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AGRICULTURAL DIVERSIFICATION AND DEVELOPMENT

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AGRICULTURAL DIVERSIFICATION AND DEVELOPMENT

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INTRODUCTION

Infusions of the new technology into traditional agriculture are gaining dramatic results in Southeast Asia. Several countries in this area have begun shifts in production as strategic moves toward agricultural development. There is spreading optimistic belief that the transformation is already sufficient to lift away the spectre of famine and to postpone, at least, the materialization of the Malthusian trap.

These gains have been most notable in basic food grains (rice, corn and wheat) and have been realized mainly from new high-yield varieties coupled with adequate supplies of fertilizer, pesticides, water and modern implements. It is expected that the new technology will quickly spread within the nations and across national boundaries. Therefore, provided that increased production is actually obtained by the presently developing countries, a new set of agricultural problems can be anticipated, for which new solutions must be discovered. The purpose of this paper is to place these probable future problems of agriculture in perspective, to suggest some methods by which solutions may be sought, and to study specifically the importance of planned agricultural diversification as a contributor to these solutions.

Viewing historically Taiwan's experience in the *Ponlai* rice revolution of the 1930's, two facts appear which are worthy of attention: the market price of *Ponlai* rice is higher than that of the native variety, and intensive cultivation with heavy fertilization and labor input is more profitable with *Ponlai* than with native rice. Thus the economic advantages of innovation persuaded Taiwan's farmers to shift from extensive to intensive cultivation.[1]

However, there is reason to believe that such favorable conditions do not yet exist in Southeast Asia. The major goal of most nations which are eagerly promoting seed/fertilizer revolutions is to reach self-sufficiency in food production. The Philippines claims to have achieved some self-sufficiency; Indonesia and Malaysia are expected to be self-sufficient in food production in the early 1970s; rice-exporting countries such as Thailand, Burma and Taiwan will increase their surpluses of rice. The prices of food crops will go down due to these domestic self-sufficiencies and regional surpluses. Domestically, this will create an unfavorable price-cost ratio for farmers who adopt the new technology. Regionally, unfavorable terms

[1]T. H. Lee "Intersectoral Capital Flows in the Economic Development of Taiwan, 1895-1960", Chapter 4, p. 64 (forthcoming publication of Cornell University Press).

of trade will worsen the trade positions of the food-exporting countries. These factors will be retarding influences upon the seed/fertilizer revolution in Southeast Asia.

The current success of the seed/fertilizer revolution is merely the result of national drives to "catch up", to close the technological gap between developed and developing countries. In Southeast Asia, however, there are no strongly organized systems for the spread of technology, no systems for protection against crop disease nor for the breeding and multiplication of new seeds. These lacks inevitably leave farm incomes unstable as farmers assume the risks of innovation. If the influences of price and other technical factors upon farm income are disregarded, population increases will quickly offset the effects of agricultural progress. To bridge the gap between the seed/fertilizer revolution and its economic consequences, agricultural diversification is cited more and more by economists and others concerned as being vitally important to technical and economic considerations relating to agricultural development.

In order to demonstrate the importance of diversification relative to agricultural development in Southeast Asia, this paper will examine:

I. The relationship between farm-income and land productivity in a labor-surplus economy;

II. Technological and economic interpretations of agricultural diversification;

III. Cropping systems with high labor-absorbing capacity;

IV. The conditions necessary for promoting diversification with labor-intensive farming as exemplified by Taiwan.

The paper will conclude with suggestions as to the types of research which should be undertaken in promoting diversification. To sustain the process of agricultural development in Southeast Asia, technological innovation in labor use must become increasingly effective. In choosing crop patterns and crop-livestock combinations, high labor absorption as well as technical efficiency will be good criteria to follow.

I. *The relationship between farm income and land productivity in a labor-surplus economy*

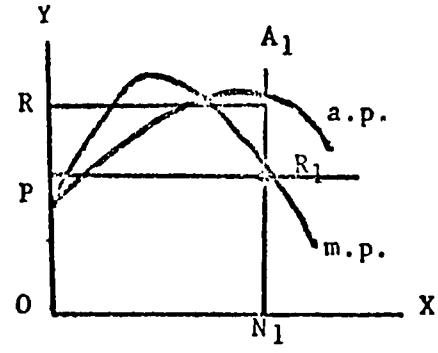
To understand clearly the prerequisite conditions for agricultural diversification, it is necessary to understand the objectives of farmers' economic behavior and the basic principles underlying production factors on Asian peasant farms. From the standpoint of economic theory, labor productivity is the most reliable indicator of economic efficiency. It is believed that when labor is basic to production, the more a unit of labor produces, the more it will contribute toward increasing the net national product; and that, as a result, per capita income will be increased and the standard of living improved. In other words, to increase labor productivity is to take an important step toward a sound national economy. And, where land and capital are abundant, capital-intensive production is being introduced with a view toward reducing the relative input of labor. However, where labor is in surplus and potential farm land is limited, it is impossible to raise farm-labor productivity through labor-saving.

The conditions basic to the current agricultural productivity of Southeast Asia are the virtual human saturation of all farm lands and the heavy pressures of population upon agriculture. Southeast Asia's prime agricultural problems are population and unemployment. Increased employment opportunities and increased agricultural production can be had by encouraging the types of farming and cropping systems that can absorb large labor inputs and turn out increased production per unit of area. Given such limited land areas as those in Southeast Asia, it is quite logical to assume that increasing land productivity is the only feasible way toward agricultural development. Increasing land productivity would enhance the gross labor return; and gross labor return is directly affected by intensive utilization of farm land and labor as well as by improvements in the cropping system. This relationship is described below.

Chart 1-A relates to the production function of crops under the extensive farming system. The wage rate is represented by the line OP, and the degree of intensity of labor is revealed at point R_1 where lines m.p. and P intersect. Labor input is represented by the line ON_1; if after the use of labor (ON_1) there still remains some surplus labor which cannot find employment, it is anticipated that

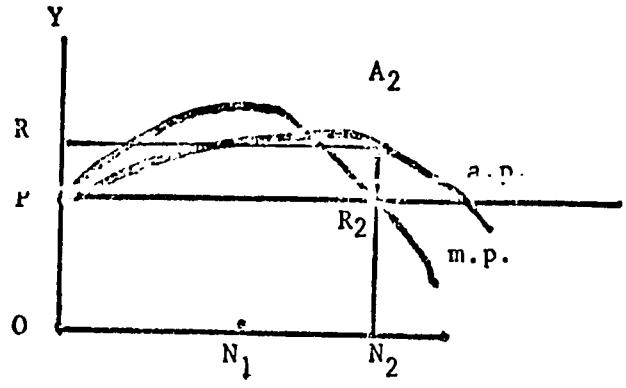
farmers will be generally unwilling to invest more hours when their gross labor return is already equal to or greater than the disutility of working or of family outlays. But when there is no labor surplus, when the wage rate is high, and a bountiful harvest is in sight, farmers will then be glad to adopt the extensive farming system illustrated in Chart 1-A.

Chart 1-A. Extensive farming system



However, on small peasant farms the case is different. There is surplus labor, and this labor needs living expenses not covered by income from farming. Here the farmers desire to put more labor into farming in order to get more return from the land. This is quite commonly true in countries where the owner-farmer system predominates and increase in land productivity belongs to the owner-farmer. These farmers wish to adopt intensive farming so as to incorporate a greater labor force into agricultural production. Chart 1-B illustrates the production function of the intensive farming system. In one small farm area a farmer may plant several kinds of crops, and while there are different ways of setting up an intensive diversification system, its labor input is greater than that shown in Chart 1-A (lines N_1N_2), its average labor productivity is less (N_2A_2), and its gross labor return is higher (OR A_2N_2).

Chart 1-B. Intensive farming system



*II. Technological and economic interpretations of agricultural diversification**

When the intent is to increase and stabilize farm income, the method of iso-land analysis offers means to investigate the quantitative relationship between one product and another in conditions where land is limited. The best cropping system for Southeast Asian agricultural diversification is shown to be a combination of crops and livestock, one which brings the largest returns from allocating limited resources to each cropping system.

Essentially, there are three "basic relationships" in production economics: the factor-product relationship, the factor-factor relationship, and the product-product relationship. It is the last relationship which concerns the allocation of fixed resources as between crops and livestock.

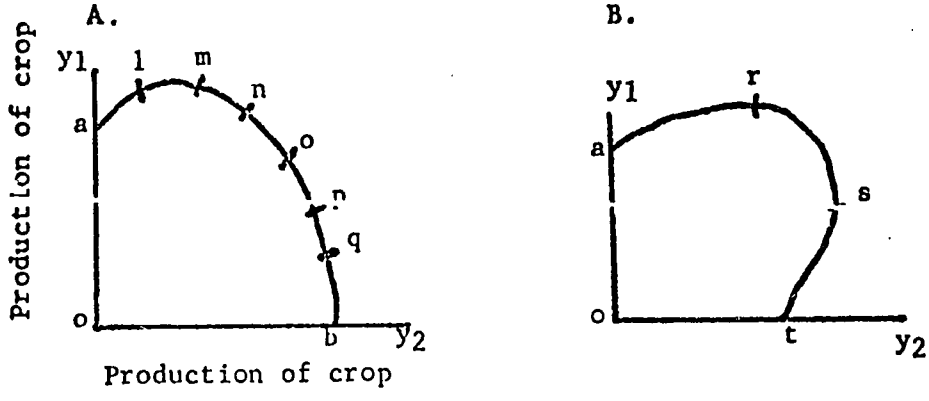
Analyzing the third relationship in further detail, we find three kinds of relationships existing between two kinds of crops (or enterprises) when they utilize the same fixed resources, whether at the same or at different times. When resources are fixed, two crops (or enterprises) have (1) a competitive relationship, if the increased production of one crop or enterprise would cause a decrease in the production of the other; (2) a supplementary relationship, if the production of one crop or enterprise could increase whether

* For information given in this section the author has drawn extensively from Tohei Sawamura's articles on paddy cropping patterns in Japan.

or not there were changes in production of the other; (3) a complementary relationship, if increased production of one crop or enterprise would cause an increase in the production of the other. Now, if the quantities produced from each of the two crops or enterprises are represented by y_1 and y_2 respectively, and their changes by Ay_1 and Ay_2, then Ay_1 and Ay_2 represents the marginal rate of substitution. Competitive, supplementary, or complementary relationships correspond respectively to rates less than, equal to or larger than zero.

For example, when two crops such as grain and beans alternate in a cropping system, various types of rotation can apply based on different cropping ratios. When the type which is basically a cropping of grains shifts gradually to the type which includes more beans, the production-opportunity curve often shows a complementary relation at first, and then becomes competitive. Such a curve is called a rotation curve. On the rotation curve in Chart 2-A, each point on the curve ab (a,l,m,n,p,q,b) represents a cropping system or a type of rotation. The two crops are complementary between points a and m; at m, they become briefly supplementary; and from m to b they are competitive.

Chart 2. Rotation curve



Two conditions are necessary for establishing a supplementary relationship, without competitiveness, between two crops in a

cropping system. The first condition is that the supply of the limited resource under consideration, such as land, should be constant and continuous. If the fixed resource is capital services, such as fertilizers and chemicals which vanish after they are applied, the relationship is always competitive, never supplementary.

The second condition is that the two crops differ in their cropping seasons. It is very rare that a supplementary relationship emerges if the two crops have the same cropping season. If one crop can mature fully by utilizing the sunshine, heat and water remaining from the cultivation of the other (as soybeans, for example, can grow between the rows of rice) a supplementary relationship may occur between them but such a case is very rare. For these reasons, it becomes useful to classify crops according to their seasons, as winter, spring, summer and autumn crops.

What is really noteworthy here is that both necessary conditions are related to time. Since it is basic to the formulation of a supplementary relationship that the service of the fixed resource be a constant flow, the use of that resource may be called a supplementary service; at the same time, it may also be called a non-interchangeable service, since the use of the resource cannot be diverted into a different cropping season.

We see then that two crops in the same cropping system can become supplementary if for each the services of fixed resources remain in constant flow and if their cropping seasons are (usually) different. Where such a supplementary relationship occurs, it is possible that a complementary relationship will also emerge, provided that certain other conditions pertain.

A complementary relationship emerged between grains and beans when the production of grains from a given area of land increased after the introduction of beans into a cropping system which had consisted soley of single-crop grains. Suppose a field produces an average 2.0 M/T of brown rice per hectare yearly in single-cropping of rice. If soybeans are introduced as a winter crop and rotated with rice, and the yield of rice increases to 2.5 M/T per hectare in addition to the new production of soybeans, a complementary relationship exists.

This is so because soybeans give, in addition to the harvested

stems and leaves, some nutritive by-products which improve the yield of rice. In many cases, soybeans are used as a leguminous crop which provides to rice (or grains) such by-products as these:

> fertilizing elements, especially nitrogen, which are accumulated in the soil by soybeans;
>
> residues of the roots of soybeans (organic matter) remaining in the soil;
>
> physiological, chemical and biological improvements to soil conditions which occur with the growing of soybeans.

What should be noted here are the causes of the complementary relationship. Not only do by-products of soybeans remain in the soil and become inputs to rice, but other important effects are the physical, chemical and biological improvements to soil fertility. Also important is the fact that the investment of scarce resources (capital other than land) used in growing the rice crop was kept equal to or less than that needed in growing rice alone. If these conditions were not fulfilled, the iso-land analysis procedure would hardly be appropriate.

In applying the iso-land method of analysis to the production relationships between two crops in double cropping, there will be no problem if the input of capital to crop y_2 is negligible. But if crop y_2 requires a substantial input of capital, the net product of crop y_2 (calculated by subtracting from the value of gross produce the value of capital used) should be compared to its gross product in order to ascertain which kind of marginal relationship, i.e., competitive, supplementary or complementary, exists between them. Further, it may also be possible to study the relationship between the net products of each crop, by calculating also the net product of crop y_1. In the case of labor redundancy, the net product of each crop should reflect the return to labor, and the labor-absorbing capacity of each crop will be taken into consideration together with the technological relationship between the crops.

III. Cropping systems with high labor-absorbing capacity

The intensive farming system is, as has been stated above, only an explication of theory. There are, however, varying forms of cropping systems as adopted by the farmers, corresponding to the natural conditions, marketing systems and supplies of farm labor. Generally speaking, these are the multiple cropping system, the rotational cropping system, the crop-and-livestock integrated farming

system, and the crop-and farm-product-processing integrated system. This discussion will concern only the relation between intensity of labor use and the several intensive cropping systems. The labor inputs for crops grown in Taiwan follow below (Table 1).

The shortest growing period is 45 days, the average period is 185 days, the longest period (fall-planted sugarcane) is 16 months. The lowest labor requirement is 78 man-days and the highest is 800 days. There are wide differences in capacities for labor-absorption in these varying growing periods. Generally the grain crops require fewer labor-days; vegetables and horticultural crops require more. Different varieties of the same basic crop, such as *Ponlai* and native rice differ in their requirements for labor.

These basic crops, which differ in growing periods, and require differing numbers of labor-days, can be integrated into a cropping system designed to absorb the highest practicable labor input. Fertility of the soil, capacity for labor input, and gross labor return are the determining factors in setting up a cropping system. In Taiwan, farmers usually combine two or three kinds of cropping. The increased number of labor-intensive cropping systems is reflected in the rise in the multiple-cropping indexes which are shown in Table 2.

Over the past fifty years, arable land in Taiwan has increased by 26% while the agricultural population has grown by 125% and the farm labor force by 50%. With the rapid increases of agricultural population, there has been a decline in the farm labor force in proportion to the total agricultural population and a decrease in size of cultivated areas. Prior to 1935, increases in cultivated land were possible due to the fast expansion of newly-reclaimed lands. After 1940, however, population pressure grew rapidly and the only way to meet the changing need is to make intensive use of land and multiply the croppings. The multiple-cropping index indicates that the number of crop plantings steadily increased after 1935 with the result that there has been also a gradual increase in the cropping area per farm laborer. These changes are reviewed in the following tables.

The labor input per hectare of cultivated land has increased from 195 man-days in 1911-1915 to 220 days in 1931-1935, and further increased to 305 days in 1956-1960. The seasonal distribution of labor is more equitable following the introduction of the labor intensive system. The impact of intensive-cropping upon the seasonal

Table 1. LABOR REQUIREMENTS OF BASIC CROPS

	Labor Requirement (Man-days)	Growing period (days)	Planting Time	Harvest Time
1st rice crop (Ponlai)	103	125	Late February	Early July
1st rice crop (Native)	99	100	Late February	Early June
2nd rice crop (Ponlai)	100	125	Mid-July	Mid-November
2nd rice crop (Native)	98	125	Late July	Late November
Fall plantings (potato)	78	185	Mid-July	Early January
Winter-crop potatoes	106	130	Mid-November	Mid-February
Wheat	97	120	Early November	Late February
Peanut	107	136	Mid-February	Early July
Rapeseed	80	105	Early November	Early February
Musk Melon	172	75	Early June	Late July
Cabbage	256	98	Late October	Early February
Leaf Mustard	207	103	Early November	Early February
Chinese Cabbage	354	95	Early November	Mid-February
Tobacco	800	110	Mid-November	Late February
Fall-crop sugarcane	145	480	Early September	Mid-December

Table 2. CULTIVATED AREA, CROPPING AREA, LABOR FORCE

Period	Cultiv. area (ha)	Crop area (ha)	Labor (1,000 Persons)	Ag.Pop (1,000 Persons)	Cultiv. Area/Ag. Pop. (ha)	Cultiv. area per Laborer (ha)	Crop area per Laborer (ha)	Multi-crop index %
1911-1915	692,272	806,282	1,155	2,199	0.31	0.60	0.70	116
1916-1920	731,288	865,561	1,124	2,288	0.32	0.65	0.77	118
1921-1925	758,538	920,177	1,126	2,271	0.33	0.67	0.82	121
1926-1930	802,222	982,261	1,188	2,452	0.33	0.68	0.83	122
1931-1935	820,304	1,079,004	1,286	2,658	0.31	0.64	0.84	132
1936-1940	856,108	1,138,520	1,374	2,908	0.29	0.62	0.83	133
1941-1945	837,015	1,098,007	-	3,242	0.26	-	-	131
1946-1950	852,911	1,288,308	1,658	3,752	0.23	0.51	0.78	151
1951-1955	873,962	1,501,891	1,741	4,378	0.20	0.50	0.86	172
1956-1960	875,897	1,575,849	1,725	4,944	0.18	0.50	0.91	180

Source: T. H. Lee, "Intersectoral Capital Flows in Economic Development of Taiwan, 1895-1960", Ph.D. Thesis, Cornell University, 1968; Chapt. 4.

A. Paddy Land

Period \ Month	J	F	M	A	M	J	J	A	S	O	N	D
1910-20: initial period			1st rice crop					2nd rice crop				
1920-40: developing period	crop		1st rice crop					2nd rice crop				winter
1940-60: later period	crop		1st rice crop					2nd rice crop				winter
							summer crop					

B. Single-cropping paddy land

Period \ Month	J	F	M	A	M	J	J	A	S	O	N	D
1910-20: initial period			sweet potatoes					2nd rice crop				
1920-40: developing period			sweet potatoes					2nd rice crop				
1940-60: later period	potatoes		miscellaneous crop					2nd rice crop				sweet

C. Dryland

Period \ Month	J	F	M	A	M	J	J	A	S	O	N	D
1910-20 initial period			sweet potatoes or other crop					sweet potatoes or other crop				
1920-40: developing period			sweet potatoes					peanuts				
1940-60: later period	crop		peanuts			miscellaneous crop				peanuts		
						sweet potatoes						miscellaneous

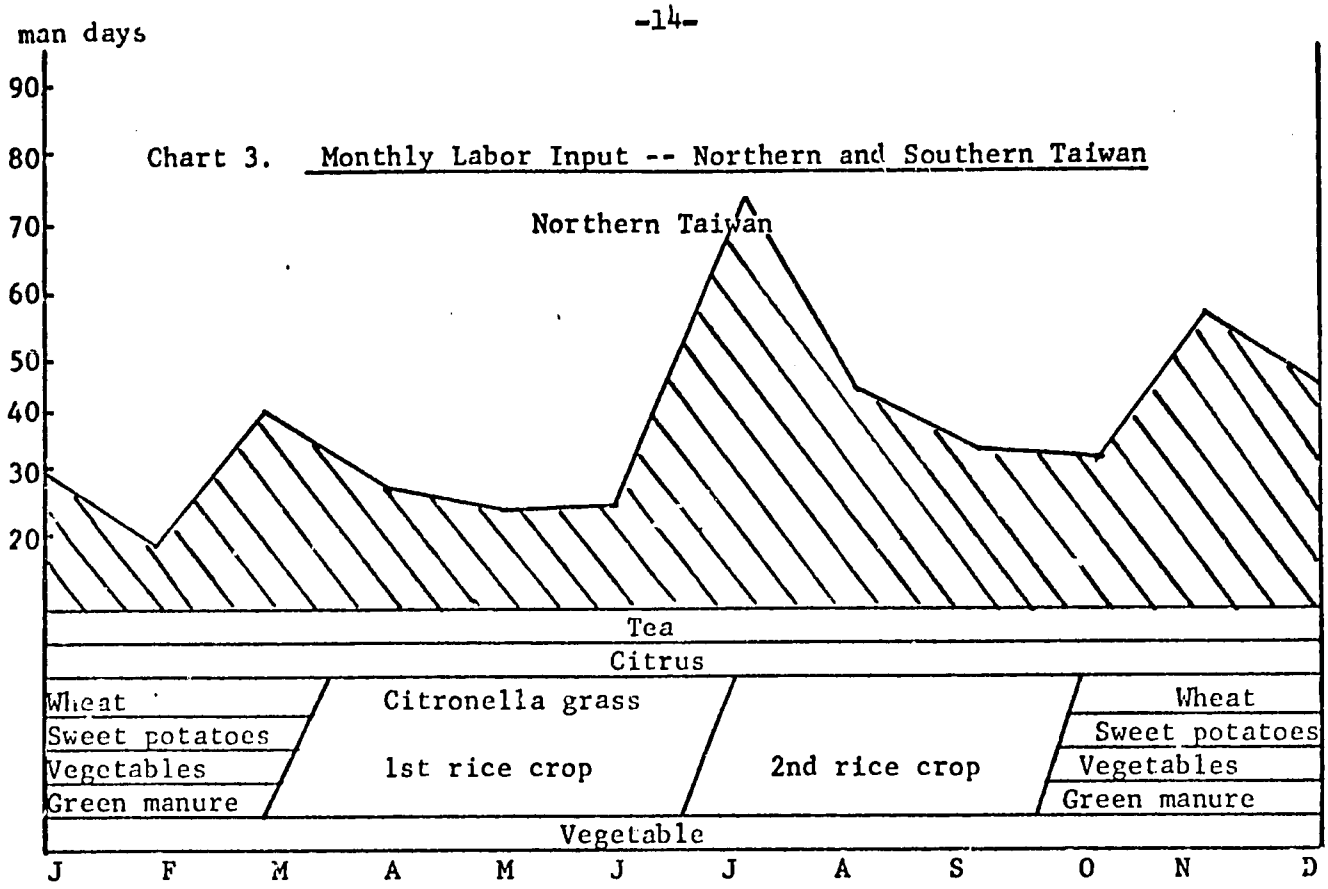
distribution of labor can be seen in a cross-section of the intensities of labor in different areas. As indicated in Chart 3, the average cultivated area of the investigated farmers in northern and southern Taiwan is 1.45 hectares; the annual labor input in northern Taiwan is 577 man-days, in southern Taiwan it is 658 man days. The monthly distribution of labor is more equitable in southern Taiwan than in northern Taiwan because the cropping system adopted in the south is more complex than that of the north.

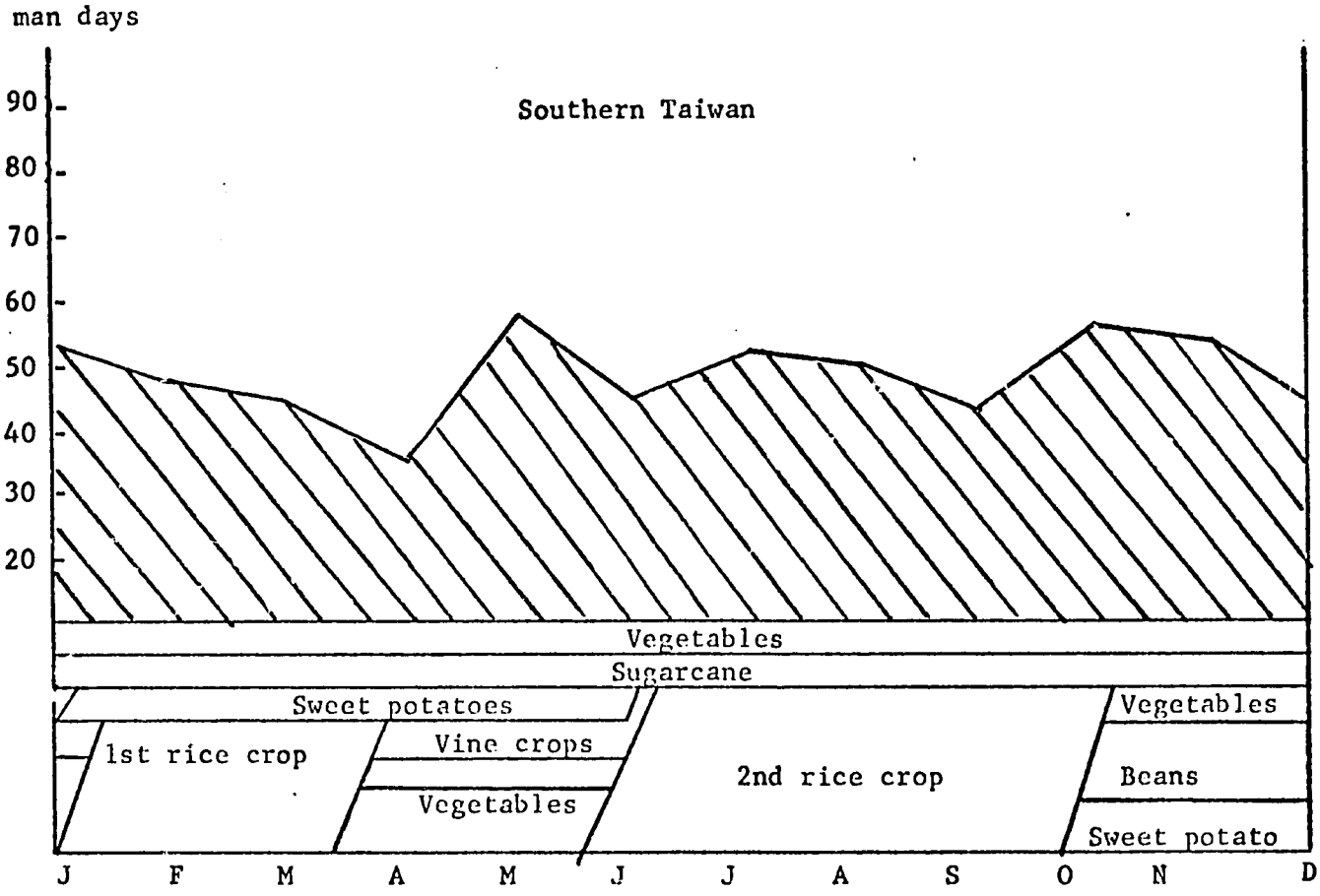
Farmers in Taiwan have adopted labor-intensive cropping in order to absorb more family labor, and so plant various crops that require different labor inputs. Such a system will waste no labor, but instead tends to increase simultaneously the average productivity of both land and labor. Under it the demand for labor is high as the time available for harvesting one crop and planting the following crop is extremely short. Some farmers use power tillers to supplement human labor in peak demand periods. Sometimes, a crop is planted between the rows of the previous crop in order to avoid concentrating labor demand into a short period of time. The vine and vegetable crops of southern Taiwan are planted in this way. An advantage of this method of planting is that it permits use of surplus labor to speed harvest.

IV. The conditions necessary for promoting diversification with labor-intensive farming as exemplified by Taiwan

Labor-intensive cropping is one of the useful methods of relieving population pressure and seasonal labor surpluses. Favorable social and economic conditions are required to facilitate adoption of this cropping system. First of all, it should provide the increases in farmers' income without which the farmers will be reluctant to accept such a system. For instance, if the system of "rice-rice-winter crop" is to be changed into "rice-vegetable-rice-winter crop", yet there is no profit to be realized from this change in system, it is quite natural that the new system will not be accepted. Therefore, the increase of the productivity of land (including the improvement of crop varieties, culture practices, cultivated land and the increase of the demand for farm products) is prerequisite to the success of this system. The following is a statement of the improvement of crop varieties, culture practices and cultivated lands in connection with the adoption of labor-intensive cropping in Taiwan.

Chart 3. Monthly Labor Input -- Northern and Southern Taiwan





(a) Improving crop varieties and culture practices

There is a shortage of vegetables in Taiwan in summer. If vegetables can be planted in May and June without adversely affecting the second rice crop, income will be increased. There are technical difficulties but following upon improvements in adopting the crop varieties, and practice of interplanting vegetables with other crops, farms in central and southern Taiwan have changed from three crops to four crops per year.

(b) Improving cultivated lands

Improvements to cultivated land includes irrigation, drainage, soil enrichment and other investments. The purposes are twofold: in time of drought or inadequate water supply, irrigated land can support one or even two crops; and after having made such improvements, fertilizer and labor inputs are considerably increased, the farming is more intensive and is then capable of absorbing still more inputs.

Using Table 3 we can visualize the positive correlation between the amounts of irrigated land and the multiple-cropping index.

(c) Altering the demand for farm products

Demand here includes human consumption plus expanded uses by industrial and other consumers. Rice and sweet potatoes are labor-extensive crops. If we wish to substitute plantings of vegetables, citrus, tobacco, and rapeseed for grain crops, for example, we must first find out the market for the intensive crops. If market demand is low, increasing production will tend to lower the prices of these crops and the profits from them would also drop. Vegetables are daily necessities in Taiwan, and therefore the increase of population as well as the large demand for summer vegetables in particular have helped to stablize farm profits by encouraging the introduction of inter-plantings. Winter-planted crops such as tobacco are profitable because the Taiwan Tobacco and Wine Monopoly Bureau purchases tobacco leaf under contracts which offer attractive prices to the sellers. It is logical that farmers should be more inclined toward accepting labor-intensive cropping when those crops reap high profits. Thus, aside from improvements to culture practices and cultivated land, it seems necessary that labor-intensive cropping systems should be further supported by the development of agricultural processing industries and by increases in consumption.

Table 3. Cultivated land, Irrigation, Multiple-cropping Index*

Locality	Cultivated area (ha)	Irrigated area (ha)	Ratio: irrigated area / cultivated area	Multiple cropping index %
Taipei	50,950	21,497	42.19	165
Ilan	27,949	23,122	82.73	190
Taoyuan	54,842	32,998	60.17	193
Hsinchu	42,440	10,616	25.01	165
Miaoli	41,415	16,076	38.82	187
Taichung	46,331	38,781	83.70	232
Changhua	76,070	59,908	78.75	233
Nantou	46,228	19,190	41.51	143
Yunlin	86,441	20,730	23.98	195
Chiayi	71,685)	149,333	34.31	159
Tainan	96,948)			
Kaohsiung	53,803	24,001	44.61	187
Pingtung	77,820	41,154	52.88	196
Taitung	30,612	8,572	28.00	147
Hualien	31,818	10,673	33.54	167
Penghu	7,283	-	-	132
Average	-	-	41.96	184

*From the Agricultural Yearbook, 1960 and 1961, published by the Taiwan Provincial Department of Agriculture and Forestry.

(d) Labor-intensive cropping and the linear programming approach in Taiwan

It was asserted earlier that adoption of labor-intensive cropping in an over-populated area having seasonal labor surpluses will help to reduce unemployment and will increase farm income. In order to introduce the system effectively, a cropping system should be devised for a given area, to serve as a guide for individual farm planning. The linear programming approach serves this purpose. If the scales and patterns of operation of farms vary widely in the given area, it may be appropriate to devise several model systems for consideration by the farmers. The model system can be divided into component types of cropping according to these criteria:

a. climate, soil and topography

b. size of cultivated area, labor force and animal stocks

c. availability of farm implements and other equipment

Of these criteria, one or two may be chosen as the basis for establishing a particular cropping system. When the several areas are similar to each other, in natural and equivalent farm conditions, for example, the choice as to the type of farming can be based upon the size of the cultivated area, the labor force and the animal stocks. The objectives include achieving the maximum income derivable from the family's labor and from their land. Attaining these objectives means making full use of the available crop area and labor force. Following is an account of several of the most profitable systems adopted by Lung Tung Village of Lung Chin Township in central Taiwan.

This township carried out a large-scale-land-consolidation project. It has fertile soil, adequate irrigation and drainage facilities. With the exception of monsoon winds, the climate is favorable for various kinds of crops. The land is on the plain and with Taiwan Strait to the west and Taichung city to the east, it became a center of food production and consumption. Its agricultural products are accessible to northern and southern Taiwan through railway and highway transport.

The informational base for planning was derived from surveys of farm economy and production costs of the staple crop in Lung Chin

Farm Families, livestock and poultry, Lung Tung Village

	No. of fami-lies	No.of family mem-bers	Farm labor force	Livestock			Culti-vated land (ha)	Paddy land (ha)	Dry land (ha)
				Cattle	Hogs	Chickens			
Totals	198	1,643	614	163	240	1,230	81.33	77.17	4.16
Average family		8.3	3.1	0.8	1.2	6.2	0.44	0.39	0.05

The above table shows that in Lung Tung Village the man-land ratio is very high.

Acreage allocations: Lung Tung Village

Existing conditions of crop production

	Planted area (ha)	Average area per family (ha)	Distribution of planted areas (%)
Total	202.40	1,023	100
1st rice crop	76.38	0.39	38.12
2nd rice crop	76.13	0.38	37.15
Wheat	32.05	0.16	15.64
Sweet potato	3.72	0.019	1.86
Beans	0.24	0.001	0.10
Rapeseed	6.91	0.035	3.42
Flax	0.44	0.002	0.20
Muskmelon	2.99	0.015	1.47
Vegetables	2.16	0.011	1.07
Other	1.38	0.01	0.97

Township, conducted by the Taiwan Provincial Department of Agriculture and Forestry in 1961 when land consolidation had been carried out.

The rate of land utilization or index of multiple cropping is 249%. Rice occupies the largest portion of the total planted acreage, and we can see that Lung Tung Village is much like other areas which emphasize the cultivation of rice.

The first step in planning is determination of the average size of cultivated areas and of the labor force; from this planners proceed to considerations of the five types of systems and make trial computations in each system. (In the following table, 0.5 hectare and 3 workers represent the "average" farm.)

Cultivated area (ha)	Labor force		
	I	II	III
0.3	2.5	3	3.5
0.5		3	3.5
0.7			3.5

The important crops that can be planted in this village during the first crop season (March-June) are rice, vegetables, watermelons, peanuts, tomatoes, cucumbers; during the summer season (June-August), muskmelons, watermelons, vegetables; during the second crop season (August-November), rice, sweet potatoes, vegetables; during the winter season (November-March), wheat, vegetables, rapeseed, peas, flax, etc. The raising of livestock and poultry is so restricted by the shortage of feed crops that the average number of hogs per family is 1.2; of chickens 6.2; of cattle 0.8. In spite of the underdevelopment of livestock and poultry in this village, some land is devoted to sweet potato intended for animal feed. The raising of livestock and poultry will not be considered in this program plan, however.

The labor coefficient of crop planting represents the number of days required for planting that crop on one hectare of land and was calculated on the basis of survey figures from one village and verified in the survey of the township. Farm price represents the average over a three-year period.

The information presented above may be summarized as follows:

a. Resource limitations

The standard cropping area is 0.5 hectare, of which 0.45 hectare is paddy land and 0.05 hectare is dryland. The average family owns one hog, for which 0.03 hectare of dryland is needed for raising 400 kilograms of sweet potatoes annually. Cropping is then confined to 0.45 hectare of paddy land in the first, summer, second and winter seasons, and 0.02 hectare of dry land in the first, second and winter seasons.

The Taiwan Food Bureauextends loans to farmers for purchases of fertilizers. No special or additional farm implements or other capital goods are needed in the labor-intensive cropping system.

b. Labor limitations

Working 25 days each month, the three workers in an average family contribute 75 man-days. Five days are spent on hog raising and sweet potato planting, leaving a net labor supply of 70 days.

No restriction is assumed with respect to the rate of land utilization for various crops. All factors relating to pest and disease damage and to economic risk dispersion are omitted from consideration in this program.

The simplex table:

Based on revenue coefficients, technical coefficients and resource limitations, a simplex table of the first stage is prepared as follows (0.5 hectare and 3 workers represent a "typical" unit for computation purposes).

Table 5 supplies the basic information required for the simplex table. The simplex table reveals the input and output coefficients derived from the basic information and the resource limitations shown in Table 4. The results of computations of the first and last (seventh iteration) stages of the simplex table are shown in Tables 6 and 7. Since the iteration of computation in linear programming is a purely mechanical process, the intermediate stages are omitted. The intensive use of paddy land and dryland as outlined in Table 7 may be summarized as follows:

Cropping system

Month	J F M A M J J A S O N D
Paddy land	First crop paddy rice (0.45 ha) Second crop paddy rice (0.45 ha)
	Winter cabbage (0.45 ha) Muskmelon (0.45 ha) winter cabbage
Dry land	Peanuts (0.02 ha) Fall-planted sweet potato (0.02 ha)
	Winter cabbage (0.02 ha) winter cabbage

Farmers spend 330 days planting the above crops on an area of 0.47 hectare, or 702 days on one hectare. Also the 60 days required for annual feed production and livestock raising should be added. This represents a yearly increase of 83 days as compared to the average labor of 307 days per family in the extensive system. Farm income has risen from NT$11,825 (before programming) to NT$25,941 (after programming), an increase of NT$14,116. The man-land ratio in Lung Tung Village seems very high inasmuch as the labor force is 3 persons and cultivated land is 0.5 hectare per family. Hence there is no effective way for the labor-intensive system to make full use of the labor force. The shadow price of labor, as indicated in Table 7, is zero.

Aside from the changes made in the cropping system, other farm sidelines such as livestock and poultry, should also be encouraged in order to make the fullest use of the family's labor.

The cropping system computed by linear programming can be developed into easily-adopted types if various conditions are changed. These will serve as bases for improving farm management.

CONCLUSIONS AND RESEARCH SUGGESTIONS

Drawing upon theoretical and historical backgrounds, we have examined in detail the impact of farm labor surpluses on cropping systems and we have reviewed the system of intensive farming. The linear programming approach has been used to compute, using concrete examples, a labor-intensive cropping system which can become the basis for improving farm management. Results show that such a system produces great effects upon the use of labor coupled with limited

Table 4. Resource limitation under the base program

Cultivated area (ha)	0.3		(typical situation) 0.5		0.7
Labor force (workers)	2.5	3	3	3.5	3.5
1st crop paddy land (ha)	0.3	0.3	0.45	0.45	0.65
Summer crop paddy land (ha)	0.3	0.3	0.45	0.45	0.65
2nd crop paddy land (ha)	0.3	0.3	0.45	0.45	0.65
Winter crop paddy land (ha)	0.3	0.3	0.45	0.45	0.65
1st crop dryland	-	-	0.02	0.02	0.05
2nd crop dryland	-	-	0.02	0.02	0.05
Winter crop dryland	-	-	0.02	0.02	0.05
Labor (man-days)					
January	62.5	62.5	70	82.5	80*
February	62.5	62.5	70	82.5	80
March	62.5	62.5	70	82.5	80
April	62.5	62.5	70	82.5	80
May	62.5	62.5	70	82.5	80
June	62.5	62.5	70	82.5	80
July	62.5	62.5	70	82.5	80
August	62.5	62.5	70	82.5	80
September	62.5	62.5	70	82.5	80
October	62.5	62.5	70	82.5	80
November	62.5	62.5	70	82.5	80
December	62.5	62.5	70	82.5	80

*Some labor has been allotted for a larger dryland acreage of sweet potatoes (0.045 ha.) and only 80 labor days remain available.

Table 5. Basic Information

Items	Crops	1st paddy	2nd paddy	Fall sweet potato	Winter sweet potato	Leaf mustard	Wheat	Rape green	Musk-melon	Cabbage	Chinese cabbage	Cauli-flower	Pea-nuts
Yield	kg.	4,396	3,334	14,111	17,042	31,200	1,978	1,602	15,181	52,841	25,688	12,453	1,001
Unit price	NT$	3.90	3.78	0.62	0.56	0.52	3.55	6.64	1.07	0.53	0.96	1.09	6.00
Total return	NT$	17,158	12,597	8,811	9,626	16,329	7,108	10,434	16,313	28,261	24,693	13,673	6,006
Fertilizer	NT$	2,094	1,723	1,232	1,884	4,151	2,396	2,091	3,374	4,333	3,688	2,185	537
Pesticides	NT$	441	296	56	13	443	143	150	1,747	677	883	304	9
Seed & Seedlings	NT$	214	227	491	536	829	462	67	118	1,468	1,306	736	743
Depreciation	NT$	463	293	196	196	270	243	243	352	320	228	227	210
Total cost	NT$	3,212	2,539	1,975	2,629	5,693	3,244	2,551	5,591	6,798	6,105	3,452	1,499
Net income	NT$	13,946	10,058	6,836	6,997	10,636	3,864	7,883	10,722	21,463	18,588	10,221	4,507
Labor (man-days)	Jan.				15	25		7		26	38	68	
	Feb.	33			25	69	44	35		85	111		13
	Mar.	49											16
	April	26											18
	May	32											10
	June	3							87				49
	July		44	29					87				
	Aug.		29	19									
	Sept.		21	4									
	Oct.		13		40								
	Nov.		33	6	26	77	40	31		93	143	79	
	Dec.			19		39	30	24		52	57	23	

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Table 6. The First Stage of Simplex Table

(Cultivated land 0.47 ha. and labor force 3 persons)

C		13,946	10,058	6,836	6,997	10,636	3,864	7,883	10,722	21,463	18,588	10,221	4,507		
Basis	P_o	1st paddy P_1	2nd paddy P_2	fall sweet potato P_3	winter sweet potato P_4	leaf-mustard P_5	wheat P_6	rape greens P_7	musk-melon P_8	cabbage P_9	chinese cabbage P_{10}	cauli-flower P_{11}	Peanut P_{12}	1st paddy field P_{13}	inter croppin field P_{14}
P_{13}	0.45	1												1	
P_{14}	0.45								1						1
P_{15}	0.45		1												
P_{16}	0.45				1	1	1	1		1	1	1			
P_{17}	0.02												1		
P_{18}	0.02			1											
P_{19}	0.02				1	1	1	1		1					
P_{20}	70				15	25		7		26	38	68			
P_{21}	70	33			25	69	44	35		85	111		13		
P_{22}	70	49											16		
P_{23}	70	26											18		
P_{24}	70	32											10		
P_{25}	70	3							87				49		
P_{26}	70		44	29					87						
P_{27}	70		29	19											
P_{28}	70		21	4											
P_{29}	70		13		40										
P_{30}	70		33	6	26	77	40	31		93	143	79			
P_{31}	70			19		39	30	24		52	57	23			
Z	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Z-C	0	-13,946	-10,058	-6,836	-6,997	-10,636	-3,864	-7,883	-10,722	-21,463	-18,588	-10,221	-4,507	0	0

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...ping ...d	2nd paddy field P_{15}	Winter cropping field P_{16}	1st upland P_{17}	2nd upland P_{18}	Winter Cropping upland P_{19}	Labor Jan. P_{20}	Feb. P_{21}	March P_{22}	April P_{23}	May P_{24}	June P_{25}	July P_{26}	Aug. P_{27}	Sept. P_{28}	Oct. P_{29}	Nov. P_{30}	Dec. P_{31}	R
																		∞
																		∞
	1																	∞
		1																0.45
			1															∞
				1														∞
					1													0.02
						1												2.69
							1											0.82
								1										∞
									1									∞
										1								∞
											1							∞
												1						∞
													1					∞
														1				∞
															1			∞
																1		0.75
																	1	1.35
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

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Table 7. The Last Stage of Simplex Table (Seven interation)
(Cultivated land 0.47 ha. and labor force 3 persons)

C															
Basis	P_0	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}
P_1	0.45	1												1	
P_8	0.45								1						1
P_2	0.45		1												
P_9	0.45				1	1	1	1		1	1	1			
P_{12}	0.02												1		
P_3	0.02			1											
P_7	0.02				1	1	1	1		1					
P_{20}	57.78				-11	-1	-26	-19		0	12	42			
P_{21}	14.94	0			-60	-16	-41	-50		0	26	-85	0	-33	
P_{22}	47.63	0											0	- 49	
P_{23}	57.94	0											0	-26	
P_{24}	55.40	0											0	-32	
P_{25}	28.52	0							0				0	- 3	-87
P_{26}	10.47		0	0					0						-67
P_{27}	56.57		0	0											
P_{28}	60.47		0	0											
P_{29}	64.15		0		40										
P_{30}	11.32		0	0	-67	-16	-53	-62		0	50	-14			
P_{31}	45.18			0	-52	-13	-22	-28		0	5	-29			
Z	25,941.17	13,946	10,058	6,836	21,463	21,463	21,463	21,463	10,722	21,463	21,463	21,463	4,507	13,946	10,722
Z-C	25,941.17	0	0	0	14,466	10,827	17,599	13,580	0	0	2,875	11,242	0	13,946	10,722

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P_{15}	P_{16}	P_{17}	P_{18}	P_{19}	P_{20}	P_{21}	P_{22}	P_{23}	P_{24}	P_{25}	P_{26}	P_{27}	P_{28}	P_{29}	P_{30}	P_{31}
1																
	1															
		1														
			1													
				1												
	-26			-26	1											
	-85	-13		-85		1										
		-16					1									
		-18						1								
		-10							1							
		-49								1						
-44			-29								1					
-29			-19									1				
-21			- 4										1			
-13														1		
-33	-93		- 6	-93											1	
	-52		-19	-52												1
10,053	21,463	4,507	6,836	21,463	0	0	0	0	0	0	0	0	0	0	0	0
10,058	21,463	4,507	6,836	21,463	0	0	0	0	0	0	0	0	0	0	0	0

land resources, upon farm income, and upon farm labor unemployment. It does not, however, solve the problem of labor surplus if the surplus is excessively large. Given limitations in variety of crops plus seasonal variations in demands for labor, the key to solving the labor surplus lies in improving culture practices and expanding domestic consumption. When arable land is extremely scarce, the important pre-conditions are to make intensive use of land, as a land-saving device, and to widen the variety of crops as was done in Taiwan.

In order to form crop complexes or to diversify farming more efficiently, these research programs are recommended:

(a) To understand the different requirements and possibilities of various products and the technological characteristics of land use for various crops, a farm economy survey and research should be made on: climate, soil requirements, input-output relationships between grain and non-grain crops and livestock.

(b) Long-term projections of national food consumption, which are necessary to an understanding of future patterns of crop and livestock requirements, will throw light on the economic considerations related to choosing an efficient cropping system.

(c) Farmers' responses to price changes in crops other than grain should be surveyed. This will bring out a clearer picture of feasible resource allocations.

(d) Some search of domestic and regional crops and livestock should be undertaken in terms of their comparative economic advantages.

(e) Farmers' organizations for the extension of new technology, for breeding new varieties, and for protection against natural risks will be important in promoting agricultural diversification. Sociological analyses of the impact of farmers' organizations will be useful.