different crops, livestock or even fish in a given area at the same time or in a sequence during the year.

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Table 1 – Selected Basic Information for Countries Studied

Country	Area			Population	Density		Employment		
	Total Land	Agricultural 1975	Cultivated 1975	Mid-1977	Persons Per Sq. Km.		Total 1977	Agricultural Latest Year	Manufacturing Latest Year
		Million Hectares		Million	Annual Population Growth (% 1973-77 ave.)		Millions	Per Cent	
Indonesia	190.43	28.48	18.60	136.91	72	2.4	46.17	58.8	9.4
Nepal	14.08	4.00	2.00	13.14	93	2.2	4.85	94.4	1.1
Philippines	30.00	8.56	7.90	44.66	149	2.8	15.43	52.7	10.9
Sri Lanka	6.56	2.42	1.98	19.94	213	1.6	3.33	50.4	9.6
Thailand	54.24	16.89	16.58	44.16	81	2.8	13.82	62.6	n.a.*

Source of Basic Data: Asian Development Bank, Statistics Unit, Economic Office, April, 1978.

*Not available

The systems approach considers the following: an enumeration of components, the resources use of the system, the productivity of each component, the potential for achieving greater productivity in the system improvement of component technologies, potentials for better resource use, potential for greater efficiency of resource use and greater productivity through improvement of interactions and possible changes in farm family well-being (Harwood, 1980).

Thus, the farming system implies the combination of enterprises (cropping pattern, animals, or other ventures, etc.) of a single farm and their management and interaction within the system, between it and its environment. The ultimate objective of a desirable farming system is for a farmer to use his skill, ability, knowledge, and experience to obtain the highest productivity from his farm and to achieve a higher income from his limited resources and environment.

1.2 Objective of the Review

The objective of this review is to formulate a program of action on farm management in support of farming systems development at the national and regional levels. The intermediate objectives are to:

a) analyze the present farming systems in the different agro-ecological zones of selected countries in the region and to assess their impact on resources and income of the small farmers;

b) study recent developments in farming systems development and examine the farm management constraints that hinder further development; and

c) examine national policies hastening or hindering the accelerated development of farming systems with a view to offering alternatives as improvements.

This analytical review is based on various sources of information obtained from five Asian countries, namely: Indonesia, Nepal, the Philippines, Sri Lanka and Thailand.

2. Background Setting of Farming Systems Development

The physical environment, particularly its climate and soil type, the agro-ecological zones, cropping patterns, and the agricul-

tural development background of farming systems in the different countries are briefly described in this section.

2.1 Climate, Soils, Topography and Agro-Ecological Zones

The countries included in the review are situated in the tropical belt and have remarkable similarities in physiographic and climatological features. The topography ranges from low flat coastal plains and swamps to rolling hills and plateaus with climate mostly equatorial or monsoonal. In most parts of the region, the annual precipitation may exceed 1,000 millimeters except in small isolated pockets in the rain shadows of hill features. The number of wet months ranges between 5 and 9. There are, however, two extremes where there is a poorly defined dry season (more than 9 wet months) and a pronounced dry season (2 to 5 months). The location in the tropical belt and the moderating effect of nearby large bodies of water influence the mean daily temperature. This may range from 25° to 28°C except in places where higher altitudes cause a lowering of temperatures.

All islands in Indonesia contain mountain areas and most of them have extensive structures of lowland plains. The climate is hot and humid. The rainfall for most parts of the country is in excess of 2,000 millimeters. The true dry season does not exist but certain months may be drier than others, mostly in the rain shadow areas. The equatorial tropical rain forests cover more than 60 per cent of the country.

The Kingdom of Thailand is divided into five broad physiographic regions: (a) the Central Plains; (b) the Southeast Coast; (c) the Northeast Plateau; (d) the North and West Continental Highlands; and (e) Peninsular Thailand. Climatically, four seasons are recognized, namely: (1) the southwest monsoon season from May to September (rainy season), (2) the post-monsoon season during October (a transitional period from the southwest to the northeast monsoon), (3) the northeast monsoon from November to February, and (4) the pre-monsoon during March.

The country of Sri Lanka has a central mountainous mass that rises in a series of tiers or ramparts from a low, undulating plain surrounding it on all sides and extending to the sea. Rivers radiate out from the central highlands following geological fault lines in their upper reaches.

Due to its particular location in the Indian Ocean, the rainfall over most parts of the country follows a bi-modal pattern. The mean annual rainfall ranges from 200 inches in the very wet area to 35 inches in the semi-arid to dry areas. The dry zones of Sri Lanka fall within the rain shadow of the southwest monsoon and thereby experience dry dessicating conditions from June through September. Based on rainfall, vegetation, soils of present land use, the country can be divided into three main agro-climatic zones, namely: (a) wet zone, (b) intermediate zone, and (c) dry zone.

Nepal, which is landlocked, has an area of 14.08 million hectares with lands having an elevation ranging from 61 to over 8,000 meters. More than half of the area is over 1,500 meters above sea level. Geographically, Nepal can be divided into three main regions, namely: Himalayan belt and mountains, Hill, and Terai (plains). Out of the total cultivated area, 60 per cent is in the Terai region.

The Terai region occupies 17 per cent of the total land area and has alluvial soils. The climate is sub-tropical and the altitudes go up to 305 meters. Paddy is the main cereal crop. The Hilly region comprises the best pasture land and agricultural land. This region lies between the Himalayan and the inner Terai region. The altitude varies from 610 to 3,658 meters and occupies 64 per cent of the total area of the country. The third region, the Himalayan, and so-called because of the high broader ranges and peaks with perpetual snow from 4,876 to 8,748 meters, has only the southern part cultivable.

The main rainy season is in the summer. The rain is fairly well-scattered but is unevenly distributed throughout the country. In summer, the eastern part of the country gets the maximum rains and decreases towards the west. In winter, the process is reversed. The average rainfall of the country is approximately 2,200 millimeters.

Temperature is quite variable over the agricultural land from south to north. As a consequence of altitudes and topography, the climate ranges from sub-tropical to tundra or polar. Mean air temperature ranges from 8.5° to 27.6°C.

The Philippines has two pronounced seasons, namely: wet and dry seasons. Heavy rains come from June to September. However,

the country may be divided into seven rainfall patterns (based on rainfall distribution during the year). The average annual rainfall is 2,533 millimeters with the following averages for the three main geographical regions: Luzon, 2,724 millimeters; Visayas, 2,392 millimeters; and Mindanao, 2,350 millimeters. The country has 175 days as the mean annual number of rainy days.

The temperature is moderately warm which may range from 24° to 31°C (during unusually hot months occurring in March, April and May). In December and February, temperatures may drop to 18°C or even lower.

2.2 Major Farming Systems

There can be as many farming systems as the number of farmers. The inventory and generalizations become more complex and less manageable because innumerable combinations of cropping patterns can be found in the countries under consideration.

The term *farming systems* will be used loosely in the following discussion since not all the available information in each country included in this analysis will fit the definition. As indicated in an earlier section, the farming system includes the crop and/or livestock production patterns and their environments. Since production patterns are influenced by physical and economic environments, the farming systems may, therefore, be taken as the crop and/or livestock production patterns which operate under given physical and other environments.

Indonesia has a rich natural resource base of soils and climate. This condition contributes to a wide diversity of cropping patterns.

A rice-based cropping pattern that can be identified is the practice that prevails in East Java where there is the usual succession of paddy, and dry grains such as legume and sugarcane. The cycle is of one year duration and the sugar crop is heavily manured. Aside from the rice-sugarcane-pulses-corn cropping system, annual crops including root crops such as cassava, yams, taro, sweet potatoes, grain legumes and bananas are planted. Cigar wrapper tobacco is sometimes grown in rotation with rice. Relay planting, or the intercropping of one crop before the first is harvested, is a widely used technique. There are other intensive rotations and mixtures.

Estate crops have been developed to a high degree in parts of Sumatra.

In homestead areas, native villages are surrounded by an enclosure called "pekarangan desas" (a sort of garden) which provides a supply of beans, cucumbers, gourds, melons, yams, papayas, etc. on a year-round basis.

Cropping patterns used by farmers, particularly in transmigration areas, usually consist of upland rice integrated with corn which is interplanted with or followed by cassava.

In the perennial crop-based cropping system, food crops, like rice and cassava, are planted generally for a couple of years. Then the perennial crops like coffee and rubber trees become the sole crops.

In Nepal, crop cultivation and raising livestock are two main interrelated activities of Nepalese farmers. Predominantly crop-based farming systems exist in the plains (Terai). The major cropping patterns of the Terai area are rice-wheat, rice-rice-wheat, rice/lentils-fallow, rice-potato, and maize-mustard or wheat. Depending upon the ethnic groups, the livestock raised are goats, pigs, and poultry. Forest and fallow land grazing are practised.

In the hill farming systems, maize and millet are the important crops with cattle and goats as integral part of the farming systems. The major cropping patterns are rice-wheat, maize-beans/finger millet-wheat, maize-soybean-mustard or wheat, and rice-wheat-potato or barley. In mountains, barley, buck wheat and potato have been the main crops with yak, chauri and sheep as the predominant animals. Farmers also grow many kinds of fruits and vegetables.

For the Philippines, only the following types of farming systems will be considered briefly: (a) upland crop-based farming systems; (b) lowland rice-based farming systems; (c) coconut-based farming systems; and (d) sugarcane-based farming systems.

In the upland areas, the base or main field crop is usually upland rice and corn. Recently, soybean and sorghum have been added

to these crops. The multiple cropping practices include corn-legume, soybean-corn, and corn-vegetables.

Rice monoculture is still a predominant practice in the lowland areas, but some farmers are now utilizing multiple cropping with vegetables and other crops. There are at least two types of cropping patterns used by rice farmers, namely: (a) rice followed by rice, and (b) rice followed by upland crops. Under the first type, there are three cropping patterns, namely: (a) rice-rice-fallow, (b) rice-rice-rice, and (c) rice-garden. With respect to the second type, there are four upland crop sequences: (a) fallow-rice-upland crops, (b) upland crop-rice-fallow, (c) upland crop-rice-upland crop, and (d) rice-rice-upland crop.

In the coconut-based farming system, a large number of farmers have been traditionally planting crops between trees. Among the most common intercrops are bananas, coffee, lanzones, papaya, ginger, gabi, peanut, rice and sweet potato.

Reports indicate that sugarcane-based cropping systems are still in the experimental and demonstration stages. The major crops that have been used as intercrops in sugarcane areas are rice, mungbean, peanut and soybean. In some provinces, rice is the most popular intercrop. In some places, legumes such as mungbeans, peanut and soybean are used as intercrops.

Studies have shown the potential for more extensive adoption of integrated crop and animal systems. These include (a) livestock-coconut-farming system and (b) livestock-rice-based farming system.

In Sri Lanka, the traditional pattern of cropping in the irrigated lands is rice followed by rice and the cropping intensity is about 1.2. Attempts are now being made to grow subsidiary food crops such as grains, pulses and some spices on these lands.

Coconut lands cover about 0.4 million hectares and most of the lands are in small holdings. The potential crops for intercropping are pineapple, ginger, turmeric, and manioc, among others. There exist nearly 142,000 hectares suitable for intercropping.

The following discussion categorizes farming systems in Thailand along geographical regions.

In the central region, there has been extensive irrigation development. Consequently where water is available, part of the area is under extensive cultivation resulting in a year-round growing of rice. However, areas close to urban centers like Bangkok practice land uses where rice cultivation is modified for growing of vegetables and fruit crops for the urban markets.

In areas less endowed with water, other crops such as sugarcane and maize have replaced old rice areas along with new areas. In some farming areas, for example, in Sumutsakorn and Samutsongkram, southeast of Bangkok, insufficient river water flows resulted in sea water intrusion. A number of the ruined farms have been converted into fish-prawn farming while others have been abandoned. The northeast region is involved in cassava production. In the north, particularly in the Chiangmai Valley, where irrigation is well developed, the farmers have developed their own farming systems of which some 20 cropping systems have been identified. Meanwhile, highland minority farmers practise the swiddening system.

In the south, due to different physical environments, particularly rainfall, climate and topography, perennial crops and fruits are grown with only limited areas allotted for rice production. The extensive seacoast makes coastal fishing a part of the farming system.

3. Farming Systems Development: Implications on Productivity, Resource Use and Income on Small Farms

Agricultural development has been a major concern in the countries included in the study. Since there is a preponderance of small landholdings, this concern is obviously focused on how to attain food self-sufficiency for these small farmers, many of whom hardly attain a subsistence level of production from their farming activities.

The system of production in these farms is generally crop-based with rice being the usual monocrop or the major crop if combined with other crops. The advent, and later, the introduction and partial or full adoption of high-yielding varieties (HYVs) of rice in both irrigated and rainfed rice farms, however, paved the

way for a similar acceptance of other nontraditional inputs such as chemical fertilizers, insecticides, weedicides, etc. Likewise, new or expanded services and assistance from supporting institutions became more readily available. Consequently, the impact of these innovations has been the major feature of the contemporary developments in agricultural production.

This breakthrough in traditional farming has become a model for developing and packaging appropriate technologies and their ultimate transfer, hopefully, to small farms. A note of disagreement has been voiced by some observers who aver that the real beneficiaries of this so-called "green revolution" are the higher income farmers who are more financially able to muster the use of the package technology and needed inputs.

Many farmers have been traditionally raising a number of enterprises in the same farm during any given period. Cropping patterns, however, vary greatly from place to place depending on the soil, topography and weather conditions. Despite the seemingly favourable conditions for increasing agricultural production the small farmers continue to exist under subsistence level of living.

The fundamental issue with reference to small farmers is how to raise their income levels. This can come about by: (a) a rise in production levels of those farms, (b) incorporation of new and remunerative enterprises in their farm organization, and (c) concommittantly removing the barriers which prevent access of the small farmers to the most fundamental set of inputs, i.e. education extension and institutions. Education and extension enable the farmer to acquire the production skills while it is the institution and method and manner of functioning which determine the accessibility of the farmers to the production prerequisites (Kanungo 1974).

4. Recent Development in Farm Systems Research and Changes in Farm Productivity and Income

Farm systems research, although it has existed for many years has taken different forms at different times in the different countries studied.

Farm systems research in Nepal has been considered as a new approach (Mathema, 1981). Although the different disciplines

of agriculture and commodity programs (rice, wheat, maize, potato, pulses, etc.) have developed new crop varieties and technology which have contributed to increased production of these crops, these new varieties and technology were not immediately accepted by the farmers. The latter observed that the results in the farmers' fields were not the same as those found in the experimental fields.

The introduction of the cropping systems approach brought about the integration of different components (disciplines of agriculture) and commodities of the systems. In addition, the cropping systems research has been conducted directly in the farmers' fields with the farmers' participation which resulted in the identification of stable production and profitable technology to increase total production and income of the farmers. Thus, the role of farm management as a link discipline came into the picture.

After three years of research (which started in 1977) in the farmers' fields, several improved techniques which substantially improve the cropping systems of small farmers have been identified at the different sites.

Results from cropping systems trials in all sites showed very high potential for increasing production. Increases in yields of major crops in the patterns can be achieved by changing some of the components like variety and/or practices in the pattern.

The concept of multiple cropping in the Philippines was adopted as a national program of research and development in the seventies. Eventually, it was expanded into what is now known among the researchers as the farming systems. The reported programs in 1979 were grouped into three general categories, namely: (a) cropping pattern testing in farmers' fields; (b) testing of component technologies; and (c) development programs (Deomampo and Bardido, 1981).

To assess the performance of the various cropping patterns, costs and returns studies were conducted in various areas. Table 2 shows the combination of enterprises with high net returns in the different lowland rice-based farming systems. It must be recognized, however, that the relative profitability of specific enterprise combinations will depend upon cost/price relationships of inputs and products at a given set of market conditions. Never-

Table 2—Costs and Returns by Cropping Patterns, 327 Farms, Nueva Ecija 1976-1977

Cropping Pattern	Crops Planted	No. of Farms	Farm Size (Ha.)	Effective Crop Area (Ha.)	Cost/ Hectare (Pesos)	Returns/ Hectare (Pesos)	Net Farm Income/ Hectare (Pesos)
I	Rice-Watermelon	10	3.4	4.5	1462	2592	1130
II	Rice-Stringbeans	10	1.8	2.3	1457	2453	996
III	Rice-Sugarcane	14	2.6	3.2	873	1229	956
IV	Rice-Tobacco	10	1.8	2.5	929	1783	854
V	Rice-Onion	13	1.8	2.5	1050	2857	1807
VI	Rice-Corn	10	1.4	2.5	454	404	(−50)
VII	Rice-Corn-Onion	10	2.3	3.4	1760	3065	1305
VIII	Rice-Corn-Sweet Potato	10	3.4	4.7	1209	2207	998
IX	Rice-Onion-Peanut	10	2.7	4.0	1044	2113	1069
X	Rice-Corn-Peanut	10	1.6	2.7	697	1758	1061
XI	Rice-Onion-Cabbage	10	2.0	3.1	2127	4184	2157
XII	Rice-Corn-Cassava	20	2.7	3.8	763	1681	918
XIII	Rice-Corn-Eggplant	20	3.2	4.5	1567	2658	1091
XIV	Rice-Corn-Stringbeans	20	2.4	3.4	1447	2252	805
XV	Rice-Eggplant-Tomato	30	2.3	3.2	1543	2357	814
XVI	Rice-Tomato-Mungbean	10	3.0	4.0	1055	1916	861
XVII	Rice-Eggplant-Bitter Gourd	10	2.8	4.0	1371	2410	1039
XVIII	Rice-Mungbean	10	2.3	2.7	983	1513	530
XIX	Rice-Stringbeans-Mungbean	10	2.5	3.2	1459	2974	1515
XX	Rice-Stringbeans-Eggplant	30	2.4	3.3	1388	2433	1045
XXI	Rice-Corn-Onion-Eggplant	10	3.4	4.8	1516	2155	639
XXII	Rice-Corn-Tomato-Eggplant	10	2.6	4.2	1406	2245	837
XXXIII	Rice-Mongo-Tomato-Eggplant	10	3.1	4.3	1213	2058	845
XXIV	Rice-Corn-Tomato-Eggplant-Turnip	10	2.4	4.0	1790	2750	960
XXV	Rice-Stringbeans-Mungbean-Eggplant	10	1.9	2.7	1294	2166	872
ALL CROPPING PATTERNS		327	2.5		1274	2272	998

Source of basic data: Alviar, N.G., Multiple Cropping in Nueva Ecija, 1977.

theless, this type of economic analysis is an area where farm management extension can provide tremendous assistance to small farmers in helping them choose the enterprise combinations under a given set of cropping system alternatives.

Coconut farmers who have recognized the benefits of intercropping have been planting other crops between the coconut trees. The most common intercrops are banana, lanzones, papaya, ginger, gabi, peanut, rice and sweet potato. These crops considerably increase the net returns of the farmers. Table 3 shows some of the results of studies on coconut-based farming systems.

Table 3 – Costs and Returns of Intercropped Coconut Farms in Quezon, Laguna, Cavite, 1974-1977

Item	Intercrops			
	Banana	Cassava	Lanzones-Banana-Coffee, etc.	Coffee-Rootcrops
	Per Hectare			
Number of farms reporting	18	10	50	25
Area/farm (has.)	2.29	2.85	–	1.2
Total Returns (Peso)	1,205	1,362	5486	3836
Total Costs (Peso)	815	848	4969	473
Net Returns (Peso)	390	514	517	3836

Sources:

1. Eusebio, E., "An Economic Comparison of Coconut Farms Intercropped with Cassava and Bananas in Candelaria, Quezon, 1973-74" (Unpublished undergraduate thesis).
2. Pujanes, O.M., "Farm Management Study of Intercropped Coconut Farms in Alaminos, Laguna, 1977" (Unpublished B. S. thesis).
3. Eguia L. D., "Farm Management of Multiple Cropping Scheme in Silang, Cavite, 1974-75" (Unpublished B. S. Thesis).

Similarly, sugarcane farms intercropped with other crops have shown higher net incomes for the small farmers.

The vast majority of the livestock and poultry producers in the country are the "backyard" or smallholder type. Most of these livestock enterprises are integrated with crop enterprises since the animals subsist mainly on grass weeds, crop residues and other farm by-products.

Livestock has also been integrated with rice. These crop-livestock farming systems have boosted income of small farmers as indicated by a limited number of studies conducted in this type of farms.

The cropping systems program in Sri Lanka was evolved in 1976 by the Department of Agriculture and its emphasis is the development of new cropping systems that would be suitable for farming utilizing minor tanks. This program was eventually expanded to include some up-country intermediate zone areas. The predecessor of this program was the development of technology to meet the needs of the rainfed farming system. The emphasis at that time was monocrop development at the Agricultural Research Station at Maha Illupallama (Ranaweera, 1981).

The Sri Lanka rice-based cropping system research program aims to increase food production by increasing: (a) the yield per unit area; (b) the crop intensity; and (c) land area under cultivation of marginal lands.

The cropping system research revolves around the use of rice as a main crop during the wet season and rice or other food crops during the dry season depending on the availability of water.

A notable component of the research program is the dry zone village tank settlement project. In this zone, there are approximately 10,000 village tanks servicing an estimated area of 120,000 hectares. The tank is essentially a man-made water reservoir which collects water during the rainy season and the stored water is utilized to irrigate the farms in its area of influence. A typical village tank settlement comprises 43 farm families who own a total of

12 hectares of paddy fields or an average holding size of 0.3 hectare. Prior to the conduct of the experiment in 1976, the cropping intensity in a village was less than 1.0.

The traditional practice of agricultural production which the research project is attempting to modify is the farm operations relation to land preparation in the *chena* which starts by clearing land in the jungle in July and their growing of the *chena* crops of maize, mustard, grain legumes sown in September with the first rains. Rice production starts in mid- or late December after sufficient water has been collected in the tank. When rainfall is inadequate, and there is sufficient water in the tank, the land is left to fallow or at most only one crop of rice is obtained.

Briefly stated, the new approach: (a) advances the planting date for rice so that the farmer can benefit from the first rains and this involves the dry sowing of rice for which land has to be prepared in early September; and (b) uses early maturing varieties so that the wet season paddy crop can be harvested earlier with a minimum of supplementary irrigation. A second crop of rice can be obtained provided there is sufficient water in the tank. Nevertheless, the early planting of rice assures at least one crop of rice.

The experience during the four-year research period has demonstrated that the new technology could significantly improve the small farmers' productivity and income. The new varieties have doubled the yields and the new practice permitted double cropping which almost doubled the effective crop area. The net effect has almost quadrupled farmers' productivity and income.

Agricultural research in Thailand has been conventionally undertaken along disciplinary lines. Although in some cases a research project may include researches from several disciplines, the identification of problems is made along separate disciplinary perspectives. This, inevitably, results in a disciplinary research which views the farming system as a linear combination of component activities. Hence, farming systems research and development is one of the research areas being proposed in the Department of Agriculture and Cooperatives (Seetisarn, 1981). However, multiple cropping research has been an ongoing activity and there exist various cropping patterns from place to place depending on the soil,

topography and weather conditions. Among the institutions engaged in cropping systems research for both rainfed and irrigated areas are the Department of Agriculture, Chiangmai University and Khon Kaen University.

The Multiple Cropping Project (MCP) is an inter-disciplinary research project of the Faculty of Agriculture, Chiangmai University. Started in 1969, the program evolved two main programs, namely, the agronomy and social science programs.

The agronomy program has focused on the design and testing of various cropping systems while the social science program has set about identifying the economic and social constraints to increasing cropping intensity. This project is aimed at eliminating the weaknesses of recommended cropping systems which have maximum production potential but employ a package of practices designed for optimal conditions of water supply, labor, etc. However, the resulting cropping systems may not suit the needs of farmers with social, economic and physical constraints different from those in the experimental plots. The project involves a team of staff members representing the disciplines of agronomy, soil physics, crop breeding, crop physiology, weed science, entomology, plant pathology, agricultural extension, agricultural economics and systems ecology.

Among the objectives of the MCP were to find cropping systems that, under near optimum conditions, gave high net returns to farmers willing and able to invest in and take the risks associated with adopting new technology and ideas. In general, the cropping systems which gave high net returns are usually the ones where total costs, labor and cash costs are relatively high and vice versa. The important implication of these research results is the need for a farm management extension man to work closely among the researchers in the other disciplines and to make this information available to farmers for their decision-making in the choice of crops.

5. Implications on Resource Use: Land, Labor, and Capital

Farm systems research has shown the potentials for increasing agricultural production per unit of land by modifying existing cropping patterns and/or introducing new ones. Farmers have, however, traditionally grown two or more crops per unit of land a year under matching agronomic seasons. Generally, the cropping systems

are specific to a particular location and most likely have evolved to suit particular combinations of topographic, soil, water supply and socioeconomic factors.

Conventionally, the measure of cropping intensity is the cropping index which is defined as the number of crops grown on the same piece of land in one year, times one hundred. Effective crop area, as a measure of land use intensity, means the total area planted to one or more crops on the same land at a particular year.

Multiple cropping systems have substantially increased the intensity of land use under favourable combinations of agro-ecological and socioeconomic factors. This is particularly significant for the small farmers whose agricultural production from their small landholding may even be doubled or tripled if the recommendations of the farm systems research are adopted or accepted.

The cropping intensity prior to 1976 in Walagambahuwa, Anuradhapura District in Nepal was less than one. The research project attempted to increase this cropping intensity by advancing the planting date of the first crop of rice, thus taking advantage of the rainy season. With the use of early-maturing varieties, the first crop could be harvested earlier which was followed immediately by a second crop. The second crop was irrigated by means of water stored in the tanks for the purpose. The effective crop area was, therefore, almost doubled. The yields per unit area beginning 1978 were almost quadrupled compared to 1976 as a consequence of double cropping and the use of HYVs.

Similarly in the Chiangmai Valley multiple cropping project, the average cropping index was estimated to be 163 per cent in 1978. Rice in the wet season is the main crop in the valley and almost all of the cropping systems are built around this crop. However, it is to be noted that the cropping intensity is closely related to water supply. Single cropping is still found in areas with no water supply during the dry season. Throughout the valley, farmers often devote a very small fraction of their land to continuous cropping of vegetables, mainly for home consumption. Triple cropping on a large scale is restricted to the areas served by irrigation systems.

In areas where perennial crops are planted, caution must be made in the interpretation of land utilization and cropping intensities. In Sri Lanka, the Philippines, and Indonesia where some small landholdings are planted to coconuts, the tree population per unit area may be less than the desired optimum. Consequently, the average productivity per hectare of coconut land will be low. These small landholdings, however, may also be intensively intercropped with coffee, cacao, bananas, fruit trees, etc. either singly or in combination. In the Philippines, cattle are allowed to graze in some of the coconut tree farms. A farm business analysis of coconut-based cropping and/or livestock farming systems could indicate that higher returns could be obtained from the farm enterprises other than from coconuts. There are no figures available from the countries studied as to how much of the small coconut landholdings is fully intercropped. This is a topic that could be a subject for research as the potential for increasing incomes of small farmers exists.

The cropping system studies in Nepal indicate that, at present, labor and/or power shortages do not pose a constraint for more intensive cropping. As a matter of fact, the labor absorption capacity of the new or modified cropping systems will be a boon and a solution to the problems of unemployment and underemployment. It is even anticipated that labor shortages could develop as more of the land in the Pumdi Bhumdi site in the Western Hill Region of Nepal is double– or triple-cropped. This situation can happen because more working days are required to prepare the land area for the additional crops and because fewer days are available between crops for land preparation. Actually, there is a shortage of labor in peak periods for some of the field operations (Mathema, 1981).

Labor utilization also varies by crops and the level of management. In the Chiangmai studies, the labor profiles of eight multiple cropping systems developed by the research project and six traditional systems were compared. Of the eight introduced systems, the rice-peanut sequence has the highest peak labor demand when farmers prepare the land and plant tomatoes. High peaks also occur in sequences with garlic for land preparation and planting and in sequences with peanuts for harvesting.

In the traditional systems, the highest peak is still lower than the peak labor demand in the MCP systems. In general, the introduced systems require more labor in the peak periods than the

traditional cropping systems. Some of the introduced crops also have peak labor requirements at times different from those of traditionally grown crops. Farmers will then be faced with the following situations: (a) whether farmers can reallocate their labor to meet the new peak demand; and (b) whether there will be enough hired labor and/or exchange labor to help in the operations. In the event that a farmer may be able to meet the peak labor demand through hired labor, he may be faced with the problem of obtaining the cash requirements of the additional labor (Gypmantasiri, *et al.*, 1980).

In Sri Lanka, the average family size in the research site is 6.4 with four adult members. The women participate primarily in the *chena* (shifting) cultivation farms. The research data indicated an underutilization of labor (about 50 per cent) of the total available labor of nearly 160 hours per week per family. The weekly labor studies indicate that: (a) two peak periods exist, the first being around four weeks after the first rains and the second during the harvesting period; (b) there is low labor use (both family and hired) even during the crop season; and (c) the advancement of the season due to the new approach has led to a stabilization of labor use between the different components of the farm (Ranaweera, 1981).

A perennial crop, like coconut, when planted under a monocrop system, will have underutilized labor specially in small landholdings. The only major requirement for the coconut farm will be for harvesting which comes only between 45 to 60 days each harvest and for periodic underbrushing once or twice annually. The advantage of multiple or intercropping coconut trees to increase labor utilization is, therefore, very obvious. The only possible bottleneck would be the landowner himself if the farmer operator is a tenant. As pointed out earlier, some landlords do not want any intercrops in their lands.

There is, therefore, a very favourable impact of developing and adopting new farming systems, particularly multiple-cropping, where agronomically and economically feasible, for small farmers to increase their labor utilization.

Fixed capital, excluding land, on small farms is generally low with only a few hand tools and work animals for some farmers. The operating capital is also low and sometimes minimal or even none at all. The chief source of the cash flow is the sale of produce and the

amount coming from off-farm earnings whenever available. Because of the absence of collateral, institutional credit is not readily available.

The studies in the introduction of improved farm systems indicate an increase in the cash requirements for such expenditures as hired labor, seed, fertilizer, chemicals, insecticides and, in some cases, farm equipment. Philippine studies showed that a livestock-rice farming system required about 80 per cent cash operating cost.

The implication of the introduction of new farming systems is, therefore, very clear. There is a need for the small farmer to obtain additional operating capital generally in the form of credit. This may pose a problem since most credit institutions require collateral which the small farmer may not have. Alternatively, the farmers may obtain credit from money lenders, stores, landlords and others who may charge higher interest rates.

6. Some Critical Factors in Farm Systems Development

A cursory review of the farm systems research suggests varied impacts of a number of critical factors. These factors have either fostered or hindered farm systems development. They have been categorized as follows: (a) natural, (b) technological, (c) socioeconomic, (d) institutional, and (e) administrative factors.

Natural Factors. Lack of water for irrigation appears to be a critical factor for areas with distinctive wet and dry seasons. The provision of irrigation facilities is more feasible where water resources are available either through dam diversion or pumping. This could entail, however, huge capital investments for infrastructure construction. Where irrigation is available on a year-round basis, triple cropping systems are even possible. In dry zones without water resources that can be tapped for irrigation, the experience of Sri Lanka with the use of tanks is very relevant. These tanks have been built many centuries ago and have been found to be a critical factor in the successful introduction of multiple cropping farming system through judicious water management practices in the dry zones. On the other hand, the negative effects of water can also be found in flooding or poor drainage. In coastal areas, there may be salt

intrusion through natural waterways. Weather disturbances such as typhoons, droughts, or hail in upper altitudes are also considered as critical problems.

Technological. None of the countries considers the lack of technology as a constraint to farm systems development. Technologies can be developed through cropping systems research which, in turn, can fit the appropriate technology to a specific agro-climatic zone. The problems often arise when successful results of experiments do not correspond to the results obtained in the farmers' field and the farmers are unable to increase their crop yields substantially.

Socioeconomic. Despite the distinct advantages of the new technologies and the benefits to be derived from them, there still exists the reluctance of farmers to accept the innovations. This attitude may be traced to the higher monetary risks associated with the increased cash costs of adopting the new technology. This implies that there is a need for the researcher to develop farm systems technology with minimal cost or risk to the farmer.

Crops marketed may also receive lower prices due to lack or absence of roads and transport facilities. In addition, lack of ready or easy access to processing and canning factories can cause problems for perishable crops such as tomatoes, cabbage and other vegetables.

Farmer attitudes and practices were also observed as constraints to a programme of intensified multiple cropping. For example, in one country the tradition of transplanting being carried out by women and children and plowing and land preparation by the men, resulted in longer turn-around times in the cropping sequence. Preparation for and participation in festivals during certain times of the year reduce attention to cropping at that time.

Institutional. Many of the inputs required in the new cropping system have to be purchased, and hired labor have to be paid. Unless the small farmers have the necessary working capital, credit will be required. In some countries, credit institutions, where they are available, may not cater to farmers who may not have the required collateral. In the Philippines, this problem has been partly met through the institution of supervised credit. In addition, an integrated agricultural financing scheme had been adopted to take care of the needs of integrated farming. Normally, credit is made available on a crop

or commodity basis which becomes unwieldy to be administered when several enterprises are combined in the same farm.

In research, the technologies that have been developed are only for single activities either for crop or livestock. However, when such technologies are combined as a package, they may be found not fully relevant to many farming situations. In such package strategy, it may be difficult to fit the different physical, biological, social and economic conditions of a location and the individual farmer's preferences. The farming systems research that must be undertaken, therefore, must not only consider the interactions of the combined crop and/or livestock technologies but their adaptability to specific locations.

Administrative. In some countries, the organizational structure of extension programs may also be detrimental to the development of farming systems. It has been observed that within a country, there could be two or more agencies performing extension functions without any inter-agency coordination. Thus, the confused farmers become a target clientele of each agency whose efforts may become counterproductive of each other.

7. Promotion of Farming Systems Research and Development: Relevant Policies and Programmes

The national development plans of the countries included in this review emphasize the development of the agricultural sector. Agriculture has received higher priority in the plans because of its relative importance in the different economies in terms of increasing farm production to meet the national food requirements, bolster employment generation, increase export earnings and reduce dependency on imported inputs.

The policy goals and programmes are however, broad enough such that they could easily enhance the promotion of farming systems research and development. In general, these policies and programmes may be categorized into those which will: (a) encourage domestic production; (b) promote supply and price stability; (c) promote marketing efficiency; (d) strengthen the bargaining position of producers (farmers); and (e) provide general incentives.

Policies which encourage domestic production include such policy/programme instruments as intensified commodity production

programmes, liberalized agricultural credit and financing schemes, provision of inputs at subsidized prices, and construction of agricultural infrastructure (irrigation, drainage projects and farm-to-market roads).

To promote supply and price stability, countries adopt such policy/programme measures as price support, buffer stock operations, and provision of storage facilities, especially for perishable products.

The overall efficiency in marketing may be attained by measures, such as providing readily available and timely marketing (primarily price) information for farmers, grading and standardization regulations, and a standard system of weights and measures.

The bargaining position of producers (farmers) is strengthened by programme measures which promote and develop farmers' marketing cooperatives and allied forms of associations.

General incentive policies may take the form of tax exemptions for important farm machinery and reduction of export taxes (if any) for agricultural export production. Land reform, or agrarian reform for even a broader programme, is perceived to promote a more egalitarian income and wealth distribution by diffusing and diversifying property ownership.

Thus, policies and programmes needed to promote farming systems development and research already exist in the different countries, although they may not be specifically directed to such an activity. Also, different countries have different emphases and/or priorities in programme/project implementation. To cite a few examples, Indonesia has its intensification programmes, the BIMAS programme, and infrastructural projects; Thailand, infrastructural projects, agricultural credit schemes, land reform programme, and price policy measures; Sri Lanka, paddy development schemes and guaranteed prices; Nepal, integrated rural development programme, crop intensification and export promotion programmes; the Philippines, crop production programmes (Masagana 99 and Masaganang Maisan Programmes), supervised credit and integrated agricultural financing schemes, etc.

8. Supporting Institutions and Services

Supporting institutions and services promoting farming systems development among small farmers exist in the countries in varying

degrees and scope. These are being undertaken in any one or more o the following agencies or organizations in a particular country: re search institutions (international crop institutes, commodity insti tutes), educational and training institutions, government ministries departments of agriculture (for extension, pest and disease control marketing services, etc.), farmers' organizations (cooperatives, farm ers' associations, credit unions, etc.), banking and credit institutions and other non-governmental organizations.

9. Future Directions in Farm Management Work

The salient points of farming systems research and developmen may be summarized as follows:

1. The farming systems concept involves the combination o enterprises (i.e. cropping patterns, livestock, or other ventures etc.) of a single farm and their management and interactions within the system, between it and its environment.

2. Farm systems studies have existed for many years and have taken different forms at different times in the countries studied. For the most part, these studies are crop-based and mainly oriented on rice cropping systems. The initial successful results o studies in double-cropping, including triple-cropping, have been dependent on the availability of water and/or the reliability of irri gation systems.

3. The researchers have shown the potentials for increasing agricultural production per unit of land through the modification o existing cropping patterns and/or the introduction of new ones along with the use of appropriate technology. There has been a favourable impact of the development and adoption of new farming systems, particularly multiple-cropping. Where they are agronomically and economically feasible, farmers with small landholdings have been able to increase their labour utilization. Furthermore, the studies on the introduction of improved farming systems indicate an increase in cash requirements needed for purchased inputs and hired labour.

4. Critical factors either fostered or hindered farming systems development. Some examples of these are lack of and/or presence of too much water, socioeconomic factors, lack of credit, etc.

5. Government policies and programmes are in existence but they are not directly focussed on farming systems research and deve lopment. They are however, broad enough to be tapped to promote such research and development activities.

6. There are existing supporting institutions and services that are already promoting farming systems development among small farmers. They may need further strengthening to enable them to expand their scope and efficiently conduct their work.

The future directions for farm management as a link discipline in farming systems research and development need to focus on the following:

1. Research – Farm management and economic aspects which are neglected in present farming research and development programmes should be conducted, with the possible exception of studies in rice-based farming systems (mostly economic surveys).

2. Extension – With the identification of agronomically and economically feasible farming systems, small farmers will be faced with the problem of choosing alternative farming systems for adoption. The direct training of farmers in farm decision-making can be undertaken with the use of a simplified farm management extension manual.

3. Training – A reorientation of the training of researchers and extension workers is necessary to prepare them for the complex tasks involved in farming systems. Dillon (1976), as cited by Barker, (1980) indicated that the adoption of systems approach to resources requires a complete shift in the emphasis on professional training. He suggested a period of training in discipline specialization by capping it off with the bringing together of different disciplines in the context of some relevant agricultural system.

4. Seminars and Workshops – Farming systems research and development need a good deal of interaction among disciplines, principally agriculturists and social scientists. To ensure that there is an understanding of the systems approach and farmers' systems and to provide effective communication or to establish linkages in farming systems research, more seminars and workshops should be held or conducted among the researchers and extension workers, including farmers.

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