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STRATEGIES FOR INCREASING FOOD PRODUCTION AND INCOME ON SMALL UPLAND FARMS IN LAMPUNG, INDONESIA--A LINEAR PROGRAMMING ANALYSIS

By

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ABSTRACT

STRATEGIES FOR INCREASING FOOD PRODUCTION AND INCOME ON SMALL UPLAND FARMS IN LAMPUNG, INDONESIA--A LINEAR PROGRAMMING ANALYSIS

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The major purpose of this study was to analyze empirically the effects of the adoption of the new technology on the traditional cropping system on the small upland farms in the transmigration areas of Lampung, Indonesia. The analysis emphasized the changes in key farm variables of farm income, crop enterprise combinations, resource use and productivity. Also estimates were made of the price elasticities of the normative supply functions of the major food crops of rice, corn, and cassava.

The survey method was used to collect empirical data from a number of sample farms in the transmigration areas of Lampung where upland farming for food crop production is the main agricultural activity. For the selection of the sample farms a two stage sampling method was used. The first stage identified four villages to represent Lampung province. The second stage involved random sampling of farms in each village. Tatakarya Village, Adiluih and Bulusari Villages, and Pugung Raharja Village

were selected to represent the North, Central, and South of Lampung respectively.

A static linear programming model, designed to maximize the gross margin subject to meeting minimum food crop consumption requirements of the farming household, was the computational tool in this farm planning analysis. Variable price programming was used to generate data for normative supply functions of the three major food crops. Then regression analysis was used to estimate the price elasticities of the normative supply of these major food crops.

The study suggests that in 1979 only one of the three regions has much possibility to increase food production and farm income. This is in North Lampung. The results of the analysis show that there is little potential to increase farm income and food production through the adoption of currently available new technology for the representative farms in Central and South Lampung. Most of the currently available new technology apparently has been adopted. In North Lampung some potential appears to remain for further adoption of currently available new technology, in this relatively newly settled transmigration area.

For Central and South Lampung the major efforts to increase food production and farm income could be the development of research to produce new highly profitable inputs or import them from the other areas with testing at the farm level. Examples of such new inputs include new seeds, fertilizers, insecticides, new cultural practices, and mixed cropping for the small farmers. Also needed is the training of the farmers for the use of these new inputs, and farmers' organizations for the distribution of these new inputs and for marketing the products. The efforts such as of Tani Makmur Project in this regard need to be continued and expanded.

The analysis also shows that there is a comparative advantage in producing specific crops with specific cropping patterns in each region. North Lampung has a comparative advantage in producing cassava and upland rice with the cropping pattern: corn + upland rice +/ cassava. Central Lampung has a comparative advantage in producing rice and cassava with cropping patterns consisting of crop mixtures: corn - soybeans + cassava, and corn + upland rice +/ cassava. South Lampung has a comparative advantage in producing soybeans with cropping patterns: upland rice - soybeans, upland rice + corn - soybeans, and triple crops of soybeans.

Labor is particularly limiting during land preparation and weeding seasons in North Lampung. The increase in the availability of labor in these peak seasons could significantly increase farm income and output. Hired labor is very small during these peak seasons which may be due to the absence of landless farmers in the study area. In general operating capital was not a limiting factor for the representative farmers, most of whom practiced mixed cropping. But medium to long term credit may be needed for investment in the additional sources of power (e.g., cows and other sources of power) to reduce the labor constraints in the peak seasons.

The products of the variable price programming analysis were the step normative supply functions for rice, corn, and cassava under traditional and new technologies. These step supply functions were then transformed into the continuous supply functions by means of regression analysis. From these continuous supply functions then, price elasticities were calculated for these three major food crops. For specific use for policy makers these elasticity coefficients were converted into absolute changes in output response to a 1 percent change in prices.

All the supply functions of the three major crops were inelastic in the price range from existing levels to somewhat higher levels. Under the new technology the supply curves of the three crops shift upward to the right indicating that the new technology would increase production of rice, corn, and cassava at all price levels in the study area.

The price elasticities for cassava and corn are higher under the new technology than under the traditional technology. In all cases the price elasticity of cassava is the highest and price increases for cassava are the most effective means to increase both cassava production and farm income compared with the other two crops.

Dedicated to my parents Saul br. Lumbanraja and Jabidu Parhusip for all sacrifices they have made for my education in Indonesia and the United States

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CHAPTER I

INTRODUCTION

1.1 The Problem and Its Setting

Indonesia has an area of about 2,027,000 square kilometers covering about 13,000 islands, of which about 2,000 are inhabited. The major islands are Sumatra, Java, Sulawesi, Kalimantan and Irian Jaya. Lampung is located in the south part of Sumatra. See map in Appendix A. For the purpose of agricultural statistics, the country is divided into (a) Java and Madura and (b) Outer Java Islands (FAO/UNDP, 1976). Indonesia to a great extent relies on the agricultural sector. For 1978 the agricultural sector's contribution to the Gross Domestic Product accounted for 31.1 percent compared with 17.8 percent for mining, manufacturing 9.3 percent, trade and financial intermediaries and other services 31.4 percent (Central Bureau of Statistics, Indonesia, 1979). It is also estimated that about 75 percent of the total population is directly dependent on the agricultural sector for their livelihood. About 61.5 percent of the total labor force engages in agricultural activities. This sector is expected to supply food, raw materials, labor, and capital to the other sectors of the economy.

The performance of agricultural sector has not kept pace with the growing population of Indonesia, even though the program for increasing food production, especially rice was initiated a long time ago. For example, in 1977/78 Indonesia imported about 3.3 million tons of food grain consisting of 2.3 million tons of rice and 1.0 million tons of wheat (Glassburner, 1978; World Bank, 1979). Even assuming an expanded government investment in the food crop subsector, improved technology, efficiently operating services and marketing management, and a growth rate of production at an average 3.5 percent per annum, with demand increasing at a rate of 5.0 percent per annum (Timmer, 1974; Parhusip, 1976), it is likely that Indonesia will continue to face a basic food deficit, i.e., rice. It is projected that the rice deficit could be between 2.0 and 3.0 million tons in 1990 (World Bank, 1979).

The problem of increasing food production in Indonesia is also aggravated by the concentration of population on the island of Java. Table 1.1 shows the detail of population distribution by provinces. As can be seen from the table, for 1976, the population of Indonesia consisted of 130.7 million people of which 82 million people or 65.3 percent live in Java, an island with only 7 percent of the total area of Indonesia.

Table 1.1.--Areas and Population of Indonesia by Province for 1976.

	Province	Total Area		Population (thousand)
		Sq. Km.	Percent	
1.	D.K.I. Jakarta	590	0.03	4925
2.	West Java	46300	2.43	23849
3.	Central Java	34206	1.80	23675
4.	D.I. Jogyakarta	3169	0.17	2637
5.	East Java	47922	2.52	27079
	JAVA & MADURA	132187	6.95	82166
6.	D.I. Aceh	55932	2.91	2299
7.	N. Sumatra	70787	3.72	7347
8.	W. Sumatra	49778	2.61	3077
9.	Riau	94652	4.96	3070
10.	Jambi	44924	2.36	1746
11.	S. Sumatra	103688	5.44	3847
12.	Bengkulu	21168	1.11	625
13.	Lampung	33307	1.75	3452
	SUMATRA	473606	24.86	22480
14.	W. Kalimantan	146760	7.70	2136
15.	C. Kalimantan	152600	8.01	834
16.	S. Kalimantan	37660	1.98	1872
17.	E. Kalimantan	202440	10.63	929
	KALIMANTAN	539460	28.32	5773
18.	N. Sulawesi	19023	1.00	1931
19.	C. Sulawesi	69726	3.66	1047
20.	S. Sulawesi	72781	3.82	5729
21.	SE. Sulawesi	27686	1.45	798
	SULAWESI	189216	9.93	9057

Table 1.1.--Continued.

	Province	Total Area		Population (thousand)
		Sq. Km.	Percent	
22.	Bali	5561	0.30	2333
23.	W. Nusatenggara	20177	1.06	2474
24.	E. Nusatenggara	47876	2.51	2496
25.	Maluku	74505	3.91	1309
26.	Irian Jaya	421981	22.16	1042
	INDONESIA	1904569	100.00	130766

Source: Central Bureau of Statistics, Jakarta, Indonesia.

Lampung province, the south part of Sumatra island has a population of 3.5 million people or 2.5 percent of the total population of Indonesia. Of the land area cultivated in Java (46.7 percent of the total area) more than 70 percent of the farms had less than one hectare. The average family size on all farms was five. The land area cultivated in Lampung is only about 24.7 percent of the total area (Central Bureau of Statistics, 1979). On the outer islands there are vast areas of land potentially available for increasing food production. In Lampung itself there are 2.0 million hectares of such land (Bogor Soil Research Institute, 1971).

The problem of population distribution has been partly tackled by the transmigration program from Java to outer islands. Thus these programs have the dual strategies of easing Java's population pressure and also developing the outer islands. The intended impact is to increase food production, increase income per capita, create employment opportunities and create new economic growth centers outside Java which are intended to attract new migrants.

Lampung province has great potential both for increasing food production and as a transmigration program recipient. Lampung has been the major recipient of the transmigration in terms of the number of families for the period of 1969/70 through 1974/75. This is primarily due to its strategic location which is very close to Java, only one half hour by air or two hours by bus plus four hours by ferry. It also has relatively good transportation and communication facilities compared to the other regions of the outer islands.

Another significant constraint on the development of agriculture is the low level of farm investment. The result is that land and labor continue to be the main inputs in food production, especially for upland crops in Lampung. The use of purchased inputs such as fertilizers and pesticides/insecticides are extremely low, especially in upland farming. The tools used in farming are mostly hoes and ploughs. The low level of production technology has been cited as one of the causes of poor performance of agricultural sector. Low productivity in Lampung province can be also attributed to the lack of the price incentive, insufficient resource base including lack of capital or credit, managerial know-how, shortage of labor and low land fertility.

In Lampung the increase in food production is mostly due to increases in areas of lowland and upland cultivated. The following table shows the area expansion of upland and lowland for food crop production during the period of 1969-1976. From the table we can see that, during that period, the total acreage increase was 30,000 ha and 90,000 ha or the rate of 5.6 percent and 7.5 percent per annum for low-land and upland respectively.

In terms of acreage, upland contributed about 72 percent of the total area cultivated for food production.

Table 1.2.--Acreage Expansion of Lowland and Upland in Lampung for the Period of 1969-1976.

Year	Lowland (ha)	Annual Change		Upland (ha)	Annual Change	
		ha	%		ha	%
1969	65,793	-	-	150,000	-	-
1970	71,282	5,489	8.34	168,188	18,188	12.13
1971	77,836	6,554	9.19	198,877	30,689	18.25
1972	83,431	5,595	7.19	220,955	22,070	11.10
1973	90,791	7.360	8.82	227,014	6,059	2.74
1974	89,843	-3,703	-4.08	233,044	6,030	2.66
1975	89,843	2,755	3.16	227,103	-5,941	-2.55
1976	95,792	5,949	6.62	240,900	13,797	6.08
Average Annual Change		4,300	5.5		12,965	5.5

Source: Dinas Pertanian Rakyat Lampung: Repelita III Subsector Pertanian Tanaman Pangan Propinsi Lampung 1979/80-1983/84.

This is due to the well distributed rainfall during the year, and a very short dry season which is suitable for a year around upland cropping system (Kongres Agronomi, Jakarta, 1977).

1.2 Theory of Agricultural Development

A background framework of theory of agricultural development will help place the results of this study in perspective. Schultz (1964) viewed that peasants, in traditional agricultural systems, were rational, efficient resource allocators. They remain poor, because they had limited technical and economic opportunities to which they could respond. In this theory the agricultural transformation requires investment in producing and introducing the new higher productivity agricultural inputs, such as high yielding seed varieties, and chemical fertilizers. This theory is incomplete since it treats technical change as exogenous to the economic system. Ruttan and Hayami (1971) augment agricultural development theory with an "Induced Development Model" which treats technical change as endogenous to the development process in which both the private and public sectors are responsive to the relative price of factors. For example the mechanical technology is induced to be developed where there is labor scarcity (high cost labor) and biological technology is induced to be developed where land is a scarce resource (has high cost).

Competitive conditions are assumed with profit maximizing behavior by farmers.

To achieve a sizeable increase in agricultural production and productivity through the introduction of the new technology, "development services" or "unconventional inputs" such as agricultural research, education, and extension are required that broaden the range of alternative production possibilities available to the farm operators. New information which strengthens their capacity to make and execute decisions on the basis of more adequate knowledge of productive agricultural technology is of particular importance (Johnson, B. F. and Mellor, J. W., 1961).

In Lampung currently in the dryland farming, the status of agricultural transformation is uncertain. Two hypotheses are proposed here that may reflect the status of agricultural transformation in Lampung as follows:

Hypothesis 1: That the traditional agricultural technology brought over from Java has reached its equilibrium.

Hypothesis 2: That a certain amount of new technology has been adopted by the farmers. Subhypotheses here are: (a) that whatever new technology has become available it has already been incorporated and new equilibrium has been reached; and (b) that there remains significant opportunity for greater use of the currently available new technology for increasing food production and farm income.

To explore these hypotheses the study was conducted in various regions of Lampung where transmigration is concentrated and the upland farming system for food crop production is the main agricultural activity. Lampung is divided into three Regional Development Areas (North, Central, and South) based on population density and administrative regions, and perhaps agroclimatic conditions (BAPEPPDA Lampung, 1979). See the map of Lampung province in Appendix A.

The Third Indonesian Five Year Plan states that large scale mechanized public or private farms should also be encouraged outside Java to increase food production through the opening of new land. These large scale farms make extensive use of machinery and other modern inputs such as improved seeds, fertilizers, insecticides, herbicides, and better management. Examples of such farms are P.T. Mitsugoro, P.T. Daya Itoh, and P.T. Pago in Lampung province. These three farms have demonstrated the possibilities of turning alang2 land (Imperata cylindrica, which due to this tenacious grass before was considered as waste land) into productive ground. Food crops grown include corn, upland rice, and cassava. The yields were more than double that obtained on local traditional farms (Tsurumi, 1977). But in this study, these large scale highly mechanized farms are excluded and attention was given only to to the traditional and transitional small scale (subsistence) farms. This is not to say that the large scale mechanized farm is unimportant, but our emphasis here is to study those small scale subsistence farms. We assumed that the development of small scale farms in Indonesia will be the right strategy for increasing food production and income of millions of small farmers. This approach is supported by R. D. Stevens (1977) whose arguments can be summarized as follows:

1. Increasing food production on small farms is a primary route for improving national income distribution.
2. In rural areas where unemployment is endemic and sufficient off-farm employment opportunities are unlikely available in the coming decade, due to a combination of rapid population growth and low rates of growth in employment in the service and particularly in the industrial sectors of developing nations.
3. The rising of food prices and global food scarcities has drawn attention to role of small farmers might play in food production.
4. Increasing energy costs for agricultural production, contributed sharply by recent sharp rises in petro prices and subsequent increases in the cost of nitrogen fertilizers.

Robert S. McNamara (1972), President of the World Bank, also registered concern about progress on small farms when he states "without rapid progress in small holder agriculture throughout the developing world, there is little hope of achieving long term stable economic growth or significantly reducing the level of absolute poverty."
Fred Winch (1976) conducted research in Northern Ghana on costs and returns of six alternative rice production systems based on farm size and source of power for land preparation, and concluded that the small farm (3.9 acres) labor intensive approach produced substantial output and income to farmers and generated economic profits. This implied that, in a strategy to increase rice production and farm income, emphasis should be given to the development of small farms.

These authorities have indicated that the solution to the national problems of food supply, income growth, and employment depends on the increasing productivity and creating new job opportunities among the vast number of small farmers throughout the developing nations.

Korea is the example of a success in developing its agriculture through the development of small farms under a noncommunist system as a strategy to increase food production and improve the welfare of the rural population.[1]

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[1]See Workshop on the Development Strategies for Small Farmers, National Agricultural Economics Research Institutes, Ministry of Agriculture and Fisheries, Republic of Korea, 1974.

The development of small scale farms is also consistent with the food policy in Indonesia, i.e., increasing per capita food consumption to improve nutritional standards, especially among the poorest groups of the society, and improvement of productivity of small farms in order to increase their incomes. At present, the new technology for increasing food production is chiefly offered through "BIMAS" (Mass guidance for increasing food production) for lowland rice. Less attention is given to the development of upland crops. Programs aimed at investigating upland cropping patterns are rarely applied in the outer islands. But in Lampung this cropping system research has been conducted by the two separate agencies: The "Tani Makmur Project" and the Central Research Institute for Agriculture (CRIA), which are operating independently. The Central Research Institute for Agriculture received technical assistance from the International Rice Research Institute (IRRI) and the Tank Makmur Project received technical assistance through Japanese bilateral foreign assistance and guidance from the Directorate General of Food Crops in the Ministry of Agriculture. In general, CRIA cropping system experiments feature higher level of cropping intensity than the Tani Makmur Project system, but the CRIA system has not yet been extensively tested in the farmer's fields, as has the Tani Makmur system. The Tani Makmur Project also enhances the farm organizations' ability to cope with the introduction of the new technology, especially by farmer's training, distribution of agricultural inputs, and introduction of revolving funds. For the purpose of this study the Tani Makmur Cropping system experiment output is more relevant than the CRIA as a source of data, since we are focusing on an analysis of the farmers' cropping activities.

1.3 Objectives

The primary aim of this study is to analyze the effects of the new technology on food production, resource use, productivity, and income of small farmers on the dry upland farming systems in Lampung. The specific objectives are:

1. To develop a comprehensive description of the cropping systems presently used on upland farms in the study area.
2. To identify and analyze the technological potentials presently available to increase food production and farm income, by studying the effects of new technology on cropping patterns, resource use and productivity, the use of new inputs, and on farm income.
3. To identify the major constraints facing small farmers in increasing food production and their income.
4. To derive the normative supply functions of major food crops, i.e., rice, corn, and cassava; and to

estimate their price elasticities of supply of these major crops.

5. To derive from the result of the study some possible implications for development policies and strategies for increasing food production and income of small upland farmers in Lampung.

To achieve the above objectives various analytical tools are available: (1) linear programming in its multi-faceted forms; (2) budgeting; (3) aggregate time series data analysis; (4) marginal analysis; and (5) simulation. These techniques are not necessarily exclusive, but each can be combined with one or more of the others. In general, the choice of analytical technique depends, most importantly, upon the availability of data and the purpose of the study.

1.4 The Research Approach

Previous studies in Indonesia were conducted by McCarl (1978) who used a combination of linear programming and budgeting in studying the prospects of food production in Indonesia employing secondary data. Dibyo Prabowo (1977) conducted research in the Solo river basin (Central Java) using linear programming approach to determine the agricultural production activities to which farmers should allocate their scarce resources of land, labor, capital, and water so as to maximize net returns to the limited resources. He also determined how resource use and production are affected when certain constraints are relaxed.

The study shows that the irrigated farm has the highest potential for increasing farmers' income and unirrigated farm has the lowest potential for increasing small farm income.

These linear programming studies have been carried out in Lampung. Sultoni Arifin (1978) examined the effect of village labour resource on the feasibility of new cropping system in Central Lampung, by the use of linear programming approach. Rusdian Lubis (1978) examined the impact of cropping system on production, employment and income in resource management of upland areas in Central Lampung. Nurzaman Bachtiar (1978), examined the cash liquidity in adoption of the new cropping system in Central Lampung by using linear programming approach. All of these studies that have been conducted in Central Lampung used data from multiple cropping experimental plots of 1,000 square meters in one village (Bandarjaya) conducted by Central Research Institute for Agriculture in 1976/77. There is no clear way of how to adjust the data example of yields from the experimental plots to the real farm conditions (physically, economically, institutionally, etc.) on the small farm in Lampung. Wardhani (1976) used linear programming approach to examine various constraints for food production in the settlement areas of Lampung with the use of secondary data from various government agencies which most frequently are unreliable in developing countries, so that the results of the analysis may be questionable.

Linear programming approach as an analytical tool has proved to be useful in the analysis of the small farmer's behavior in Indonesia as indicated by these studies. Other approaches could have been followed. Linear programming was selected because standardized technique have been developed and it is to somewhat easier to apply than certain other methods such as simulation. The major problem has been data sources and quality. In this study, primary data were collected through survey methods in the areas where new technology has been introduced by "BIMAS" and/or "TANI MAKMUR PROJECT" to the small upland farms in Lampung province. The data provided estimates of relevant parameters under new and traditional technologies on the representative operating farms.

1.3.1 The Analytical Framework

To achieve the above objectives, the linear programming tool was chosen. Linear programming is highly suitable for analyzing farm adjustment problems and estimating supply functions in the approach of previous environment where no time series data exist. A static linear programming model of the "representative farm" in the study area will be used to obtain the optimum farm plan under traditional technology and existing resource constraints as a base for comparison. And then new activities, constraints, production coefficients reflecting the use of the new technology with modern inputs under farmers' conditions were introduced into the model to find the optimal plan with new technology. A comparative analysis of these farm plans was used to indicate the direct change in farm income, resource productivity, and cropping patterns that could result from full introduction of the new technology into the existing farming system.

Static, normative supply curves of the major food crops under both technologies were derived by means of variable price (parametric) programming. Regression analysis was used to estimate the price elasticities of supply of the major food crops.

It has been recognized that production and consumption considerations are both important for small farm-firms, so an attempt has to be made at integrating the two decisions into a single methodological framework. Endogenous determination of consumption activities in linear programming allows the staple food to be grown for home consumption or for sale in the market. For example, the minimum level of rice consumption must be supplied from production or purchases. The use of linear programming as a computational tool in farm planning exercises is based on the hypothesis that peasant farmers tend to behave in ways which optimize their objective(s) given the constraints within which they operate.

Risk factors are an important consideration in smallholder decision making. Therefore some method of incorporating risk factors into the linear programming framework is needed. A number of approaches have been developed to take into account risk factors in linear programming models (McCarl, 1978; Andrew, 1976; Kennedy and Francisco, 1974), but there is yet no clear guidance for choosing the best method. Also, data such as time series on yield, prices, and production costs, needed to measure income variability may not be available. These data are required for the application of Quadratic Programming techniques to peasant farmer behavior under uncertainty. It is likely that peasant farmers are concerned about achieving a minimum level of production with certainty rather than minimizing income variance (Sow, 1974). In this study risk factors will only be incorporated in the analysis as consumption constraints for the major food crops.

The general procedure to achieve the objectives involves (Low, 1974): (i) survey the specific areas in the three major development regions of Lampung using sample farm data to define representative farm resource situations and various alternative production possibilities in each region; (ii) construct and structure the framework for the linear programming model by determining the technical coefficients, the operational constraints, activities or processes based upon the sample data, (iii) program the representative farm in order to carry out objectives 2, 3; and (iv) derive policy implications from the results of the analysis for development policies and strategies to increase farm income and food production.

1.3.2 Some Advantages and Limitations of Linear Programming Approach

The main advantages of the linear programming technique is that it can encompass in the analysis several commodities as farm activities, seasonal labor, land constraints, more than one production technique, land-capital substitution, and choice among several farm activities which are subject to different economic, resource and behavioral constraints (Mudahar, 1974). Thus linear programming can be used to provide a more adequate analytical description of the whole-farm situation than other commonly used computational techniques for farm planning. Another advantage of the linear programming technique is that it allows the determination of certain important economic measures of optimal plan. For example, it is possible to say how stable the optimal solution is, measured in terms of the changes in the net revenue of the enterprise needed to bring about a change in the level of activities in the optimal solution. The productivity of each farm resource can be assessed and the importance of the various planning constraints can be evaluated.

A limitation of linear programming is that some of its assumptions may be unrealistic. For example, traditionally in linear programming we assume that there is no farmer's enterprise preferences, they have perfect knowledge of various alternatives, there is no scale of economies in the processes, and risk and uncertainty do not enter decision making. We also assume that farmers adjust to the optimal solution instantaneously, i.e., without a lag. Upton has discussed and provided an excellent summary of some of the methodological problems that comprise the most important limitations to the application of the linear programming method to subsistence farms (Upton, 1974).

1.3.3 Sources of Data

For developing a farm plan by linear programming, data are typically needed on the production alternatives on the farm, the technical coefficients of production, prices of inputs and outputs at the farm level, and resources that are available on the farm. Data can be obtained from secondary or primary sources. Consideration of the relevance and reliability of the data on one hand, and time and funds/resources available on the other hand will determine the balance between the two sources. The use of secondary data sources are cheap, but the data available may not provide reliable estimates of the parameters of the population being studied. In developing countries it is common that data from secondary sources are frequently unreliable. Official sources may not have the data needed or the available data may be inaccurate. So the collection of the primary data from the field is the common need for social science research in developing countries. The empirical analysis in this study will draw mostly from primary data sources, by interviewing a number of sample farmers in the study area.

1.3.4 Sampling Method and the Sample Size

Sampling Method

Lampung province is administratively divided into three Kabupatens (equivalent to the county level), i.e., South, Central, and North Lampung. Each Kabupaten is then subdivided into many Kecamatans (equivalent to the township level). South Lampung consists of twenty-four Kecamatans, Central Lampung with twenty-three Kecamatans, and North Lampung with twenty-four Kecamatans. Each Kecamatan again is divided into many villages.

In terms of population density South Lampung is the most populated area (150-200 persons per square kilometer), next is Central Lampung (100-150 persons per square kilometer), and the least populated is North Lampung with less than fifty persons per square kilometer. The administrative regions are overlapped with the Development Regions as mentioned earlier. We believe that variation in population density is closely related to the length of time the area has been settled, and may be due to the variation in natural conditions, and infrastructure facilities, and consequently to the variation in cropping system and the kinds and the number of crops grown in each region. The Japanese Survey Mission for Agricultural Development in Lampung (1972) concluded that each of the three Kabupatens has its own characteristics. In terms of the cropping ratio of food crops and cash crops (perennial), South Lampung tends to cash crops rather than food crops, whereas Central Lampung points mostly to food crop production and North Lampung standing midway between the two areas. Production of the major food crops by subregion (Kecamatan) in each region (Kabupaten) can be seen in Appendix B.

These heterogenous conditions of the areas in Lampung province in terms of population densities, length of settlement, cropping patterns and number of crops grown led us to the use of a two stage sampling method. The first stage involves purposive sampling up to the village level and the second stage involves simple random sampling at the village level (Friedrich, 1977). By using stratification by region then every region (Kabupaten) was represented in this study.

After two days of observations with extension personnel and local official of the three Kabupatens and after in-depth discussion we came to the following conclusion. We should select village by the purposive method to be representative of Lampung province as follows: South region of Lampung represented by Pugung Raharja village; Central region of Lampung represented by Adiluih and Bulusari villages; North region of Lampung represented by Tatakarya village. Since Central Lampung is more diversified in terms of crop and cropping pattern, two villages were selected to represent this region. The selection of these four villages was made after discussion with each village head and with "Mantri Pertanian Kecamatan" (extension worker at the township level). The villages that have been selected were judged to be typical of the area they represented in important attributes which influence the cropping patterns. From each village selected, random sampling was used to select the representative farmers.

Sample Size

The sampling frame was drawn from the list of all farm cultivators in each village which is available in the village office.

Statistical theory can help us determine the sample size for a particular survey in a universe provided we specify the variance of the variable and the degree of accuracy of the estimates we want to derive (Yang, 1965). This system will work well for problems where only one variable is handled. However in this study we dealt with several important variables such as labor utilization for different enterprises, prices received, wage rates of hired labor, etc. These make it impossible to apply formal statistical procedure and to achieve statistical representativeness of the sample.

A statistical formula was not used in this study to arrive at the number of farmers to be selected for interview. Instead, budget and time, and the availability of the interviewer candidates, and experience of the researcher determined the size of our sample. The primary sampling unit was the family farm household representing both the production unit as well as a consumption unit.[1] The sampling frame was the whole family farm cultivators in the selected village, which can be found in the village record. From the list of cultivators in each village a random quota sample of twenty-three farm households were drawn. Yang (1965) concluded that roughly twenty farms should be included in each class (stratum) in order to make a reliable comparison. Friedrich (1977) suggested twenty to twenty-five observations being necessary to produce reliable estimates for each group. The reliability of estimates however, very much depends on the actual variability of the population. This then made up of the total sample of ninety-two farm households from the four villages that were selected. For a random selection in each village, the researcher asked for the help of the village head after instructions were given by the researcher. This was done to hopefully reduce the suspicions from the village community during the survey period. Then the village head introduced the interviewers to the selected respondent farm households and briefly explained the purpose of the survey.

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[1]Definition of household or farm family, those people eating from one pot (Norman, 1973). They also work together as a production unit.

1.3.5 Data Collection

The survey schedules (questionnaires) were designed and developed for the purpose of collecting the needed data. Data for only one year cropping cycle of 1978/1979 were collected. Four agricultural university graduates helped to conduct the interviews during the period of the survey from August 1979 through December 1979. They are Extension Specialists (government employees) who are stationed in the areas of study and are familiar with the local farm conditions.[1] But on the other hand, there is a problem of dual allegiance (dual loyalty one as extension worker/ government employee and the other as an interviewer), which makes supervision or control difficult, or if not is impossible (Friedrich, 1977). During the first month data were collected on the previous years cropping cycle farm operation (September 1978-August 1979). Again with the same interview procedure, the interview was repeated in September and October after the good "rapport"[2] between the interviewer and the respondent farmer had been established. To improve data reliability, then every month from September

[1]For detailed procedures in selection of the interviewer candidates see: Frank Lynch, S. J. (1976), Field Data Collection in Developing Countries: Experiences in Asia, Seminar Report No. 4, June 1976, Agricultural Development Council, Inc., New York.

[2]"Rapport" could be described as genuine respect and understanding of both interviewer and the farmer, which to a large extent determines the quality of communication and the accuracy of response.

through December 1979, data were collected on family farm activities, off-farm activities, and consumption of the major food crops. This allowed for relatively short recall on the part of the respondent. More emphasis was given to the collection of data on labor use and family labor allocation during the peak demand for labor (September-December). The "periodic-visit survey" method was used, which represent the compromise between "single- and multi-visit" surveys, in collecting information on a few well-timed rounds organized around the completion of crucial phases, but also require a time period of a complete production cycle, usually one year (Friedrich, 1977). So the interview was based on monthly recall by the representative farmers. Each interview lasted from one hour to one-and-a-half hours for each respondent. Each interviewer was assigned one village in each region with which he is familiar.

The problems encountered during the data collection throughout the survey period are similar to those discussed by Spencer (1972) and Norman (1973).

1.3.6 Construction of the Representative Farms

The ideal approach is to program every farm unit, but cost of programming may be prohibitive, and it is not a practical approach. This led to the use of the representative farm, the representative of farm situation as the unit of linear programming analysis. In areas where there is a reasonable homogeneity with respect to major resources particularly natural resources, such as soil type, topography and climate, linear programming can be used to obtain the solution to a "representative farm" situation in order to guide planning for individual farms.

The usefulness of the representative farm approach is limited by the manner by which the representative farm is constructed. Collinson (1974) has discussed three alternative techniques for deriving representative farms. These are:

(a) the identification of a particular farm as the typical farm,

(b) the use of an "average farm" (derived from an average resource, input-output, and net price coefficients of a sample farm) as a representative farm

(c) a "hypothetical" or synthesis of composite farm from different components of the population.

It is not easy to find a single farm that could be validly considered typical in all respects. It requires consideration of a wide range of criteria. The selection and the construction of the criteria are difficult tasks and data for this purpose may not be available nor easy to collect.

The use of "average farm" as the representative farm, brings with it the aggregation bias. Miller (1966), Buckwell (1972) and Carter (1963) have discussed the aggregation bias inherent in the average farm approach. Aggregation bias exists when the sum of the solution from the individual farms in the set does not equal the estimate obtained by the optimum solution to the entire set directly. While the synthesis of composite farms reduces the aggregation bias, it has the practical weakness in that it is difficult to identify several institutional variables and human factors and their distribution within the population. These nontypical variables involve institutional constraints, motivations, preferences, managerial ability, etc. which have an important impact on farm organization, production efficiency, and earnings (Plaxico and Tweeten, 1962). The choice of the method for construction of the representative farm depends on the purpose for which the result of the study is to be used. In this study the objective is to identify the constraints and farm adjustments and to estimate the degree of farmers response to changes in prices of major food crops in a given area, so the use of the "average farm" as representative farm can be justified. The representative farm is based on data obtained from the survey. The farms in the sample were considered sufficiently similar with respect to the key variables that affect adjustment. In the study area all the sample farmers were transmigrants from Java, and they were allocated land of about two hectares per household. Although there is a tendency toward land ownership concentration in the area of longer settlement, no one was found without land. Thus the level of initial land resources for each individual farmer was rather homogeneous.

1.5 Organization of the Study

This chapter was devoted to the problem definition and its setting, the statement of the objectives and methodological approach for achieving these objectives. Chapter II will present the description of the farming system in the study area as revealed from the data obtained from the survey. The programming model containing activities, constraints, technical coefficients and prices will be discussed in Chapter III. In Chapter IV the results of the various applications of the models will be reported. The derived impact of the new technology on farm income, cropping patterns, resource use and its productivity will be discussed. In Chapter V normative supply schedules for major food crops (rice, corn, and cassava) both under traditional and new technology will be presented. The response of the major food crops to changes in their prices will be examined. The effect of the new technology on the price elasticity of supply for major food crops will be discussed. Chapter VI contains the summary along with a discussion of the policy implications for development strategy from the result of the analysis, limitations and suggestions for further study.

CHAPTER II

DESCRIPTION OF THE FARMING SYSTEM IN THE STUDY AREA

A good knowledge of the structure of the farming system in the area under study is required for proper representation of the agricultural conditions in a linear programming framework. This chapter will try to describe some important attributes of the farming system in the study area as revealed mostly by the study conducted by the author from July through December 1979. The description is presented in terms of the characteristics of the representative farms. The description of the farming system in Central Lampung will be supplemented with the results of the Base Line Survey conducted by Central Research Institutes for Agriculture (Djauhari, Aman, 1977).

2.1 Physical Characteristics of the Study Area

There are about 46 million of hectares of red yellow podsolic soil out of a total of 200 million hectares of land in Indonesia. About 1.5 million hectares of this red-yellow podzolic soil is in Lampung. It is estimated that about 500,000 hectares of this land is covered with alang-alang grass (Imperata cylindrica) as the result of the shifting cultivation in the past.

2.1.1 Soil and Climate of the Research Area

The soil in the research area is a podzolic plain and generally flat, varying from red-yellow through brown in color. In general, this soil is very porous and very low in fertility. Under these conditions and due to cutting of the forest and lack of agricultural land conservation, alang-alang grass (Imperata cylindrica) is the dominant vegetation. The soil has a low pH, is low in nitrogen, phosphorus and potassium content (McIntosh and Suryatna, 1976). The productive capacity of these soils has been seriously questioned by many agricultural scientists. In fact these areas have been described as alang-alang infested waste lands due to production constraints such as low inherent soil fertility, excessive drainage and low pH. But on the positive side there are several assets. The rainfall and its distribution are very good for a year around upland crop production. The average monthly rainfall during the period of 1969-1975 is shown in Figure 2.1. The driest month is in July and wettest month is in March. The rainfall is well distributed and based on this data, the Lampung region falls within Type D2 in the agro-climate map. Rainfall exceeds 200 mm (80 inches) for six months and 100 mm for three months. The remaining three

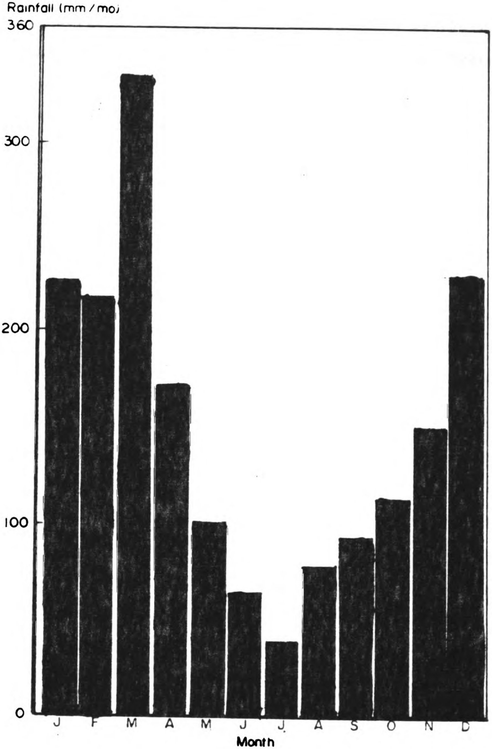

Fig. 2.1. Monthly rainfall pattern in Bandarjaya, Central Lampung, Indonesia, 1970-76.

Source: CRIA, Bogor, Indonesia, 1977.

months are drier but average rainfall is only a little less than 100 mm. Since the soils are well drained, the heavy rains during the rainy season do not inhibit upland crops production, and a year around cropping is possible. Run off problems are minimized by the rapid infiltration of the rain water. Consequently, the soils are acid and leached. But fortunately the soils do not contain excessive levels of aluminum. There is sufficient clay and organic matter to hold applied nutrients but fixation of phosphorus is not a problem. So, these soils can be highly productive if managed properly (Central Research Institute for Agriculture, 1977).

2.2 Land Use

Most of the transmigrants received two hectares of land. But they could only cultivate less than a hectare by depending on the family as a source of labor. Most of the farmers have only subsistence farming in the upland areas using multiple cropping with the major crops of upland rice, corn, and cassava or sometimes with legumes.

The research area can be divided into two categories based on the length of settlement. These are:

Category I - Old alang-alang areas (Pugung Raharja, Adiluih, and Bulusari Villages)

Category II - Newly opened areas (Tatakarya Village which was settled about six years ago).

Usually the farmers start land preparation in the beginning of the rainy season (in September) and planting in October and November each year with rice, corn, and cassava in a mixed cropping system.

2.3 Crop Productions and Cropping Patterns

There were nine crops grown in the study area during the survey period. These crops included cereals, root crops, and legumes, and perennial crops. They are grown either as a sole or as a mixture, but are mostly grown as a mixture (multiple cropping or intercropping). Technical reasons for mixed cropping are: complementary relationships derived by the crops, soil protection and reduction in the incidence of disease and pest attacks. The socio-economic reasons included the maximization of returns by more efficient uses of resources and higher total output and the need for security by more frequent harvest. The crop combinations and the number of farmers growing each combination are presented in Table 2.1.

The table shows that the number of farmers that practiced the mixed cropping system accounted for 60 percent, 70 percent, 98 percent, and 48 percent for Adiluih, Bulusari, Pugung Raharja, and Tatakarya villages respectively. The newly opened areas, Tatakarya had the lowest number of farmers with multiple cropping system in their farming operation. Perhaps they are not yet fully adjusted to the local farming conditions.

Table 2.1.--Number and Percentage of Farmers by Cropping Patterns of the Representative Farms in Lampung.

Cropping Patterns*	Adiluih		Bulusari		Pugung Raharja		Tatakarya	
	No.	%	No.	%	No.	%	No.	%
1. C + ULR ⌿ CV	4	20	8	38	-	-	16	69
2. ULR ⌿ CV	2	10	10	47	-	-	6	26
3. ULR	4	20	2	9	-	-	-	-
4. CV	5	25	10	5	-	-	20	87
5. LLR	8	40	1	-	-	-	1	4
6. ULR - SB	-	-	-	-	13	65	1	4
7. C + ULR - SB	5	25	-	-	2	10	-	-
8. C + SB ⌿ CV	-	-	-	-	8	40	-	-
9. C + ULR/CV	-	-	-	-	5	25	-	-
10. SB-SB-SB/CV	-	-	-	-	6	30	-	-
11. C/COC	4	20	-	-	-	-	-	-
12. GNDT	-	-	-	-	-	-	4	17
13. PEP	-	-	-	-	1	5	2	8
14. C ⌿ CV	-	-	-	-	-	-	2	8
15. ULR + SB/COC	1	5	-	-	-	-	-	-
16. COF + COC	1	5	2	9	-	-	-	-
17. CLO + COC	3	15	-	-	-	-	-	-
18. COC/FC	2	10	1	5	5	25	-	-
19. COF/FC	3	25	3	13	-	-	-	-
20. PEP + CLO	-	-	-	-	5	25	-	-
21. CLO/FC	-	-	-	-	3	15	-	-

Source: Field Survey.

*+ Two crops planted together at the same time or the second crop planted within a week after the first crop.

⌿ The second crop planted a month later after the first crop.

\- The second crop planted after the first crop harvested.

/ The last crop planted between border or fencing or between the existing perennial crop.

For explanation of abbreviations, see Table Cl, Appendix C.

Table 2.2 shows the number of hectares devoted to different crop enterprises by the representative farmers in the study area during the survey period. Mixed cropping accounted for 61 percent, 70 percent, 77 percent, and 68 percent for Adiluih, Bulusari, Pugung Raharja, and Tatakarya villages respectively. Both in terms of the number of farmers and the total area, multiple cropping or mixed cropping is dominant cropping pattern in the study area. It can be also expected that the longer the area is settled, the more land will be devoted to perennial crops such as clove, coconut, coffee, and pepper. Such crops occupy very little cultivated land on farms in Tatakarya, the newly settled area, and average 0.2 ha or 13 percent for Bulusari, 0.21 ha or 14 percent for Adiluih, 0.35 ha or 24 percent for Pugung Raharja villages. Area devoted to food production decreases as the longer the area has been settled. This can be explained as follows: First, the deterioration of soil fertility, which more and more suitable for perennial crops rather than for food crop production. Second, land ownership concentration increases as the longer the area settled, so perennial crops again is the answer to cope with labor shortage for these larger farms, since perennial crops require less labor both in the total labor per hectare and seasonality in labor use. Third, that relative price between food crops and perennial crops deteriorated, may be due to the effect of government policy and external effect of the increasing demand for coffee,

Table 2.2.--Average Area Devoted to Each Cropping Pattern by the Representative Farms in Lampung.

Cropping Patterns*	Areas/Villages: Adiluih (ha)	Bulusari (ha)	Pugung Raharja (ha)	Tatakarya (ha)
1. C + ULR ≁ CV	0.28	0.40	-	0.62
2. ULR ≁ CV	0.18	0.31	-	0.19
3. ULR	0.17	0.10	-	-
4. CV	0.16	0.27	-	0.37
5. LLR	0.25	0.23	-	0.02
6. ULR - SB	-	-	0.36	0.03
7. C + ULR - SB	-	-	0.28	-
8. C + SB ≁ CV	0.11	-	-	-
9. ULR + C/CV	-	-	0.20	-
10. SB-SB-SB/CV	-	-	0.24	-
11. CV/CO	0.10	-	0.02	-
12. GNDT	-	-	-	0.06
13. PEP	-	-	-	-
14. C + CV	-	-	-	0.09
15. ULR + SB/CO	0.02	-	-	-
16. COF + CLO	0.02	-	-	-
17. CLO + CO	-	-	-	-
18. COF/FC	0.10	0.05	-	-
19. CO/FC	0.09	0.04	-	-
20. CLO + PEP	-	-	0.12	-
21. CLO	-	-	0.23	-
Average Size of Farm	1.48	1.44	1.45	1.38
Average Food Crops	1.27	1.25	1.10	1.38
Average Perennial Crops	0.21	0.19	0.35	0.00

Source: Field Survey.

*For explanation of the abbreviations, see Table C1, Appendix C.

clove, by international market. Government policies with respect to food and price stabilization in a low level (consumer oriented policies) for the price of food crops, e.g., rice, corn. There is no such effort for perennial crops which is promoted for export commodities. The likely impact to the farmer's decision in the longer run is to devote more land for perennial crop production and less for food crops. This trend is unfavorable or contradicted with the self-sufficiency food program at the national level. The transmigration area is expected at least to become self-sufficiency in food, and some food surplus to be supplied to the city, e.g., Jakarta. This hope may not be fulfilled if this trend continued. It seems there is a conflict between food production self-sufficiency program at the national level and in the micro level or farm level in the transmigration area in Lampung.

2.4 Technology of Agricultural Production

Two kinds of agricultural production technology found in the study area, the traditional and the new technologies. The traditional technology are two types, one is the indigenous traditional technology with shifting cultivation or slash and burn is still exists mostly practiced by the indigeneous population (Lampungnese) and the second type is locally developed by the transmigrants in their settlement areas, e.g., mixed cropping and/or sole cropping without use of any new modern inputs. The practice of multiple cropping may be influenced by multiple cropping system in Java, the origin of the transmigrants. In this study the traditional technology considered is the one that locally developed by the transmigrants only, not included the shifting cultivation. New technology is use of new inputs and/or new techniques such as the use of fertilizers, insecticides, improved seeds, tractor for land preparation to the traditional farming. The traditional food crop production technology currently being replaced partly by the new technology through the extension activities of BIMAS and TANI MAKMUR PROJECT, which introduce the use of improved seeds, fertilizers, insecticides/pesticides to the existing locally traditional cropping systems. Seeds use are mostly local varieties for rice, cassava, soybean. Corn seeds used were improved varieties (such as Metro, DMR). Fertilizers input is considered to be the main modern input of the new technology. On the average about forty kilograms of urea and twenty kilograms of phosphate fertilizers and two liters of insecticides were used per hectare by the representative farm in the study area, much less than recommended level at 200 kilograms of urea and phosphate fertilizers. Land preparation starting in August/September up to November/ December. Land preparation by manual labor and some with the use of animal power both for traditional and new technologies are existing in the study area. Use of tractors and other farm machineries are absent in the small upland farm operations.

The large scale highly mechanized farms do make extensive use of machinery and other modern inputs such as improved seeds, fertilizers, insecticides, herbicides, and better management including better products, processing and marketing. Examples of such farms are P.T. Mitsugoro, P.T. Daya Itoh, P.T. Pago and other similar estate farms in Lampung, both foreign and domestic enterprises. Food crops grown including upland rice, corn or maize, and cassava as a single crops or pure stands. The yields were more than double that obtained on local traditional farm. However these large scale highly mechanized farms were not included in this study because of the particular objectives as has been mentioned before was emphasized on small upland farms.

2.5 Some Demographic Characteristics of the Representative Family Farms in the Study Area

In the following table shows the main demographic characteristics of the representative family farms population in the study area. Sex ratios in all villages are above one, that is the proportion of males is more than 50 percent. The sex ratios of the active populations are below 60 percent and vary between 53.8 percent to 59.4 percent. The dependence ratio[1] is the highest in the newly settled area, i.e., Tatakarya Village with a 0.87 ratio. This can be

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[1]Dependent ratio is the ratio between the number of dependent children plus the number of dependent aged and the number of active population. See Table 2.3.

Table 2.3.--Some Demographic Characteristics of the Representative Farm Households in Lampung.

Demographic Characteristics	Villages			
	Adiluih	Bulusari	Pugung Raharja	Tatakarya
1. Sex Ratio = $\frac{\text{No. Males}}{\text{No. Females}}$	1.40	1.00	1.30	1.06
2. Dependent Children (0-14 years old)	39.6%	43.6%	45.0%	50.0%
3. Proportion of Males	58.0%	50.0%	56.6%	51.6%
4. Dependent Aged (over 65 years old)	1.0%	0.0%	1.2%	0.0%
5. Active Population (15-64 years old)	59.4%	56.5%	53.3%	54.4%
6. Dependence Ratio $\frac{(2 + 4)}{5}$	0.68	0.77	0.86	0.87
7. Average Family Size	5.3	5.9	5.6	6.0

Source: Field Survey

understandable since most of the family heads are relatively young with more dependent children. This ratio is 50 percent for the Tatakarya Village. The number of dependent aged (over 65 years old) is low in all the villages. The average family size in the study area is 5.7 persons. The highest size of the family is in the newly settled area, i.e., six persons for Tatakarya, 5.9 persons for Bulusari, 5.6 persons for Pugung Raharja, and 5.3 persons for Adiluih.

2.6 Educational Level of Representative Farm Household's Head

The following table shows the educational level of the representative farm household's head for each village. On the average it is very low at 3.3 years varying from 0 to 6 years. This is near to the illiterate level. They can hardly keep records on their farming operations.

Table 2.4.--Average Representative Farm Household's Head Educational Level.

Village	Average Age (years)	Education (years)	Average Family Size
1. Tatakarya	41.6	3.2	6.0
2. Bulusari	43.4	3.6	5.9
3. Pugung Raharja	45.3	3.0	5.6
4. Adiluih	48.0	3.4	5.3
Overall Average	46.1	3.3	5.7

Source: Field Survey

A. Raji Ahmed (1972) in his research on the size of cattle feeding operations has concluded that the success of the optimum size unit is a function of quality of the managerial inputs, the managerial behavior of which is characterized by willingness to accept a higher degree of risk, appreciation for and application of scientific criteria in decision making, and higher levels of formal education.

The low level of agricultural productivity in this transmigration area may be related also to the high risk factors in adapting the new profitable technology. So, it is not just enough to provide them with more profitable new production techniques, but also measures to reduce risk to an acceptable level are required. For more detailed discussion of these problems, see Ruttan and Hayami (1971) and comment by George L. Beckford. Supply of goods and services and provision of better institutions and better opportunities may not be sufficient to achieve the farm income goals although they are necessary conditions for the development of the small farmers. The managerial skills of the small farmers should be improved for small farmer development.

2.7 Farm Labor Force

The family is the major source of the farm labor force. The representative farm in the study area on the average consists of 5.7 persons. A detailed composition of the labor force of the representative family farms can be seen in Table 2.5 which is recorded at the beginning of the survey. The available labor on the representative family farm is 2.75 adult male equivalents. The availability of family labor is determined by many factors such as the family structure (age and sex), health, nutrition, major occupation of each member of the family, customs, and job opportunities outside the farm. It is estimated that about 240-260 days of farm work per year for adult male workers and only about 125 days of farm work for women are available for the representative family.

As one would anticipate in a society where landless does not exist, most work is undertaken on the farm by the family itself. In Pugung Raharja Village the total labor inputs by the representative farm is 315 mandays equivalent per year, of which about 92 percent come from the family sources and only about 8 percent from hired daily labor. This labor hiring activity is small, but it may be important due to their use in the critical season such as for land preparation, weeding, and harvesting. Monthly labor inputs and wage rates are presented in Tables 2.6 through 2.9. Exchange labor is common in the study area ranging from 7 to 20 percent of the total labor input on the farm. The highest percentage of exchange labor is found in the relatively new settled area, i.e., Tatakarya and becomes less and less as the area becomes longer settled. Exchange labor tends to switch to hired labor system, especially when cash crops and perennial crops become more important

Table 2.5.--Representative Farm Family Composition by Age Groups in Lampung.

	Village	Average Number of Persons in Age Groups (years)				Average Family Size (person)	Work Force Available (man-day)*
		Less Than 8	8-14	15-64	Over 64		
1.	Tatakarya	1.70	1.20	3.10	-	6.0	2.50
2.	Bulusari	1.50	1.10	3.30	-	5.9	2.80
3.	Pugung Raharja	1.00	1.56	3.05	0.09	5.7	2.90
4.	Adiluih	1.00	1.10	3.15	0.05	5.3	2.78
	Average	1.30	1.24	3.15	0.03	5.7	2.75

Source: Field Survey

*Marwoto (1975) has calculated the available labor force for a family in Lampung area with unit labor as follows:

Adult Male (Father)	:	1.0 labor unit
Adult Female (Mother)	:	0.3 (if all children under 12 years old)
	:	0.5 (some children over 5 years old)
	:	1.0 (if all children over 12 years old)
Children less than 8 years	:	0.0
Children 8-14 years old	:	0.2
Children over 14 years old	:	1.0 (if not attending school)
Other Adult	:	1.0

Table 2.6.--Total Labor Inputs by Month and Wage Rates on the Representative Farms (Adiluih Village) in Lampung.

Month	Family Labor (Mandays)	Exchange Labor (Mandays)	Hired Labor (Mandays)	Total Labor (Mandays)	Wage Rates (Rupiah/Day)
August	13	3	8	24	500
September	16	8	3	27	500
October	24	4	8	36	600
November	19	6	7	32	600
December	8	11	4	23	500
January	13	8	2	23	500
February	10	5	7	22	500
March	9	3	4	16	500
April	14	5	2	21	500
May	4	3	2	9	500
June	37	3	2	42	600
July	35	3	6	44	600
Total	202	62	57	321	
Percentage	63	19	18	100	

Source: Field Survey

Table 2.7.--Daily Wage Rates and Total Labor Inputs by Month on the Representative Family Farms (Bulusari Village) in Lampung.

Month	Family Labor (Mandays)	Exchange Labor (Mandays)	Hired Labor (Mandays)	Total Labor (Mandays)	Wage Rates** (Rupiah/Day)
August	8	2	12	22	450
September	18	5	2	25	450
October	27	11	2	40	500
November	37	7	1	45	500
December	23	8	1	32	500
January	22	4	2	28	500
February	15	2	2	19	450
March	21	0	14	35	450
April	12	-	-	12	450
May	4	-	-	4	450
June	-	-	-	-	450
July	-	-	-	-	450
Total	185	41	36	262*	
Percentage	69	17	14	100	

Source: Field Survey

*Not including ten animal hiring working days.

**Not including breakfast and lunch which is counted at Rp. 50 and Rp. 100.

Table 2.8.--Daily Wage Rates and Total Labor Inputs by Month on the Representative Family Farms (Pugung Raharja Village) in Lampung.

Month	Family Labor (Mandays)	Exchange Labor (Mandays)	Hired Labor (Mandays)	Total Labor (Mandays)	Wage Rates (Rupiah/Day)
September	31	4	-	35	550
October	15	2	3	20	550
November	23	5	3	31	600
December	32	5	4	41	600
January	30	4	3	37	500
February	18	-	2	20	500
March	16	-	2	18	500
April	15	-	2	17	500
May	32	5	2	41	550
June	12	0	2	14	550
July	20	3	2	25	550
August	16	-	2	18	500
Total	260	28	27	315	
Percentage	82.6	8.8	8.6	100	

Source: Field Survey

Table 2.9.--Monthly Labor Inputs and Daily Wage Rates on the Representative Farms (Tatakarya Village) in Lampung.

Month	Family Labor (Mandays)	Exchange Labor (Mandays)	Hired Labor (Mandays)	Total Labor (Mandays)	Wage Rates (Rupiah/Day)
August	20	5	7	32	500
September	26	9	3	38	600
October	32	14	7	53	600
November	30	11	4	45	550
December	17	4	-	21	550
January	27	-	-	7	550
February	17	-	-	17	600
March	15	-	-	15	600
April	23	-	8	21	600
May	19	-	-	19	600
June	6	-	-	6	500
July	16	-	-	16	500
Total	248	43	29	320	
Percentage	78	13	9	100	

Source: Field Survey

in the areas. Exchange labor is mostly evident during the planting and weeding seasons. There is no clear social arrangement on how to use and repay exchange (gotong royong) labor, but everybody understands and agrees that the farmer or members of his family can work as repayment. There is no standard time within which to repay borrowed labor, but on the average the time span for repayment is within two weeks (Sultoni Arifin, 1978). In this study exchange labor will be treated as family labor and should be repaid in labor within a month.

Hired labor generally is obtained simply on the daily hiring basis. The average wage rates for hired labor in the study area ranged from Rp500 to Rp600 per day, which included two meals, breakfast and lunch. These meals accounted for Rp 50 and Rp 150 respectively. There is not much variation of wage rates between seasons, except for rice harvesting with the "bawon system."

The bawon or "harvest share" is common in the study area for rice harvesting. In the traditional bawon system, rice harvesting takes the form of a community activity in which all or most of the community members can participate and receive a certain share of output. The owner normally gives a harvest share to the harvesters of one-sixth to one-fifth of what they harvested in Lampung area. This is called "bawon." So, the amount of bawon received depended upon the amount harvested, which in turn related to age and sex. The value of bawon in money terms was between Rp 1000 and Rp 1300 per day in 1979 in Lampung for adult males, which was more than double the average daily wage rates at Rp 500. That is why workers prefer joining the rice harvest rather than other farm activities. Hiring labor with bawon system for rice harvesting is also as a social device to redistribute output or income to the less beneficial groups in the village society. For more detailed discussion on the bawon system and recent change in this system see Collier *et al*. (1973) and Sturgess and Wijaya Hesti (1979).

The family labor is the most important in the relatively new settled area, where cash flow is also the lowest, i.e., Tatakarya. The higher percentage of hired labor is in the older settled area with 18 percent for Adiluih, 14 percent for Bulusari, and only 9 percent for Tatakarya Village. In Pugung Raharja Village, the oldest settlement, hired labor is only 8.6 percent. This low percentage of hiring labor may be due to differences in crop production emphasis and cropping system. In Pugung Raharja soybeans and corn are the major crops rather than rice as in the other villages. So the labor distribution is more even in Pugung Raharja Village during the year, because weeding and harvesting is less critical seasons for labor demand for both crops. It is also true that land devoted to food crop is the smallest at 1.10 ha in Pugung Raharja from 1.45 hectare area under cultivation (see Table 2.2). But there is no landless in this area. Cropping intensity may also be higher in this area.

In this study it is sufficient to measure labor use in mandays. The assumption in measuring manday units is that the length of the working day is in part dependent on the cultural pattern of the society. It is about eight hours per day in Lampung area, starting early in the morning at 7 o'clock up to 12 o'clock, then resting for two hours, and then starting again at 2 o'clock up to 5 or 6 o'clock in the afternoon.

Another problem in measuring labor inputs is what weight to use in aggregating man, woman, and children days of work. Work may be affected by the age and sex of the worker as well as by the task being performed and the culture in the society. Norman (1973) has estimated for North Nigeria the weights to a common denominator for converting to labor units. His assumption is that initially there is a positive correlation with age and then a negative correlation with age. He also assumes that the physical productivity of woman is lower than man. The following table shows the Norman equivalent to adult male worker.

Marwoto (1975) has calculated the available number of labor units for settlement areas in Indonesia as is shown in Table 2.11.

Table 2.10.--Man Equivalents Used in the RERU Farm Management Studies.

Labor Class	Age	Male Adult Equivalents
Small child	Less than 7	0.00
Large child	7-14	0.50
Female adult	15-64	0.75
Male adult	15-64	1.00
Female adult	65 or more	0.50
Male adult	65 or more	0.50

2.8 Farm Capital

The two main inputs of traditional agriculture are labor and land. The amount of capital and the proportion of income invested are very low. Mellor (1967) has, however, emphasized that saving and investment are functions of two main factors: (a) the attitude toward saving, investment, and consumption; (b) the low level of capital formation in traditional agriculture is not necessarily because the capacity of saving is low but because of the low rates of return on investment. Most of the capital is actually simple tools or improvements produced mainly by labor. At this low level of technilogy the productivity of additional capital of this type is very low.

Capital in farming includes items such as machines, tools, buildings, roads, land improvements, tree crops, livestock, seeds, fertilizers, etc. These assets are

Table 2.11.--Table of Conversion of Various Working Age and Different Sex for Settlement Areas.

Labor Class	Male Adult Equivalents
Adult male (father)	: 1.00 labor unit
Adult female (mother)	: 0.30 (if all children under 5 years)
	: 0.50 (if some children over 5 years)
	: 1.00 (if all children over 12 years)
Children less than 8 years	: 0.00 labor unit
Children 8-14 years	: 0.20 labor unit
Children over 14 years	: 0.50 labor unit (if attending school full time)
Children over 14 years	: 1.00 labor unit (if not attending school)
Other adults	: 1.00 labor unit

Source: P. T. Agrindo/Harrison Fleming.

usually classified into fixed capital (such as machines, tools, buildings, land improvements, tree crops) with a productive life more than a production cycle;[1] and working capital or operating capital (such as seeds, fertilizers, insecticides/pesticides, hired labor) which are used up in a single production cycle.

The level of fixed capital in the study area is very low compared to labor. Use of capital equipment to substitute for labor is very small. Each family farm owns three hoes, three sickles, one chopping knife, and three "arit" which is used for weeding and cutting grasses. The total value is about Rp 7,800 ($12). In fact most of other capital costs such as in tree crops, land improvement, livestock are the embodiment of labor provided by the farmers. Livestock activity is not important in the study area, restricted only to the backyard poultry.

Operating capital is the value of fertilizer, seed, insecticides/pesticides, and hired labor used in the production process. Use of hired labor and seed do not necessarily mean cash expenditures since most of the labor hired is paid in kind (bawon system) and seed used is mainly saved from the farmer's previous harvest. Fertilizer is Rp 80 per kilogram supplied by the government at subsidized and controlled proces.

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[1]Production cycle in this study can be grouped into: (1) clearing and preparation of land; (2) sowing, planting, and fertilizing; (3) cultivation--weeding, and (4) harvesting.

Personal saving is the main source of cash for purchase of operating capital. Institutional credit is not available except for the farmers who joined the "BIMAS" program. Table 2.12 shows the cash expenditures of the representative farm on purchased inputs by month. These are the amounts estimated that have been spent on hired labor, fertilizers, seeds, insecticides/pesticides, and for food and drinks for hired and exchange labor during the 1978-1979 production season. The total cash expenditure for one year production cycle amounted to Rp 30,000, Rp 54,250, and Rp 18,000 for Tatakarya, Buluwari and Adiluih, and Pugung and Raharja respectively.

Table 2.12.--Cash Expenses by the Representative Farms by Month in Lampung.

Month	Cash Expenses (Rupiah)		
	Tatakarya	Adiluih & Bulusari	Pugung Raharja
August	6000	4500	-
September	1000	5000	1500
October	9600	19750	1500
November	325	5000	4500
December	500	4000	2000
January	1000	5000	1500
February	500	2000	3000
March	500	4500	1000
April	7000	500	1000
May	-	500	1000
June	-	2000	1000
July	-	1500	1000
Total	29250	54250	18000

Source: Field Survey

CHAPTER III

THE STRUCTURE OF LINEAR PROGRAMMING MODEL OF THE REPRESENTATIVE FARMS FOR THE STUDY AREA

3.1 Introduction

A typical decision faced by management is the optimum allocation of scarce resources. Management's task is to achieve the best possible outcome with the given resources. Linear programming is very useful technique in aiding management for making these decisions. This new technique has been accepted by farm management workers in many countries to solve management problems of individual farms (Yang, 1965).

Linear programming problems must meet the following requirements (Lee, 1976).

a. The objective function: Linear programming problems must have an explicit objective criterion to optimize. The objective function may be one of either maximization or minimization of the criterion.

b. Limited resources: In order to apply linear programming, a decision problem must involve activities that require consumption of limited resources.

The amount of limited resources is usually expressed as constraints for the problem.

c. Linearity and additivity: The primary requirement of linear programming is the linearity in the objective function and in the constraints. The word "linear" implies that relationships among decision variables must be directly proportional.

d. Divisibility: Linear programming requires complete divisibility of resources utilized and the units of the decision variables. In other words, fractional values of decision variables and resources must be permissible to obtain optimal solution.

e. Deterministic: In linear programming all model coefficients (e.g., unit profit contribution of each product and the amount of available resources) are assumed to be known with certainty. In other words, linear programming implicitly assumes a decision problem in a static time period.

Linear programming is usually applied to the complex problems which involve many interacting variables that contribute to objective criterion functions.

In linear programming, if a problem involves n-decision variables and m-constraints, the typical linear programming model can be constructed mathematically, as either a maximization or a minimization formulation.

The maximization problem,

$$\text{Maximize } Z = \sum_{j=1}^{n} Cj\ Xj$$

subject to

$$aij\ Xj \leq bi \quad (i = 1, 2, \ldots, m)$$

$$Xj \geq 0 \quad (j = 1, 2, \ldots, n)$$

The minimization problem

$$\text{Minimize } A = \sum_{j=1}^{n} Cj\ Xj$$

subject to

$$aij\ Xj \geq bi \quad (i = 1, 2, \ldots, m)$$

$$Xj \geq 0 \quad (j = 1, 2, \ldots, n)$$

only nonnegative level of each decision variables will be considered.

where:

Cj = unit contribution rate, the marginal contribution of each decision variable.

Xj = decision (or activity) variables

aij = technological coefficients, how much a resource is required for each activity unit

bi = given resources or the amount of resources available (right hand side value)

For a mathematical formulation of linear programming models in matrix notation, see Heady and Candler (1973). The assumptions of linear programming include addivity of resources and activities, linearity of objective function, nonnegativity of decision variables, divisibilities of activities and resources, finiteness of the activities and resource restrictions, proportionality of the activity level to resources and single value expectation, also discussed by Agrawal and Heady (1972).

In the following section, the three essential elements of linear programming, the objective function, the activities and system constraints, will be discussed.

3.2 The Objective Function

It is likely that small farmers entertain a number of objectives (e.g., profit or income maximization, output maximization, cost minimization, security) although they are not necessarily exclusive, Schultz (1964) and Hopper (1965) believe that peasant farmers are profit maximizers. Miller and Charles (1964) argued that, "profit maximization is not always the primary goal of farm management. Others demand sure and sometimes substantial returns before they risk additional operating capital for problems that are compounded by great variability in production, and a high level of risk and uncertainty. Under such circumstances it is difficult to follow rigorous decision-making criteria. As a result, many of these farmers do not follow a management strategy that would maximize their profits but instead follow a strategy that minimizes costs." Norman (1973) concluded that for small farmers in Zaira area in Northern Nigeria, both security and profit maximization were relevant goals. Heyer (1971) in her study on constraints on peasant farmers in Kenya had difficulties in finding out what it is the subsistence farmers aimed for. Subsistence farmer's objectives are ambiguous, but then she suggested, "insuring an adequate food supply during a drought years, producing preferred variety of diet, maximizing the number of people fed, maximizing the market value of output" were possible alternatives to be considered. The complexities of small farmer objectives make it difficult to operationalize their decision in a linear programming framework.

Risk factors are an important consideration in small holder decision making. Risk aversion is a rational and almost universal characteristic of small farmers, particularly with respect to the family food subsistence crops. A number of recent studies have cited the importance of risk on the decision making by peasant farmers (Norman, 1973; Dillon and Anderson, 1971; Woglin, 1975). As recent empirical studies of peasant behavior indicate, "safety first criteria" tend to be followed whenever the satisfaction of the basic needs may be at stake.

In this study the safety first criterion will be used in the formulation of the linear programming. Small farmers in the study area are assumed seeking security and risk aversion (such as provided by the practice of multiple cropping) as well as maximization of net farm income. The security objective will be incorporated in the matrix table as constraints, so that necessary amounts of rice, corn, cassava for meeting the minimum family consumption levels will be obtained first. According to this rule, an important motivating force for the decision maker in managing the productive resources that he controls and, in particular, in choosing among technological options is the security of generating returns large enough to cover subsistence needs (Moscardi and Janvry, 1977). The required amounts of food crop consumption were estimated from the simple consumption survey conducted by the researcher in the study area. It was found that rice is the most preferred food staple, then corn and the last one is cassava. These consumption requirements can be either produced or bought.

Net farm income in this study will be expressed as "gross margin." Gross margin is defined as the total value of production less variable costs of production. In other words, net return to resources such as land and labor which are considered "fixed" in this study. Fixed cost other than land and labor are negligible in the study area.

3.3 Activities in the Model

There are seven groups of activities which will be included in the model for the representative farm of Tatakarya Village:

(a) Crop production activities

(b) Labor hiring activities

(c) Fertilizers, insecticides, food crop buying activities

(d) Food crop consumption activities

(e) Crop selling activities

(f) Capital borrowing activities

(g) Transfer activities

(a) Crop Production Activities

The crop production activities for the representative farm are outlined in Table 3.1, Column A1 through A14. They consist of four food crops: upland rice, corn, soybeans, and cassava in a single crop stand and in mixed crops. They are comprised of four sole crops (upland rice, corn, soybean, and cassava), three crop mixtures of two crops (upland rice + cassava, corn + cassava, upland rice - soybeans) and one three crop mixture (upland rice + corn + cassava) enterprises. These identified crop production possibilities are the most important production opportunities with respect to the area devoted to each crop/crop mixture and the number of farmers involved. They are significant in terms of their contribution to family food

Table 3.1.--Crop Production Activities in Tatakarya Village (North Lampung).*

Row No.	Objective Function (C_j) / Resources	Units	Crop Production Activities (Unit: 1 HA)														Sign	RHS
			A_1 C+ ULR /CV TT_1	A_2 C+ ULR /CV TT_2	A_3 C+ ULR /CV NT_1	A_4 C+ ULR /CV NT_2	A_5 ULR + CV TT	A_6 ULR + CV NT	A_7 C + CV TT_1	A_8 C + CV TT_2	A_9 C + CV NT	A_{10} ULR - SB TT	A_{11} ULR - SB NT	A_{12} CV TT_1	A_{13} CV TT_2	A_{14} CV NT		
			0	0	0	0	0	0	0	0	0	0	0	0	0	0		
01	Land	HA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	<	1.38
02	FLXAUG	MD	20	6	13	15	33	21	13	20	24	20	20	15	-	-	≤	26
03	FLXSEP	MD	20	8	11	17	21	18	16	18	18	30	32	19	4	15	≤	34
04	FLXOCT	MD	26	14	17	23	28	16	17	20	17	10	10	24	8	28	≤	30
05	FLXNOV	MD	15	9	24	25	25	28	4	26	16	18	20	13	16	24	≤	30
06	FLXDEC	MD	15	11	13	17	17	15	14	20	16	22	24	11	12	4	≤	25
07	FLXJAN	MD	6	13	4·	30	5	3	13	13	15	21	20	6	-	13	≤	27
08	FLXFEB	MD	15	11	22	18	14	4	8	20	18	14	15	11	12	4	≤	27
09	FLXMAR	MD	4	13	3	20	10	16	28	24	26	2	4	6	-	3	≤	25
10	FLXAPR	MD	16	10	15	25	12	3	3	16	15	8	9	2	-	-	≤	23
11	FLXMAY	MD	11	14	12	20	12	8	22	17	-	-	-	13	12	5	≤	18
12	FLXJUN	MD	2	-	-	-	3	15	-	4	24	-	-	3	-	8	≤	18
13	FLXJUL	MD	-	-	-	10	10	-	6	-	-	-	-	16	17	5	≤	17
14	HLXAUG	MD	12	12	10	8	9	12	-	12	12	-	-	8	15	20	≤	0
15	HLXSEP	MD	4	-	3	-	-	-	-	-	-	-	-	-	-	10	≤	0
16	HLXOCT	MD	3	-	-	5	6	-	-	10	6	-	-	-	-	5	≤	0
17	HLXNOV	MD	5	7	4	-	7	15	-	12	18	-	-	-	-	9	≤	0
18	HLXDEC	MD	6	8	2	-	2	-	-	-	4	-	-	-	-	-	≤	0
19	HLXJAN	MD	-	-	-	3	-	-	-	-	-	-	-	-	-	20	≤	0
20	HLXFEB	MD	-	-	-	-	-	-	16	-	-	-	-	-	-	-	≤	0
21	HLXMAR	MD	-	-	-	-	-	-	10	-	-	-	-	-	-	20	≤	0
22	HLXAPR	MD	9	10	8	8	10	14	-	-	-	22	24	-	-	-	≤	0
23	HLXMAY	MD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	≤	0
24	HLXJUN	MD	-	-	-	-	-	-	-	-	-	-	-	4	-	10	≤	0
25	HLXJUL	MD	-	-	-	-	-	-	-	-	-	-	-	6	10	15	≤	0
26	AHXAUG	AMD	-	6	4	-	-	6	6	-	-	-	-	-	-	-	≤	0
27	AHXSEP	AMD	-	8	5	10	-	10	7	-	-	-	-	-	12	-	≤	0
28	AHXOCT	AMD	-	3	8	9	-	5	6	-	-	-	-	-	8	-	≤	0

Table 3.1.--Crop Production Activities in Tatakarya Village (North Lampung).*

Row No.	Objective Function (C_j) / Resources	Units	Crop Production Activities (Unit: 1 HA)														Sign	RHS
			A_1 C+ ULR /CV TT_1	A_2 C+ ULR /CV TT_2	A_3 C+ ULR /CV NT_1	A_4 C+ ULR /CV NT_2	A_5 ULR + CV TT	A_6 ULR + CV NT	A_7 C + CV TT_1	A_8 C + CV TT_2	A_9 C + CV NT	A_{10} ULR - SB TT	A_{11} ULR - SB NT	A_{12} CV TT_1	A_{13} CV TT_2	A_{14} CV NT		
	Resources		0	0	0	0	0	0	0	0	0	0	0	0	0	0		
01	Land	HA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	<	1.38
02	FLXAUG	MD	20	6	13	15	33	21	13	20	24	20	20	15	-	-	≤	26
03	FLXSEP	MD	20	8	11	17	21	18	16	18	18	30	32	19	4	15	≤	34
04	FLXOCT	MD	26	14	17	23	28	16	17	20	17	10	10	24	8	28	≤	30
05	FLXNOV	MD	15	9	24	25	25	28	4	26	16	18	20	13	16	24	≤	30
06	FLXDEC	MD	15	11	13	17	17	15	14	20	16	22	24	11	12	4	≤	25
07	FLXJAN	MD	6	13	4	30	5	3	13	13	15	21	20	6	-	13	≤	27
08	FLXFEB	MD	15	11	22	18	14	4	8	20	18	14	15	11	12	4	≤	27
09	FLXMAR	MD	4	13	3	20	10	16	28	24	26	2	4	6	-	3	≤	25
10	FLXAPR	MD	16	10	15	25	12	3	3	16	15	8	9	2	-	-	≤	23
11	FLXMAY	MD	11	14	12	20	12	8	22	17	-	-	-	13	12	5	≤	18
12	FLXJUN	MD	2	-	-	-	3	15	-	4	24	-	-	3	-	8	≤	18
13	FLXJUL	MD	-	-	-	10	10	-	6	-	-	-	-	16	17	5	≤	17
14	HLXAUG	MD	12	12	10	8	9	12	-	12	12	-	-	8	15	20	≤	0
15	HLXSEP	MD	4	-	3	-	-	-	-	-	-	-	-	-	-	10	≤	0
16	HLXOCT	MD	3	-	-	5	6	-	-	10	6	-	-	-	-	5	≤	0
17	HLXNOV	MD	5	7	4	-	7	15	-	12	18	-	-	-	-	9	≤	0
18	HLXDEC	MD	6	8	2	-	2	-	-	-	4	-	-	-	-	-	≤	0
19	HLXJAN	MD	-	-	-	3	-	-	-	-	-	-	-	-	-	20	≤	0
20	HLXFEB	MD	-	-	-	-	-	-	16	-	-	-	-	-	-	-	≤	0
21	HLXMAR	MD	-	-	-	-	-	-	10	-	-	-	-	-	-	20	≤	0
22	HLXAPR	MD	9	10	8	8	10	14	-	-	-	22	24	-	-	-	≤	0
23	HLXMAY	MD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	≤	0
24	HLXJUN	MD	-	-	-	-	-	-	-	-	-	-	-	4	-	10	≤	0
25	HLXJUL	MD	-	-	-	-	-	-	-	-	-	-	-	6	10	15	≤	0
26	AHXAUG	AMD	-	6	4	-	-	6	6	-	-	-	-	-	-	-	≤	0
27	AHXSEP	AMD	-	8	5	10	-	10	7	-	-	-	-	-	12	-	≤	0
28	AHXOCT	AMD	-	3	8	9	-	5	6	-	-	-	-	-	8	-	≤	0

Table 3.1.--Continued.

Row No.	Objective Function (C_j) / Resources	Units	A_1 C+ ULR +CV TT_1	A_2 C+ ULR +CV TT_2	A_3 C+ ULR +CV NT_1	A_4 C+ ULR +CV NT_2	A_5 ULR + CV TT	A_6 ULR + CV NT	A_7 C + CV TT_1	A_8 C + CV TT_2	A_9 C + CV NT	A_{10} ULR - SB TT	A_{11} ULR - SB NT	A_{12} CV TT_1	A_{13} CV TT_2	A_{14} CV NT	Sign[a]	RHS
			0	0	0	0	0	0	0	0	0	0	0	0	0	0		
29	AHXNOV	AMD	-	-	4	-	-	-	1	-	-	-	-	-	-	-	=	0
30	SEEDRC	KB	30	30	30	30	36	36	-	-	-	36	30	-	-	-	=	0
31	SEEDC	KB	12	12	12	12	-	-	12	12	12	-	-	-	-	-	=	0
32	SEEDSB	KB	-	-	-	-	-	-	-	-	-	20	20	-	-	-	=	0
33	SEEDCV	STICK	5,000	5,000	5,000	5,000	5,000	5,000	5,000	7,000	6,000	-	-	10,000	10,000	10,000	=	0
34	FERTXN	KG	-	-	25	170	-	15	-	60	-	-	30	-	-	75	=	0
35	FERTXP	KG	-	-	25	20	-	15	-	-	-	-	20	-	-	75	=	0
36	INSECTD	UTER	-	-	-	2	-	15	-	-	-	-	2	-	-	2	=	0
37	OCXAUG	RP	5,400	14,400	10,500	3,600	4,050	11,400	9,000	5,400	11,400	-	-	3,600	6,750	9,000	<	6000
38	OCXSEP	RP	1,800	12,000	8,850	15,000	-	15,000	10,500	-	10,500	-	-	-	18,000	-	≤	8000
39	OCXOCT	RP	1,500	4,500	16,000	34,200	3,000	12,150	9,000	9,800	15,000	-	7,000	-	12,000	17,500	≤	5000
40	OCXNOV	RP	2,500	3,500	8,000	-	3,500	7,500	1,500	6,000	4,000	-	-	-	-	4,500	≤	4000
41	OCXDEC	RP	3,000	4,000	1,000	-	1,000	-	-	-	2,000	-	-	-	-	-	≤	5000
42	OCXJAN	RP	-	-	-	1,500	-	-	-	-	-	-	-	-	-	10,000	≤	4000
43	OCXFEB	RP	-	-	-	-	-	-	7,200	-	-	-	-	-	-	-	≤	5000
44	OCXMAR	RP	-	-	-	-	-	-	5,000	-	-	-	-	-	-	10,000	≤	5000
45	OCXAPR	RP	4,500	5,000	4,000	4,000	5,000	7,000	-	-	-	11,000	12,000	-	-	-	≤	2000
46	OCXMAY	RP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	≤	3000
47	OCXJUN	RP	-	-	-	-	-	-	-	-	-	-	-	1,800	-	4,500	≤	3000
48	OCXJUL	RP	-	-	-	-	-	-	-	-	-	-	-	2,700	4,500	6,750	=	0
49	OPTRICE	KG	-700	-750	-1,050	-1,680	-900	-750	-	-	-	-1,050	-1,150	-	-	-	=	0
50	OPTCORN	KG	-500	-500	-600	-800	-	-	-500	-550	-600	-	-	-	-	-	=	0
51	OPTSOBN	KG	-	-	-	-	-	-	-	-	-	500	600	-	-	-	=	0
52	OPTCASV	KG	-8,000	-8,500	-10,000	-16,000	-8,500	-15,000	-10,000	-9,000	-11,000	-	-	-8,000	-9,600	20,000	=	0
53	CONSRICE	KG															=	500
54	CONSCORN	KG															=	150
55	CONSCASV	KG															=	3000

[a]For explanation of abbreviation, see Table D1, Appendix D.

Source: Computed.

requirements as well as their contribution to farmer's income. Two levels of production technologies are identified for each cropping pattern. One represents the production of crops under traditional technology with no use of modern/new inputs and the new technology with the use of new inputs such as fertilizers, insecticides/pesticides. Only for upland rice + corn ≠ cassava cropping pattern did the data from the survey distinguish two levels of fertilization by the representative farms in the study area.

When two or more crops are interplanted in a mixture, then the production activities are considered as single enterprise in terms of the mixture, rather than the individual crops in the mixture as a separate enterprise. This method saves us from the problem of allocation of join resources such as labor and land use for each crop. There are other problems associated with the use of mixed cropping as production activities in linear programming models as discussed by Crawford (1977).

The activity unit is one hectare. The objective function coefficients (Cj) for the crop production activities represent the costs of fertilizers, insecticides, and wages for hired labor for each unit of the activities. Negative signs are assigned because costs reduce the income of the farmers.

The input-output for traditional and new technologies are presented in Table 3.1. These coefficients are the amounts of various resources required to produce one unit of production activities (e.g., to produce one hectare of mixed crop corn + upland rice ≠ cassava). They are assigned positive signs because each activity used up the available resources or decreased the magnitude of restrictions in the model. Coefficients with negative signs indicated the increase in the magnitude of the restrictions or resources associated with them.

Both technological coefficients for the traditional and the new technologies were generated from the results of the survey in the study area. Some of the characteristics of the study area and the representative farms were presented in Chapter II. The elements of the study design were presented in Chapter I. The average input-output coefficients for each crop production activity in the model were determined from the grouping of farmers assumed to be similar in the planting time, rate of fertilizer applications, monthly labor use, yield per hectare, seeding rate, plant population, and level of management. It was also assumed that the soil conditions were similar from farm to farm in the study area. Each coefficient in the model is the mean of the small sample observation from relatively similar farm situations.

The differences of coefficients between traditional and the new technologies are mostly due to the differences in the rate of fertilizations and use of insecticides. The labor inputs are consequently higher per hectare for the new technology due to more labor use for fertilization, spraying, weeding and harvesting due to a higher yield. In fact, as the rate of fertilization increased, the land required more intensive weeding by the family labor plus some exchange labor. The following table represents the average annual labor requirement under traditional and new technologies for selected crop enterprises. The adoption of the new technology increased the labor requirements in all cases.

Table 3.2.--Labor Requirement per Hectare of Selected Crop Production Activities under Traditional and New Technologies.

Crop Enterprises*	Labor Requirement per Hectare (mandays)		
	Traditional Technology	New Technology	Percent of Change
C + ULR ≠ CV	193	266	38
ULR + CV	224	251	12
C + CV	224	259	13

Source: Field Survey

*For explanation of abbreviations, see Table Cl, Appendix C.

(b) Labor and Animal Hiring Activities

In the study area farmers needed to augment their family labor with hired labor. For land preparation oxen power is sometimes used to replace man labor. Labor and animal hiring activities are presented in Column A15 to A30 in Table 3.3. Hired labor can be attained through various hiring arrangements including exchange labor, contract basis for specific farm operations or simply on a daily basis. Work paid per day was the most common system. The activity unit is one manday. Hiring animals for land preparation usually consists of an oxen team with one man. The unit of activity used here was the Animal Working Day (AWD) (a shorter period of time than a manday) which consists of about six hours per day for a team. The wage rates used were the wages prevailing in the study area during the period covered by the survey. Hired labor is renumerated in cash and/or in kind. For convenience of analysis the in kind payments were converted into money terms by multiplying the quantity received by its existing price.

For land preparation family labor, hired labor, and animals hired, after appropriate conversions, are assumed to be nearly perfect substitutes. For other types of activities hired and family labor are assumed to be perfect substitutes. The hiring labor activities have negative coefficients in the family labor rows, indicating that an increase in one unit of hired labor relaxes the family labor constraints by one unit. The animal hiring activities in the same way have negative coefficients of three, indicating that for land preparation an additional unit of animals hired will relax three units of family labor constraints. The use of hired labor will decrease capital by

Table 3.3.--Hiring Labor and Animal Activities in Tatakarya Village (North Lampung).*

Row No.	Objective Function (C_j) / Resources	Unit	A_{15}	A_{16}	A_{17}	A_{18}	A_{19}	A_{20}	A_{21}	A_{22}	A_{23}	A_{24}	A_{25}	A_{26}	A_{27}	A_{28}	A_{29}	A_{30}	Sign	RHS
			HLX AUG	HLX SEP	HLX OCT	HLX NOV	HLX DEC	HLX JAN	HLX FEB	HLX MAR	HLX APR	HLX MAY	HLX JUN	HLX JUL	AHX AUG	AHX SEP	AHX OCT	AHX NOV		
			-450	-450	-500	-500	-500	-450	-450	-500	-500	-450	-450	-450	-1500	-1500	-1500	-1500		
02	FLXAUG	MD	-1												-3				≤	26
03	FLXSEP	MD		-1												-3			≤	34
04	FLXOCT	MD			-1												-3		≤	30
05	FLXNOV	MD				-1												-3	≤	30
06	FLXDEC	MD					-1												≤	25
07	FLXJAN	MD						-1											≤	27
08	FLXFEB	MD							-1										≤	27
09	FLXMAR	MD								-1									≤	25
10	FLXAPR	MD									-1								≤	23
11	FLXMAY	MD										-1							≤	18
12	FLXJUN	MD											-1						≤	18
13	FLXJUL	MD												-1					≤	17
14	HLXAUG	MD	-1																≤	0
15	HLXSEP	MD		-1															≤	0
16	HLXOCT	MD			-1														≤	0
17	HLXNOV	MD				-1													≤	0
18	HLXDEC	MD					-1												≤	0
19	HLXJAN	MD						-1											≤	0
20	HLXFEB	MD							-1										≤	0
21	HLXMAR	MD								-1									≤	0
22	HLXAPR	MD									-1								≤	0
23	HLXMAY	MD										-1							≤	0
24	HLXJUN	MD											-1						≤	0
25	HLXJUL	MD												-1					≤	0
26	AHXAUG	AMD													-1				≤	0
27	AHXSEP	AMD														-1			≤	0
28	AHXOCT	AMD															-1		≤	0
29	AHXNOV	AMD																-1	≤	0

Table 3.3.--Continued.

Row No.	Objective Function (C_j) / Resources	Unit	A_{15}	A_{16}	A_{17}	A_{18}	A_{19}	A_{20}	A_{21}	A_{22}	A_{23}	A_{24}	A_{25}	A_{26}	A_{27}	A_{28}	A_{29}	A_{30}	Sign	RHS
			HLX AUG	HLX SEP	HLX OCT	HLX NOV	HLX DEC	HLX JAN	HLX FEB	HLX MAR	HLX APR	HLX MAY	HLX JUN	HLX JUL	AHX AUG	AHX SEP	AHX OCT	AHX NOV		
			-450	-450	-500	-500	-500	-450	-450	-500	-500	-450	-450	-450	-1500	-1500	-1500	-1500		
37	OCXAUG	RP	450												1500				≤	0
38	OCXSEP	RP		450												1500			≤	0
39	OCXOCT	RP			500												1500		≤	0
40	OCXNOV	RP				500												1500	≤	0
41	OCXDEC	RP					500												≤	0
42	OCXJAN	RP						450											≤	0
43	OCXFEB	RP							450										≤	0
44	OCXMAR	RP								500									≤	0
45	OCXAPR	RP									500								≤	0
46	OCXMAY	RP										450							≤	0
47	OCXJUN	RP											450						≤	0
48	OCXJUL	RP												450					≤	0
57	LMT HL-AUG		1																≤	10
58	LMT HL-SEP			1															≤	7
59	LMT HL-OCT				1														≤	6
60	LMT HL-NOV					1													≤	8
61	LMT HL-DEC						1												≤	5
62	LMT HL-JAN							1											≤	10
63	LMT HL-FEB								1										≤	8
64	LMT HL-MAR									1									≤	10
65	LMT HL-APR										1								≤	18
66	LMT HL-MAY											1							≤	6
67	LMT HL-JUN												1						≤	8
68	LMT HL-JUL													1					≤	5
69	LMT AH-AUG														1				≤	5
70	LMT AH-SEP															1			≤	5
71	LMT AH-OCT																1		≤	5
72	LMT AH-NOV																	1	≤	5

*For the explanation of abbreviations, see Table D1, Appendix A.

its wage/payment rate. The availability of operating capital will determine the extent to which family labor will be substituted by the hired labor and the availability of the family labor itself.

Labor and animal hiring activities have negative values on the Cj of the objective function. Each additional unit of labor or animal hired will reduce the value of objective function by the rate of wage/payment. Selling labor activities is not included because the representative farmers in the study area hire labor in the net.

(c) Capital Borrowing Activities

There are very limited formal loans in the study area both by government and the "Tani Makmur Project." The credit is a package deal consisting of fertilizers, insecticides, seeds, and some living allowance. Very few of the sample farmers joined this program. Borrowing activities were included in the model to evaluate the contribution (potentially) of credit facilities to farm income and enterprise organization. The capital borrowing will be specified on monthly terms with 18 percent interest rate annually. The activity unit will be in Rupiah (Rp). This activity is represented in the matrix Table 3.4 from Columns A52 to A63.

Table 3.4.--Borrowing and Transfer Activities in Tatakarya Village (North Lampung).*

Row No.	Objective Function / Resources	Units	A_{52} BC- AUG	A_{53} BC- SEP	A_{54} BC- OCT	A_{55} BC- NOV	A_{56} BC- DEC	A_{57} BC- JAN	A_{58} BC- FEB	A_{59} BC- MAR	A_{60} BC- APR	A_{61} BC- MAY	A_{62} BC- JUN	A_{63} BC- JUL	A_{64} TC- AS	A_{65} TC- SD	A_{66} TC- ON	A_{67} TC- ND	A_{68} TC- DJ	A_{69} TC- JF	A_{70} TC- FM	A_{71} TC- MA	A_{72} TC- AM	A_{73} TC- MJ	A_{74} TC- JJ	A_{75} PAY	SIGN	RHS
			-.18	-.18	-.18	-.18	-.18	-.18	-.18	-.18	-.18	-.18	-.18	-.18	0	0	0	0	0	0	0	0	0	0	0	0		
37	OCXAUG	RP	-1												1												=	0
38	OCXSEP	RP		-1											-1	1											=	0
39	OCXOCT	RP			-1											-1	1										=	0
40	OCXNOV	RP				-1											-1	1									=	0
41	OCXDEC	RP					-1											-1	1								=	0
42	OCXJAN	RP						-1											-1	1							=	0
43	OCXFEB	RP							-1											-1	1						=	0
44	OCXMAR	RP								-1											-1	1					=	0
45	OCXAPR	RP									-1											-1	1				=	0
46	OCXMAY	RP										-1											-1	1			=	0
47	OCXJUN	RP											-1											-1	1		=	0
48	OCXJUL	RP												-1											-1	1	=	0
56	AMT BC	RP	1	1	1	1	1	1	1	1	1	1	1	1												-1	=	0
73	LMT BCAUG	RP	1																								≤	6000
74	LMT BCSEP	RP		1																							≤	8000
75	LMT BCOCT	RP			1																						≤	5000
76	LMT BCNOV	RP				1																					≤	4000
77	LMT BCDEC	RP					1																				≤	5000
78	LMT BCJAN	RP						1																			≤	4000
79	LMT BCFEB	RP							1																		≤	5000
80	LMT BCMAR	RP								1																	≤	5000
81	LMT BCAPR	RP									1																≤	2000
82	LMT BCMAY	RP										1															≤	3000
83	LMT BCJUN	RP											1														≤	3000
84	LMT BCJUL	RP												1													≤	0

*For explanation of abbreviations, see Table D1, Appendix D.

(d) Fertilizers, Insecticides, and Food Crop Buying Activities

Fertilizers and insecticides are the major new inputs in the new technology and have been used by some farmers in the study area. Fertilizer buying activities are included in the model to allow farmers to purchase fertilizers. These buying activities are presented in the matrix table from Column A31 to A40 (Table 3.5). The activity unit is one kilogram (kg).

Fertilizer prices are subsidized by the government at Rp 80/kg at the farm level. Buying activities have negative coefficients in the objective function since buying one unit of it will reduce the value of objective function. Fertilizer buying activities also have negative coefficients on the fertilizer rows because they will increase the stock of fertilizer. Food crop buying activities for family consumption have positive coefficients in the food consumption rows since food crop buying increases the consumption constraints. Food crop buying activities have negative coefficients in the objective function since they will reduce the value of objective function by the price of food crop bought per unit.

(e) Food Crop Consumption Activities

The farm family consumption consists of grains (rice, corn) and root crops (cassava). The food crop consumption activities are shown in Table 3.5 from Column A41

Table 3.5.--Fertilizers, Food Crop Buying, Food Crop Consumption and Selling Activities in Tatakarya Village (North Lampung).*

Row No.	Objective Function / Resources	A_{31} BFN OCT	A_{32} BFP OCT	A_{33} BINS OCT	A_{34} BRC SEP	A_{35} BRC OCT	A_{36} BRC NOV	A_{37} BRC DEC	A_{38} BRC JAN	A_{39} BOY FEB	A_{40} BOY MEY	A_{41} CONS RICE	A_{42} CONS CORN	A_{43} CONS CASV	A_{44} SRC MAY	A_{45} SC MAR	A_{46} SSB FEB	A_{47} SCV SEP	A_{48} ORC TO SSRC	A_{49} OC TO SSC	A_{50} OSB TO SSB	A_{51} FL NOV TO SSCV	Sign	RHS
	Resources	-80	-80	-1500	-180	-180	-180	-180	-180	-60	-60	0	0	0	+100	+60	+260	+17	0	0	0	0		
05	FLXNOV																					1	≤	30
30	SEEDRICE																						=	0
31	SEEDCORN																						=	0
32	SEED SOYBEAN																						=	0
33	SEED CASSAVA																					-1000	=	0
34	FERTILIZER-N																						=	0
35	FERTILIZER-P																						=	0
36	INSECTICIDES																						=	0
38	OPER CAP SEP				180																		=	0
39	OP-CAP OCT	80	80	1500		180												7					=	0
40	OP-CAP NOV						180																=	0
41	OP-CAP DEC							180															=	0
42	OP-CAP JAN								180														=	0
43	OP-CAP FEB									60							-260						=	0
44	OP-CAP MAR															-60							=	0
46	OP CAP MAY														-100								=	0
49	OPTRICE										60	1			1				1				=	0
50	OPTCORN												1			1				1			=	0
57	OPTSOBN																1				1		=	0
52	OPTCASV													1				1					=	0
53	CONSRICE				1.7	1.7	1.7	1.7	1.7			1											=	500
54	CONSCORN												1										=	150
55	CONSCASV									3	3			1									=	3000

Source: Computed.

*For explanation of abbreviations, see Table D1 in Appendix D.

to A43. The activity unit is one kilogram (kg). These activities have positive coefficients in the output rows of rice, corn, and cassava because they reduce the stocks of these crops. Soybeans produced are mostly for sale.

(f) Crops Selling Activities and Seed Production Activities

The crop produced is either to be consumed or sold. Minimum family consumption requirements will be satisfied first before any selling activities are undertaken. Soybeans are sold without any constraints, since they are mostly produced for sale purposes. It is also assumed that selling activities are undertaken in the month of harvesting, so there will be no storage activities included in the model. Storage of food crops for the purpose of family consumption is allowed and storage for cassava could take place in the ground. Selling activities are represented in Table 3.5 from Column A44 to A47. The activity unit is one kilogram (kg). The prices of the products are the prevailing prices in the nearest market during the harvesting periods (Appendix E). The objective function coefficients are positive because selling added to the value of the objective function. The row coefficients of the output of the crops are also positive since selling activities reduce the stock of that crop.

(g) Transfer Activities

These activities were shown in Table 3.4, Columns A64 to A74 represent activities which are used to pass surplus capital from one month to the next month during the year. Column A75 represents activity which is included as a device by which any capital surplus over requirements for operating capital is accumulated at the end of the crop year. This activity has a zero value in the objective function, a positive sign for the last month (July) operating capital row and a negative sign on the amount of transfer row, which means increasing the capital accumulation at the end of the crop year.

3.4 Restrictions in the Model

In this study farming is carried out under a number of constraints or restrictions, which include the availability of land for cultivation, family labor, hired labor, operating capital, family consumption requirements, and the assumption of nonnegativity of activity levels. These constraints are outlined in Table 3.1. Each type of these restrictions will be described below.

(a) Land Restriction

The amount of land for cultivation by the representative farm is about 1.38 hectares, consisting of all dryland for the upland farming system. Each family in this transmigration area received two hectares of unprepared land from the transmigration program, so most of them have idle land not yet cultivated, possibly due to scarcity of family labor, other sources of labor or power, and capital.

There was little evidence of land selling or renting in the study area. So, no provision is made in the model for such activities.

Only upland farming is considered in the model. Lowland farming is omitted because it was nearly absent in our sample farms, except in Central Lampung. Land is also assumed to be homogeneous in quality and fertility, soil structure and other conditions that affect the soil capabilities. The row unit is in hectares.

(b) Labor Restrictions

Family labor restrictions are specified on a monthly basis in the model. The focus is in the family labor restrictions in the critical month of farming operations, but noncritical months of labor requirements are also included in the model to provide a complete accounting for labor within the system. The row unit is mandays. The amount of family labor in each month was assumed to be equal to the number of days actually spent by the family members during each month. These figures were obtained from the survey by the researcher in the study area and presented in Tables 2.6 through 2.9 in Chapter II.

Family labor could be augmented by hired labor and animals hired especially for land preparation. The amount of labor and animals hired depend on the amount of labor required relative to the family labor available, the amount of hired labor and animals available in relation to their wage rates/payments, and the amount of the operating capital available for hiring labor and animal power. The amount of animal power available was estimated from the number of adult cows and buffaloes usually used as sources of power for land preparation on the representative farms in the study area. The amount of hired labor available was assumed to be equal to the number of actual hired labor used in each month by the representative farm. The amount of operating capital was estimated from interviews at the beginning of the cropping year (August). The figure was also estimated from the actual expenditures obtained by the surveys conducted during the crop season.

(c) Operating Capital Restrictions

Difficulties were encountered in collecting the relevant data for estimation of the amount of operating capital available for farming activities. Consumption and production activities are difficult to separate in the small farmer's decision making process. In this study cash expenses of individual farm families are used as a proxy for the amount of the operating capital.

The amount of cash expenses for the representative farm was set equal to the amount estimated to have been spent on hired labor, fertilizers, insecticides/pesticides, and animals hired during that crop year (1978/1979). These were estimated from the survey conducted by the author as presented in Table 2.12 in Chapter II. The row unit is Rupiah (Rp). These operating capital constraints are also presented on the monthly basis. Transfer activities were used to pass surplus capital from one period to the next during the year.

(d) Consumption Requirements

It is assumed that the representative farm is motivated by the "first security rule," that is, the first priority is to produce their family food consumption requirements. Therefore, they need to produce the minimum amount of rice, corn, and cassava for the family consumption. For this purpose constraints were incorporated in the model to ensure the production of that minimum amount. The food consumption requirement for the family were derived from the results of a simple consumption survey undertaken by the author at the beginning of the crop year.

(e) Nonnegativity Restriction

One of the requirements for the use of linear programming in analyzing the small farm behavior is the nonnegativity of the activities in the model. None of the activities in the model can be operated at negative levels.

3.5 Some Limitations of the Model

Other activities and constraints could be included in the model. For example, nonfarm activities of family members are excluded as are various types of the activities in the farming process. For example, some activities may require different types of labor. Other activities which might have been considered include additional level of fertilizations, different planting space for each crop, different planting times, and different harvesting methods. The number of activities in the model depends on the availability of data and the objective of the study. Large and complex models are costly in terms of time, money, and other resources. It is not always certain that the benefits to be derived from additional activities in terms of precision for planning purposes are sufficient to justify the additional costs. Complex models may be difficult to interpret in terms of tracing the logical causal relationship between a change in one variable and the resulting changes in production. The model developed in this study was kept as simple as possible but complete enough to reflect the farm situations in the study area.

In this chapter we have described the linear programming model, its requirements, and the components to be employed. The results of the various applications of the models will be discussed in the following chapter.

CHAPTER IV

ANALYSIS OF THE RESULTS FROM THE LINEAR PROGRAMMING MODELS APPLICATIONS

In Chapter III the structure of the linear programming in this study was described. This Chapter presents the analysis of the results of the applications of linear programming models for the representative farms. The analysis is focused on the changes in farm income, cropping patterns, resource use and productivity. Some criteria for economic efficiency measures in relation to the use of the new technology are also presented.

The base plan is described as the optimal plan under the traditional technology[1] with existing resource situations. Then more activities and coefficients reflecting the use of the new technology were added into the model and then the optimal plan for the new technology with existing resources was determined. This plan is compared to the base plan in order to explain the likely effects of the adoption of the

[1]In the following, traditional technology is interchangeable with before the introduction of the new technology, and new technology is interchangeable with after the introduction of the new technology.

new technology. The output of the linear programming analysis in each situation provided information on the value of objective function, the optimal enterprise combination, the resources use and their respective marginal value productivities (MVPs), the nonoptimal activities with the cost associated with forcing each of them into the optimal solution and the stability limits of the optimal plan (Stephen B. Harsh and J. Roy Black, 1975).

On the first and second sections of this Chapter (Chapter IV) discussion emphasis is on the comparison of the optimal plan of the representative farm enterprises under the traditional and new technologies. The comparisons are based on the changes on farm income, resource use and productivity, average returns to resources as indications of the effects of the new technology in the three subregions of Lampung. In the third section, comparisons of the optimal plan between the three subregions are presented to see the different effects of the new technology on the cropping patterns, resource use and crop productivity, and average returns to limiting resources. In section four the effects of releasing family labor constraints are examined. In section five comparisons are made of the actual plan and the optimal plan in each subregion to see the extent of adjustments by the representative farms. In the last section of this Chapter a summary of the results of the linear programming analysis is presented.

4.1 The Optimal Organization of the Representative Farm Enterprise Under the Traditional Technology with Existing Resources in North Lampung

The validity of the optimal solution depends on the realism of the assumptions made concerning prices, technological coefficients and constraints. The optimal linear programming solution may differ from farmers' experiences due to the limitations of the linear programming analysis which includes unknown omissions of some important factors. Thus some points of the farmer's behavior when making decisions may not be captured.

The optimal plan resulting from the present analysis under traditional technology with existing resources is presented in Table 4.1. The value of the objective function or total gross margin is equal to 167,383 Rupiah. Fixed cost does not include such items as depreciation of farm tools because in general fixed cost items are neligible in the study area. Thus total gross margin is the estimate of the net farm income. Average return estimates with respect to limiting resources such as land and labor are provided as follows:

Gross margin = Total value of products - cash expenses

Returns per hectare = Total gross margins - unpaid family labor - interest on owner's operating capital (cash expenses) divided by the total area under cultivation

Return per manday of labor = Total gross margin - interest on owner's operating capital (cash expenses) divided by the total labor used.

Table 4.1.--Optimal Plan, Gross Margin, Resource Use and Average Returns Under Traditional and New Technologies with Existing Resources of the Representative Farm in North Lampung, Indonesia.

Item*	Unit	Activity Level
1. C + ULR ≠ CV (NT)	HA	0.246
2. ULR ≠ CV (NT)	HA	0.195
3. Ulr - SB (NT)	HA	0.682
4. CV (TT)	HA	0.136
Total Land	HA	1.259
Total Gross Margin	RP	167,383
Family Labor	Manday	188
Hired Labor	Manday	33
Total Labor	Manday	221
Animal Hired	AWD	2.5
Operating Capital	RP	20,500
Return/Hectare	RP	55,526
Return/Manday of Labor	RP	741

Source: Computed

*For explanation of the abbreviations see Table C.1, Appendix C.

The most critical problem is the valuation of family labor, since the family labor input is the largest portion. Using the existing hired labor wage rates as an estimate of the opportunity cost of family labor may be too high, since employment opportunities outside farm is small or lacking. Valuing the family labor at zero is unrealistic, since family labor is limiting in the peak seasons. It is also true there is a slack season for family labor use. Even in the slack seasons the value of family labor may not zero, at least the value of family labor in this season is equal to the value of leisure time, which is believed to have positive value for the farmers themselves. Based on the labor situations in the study area where there are no landless farmers and by the researcher's judgment, it is likely that the family labor valued at the existing hired labor wage rate is relevant. This is overvalued labor in a non peak season months, but in fact, wage rates are very stable from season to season and without Government regulation on the minimum wage rates that affected the study area.

The second problem is to assign the correct value to the cost of borrowing capital or the opportunity cost of own capital. This problem is not as crucial as valuing family labor since cash expenses are only small portion of total expenses and are usually formal and informal interest rates. In the study area according to the results of the interviews, the farmers are not familiar with borrowing from moneylenders, family or friends, which is somewhat surprising.

A formal source of credit is from the "BIMAS" program with 18 percent interest on loans in the form of fertilizers, insecticides, and a small amount of cash for cost of living if farmers join the program. This interest rate has been, in fact, subsidized by the Government, because inflation rate was 25 percent in 1979. By assuming that the government of Indonesia will continue this BIMAS program loan to the small farmers, the 18 percent interest rate may be relevant to be used as a cost of borrowing or lending for the study area. This is not a realistic interest rate, since in real terms it is -7 percent with the rate of inflation at 25 percent. The representative farmers in the study area are not familiar with institutional borrowing or lending. But even if the level of interest rate is under valued, it would not change the results of the analysis since cash borrowing is negligible or completely absent and cash operating expenditure is only a small portion of the total cost. Based on the above considerations, interest on borrowing and lending capital will be valued at 18 percent annually.

The optimal plan under the traditional technology for Tatakarya village in North Lampung is presented in Table 4.1. The optimal plan included all crops (upland rice, corn, soybeans, and cassava) and utilized almost all of the available land for cultivation. In the optimal plan mixed cropping covered about 90 percent of the total cultivated area and single or pure stands covered only 10 percent.

In these instances cassava was the only crop in a pure stand in the optimal plan. Within the mixed cropping, three crop mixture of corn, upland rice and cassava covered 26.5 percent, and the two crop mixtures of upland rice and cassava covered 19.5 percent, and mixture of upland rice and soybeans covered 54 percent (the largest share) of the cultivated land area. Soybeans are grown in the study area as a cash crop and not for direct consumption by the family farms.

Not all the crop mixtures grown by the representative farm in the study area, were included in the optimal plan. Examples are a mixture of corn, upland rice and soybeans, and three crops of soybeans in sequence (three crops of soybean in one crop year). They are not competitive enough to be included in the optimal plan, e.g., three soybean crops in sequence is not included in the otpimal plan due to its very intensive labor requirements.

The total labor use in the optimal plan is 221 mandays which is made of 188 mandays of family labor and 33 mandays of hired labor. This does not include 2.5 animal working days which is equivalent to about 7.5 mandays of man labor for land preparation. Very limited operating capital was used consisting of payments for hired labor and animal hired cost at about Rp20,500. This operating capital is supplied from the initial funds available in the beginning of the crop year and the sales of surplus product beyond family consumption requirements.

The marginal value products (MVPs) are presented in Table 4.2 which is the shadow prices of resources within the constraints in the linear programming model. In this case the marginal value product of disposal activities is defined as the increase in the value of total output that is obtained from the use of additional units of the resource with all other inputs held constant. This condition may not met in the linear programming framework, because technological coefficients for activities are assumed to be at a fixed ratio to one another. So, the increase in one unit of only one input will require the increase in other inputs in order to keep the ratio or coefficient fixed. Although with this deficiency, marginal value product can give information on the most likely resources to be expanded in order to increase the value of the objective function or farm income. The marginal value product of a resource is constant over the specific range and the solution holds until other resources become limiting. At that point another enterprise organization becomes optimal and the marginal product of the resources change.

The marginal value products indicate the productivity of resources on the farm. They indicate the amount of total gross margins of the farm products that could be increased by the utilization of the additional one unit of that resources. So they give information about the possible gains or losses in income which are possible through the acquisition of that scarce resource. The marginal value

Table 4.2.--Marginal Value Products of Land, Family Labor, Operating Capital (MVPs) on the Optimal Plan Under Traditional Technology with Existing Resources in North Lampung.

Resource		Unit	MVPs (RP)
1.	Land		0
2.	Family Labor in August	HA	0
3.	Family Labor in September	Manday	377
4.	Family Labor in October	Manday	6,922
5.	Family Labor in November	Manday	
6.	Family Labor in December	Manday	
7.	Family Labor in January	Manday	0
8.	Family Labor in February	Manday	0
9.	Family Labor in March	Manday	0
10.	Family Labor in April	Manday	0
11.	Family Labor in May	Manday	0
12.	Family Labor in June	Manday	0
13.	Family Labor in July	Manday	0
14.	Operating Capital in August	RP	6.8
15.	Operating Capital in September	RP	0
16.	Operating Capital in October	RP	0
17.	Operating Capital in November	RP	0
18.	Operating Capital in December	RP	0
19.	Operating Capital in January	RP	0
20.	Operating Capital in February	RP	0
21.	Operating Capital in March	RP	0
22.	Operating Capital in April	RP	0
23.	Operating Capital in May	RP	0
24.	Operating Capital in June	RP	0
25.	Operating Capital in July	RP	0

Source: Computed.

products of slack resources are zero and positive for the limiting factors or constraint resources. A higher a marginal value product of a resource indicates scarcity of that resource. The more limiting that resource the higher its marginal value product. So to be meaningful it should be compared to the cost of its acquisition or to its marginal factor cost. It is profitable to acquire an additional unit of resources if its acquisition cost is less than its marginal value product. So maximum income can be obtained only if all marginal value products of all resources are equal to their marginal factor costs.

Family labor was limiting for crop production in September and October. These months correspond to the peak periods of land preparation and planting seasons. An additional unit of labor in these months will increase farm income by the amount indicated by their respective marginal value products. The marginal value product of family labor is highest in October indicating that family labor was the most constraining in this month. The marginal value product of family labor in October is substantially higher than the prevailing wage rate. Family income could be increased if the family members are willing to work extra hours or days during this month or had the funds available for hiring labor (assuming hired labor is available). This high marginal value product of labor also indicates that the farmers could afford to pay a much higher wage than the prevailing wage rate in order to attract more hired labor in this peak season. In the month of September the marginal value product of labor is lower than the marginal factor cost of hired labor. Hence it would be unprofitable to hire more labor during this month.

The marginal value product of operating capital in August is 680 percent. Thus operating capital in August is also a constraint in crop production. In this month the marginal value product of operating capital was much higher than its marginal factor cost of 18 percent. Hence farm income can be increased if more operating capital was made available. This may imply the need for short term credit to relax that operating capital constraint which would permit purchase of more fertilizers and insecticides. In the following months the operating capital marginal value products have zero values, since there is a slack of operating capital during these months.

Operating capital can be supplied after August from the sale of crop products such as cassava in September, soybeans in February, corn in March, and rice in May. This source of funds for operating capital is more than enough to cope with the operational cash costs of crop production.

The only credit they need is at the beginning of the farming operating which is used as cash expenses for land preparation. The amount needed is also very limited at about Rp9000 or equivalent to U.S. $15. This initial operating capital is usually also made available by the farmers themselves, since there is no formal or informal credit available for the farmers in the study area. This operating capital can be obtained by working outside their farm for wage or from the previous product sales. So, it seems that credit is not a limiting factor in the context of traditional technology for the representative farmer in the study area when they practiced mixed cropping. This traditional mixed cropping system is without additional new or modern inputs.

The output of the linear programming routine also provided information on the activities excluded from the optimal plan. They are excluded from the optimal plan because they are the least profitable enterprises. The cost of forcing those excluded enterprises into the optimal solution indicates how much the value of the objective function would be decreased (income penalty) if one unit of that enterprise was forced into the optimal plan. So it reveals the competitive position of that enterprise. The higher the cost or loss in income, the lower the competitive position of that enterprise and vice versa. The lower the cost of forcing that activity into the optimal solution, the greater the potential to enter the optimal plan if one or more of the contraints is relaxed.

Low productivity of traditional farming is considered the major constraint for increasing food crop production and the income of the farmer in the study area. Without the introduction and application of the new inputs or new methods of production it is hardly possible that both production and income of small farmers can be improved.

The introduction of the new technology is believed to be the basis for improving the small farmers' conditions in the study area. But it will not guarantee this, unless supporting services are available in the right place and at the right time at the farm level, such as extension services, new agricultural inputs which are profitable, and transportation and marketing services. The following section of this Chapter will examine the changes in the cropping patterns, farm income, resource use and their productivities after the introduction of the new technology on the representative farm in the study area.

4.2. The Effects of the New Technology with Existing Resources in North Lampung

The comparison between optimum organization of the representative farm before and after the introduction of the new technology will provide information on the likely effects of the new technology. This comparison is presented in the following Table 4.3.

The total gross income of the representative farm is Rp283,089 which represents an increase of about 69 percent over the total gross income of the optimum farm plan under the traditional technology. So, it indicates that farmers who are income or profit maximizers could improve their gross income by approximately 69 percent through the adoption of the new technology. The optimum plan after the introduc-tion of the new technology with the existing resource levels included 0.214 hectares crop mixture of corn + upland rice +

Table 4.3.--A Comparison of the Optimum Farm Organization of the Representative Farm Under Traditional and New Technologies with Existing Resources in North Lampung.

Item*	Unit	Before Introduction of new Technology	After Introduction of New Technology	Change Percent
1. C + ULR ≠ CV (TT)	HA	0.246	0.214)	190
2. C + ULR ≠ CV (NT)	HA	-	0.500)	
3. ULR + CV (TT)	HA	0.195	-	-100
4. ULR - SB (TT)	HA	0.682	-)	-21
5. ULR - SB (NT)	HA	-	0.536)	
6. CV (TT)	HA	0.136	-	-100
Land	HA	1.259	1.250	0
Total Gross Margin	Rp	167,383	283,089	69
Family Labor	Manday	188	232	23
Hired Labor	Manday	33	33	0
Total Labor	Manday	221	265	20
Animal Hired	AWD	2.5	9.5	280
Operating Capital	Rp	20,500	39,025	90

Source: Computed.

*For explanation of abbreviations see Table C.1, Appendix C.

casava under the traditional technology and 0.500 hectares of the same crop mixture under the new technology. It should be noted that after the introduction of the new technology into mixed crop systems of upland rice + corn ≠ casava in the optimal farm plan, there still existed two levels of technology. One was without use of new inputs (traditional) and one was with use of new inputs such as fertilizers, insecticide, and improved seeds (new technology), which covered 0.214 hectares and 0.500 hectares respectively. This means that this crop mixture is competitive both under traditional and under the new technologies in the conditions in the study area. This crop mixture is the most popular cropping pattern practiced by the farmers both in terms of acreage devoted to it and the number of farmers practicing it (see Table 2.1 and Table 2.2 in Chapter II). The second crop mixture under the new technology in the optimal plan is upland rice - soybeans with use of new inputs of fertilizers and insecticide. This crop mixture is the most competitive under the new technology which covered 0.536 hectates.

After the introduction of the new technology, the cropping pattern is less diversified and all cropping systems are in mixtures. None of the sole crops appeared in the optimal plan under the new technology. This means that the mixed cropping pattern is more competitive than the sole cropping pattern. The cropping pattern of mixed crops of upland rice + cassava is eliminated in the optimal plan under the new technology. Sole crop of cassava is also eliminated in the optimal plan after the introduction of the new technology. The costs of forcing nonoptimal crop production activities into the optimal solution (Table 4.4) revealed that mixed crop of upland rice + corn ≠ cassava with the use of animal power for land preparation (classified as traditional technology) has the highest potential to enter the optimal plan. So, this cropping pattern with the use of animal power for land preparation has the lowest cost or income penalty when entered into the optimal plan under the new technology if one or more restrictions were relaxed.

The adoption of the new technology also changes the allocation of resources among crops or among crop mixtures. For the mixed crop of corn + upland rice ≠ cassava in the optimal plan under new technology, land devoted is 0.714 hectares from 0.246 hectares before the introduction of the new technology. There is an increase of 190 percent of land devoted to this mixed cropping pattern. For mixed crop of upland rice - soybeans there is a decrease in land devoted to it after the introduction of the new technology from 0.682 hectares before the introduction of the new technology to 0.536 hectares, a decrease of 21 percent. Crop mixture of upland rice + cassava was eliminated after the introduction of the new technology. There is no significant change in the total land devoted or under cultivation after the introduction of the new technology compared with the optimal plan before the introduction of the new technology.

Table 4.4.--Cost of Forcing in Nonoptimal Activities (Result of the Linear Programming Analysis) Under the New Technology with Existing Resources of the Representative Farm in North Lampung.

Nonoptimal Activities*	Cost of Forcing in Into Optimal Plan (RP)
1. C + ULR ≠ CV (TT2)	8477**
2. C + ULR ≠ CV (NT1)	59216
3. ULR ≠ CV (TT)	101430
4. ULR ≠ CV (NT)	21891
5. C + CV (TT2)	202163
6. C + CV (NT)	20216
7. ULR - SB (TT)	17934
8. CV (TT1)	74146
9. CV (TT2)	131800

Source: Computed.

* For explanation of abbreviations see Table C.1, Appendix C.

**The lowest cost (income penalty) of forcing in nonoptimal activities into the optimal plan.

After the introduction of the new technology there are increases in use of family labor, hired labor, and animal draft power. Family labor use increases from 188 mandays to 232 mandays or an increase of about 23 percent. There is no change in the use hired labor after the introduction the new technology. Animal draft use increases from 2.5 animal working days to 9.5 animal working days. Animal draft is only used for land preparation in the beginning of the cropping season. Hired labor is assumed as a substitute for family labor. Hired labor is used for land preparation, planting, weeding, and harvesting.

Operating capital increases from Rp20,500 before the introduction of the new technology to Rp39,025 after the introduction of the new technology. The increase in the cash expenses is for payment of hired labor, animals hired and for the purchases of the new inputs such as fertilizers and insecticides. The average return to the factors of production also increases after the introduction of the new technology.

The average return per hectare of land before the introduction of the new technology was Rp55,526. The return increased to Rp132,639 after the introduction of the new technology, an increase of about 139 percent. The average return to family labor per manday after the introduction of the new technology was Rp1,041, an increase of about 40 percent from the traditional technology.

There is a remarkable increase in the use of operating capital of about 90 percent after the introduction of the new technology.

The marginal value products of the resources under the new technology and under the traditional one are compared in Table 4.5. The marginal value product of land under both technologies is zero, i.e., land is idle. Family labor is constraining in September and October before the introduction of the new technology and family labor is limiting in November and January after the introduction of the new technology. So, it seems that there is a shift in family labor as limiting factor during land preparation under the traditional technology into the weeding season under the new technology. This may be due to more heavy weeds under the new technology.

The marginal value product of family labor is highest in October under the traditional technology during the land preparation and planting seasons. The marginal value product of family labor is highest in November and January under the new technology and is much higher than the prevailing wage rates in the two months. Farmers can afford to hire more labor at a much higher wage. These factors emphasize the need for fund availability to hire more labor to break the labor constraint during these two months with the assumption that hired labor supply is not constraint. Operating capital is the only limiting in August during the land preparation and just a month before cassava harvesting. By limiting the amount of capital to be borrowed in each month (for example

Table 4.5.--A Comparison of Marginal Value Products (MVPs) of Land, Family Labor, and Operating Capital on the Optimal Plan Under Traditional and New Technologies with Existing Resources of the Representative Farms in North Lampung.

Resource	Unit	Marginal Value Product	
		Traditional Technology	New Technology
1. Land	HA	0	0
2. Family Labor in August	Manday	0	0
3. Family Labor in September	Manday	377	0
4. Family Labor in October	Manday	6922	0
5. Family Labor in November	Manday	0	10067
6. Family Labor in December	Manday	0	0
7. Family Labor in January	Manday	0	2472
8. Family Labor in February	Manday	0	0
9. Family Labor in March	Manday	0	0
10. Family Labor in April	Manday	0	0
11. Family Labor in May	Manday	0	0
12. Family Labor in June	Manday	0	0
13. Family Labor in July	Manday	0	0
14. Operating Capital in August	RP	6.8	6.8
15. Operating Capital in Sept.	RP	0	0
16. Operating Capital in Oct.	RP	0	0
17. Operating Capital in Nov.	RP	0	0
18. Operating Capital in Dec.	RP	0	0
19. Operating Capital in Jan.	RP	0	0
20. Operating Capital in Feb.	RP	0	0
21. Operating Capital in March	RP	0	0
22. Operating Capital in April	RP	0	0
23. Operating Capital in May	RP	0	0
24. Operating Capital in June	RP	0	0
25. Operating Capital in July	RP	0	0

Source: Computed.

in August the limited amount can be borrowed is set at 6000 Rupiah (see Table 3.1 for other months limited borrowing) the linear programming analysis shows that the marginal value product of operating capital is zero except for August which is 680 percent. It is very high and it is a very crucial time for the farmers to have this fund available at the beginning of the farming operation, i.e., for land preparation.

By conducting sensitivity analysis, by changing the limited borrowing in August from 6000 Rupiah to 9000 Rupiah, the analysis shows that the marginal value product of cash operating capital in August becomes zero. The critical funding required in August for land preparation is well known by the farmers in the study area from their experience. According to the result of the interview with the farmers in August 1979 at the beginning of land preparation, the representative farm has 9000 Rupiah cash already available on hand. This amount is used as the limited amount of borrowed capital in the sensitivity analysis and the results shows that the marginal value product of cash operating capital in August becomes zero. This may imply that there is enough cash available by the farmer without borrowing to cover the cash expenses even under the new technology. The cash for expenses can be obtained by the farmer himself by working off of his farm for wages or from the previous sales of his crops.

The total cash expenditure increases dramatically with the introduction of the new technology by 90 percent from 20500 Rupiah to 39025 Rupiah. This increase in cash expenses is for payment of additional hired labor, animals hired and for purchases of the new inputs such as fertilizers and insecticides. The increase of the cash expenses after the adoption of the new technology is usually covered by the farmer by selling his crop products after harvest such as cassava in September, soybean in February, corn in March, and rice in May. This procedure is possible since the representative farmer has been familiar with the mixed cropping systems. In addition, farmers can work off of their farm for wages before the land preparation. Operating capital for the representative farmer is not critical in most of the months.

There is a very significant increase in animal draft use from 2.5 animal working days under the traditional technology to 9.5 animal working days under the new technology. The supply of hired labor is also limited since there are no landless farmers in the study area. The major source of hired labor is the newly arrived transmigrants and their family members. They have to sacrifice some of their labor for wages in order to sustain living for family at least in first season of their arrival. Seasonal labor from Java is also limited due to relatively high transportation costs compared to their expected income. Social and cultural factors also limit the mobility of labor from Java to Lampung.

The study conducted by Gloria Davis (1979) in Lampung show that the longer the transmigrants have settled in the area, the larger the area of the available unprepared land (two hectares for each family) that was brought into production of food crops as well as perennial crops. This means that the number of family labor hired out becomes less and less, so that the supply of hired labor becomes a limiting factor.

Other sources of power need to be considered to release part of these labor constraints. Investment in these sources of power such as cows and/or buffaloes, and tractors is required. For this purpose medium to long term credit may be needed by the representative farmers in the study area since they do not have enough savings due to the low income. According to the results of the interviews with the representative farms in North Lampung, this need was expressed.

The optimal plans after the introduction of the new technology for the representative farms in Central and South Lampung are presented in Table 4.6 and Table 4.7 respectively. Similar analysis could be done for each region as has been done for North Lampung (represented by Tatakarya village). The complete analysis will not be repeated here as for North Lampung. Only some differences will be discussed.

For the representative farm of Central Lampung not only upland crop production activities but also lowland rice or irrigated rice production activities are included in the

Table 4.6.--Optimum Organization of the Representative Farm Under the New Technology with Existing Resource Levels in Central Lampung.

Item*	Unit	Adiluih and Bulusari
1. C + ULR ≠ CV (NT)	HA	0.262
2. ULR ≠ CV (TT)	HA	0.240
3. C + SB ≠ CV (NT)	HA	0.518
4. LLR (NT)	HA	0.240
Total Land	HA	1.260
Total Gross Margin	RP	182,238
Family Labor	Manday	219
Hired Labor	Manday	71
Total Labor	Manday	290
Animal Hired	AWD	12.8
Operating Capital	RP	70,000
Return/Hectare	RP	52,074
Return/Manday of Labor	RP	585

Source: Computed.

*For explanation of the abbreviations see Table C.1, Appendix C.

Table 4.7.--Optimum Organization of the Representative Farm After the Introduction of the New Technology with Existing Resource Levels in South Lampung.

Item*	Unit	Pugung Raharja
1. ULR - SB/CV	HA	0.325
2. SB - SB - SB/CV	HA	0.321
3. ULR + C - SB/CV	HA	0.454
Total Land	HA	1.100
Total Gross Margin	RP	192,970
Family Labor	Manday	257
Hired Labor	Manday	5
Total Labor	Manday	262
Operating Capital	RP	7,500
Return/Hectare	RP	63,223
Return/Manday of Labor	RP	731

Source: Computed.

*For explanation of the abbreviations see Table C.1, Appendix C.

linear programming model. Total irrigated rice fields covered 0.24 hectares for the representative farm. For this irrigated rice, use of fertilizers, insecticides, and improved seeds has been far in advance of the dryland crop farming. On the average the use of fertilizers is the highest in the Central part of the Lampung subregion. Also of hired labor is the highest in Central Lampung compared to the other subregions of Lampung.

The optimum plan for Pugung Raharja (representing South Lampung subregion) after the introduction of the new technology is presented in Table 4.7. Fertilizer, the main input for the new technology, is not yet familiar to the representative farmer in this subregion. They did not use fertilizer in their crop cultivation. The only modern input they have used is insecticides for soybean crop protection. Soybeans are the major cash crop for the representative farmer in this area. For North and Central Lampung rice and cassava are the major crops for the representative farm (Table 4.9).

Component and the level of the technology on the optimal plans after the introduction of the new technology in the three subregions of Lampung is presented in Table 4.8. The comparison is in terms of the level of fertilizers, insecticides, and use of improved or local seeds. Land preparation by manual labor and/or by the use of animal draft power is still considered to be traditional technology. The table shows that the highest level of fertilizers on

Table 4.8.--Comparison of the Level of Technology on Optimal Plans for the Representative Farms in the Three Subregions of Lampung.

Item	Tatakarya (N.Lampung)	Adiluih and Bulusari (C.Lampung)	Pugung Raharja (S.Lampung)
1. Fertilizers/Hectare	112.8 kg	140.5 kg	-
2. Insecticides/Hectare	2 liters	2 liters	3.3 liters
3. Seed Variety	Mixed	Mixed	Local
4. Land Preparation	(M+A)**	(M+A)**	M

*Mixed = Use of both local and improved seeds.

**(M+A) = For land preparation by man labor and use of animal draft power.

(M) = For land preparation use of man labor only.

the optimal plan after the introduction of the new technology is for Central Lampung and next to it is North Lampung, and none for South Lampung. This is due to the fact that the representative farm in South Lampung not yet used fertilizers. So, there is no crop production activities with use of fertilizer in the linear programming model for South Lampung. The levels of fertilizers in the optimal plan after the introduction of the new technology are much lower than the recommended levels of fertilizers by "BIMAS" program or by "TANI MAKMUR PROJECT." Both of these agencies recommend fertilizer use of 200 KG/hectare. The level of insecticide use is similar to the project recommendations of about 2 liters per hectare.

4.3. Comparison of Optimal Plan Under the New Technology and Existing Resource Levels Between the Three Subregions of Lampung

In the previous sections of this Chapter the results of the applications of the Linear Programming model for the representative farms in North Lampung has been presented. The presentation included the analysis of the optimal plan under traditional technology and the analysis of the effects of the new technology by comparing the base plan with the optimal plan under the new technology. In analyzing the effects of the new technology emphasis was given to the changes in farm income, resource use and their productivities and crop enterprise combinations. In this section comparisons of the optimal plan under new technology and existing resource levels between the three subregions of Lampung will be presented. The level of technology, cropping patterns, and the level of crop productivities will be compared between the three subregions in Table 4.9 and Table 4.10.

The dominant cropping patterns in North Lampung are mixed cropping of corn + upland rice ≁ cassava and mixed cropping of upland rice - soybeans. For Central Lampung the dominant cropping pattern is the mixed cropping of corn + soybean ≁ cassava. In South Lampung the dominant cropping pattern is mixed cropping of corn + upland rice - soybeans. From the two tables it can be seen that the major crops for North and Central Lampung are rice and cassava in terms of land devoted to this crops and in terms of total crop production. For South Lampung the dominant crop is soybeans

Table 4.9.--Comparison of Cropping Patterns of the Optimal Plans Under the New Technology and Existing Resources for the Representative Farms of the Three Subregions of Lampung.

Item	Unit	Sub Region		
		North	Central	South
Cropping Pattern:*				
1. ULR + C ≠ CV (NT)	HA	0.500	0.262	-
2. ULR + C ≠ CV (TT)	HA	0.214	-	-
3. ULR + C - SB/CV (NT)	HA	-	-	0.454
4. ULR ≠ CV (TT)	HA	-	0.240	-
5. ULR - SB (NT)	HA	0.536	-	0.325
6. C ≠ CV - SB (NT)	HA	-	0.518	-
7. SB - SB - SB/CV (NT)	HA	-	-	0.321
8. LLR (NT)	HA	-	0.240	-
Total Land	HA	1.250	1,260	1.100
Total Crop Production:				
Rice	KG	1,607	1,827	624
Corn	KG	407	469	228
Soybean	KG	322	260	771
Cassava	KG	9,714	7,649	3,015

Source: Computed.

*Perennial cropping pattern not included. For explanation of abbreviations see Table C.1, Appendix C.

in terms of land devoted to this crop and in terms of the value of the crop.

The differences in crops and cropping patterns may be attributed some to the differences in soil, rainfall, prices of agricultural products and marketing services available to the representative farms. For example, the cassava processing industry recently has been concentrated in Central Lampung and now is at over capacity (Nainy, 1979). This will encourage cassava production if the price of cassava is attractive to the farmers. Cassava not only is a staple crop but also is a cash crop for the representative farm in the study area. Lampung has been a major receiving area for transmigrants and has a very active cassava based industrial sector producing both starch for domestic consumption and pellet for export. Production grew rapidly from 300,000 tons of fresh roots in 1969/70 to 8000,000 tons by 1977 (Dixon, 1979). The following table shows the level of technology in the optimal plan in terms of use of modern inputs such as fertilizers, insecticides, crop productivities in the three subregions of Lampung.

The highest level of fertilizer use is in Central Lampung and next to it is North Lampung. No fertilizer is used in South Lampung. The level of insecticide use is near the recommended level of 2 liters per hectare.

From the comparisons made in this analysis there appears to be a comparative advantage in type of crop produced and the type of cropping patterns to be used in

Table 4.10.--Comparison of Resource Use and Productivity on the Optimal Plan Under New Technology with Existing Resources of the Representative Farms in the Three Subregions of Lampung.

Item	Unit	Resource Use and Productivity in Subregions		
		North	Central	South
1. Total Land	HA	1.25	1.26	1.10
2. Fertilizers Use/Hectare	KG	112.5	140.5	0
3. Insecticides/Hectare	Liter	2	2	3.3
4. Family Labor/Hectare	Manday	195	175	234
5. Hired Labor/Hectare	Manday	38	58	5
6. Animal Draft Hired/Hectare	AWD	10	10	0
7. Total Crop Production/HA*	KG			
Rice	KG	1285	1450	567
Corn	KG	326	372	207
Soybean	KG	258	206	612
Cassava	KG	7771	6071	2741

Source: Computed.

*Crop productivity per hectare is in various mixed cropping patterns and not as a sole crop.

producing that crop for each subregions of Lampung (Table 4.11). North Lampung has a comparative advantage in producing cassava and upland rice in mixed cropping patterns of upland rice + corn ⌿ cassava and mixed cropping of upland rice - soybeans. Central Lampung has a comparative advantage of producing rice and cassava with cropping patterns in mixed cropping of corn ⌿ cassava - soybeans, upland rice + corn ⌿ cassava, upland rice ⌿ cassava, and low land rice (irrigated ricefield) as a sole crop. South Lampung has a comparative advantage in producing soybeans with cropping patterns consisting of triple cropping of soybeans in sequence, and mixed cropping of upland rice + corn - soybean, upland rice - soybeans. On every cropping pattern in South Lampung there is always a soybean crop in it. The comparative advantage is also indicated by the total crop production and per hectare basis of each crop produced by the representative farm in each subregion of Lampung (see Table 4.9 and Table 4.10). But it should born in mind that the analysis only covered a small area of upland farming in the study area and it may not represent other cropping patterns such as for perennial crops, fruits and vegetables, lowland rice, and the highly mechanized large scale upland farming in Lampung.

4.4. The Effects of Releasing Family Labor Constraints on the Optimal Plan Under the New Technology

As pointed out in the previous section, the marginal value product attached to family labor is high in November

Table 4.11.--Comparison of Crop Productivities of Various Cropping Patterns Under the New Technology Between the Three Subregions of Lampung.

Cropping Pattern*	Crop Output per Hectare (KG)											
	Rice			Corn			Soybean			Cassava		
	N.L.	C.L.	S.L.	N.L.	C.L.	S.L.	N.L.	C.L.	S.L.	N.L.	C.L.	S.L.
1. C + ULR ≠ CV (NT)	1680	1200	-	800	600	-	-	-	-	16000	10000	-
2. C + ULR ≠ CV (TT)	750	-	-	500	-	-	-	-	-	8500	-	-
3. ULR - SB/CV (NT)	1150	-	800	-	-	-	600	-	500	-	-	2800
4. ULR ≠ CV (TT)	-	800	-	-	-	-	-	-	-	-	8000	-
5. C ≠ CV - SB (NT)	-	-	-	-	600	-	-	500	-	-	6000	-
6. SB - SB - SB/CV (NT)	-	-	-	-	-	-	-	-	1400	-	-	2800
7. ULR + C - SB/CV (NT)	-	-	800	-	-	500	-	-	350	-	-	-
8. LLR (NT)	-	5500	-	-	-	-	-	-	-	-	-	-

Source: Computed.

*For explanation of the abbreviations see Table C.1, Appendix C.

**N.L. = North Lampung, C.L. = Central Lampung, S.L. = South Lampung.

and January in the optimal plan after the introduction of the new technology in North Lampung. So by increasing the availability of family labor during these months, farm income will increase. Family labor input can be increased by the family members by working more days and/or more hours in a day. Assuming the farm family members would consider an increase family labor input during these months, an attempt was made to analyse the economic effects of this family effort. It is hoped that the result of the analysis will also show the extent to which a family labor is a constraint under the new technology.

The number of mandays that the family could supply will be set equal to the number of mandays of family labor input in the peak season/month. Other resources, prices, and technological coefficients are assumed to be unchanged. The results of the analysis is presented in Table 4.12 through Table 4.14. For North Lampung (see Table 4.12) an increase in family labor input during the peak season (November and January), ceteris paribus, has an effect on the expansion of farm income. Total gross margin increased from Rp283,089 to Rp303,314, an increase of 7 percent.

Family labor use increased from 232 mandays to 252 mandays, an increase of 9 percent. Hired labor use increased from 33 mandays to 35 mandays, an increase of 6 percent. Total labor input increased from 265 mandays to 287 mandays, an increase of 8 percent.

Table 4.12.--Optimal Plan of the Representative Farm Under New Technology with Existing Resource Levels and Increased Family Labor in North Lampung.

Item*	Unit	Existing Resource	Increased Labor	Change Percent
1. C + ULR ≠ CV (TT)	HA	0.214	0.185	-13.5
2. C + ULR ≠ CV (NT)	HA	0.500	0.500	0
3. ULR - SB (NT)	HA	0.536	0.583	9
4. CV (TT)	HA	-	0.112	
Total Land	HA	1.250	1.380	10
Total Gross Margin	RP	283,089	303,314	7
Family Labor	Manday	232	252	9
Hired Labor	Manday	33	35	6
Total Labor	Manday	265	287	8
Animal Draft Hired	AWD	9.5	9.5	0
Operating Capital	RP	39,025	39,975	2
Return/hectare	RP	132,692	127,839	3
Return/Manday of Labor	RP	1,041	1,032	1

Source: Computed.

*For explanation of the abbreviations see Table C.1, Appendix C.

more family labor is used, there is the expected decrease in return to labor from Rp1041 to Rp1032, indicating diminishing return to labor. There were no changes in animal draft hired after the labor constraint was relaxed. The relaxation of the labor constraint brought more land into production of food crops and land became a limiting factor as shown by the shadow price of land at Rp88,991.

Returns per hectare decreased from Rp132,692 to Rp127,839, a decrease of 3 percent, indicating a diminishing return to land as more land was brought into production. Operating capital increased from Rp39,025 to Rp39,975, an increase of 2 percent. This increase in operating capital was due to increase in hired labor input.

There were also changes in the crop enterprise combination. Sole crop of cassava entered the optimal plan when the family labor constraint was relaxed. Land devoted to a crop mixture of corn + upland rice ≠ cassava decreased from 0.214 hectares to 0.185 hectares, a decrease of about 13.5 percent. Land devoted to a crop mixture of upland rice - soybeans increased from 0.536 hectares to 0.583 hectares, an increase of 9 percent. This increase in land devoted to this crop mixture of upland rice - soybeans was at the expense of the decrease in land devoted to the crop mixture of upland rice + corn ≠ cassava. Also more land was brought into production as family labor became more available. The effects of increasing family labor in Adiluih and Bulusari villages (representing Central Lampung) is presented in

Table 4.13. Total gross margin increased from Rp182,238 to Rp195,658, an increase of 7 percent. Family labor use increased from 219 mandays to 235 mandays, an increase of 7 percent. Hired labor also increased from 71 mandays to 78 mandays, an increase of 10 percent. Total labor use increase from 290 mandays to 313 mandays, an increase of 8 percent. The increase in labor use had an effect on the decrease in returns to labor from Rp585 to Rp578, an indication of diminishing return to labor.

Operating capital increased from Rp70,000 to Rp81,300, an increase of 16 percent. The marginal value product of dryland was Rp178,954 and the marginal value product of wetland/irrigated ricefield was Rp237,996, much higher for irrigated land. This may indicate that one of the strategies to increase farm income is to convert dry upland into irrigated land (assumed technically and economically feasible). Land becomes more limiting as more family labor is available.

The optimum farm organization became less diversified as family labor became available. The crop enterprise mixture of upland rice ≠ cassava is eliminated from the optimal plan as family labor became available in the peak season. More land was devoted to the crop mixture of corn + upland rice ≠ cassava from 0.262 hectares to 0.574 hectares as more family labor became available.

The effects of increasing family labor input in Pugung Raharja (represents South Lampung) are presented in Table 4.14. Total gross margin increased from Rp192,970 to

Table 4.13.--Optimal Plan of the Representative Farm Under New Technology with Increased Family Labor in Central Lampung.

Item*	Unit	Existing Resources	Increased Labor	Change Percent
1. C + ULR ≠ CV (NT)	HA	0.262	0.574	119
2. ULR ≠ CV (TT)	HA	0.240	-	
3. C ≠ CV - SB (TT)	HA	0.518	0.446	14
4. LLR (NT)	HA	0.240	0.240	0
Dry Land	HA	1.02	1.02	0
Wet Land	HA	0.24	0.24	0
Total Land	HA	1.26	1.26	0
Total Gross Margin	RP	182.238	195,658	7
Family Labor	Manday	219	235	7
Hired Labor	Manday	71	78	10
Total Labor	Manday	290	313	8
Animal Draft Hired	AWD	12.8	15	17
Operating Capital	RP	70,000	81,300	16
Return/Hectare	RP	52,074	55,076	6
Return/Manday of Labor	RP	585	578	-1

Source: Computed.

*For explanation of the abbreviations see Table C.1, Appendix C.

Rp195,692, an increase of 1.5 percent. Family labor use increased from 257 mandays to 268 mandays, an increase of 4 percent. The increase in gross margin was not so significant compared to increase in family labor input of 4 percent. It may not be worthwhile to increase family labor input into the farm by 4 percent if gross income increases only by 1.5 percent.

Hired labor was eliminated after the family labor became available. Total labor input increased by 2 percent, all supplied by the family labor. As the labor input increased, the return to labor decreased, again indicating diminishing return to labor. Average return to labor dedecreased from Rp731/manday to Rp717/manday. Operating capital decreased from Rp7,500 to Rp5,000 due to no more use of hired labor, and there were no changes in the use of cash inputs such as for purchasing fertilizers and insecticides.

It seems that the representative farm in South Lampung subregion has used its resources, e.g., labor, nearly optimally in most traditional techniques. The only new input used by the representative farm was insecticides, with no use of other modern inputs such as fertilizers and improved seeds. So the strategy to increase food production and farm income is to introduce new productive and profitable inputs. Farmers must be shown a tangible fashion in readily comparable circumstances, the new production techniques. They must be shown the risk involved both in yield and price fluctuations. They must also be aware of the farmer expenditure constraints.

Table 4.14.--Optimal Plan of the Representative Farm Under New Technology with Increased Family Labor in South Lampung.

Item*	Unit	Existing Resource	Increased Labor	Change Percent
1. ULR - SB/CV	HA	0.325	0.368	13
2. ULR + C - SB/CV	HA	0.454	0.411	9
3. SB - SB - SB/CV	HA	0.321	0.321	0
Total Land	HA	1.100	1.100	0
Total Gross Margin	RP	192,970	195,692	1.5
Family Labor	Manday	257	268	4
Hired Labor	Manday	5	0	-100
Total Labor	Manday	262	268	2
Operating Capital	RP	75,000	5,000	-33
Return/Hectare	RP	63,223	62,420	-1
Return/Manday of Labor	RP	731	727	-0.5

Source: Computed.

*For explanation of abbreviations see Table C.1, Appendix C.

4.5 Comparison of Actual and Optimal Plan of the Representative Farms Under New Technology with Existing Resources

Table 4.15 through Table 4.17 present the comparison of actual and optimal plans under the new technology and existing resources in the three subregions North, Central, and South Lampung. North Lampung (see Table 4.15) shows a significant difference between the actual/observed plan and the optimal plan. Land devoted to the optimal plan is smaller by about 9 percent, 1.38 hectares in the actual plan and 1.25 hectares in the optimal plan. This may be due to the fact that in the actual plan more labor is used (255 mandays) compared with 232 mandays for the optimal plan.

Crop enterprise combinations differ significantly and are less diversified under the optimal plan. Crop mixtures of corn + cassava, and upland rice ≠ cassava were eliminated in the optimal plan. Sole crop of cassava also does not enter the optimal plan. There was a relatively very large increase in land devoted to crop mixture of upland rice - soybeans from 0.03 hectares in the actual plan to 0.536 hectares in the optimal plan, an increase of 1777 percent.

In North Lampung, total gross margin is higher by 43 percent in the optimal plan compared to the actual plan even though land cultivated is smaller. Return to labor is higher in the optimal plan by 54 percent than in the actual plan. Return to land per hectare is very significantly higher in the optimal plan, by 158 percent.

Table 4.15.--A Comparison of Actual and Optimal Plan of the Representative Farm Under New Technology and Existing Resource Levels in North Lampung.

Item*	Unit	Actual Plan	Optimal Plan	Change Percent
1. C + ULR ≠ CV (TT)	HA)	0.620	0.214)	15
2. C + ULR ≠ CV (NT)	HA)		0.500)	
3. ULR - SB (NT)	HA	0.03	0.536	1777
4. ULR ≠ CV (TT)	HA	0.19	-	-100
5. C ≠ CV (TT)	HA	0.09	-	-100
6. CV (TT)	HA	0.37	-	-100
7. GNDT (TT)	HA	0.08	-	-100
Total Land	HA	1.38	1.250	-9
Total Gross Margin	RP	197,620	283,089	43
Family Labor	Manday	255	232	-9
Hired Labor	Manday	29	33	14
Total Labor	Manday	284	265	-7
Animal Draft Hired	AWD	6.5	9.5	46
Operating Capital	RP	29,925	39,025	30
Return/Hectare	RP	51,528	132,692	158
Return/Manday		677	1,041	54

Source: Computed.

*For explanation of abbreviations see Table C.1, Appendix C.

These differences can be attributed probably to the fact that North Lampung is a relatively newly opened area for transmigrants and use of modern inputs was just recently introduced to the representative farm. So the representative farm has not yet sufficient time to make all necessary adjustments to achieve optimum farm organization. The other factor that may have contributed to these differences between optimal and actual plan of the representative farm is the data limitation. Information obtained was based on the "memory" of the respondent farmers which, in the interview, covered a whole crop year of 1978/79. Problems may have developed in measuring, for example, the area of land cultivated and yields.

If we assume that the results of the linear programming applications are valid, the implication from the analysis is that there is some potential for achieving an increase in farm income and improvement in the efficiencies of resource use measured by the average return to resources such as land, labor, and operating capital. This increase in farm income could be realized through reallocation of resources among crop production activities as indicated by the optimal plan.

The slow process of adjustment in the farm organization toward the optimal plan may be due to the limited knowledge of the representative farmer. A more intensive extension effort backed by field research could probably speed up the process.

The comparison of optimal and actual plans under existing resource levels for Central Lampung is presented in Table 4.16. The table shows that there was no significant increase in farm income from the actual, even though there is a significant change in the crop enterprise combination. Sole crops of upland rice and cassava were eliminated in the optimal plan, while there was a significant change in the land devoted to crop mixtures. For the crop mixture of corn / cassava - soybeans, land devoted to it in the optimal plan covered 0.518 hectares and in the actual plan only 0.13 hectares, an increase of 298 percent. The increase of land devoted to this crop mixture was at the expense of the crop mixture of corn + upland rice / cassava and the single crops of upland rice and cassava. There was an increase of 20 percent of land devoted to crop mixture of corn - soybeans + cassava under the new technology.

Family labor use was decreased in the optimal plan compared to the actual plan by 11 percent. Returns to labor increased in the optimal plan by 3 percent compared to the actual plan.

Hired labor use increased by 51 percent and use of animal draft power increased by 35 percent. The impact on operating capital was to increase its use in the optimal plan compared to the actual plan by 29 percent. Return to land was higher in the optimal plan by 25 percent.

If the results of the linear programming are valid then there is a small potential to increase farm income,

Table 4.16.--A Comparison of Actual and Optimal Plan of the Representative Farm Under New Technology and Existing Resource Levels in Central Lampung.

Item*	Unit	Actual Plan	Optimal Plan	Change Percent
1. C + ULR ≠ CV (NT)	HA	0.340	0.262	-23
2. C + ULR ≠ CV (TT)	HA	0.200	0.240	20
3. C - SB ≠ CV (NT)	HA	0.130	0.518	298
4. LLR (NT)	HA	0.240	0.240	0
5. ULR (TT)	HA	0.100	-	-100
6. CV (NT)	HA	0.250	-	-100
Total Land	HA	1.260	1.260	0
Total Gross Margin	RP	178,500	182,238	2
Family Labor	Manday	245	219	-11
Hired Labor	Manday	47	71	51
Total Labor	Manday	292	290	-1
Animal Draft Hired	AWD	9.5	12.8	35
Operating Capital	RP	54,250	70,000	29
Return/Hectare	RP	41,548	52,074	25
Return/Manday Labor	RP	568	585	3

Source: Computed.

*For explanation of abbreviations see Table C.1, Appendix C.

but high potential to increase efficiency of the resource use such as land (as indicated by the average returns to land). This high increase in return to land resource but small increase in farm income could be achieved through the reallocation of resources among crop enterprises as indicated in the optimal plan. Then the question may arise is whether the small increase of 2 percent in farm income is worthwhile to make the changes with a decrease in family labor input by 11 percent (absolute decrease by 26 mandays) while increases in use of hired labor by 51 percent (absolute increase by 24 mandays), increase in use of hired animal draft by 35 percent (absolute increase by 3.3 animal working days) and its consequences of increasing operating capital by 29 percent (absolute increase by Rp15,750). Taken into account risk factor, it is likely that the farmer would not make any changes in order to obtain a nonsignificant increase in his income.

The comparison of actual and optimal plans under existing resources in South Lampung is presented in Table 4.17. The table shows that gross farm income in the optimal plan is higher compared to the actual plan by 6 percent. There were changes in the farm organization. The crop mixture of upland rice + corn - soybeans was eliminated in the optimal plan. Sole crop of cassava was eliminated in the optimal plan.

There was a significant change in the land devoted to each crop mixture. Land devoted to the crop mixture of

Table 4.17.--A Comparison of Actual and Optimal Plan of the Representative Farm Under New Technology and Existing Resource Levels in South Lampung.

Item*	Unit	Actual Plan	Optimal Plan	Change Percent
1. ULR - SB/CV (NT)	HA	0.360	0.325	-11
2. SB - SB - SB/CV (NT)	HA	0.240	0.321	34
3. ULR + C - SB/CV (NT)	HA	0.280	0.454	62
4. ULR + C/CV (TT)	HA	0.200	-	-100
5. CV (TT)	HA	0.020	-	-100
Total Land	HA	1.100	1.100	0
Total Gross Margin	RP	181,425	192,970	6
Family Labor	Manday	288	257	-11
Hired Labor	Manday	27	5	-440
Total Labor	Manday	315	262	-17
Operating Capital	RP	18,000	7,500	-58
Return/Hectare	RP	49,623	63,223	27
Return/Manday Labor	RP	664	731	10

Source: Computed.

*For explanation of abbreviations see Table C.1, Appendix C.

upland rice - soybeans was smaller by 11 percent in the optimal plan compared to the actual plan. Triple crops of soybeans increased by 34 percent compared to the actual plan, and land devoted to the crop mixture of upland rice + corn - soybeans increased by 62 percent compared to the actual plan. The cropping pattern was less diversified in the optimal plan than in the actual plan.

There was a decrease in family labor input in the optimal plan compared to the actual plan by 11 percent. Hired labor use declined to about one-fifth of the level of the actual plan and total labor use decreased by 17 percent in the optimal plan compared to the actual plan. There was also a decrease in operating capital by 58 percent in the optimal plan compared to the actual plan due to reduced hired labor input in the optimal plan. Even though there were decreases in resource use in the optimal plan compared to the actual plan, gross income and returns to resources were higher in the optimal plan. Returns per hectare were higher by 27 percent and returns to labor were higher by 10 percent.

Assuming that the results of the linear programming analysis are valid, then there was only a small potential to increase farm income and a small increase in returns to labor, but a substantial opportunity to increase the productivity of the land resource. These increases can be obtained through the reallocation of resources among the crop enterprises as indicated in the optimal plan under the new technology. It should also be noted that the only new input which has been used after the introduction of the new technology on the representative farm in South Lampung is insecticides.

4.6 Summary of the Results from Linear Programming Analysis

The results of the analysis from the empirical data collected in the study area has been presented in this Chapter. The findings indicated that some of the cropping patterns have a better competitive position in the optimal plan under the new technology than under the traditional one, i.e., in North Lampung this would be mixed cropping of upland rice - soybeans, in Central Lampung this would be mixed cropping of corn / cassava - soybeans, and for South Lampung this would be mixed cropping of upland rice + corn - soybeans. The cropping pattern is less diversified under the new technology. There is a comparative advantage in producing a specific crop with specific cropping patterns in each subregion as shown by the results of the linear programming analysis as well as by observations.

North Lampung has a comparative advantage in producing cassava and upland rice with cropping patterns consisting of cropping mixtures: corn + upland rice / cassava. Central Lampung has a comparative advantage in production of rice and cassava with crop mixtures: corn - soybeans / cassava, and corn + upland rice / cassava. South Lampung has a comparative advantage in producing soybeans with crop mixtures: corn + upland rice - soybean, upland rice - soybeans, and triple crops of soybeans in one cropping year.

The introduction of currently available new technology to the upland farming in Lampung indicates from the results of the linear programming analysis that there is some potential to increase food production and income of the farmers, and increase resource use and productivity. The highest potential is in North Lampung which is a relatively newly settled transmigration area. This may be due to the fact that the representative farm has not yet enough time to make required adjustments towards the optimal farm organization. For the representative farms in Central and South Lampung the results of the analysis indicated that there is little potential to increase farm income and food production through the adoption of the currently available new technology. It is also noted that in Pugung Raharja village (South Lampung) insecticides is the only new input used by the representative farm.

The results of the analysis of the representative farm in Central Lampung show that the marginal value product of irrigated land is much higher than the marginal value product of dryland. This may imply that the conversion of upland/dryland into irrigated land is one of the strategies to increase both food crop production and farm income of the small upland farmers.

Labor during the peak demand months is a limiting factor in increasing food crop production and farm income in the study area, especially for weeding under the new technology, and for land preparation under the traditional technology. Hired labor is limited in the peak seasons since there are no landless farmers in the study area. The use of animal draft power and other source of power may release part of this labor constraint. Medium to long term credit may be needed for investment in additional sources of power (e.g., cows, small tractors).

The representative farmers need no credit for operating capital if they practice a mixed cropping pattern which distributes cash income more evenly through the year. This is accomplished by selling their products after harvest of cassava in September, soybeans in February, corn in March, and rice in May.

In this Chapter the analysis emphasized the comparison of the optimal farm organization under traditional and under the new technology to present the likely effects of the introduction of the new technology. The comparison of the effects of the new technology with existing resource levels between the three subregions sheds some light on the comparative advantage in producing specific crops with specific cropping patterns. The analysis also sheds some light on the importance of some of the limiting resources in the optimal plan under the new technology. In the following Chapter the normative supply functions and estimates of price elasticities of the major crops will be discussed.

CHAPTER V

NORMATIVE SUPPLY FUNCTIONS FOR MAJOR FOOD CROPS UNDER TRADITIONAL AND NEW TECHNOLOGIES

5.1 Introduction

The previous chapter dealt with the analysis of the changes in the optimal plan of allocation of farm resources as a new technology is introduced to the traditional farming. The analysis emphasized the effects of the new technology on farm income, crop enterprise combinations, resource use and their productivities, and identification of some of the constraints. In this chapter the examination will be on the effect of the new technology on the major food crops supply functions and elasticities on the representative farms in the study area.

In Indonesia the major food crops are rice, maize or corn, and cassava. For 1977 rice harvested covered 8.8 million hectares and total production 23.9 million tons of unhulled rice, corn harvested included 2.6 million hectares and total production of 2.8 million tons, and cassava harvested was 1.36 million hectares and a total production of 12.17 million tons (Asian Development Bank, 1978). In terms of human consumption, rice is predominant providing about one half of all calories. Corn provides about a quarter and cassava about one-fifth of all calories.

For example, if the relative price of rice declined relative to the other staple food crops, rice will be consumed in a larger quantity, and vice versa. Income elasticity of rice in Indonesia is 0.6 which is very high (Timmer, 1974; Parhusip, 1976). Rice production has benefitted from the government investment program such as irrigation, credit and extension programs (BIMAS), and research programs in Indonesia. Rice production is still lagging behind the increasing demand due to the rapid population and income growth. The average annual import of rice is about two million tons since the late 1970s and now Indonesia has become the largest rice importer in the world.

In Lampung, rice, corn, and cassava are also the major food crops. Area harvested and total production of these crops for Lampung province is presented in Table B1 through Table B3 of Appendix B. Corn production has deteriorated since 1973 and cassava production only has recently had a significant increase. Lampung is still a rice deficit area and local rice production cannot compete with the increasing demand for rice. Corn is produced mostly for domestic consumption. Some corn is exported and locally traded. For example, in 1977, 3,888 tons were exported and 15,801 tons were traded to the other provinces, especially to Java. Cassava is also produced mostly for domestic consumption in the rural area as well as in the urban areas. Exports and other uses of cassava are fairly small, probably less than 15 percent of total production (Dixon, 1979; Jones, 1978).

The low prices received by the farmers for these crops have often been cited as one of the causes of the slow growth or even deterioration in their output. Many studies have shown that small farmers are rational and respond positively to increases in commodity prices (Gotsch and Falcon, 1974). Given this small farmer's behavior, then policy makers have sometimes been called upon to raise producer prices in order to increase food production. An accurate knowledge of the price elasticities of supply of these major crops is required to make a correct decision in a right direction and appropriate producer price increases in order to increase output by the required amount.

The adoption of the new technology shifts the production function and many times changes the farmer's response to commodity price changes (Gotsch and Falcon, 1974). Where rapid technological change is being experienced by the farmers, the previous estimates (if any) of price elasticities will not be a very good guide to the future supply response of the farmers in producing these crops. A recent estimate of price elasticities of these major crops may be needed in order to provide a basis for meaningful public decisions.

According to Heady (1961) there are two major directions from which empirical estimates of agricultural supply have been attacked in the past. The positive or descriptive approach is the prediction of the quantitative relationship among variables as they actually do exist at a point of time, or have existed over a period of time. The other is the normative or predictive approach which refers to what ought to exist, under certain assumptions. The major tools for positive analysis are regression procedures, e.g., econometric analysis, which attempts predictions from observations drawn out of the "actual operating world." The major tools for normative analysis include budgeting and programming. Here, certain assumptions are usually made about goal(s) and actions of decision makers. Both positive and normative approaches have been used and are being used because of the limitations of the estimates derived by each.

The most traditional positive approach is econometric analysis of aggregate time series data. This approach is descriptive since the estimation of the parameters is based on the past behavior of producers in response to product price changes and other relevant economic variables. This positive analysis of supply functions indicates responses to the real world in the past but is restricted in its ability to estimate what might be in the future when there are changes in structures or new variables.

A normative approach to estimation of supply functions is by programming individual farms for optimal solutions, indicating farmer's potential response under the assumptions of farm income maximization, perfect knowledge about prices, technological changes and institutional environmental factors. To the extent that these assumptions fail, a farmer's actual decisions may sometimes differ markedly from those indicated as optimum.

Both approaches have their advantages and limitations, and they are supplements rather than substitutes for each other. However, when rapid technological change is experienced by the farmers, and when there is a lack of accurate time series data on production and prices at the farm level, then there are definite advantages in the application of the programming approach. These advantages have been summarized by Buckwell and Hazel (1972). Programming provides a wealth of information on the farm level which is very useful for evaluation of the likely impact of policy on many small farm problems, embodied in a causal system of how individual farms function. It becomes easier to evaluate the future impact of policies. The fact that most farmers produce many products and use many resources with various enterprise combinations renders this approach well suited to evaluate the total impact of changes in relative prices on the supply of the individual crops.

These advantages may be weighted against the enormous data requirements of programming. The supply function estimated by the programming is normative in the sense that it indicates what farmer should produce in order to maximize income. The power of the analysis is dependent on the degree of correspondence between the assumptions made and reality including the structure of constraints, activities included in the model, technological coefficients, prices of outputs and inputs, and how risk factors are taken into account in the model (Heady, 1961). The normative approach by its nature may lead to an upward biased estimate of the supply function and elasticities (Anderson et al., 1965; Sheehy et al., 1964). There is no clear way to estimate to what extent normative quantities should be adjusted to closely approximate the actual supply response. Krenz et al. (1962) have suggested that the supply function could be made "less normative" or more realistic by including in the linear programming only production activities that the farmer is likely to consider.

The normative supply function estimated for the representative farm is derived from the linear programming model presented earlier. Parametric (or variable price) programming is used to derive the optimal output of the commodity concerned as its price is varied within an appropriate range while other prices are held constant. Variable price programming derives a supply function that can be formalized as follows (Krenz et al., 1962):

$$QA = f\,(P1, P2, PA, \ldots Pn, R1, R2, \ldots Rn, C1, C2, \ldots Cn)$$ in which:

QA = quantity of A produced (PA varied)

Pl to Pn = prices of factors and products at the farm level

Rl to Rn = the fixed resources of the farm (firm)

Cl to Cn = coefficients of production on the farm in all production alternatives considered.

The supply function also considered alternative products that may be produced with the given resources, at specified prices for factors, and technology of the farm under consideration. The supply function obtained is normative in the sense that it indicates what a farmer would plan to produce if he intended to maximize profits.

The functional relationship of price and quantity of the commodity derived from linear programming is discontinuous and in the form of a "step" function. Burt (1964) defined a step function as "a function such that a range is divided into a finite number of intervals with the dependent variable constant on a given interval." Graphically a step function appears as a series of steps as shown in Figure 5.1. By putting a consumption constraint or household requirement in the model, then that amount should be produced irrespective of its price (subsistence production). According to Kottke (1967) the stepped supply function consists of two parts. The horizontal segment depicted in Figure 5.1 is identified as marginal cost. The vertical segment of the step is identified by applying

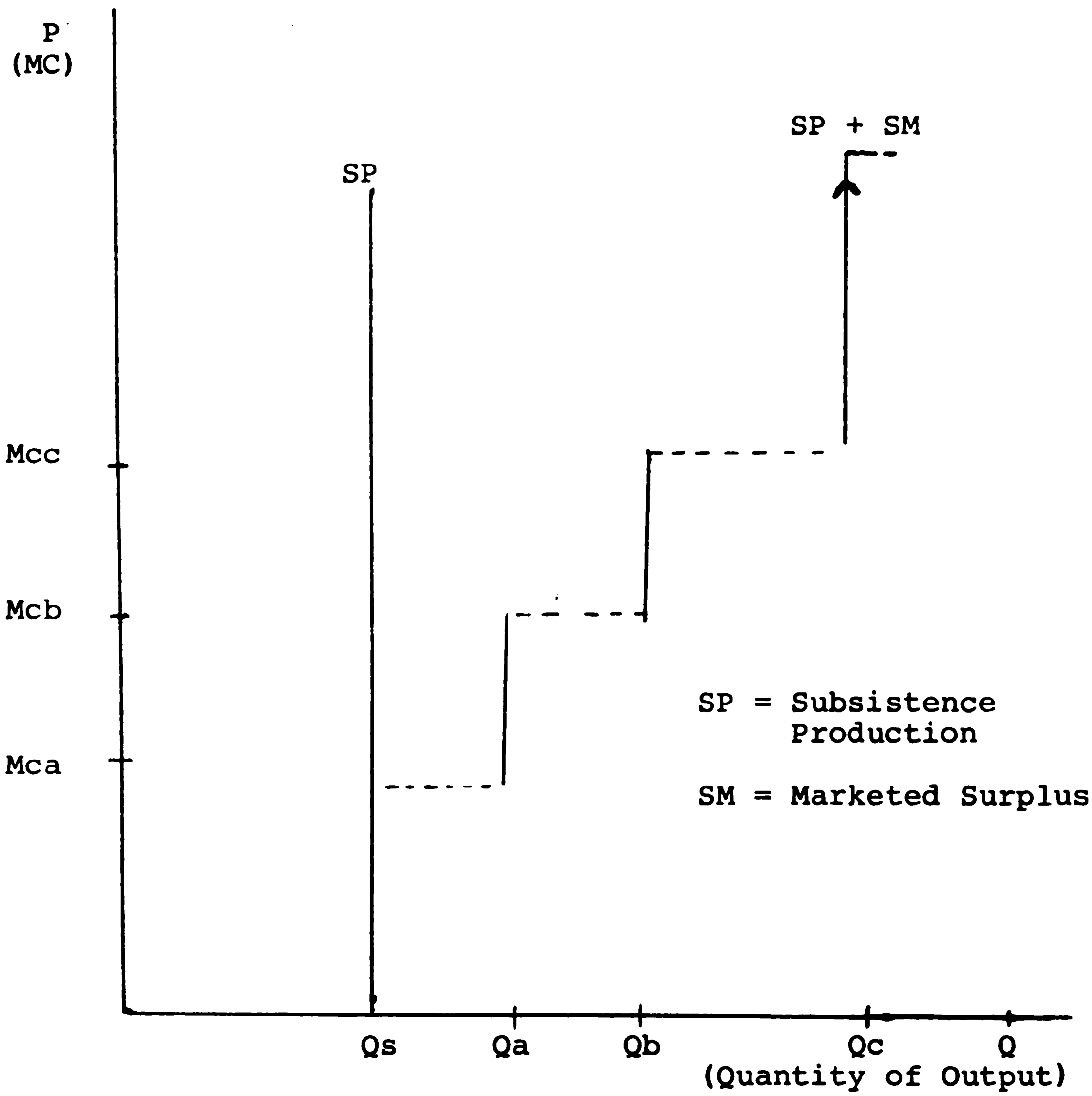

Figure 5.1. Farm-Firm Step Supply Function.

the profit maximizing criterion of MR $\geq$ MC. The vertical segments or optimal solutions and price ranges for the steps can be formulated as follows:

$$
\begin{aligned}
f(P) &= Qs \text{ for } 0 \leq P \leq MCa \\
&= Qa \text{ for } MCa < P \leq MCb \\
&= Qb \text{ for } MCb < P \leq MCc \\
&= Qc \text{ for } MCc < P
\end{aligned}
$$

where MC is the marginal cost of producing Q, and P is the price of Q.

The range of the vertical segments of the supply function is based on the profit maximizing criterion P = MR = MC. The optimum crop enterprise combination, and the optimum output, holds for all the prices included in the range of the vertical portion of any one step. The "stepped" characteristic of the supply function results from the finite number of production alternatives and rigid resource restrictions in the programming model. The number of steps and corners are the function of the number of production alternatives and restrictions. Including more production alternatives and restrictions will generate a normative supply function with more and smaller steps.

A supply function derived by means of parametric programming is static and in partial equilibrium in that no changes are assumed other than the price of the product (e.g., no changes in asset structure, no changes in technological coefficients). Supply elasticities associated with normative supply functions are biased upwards when compared with those obtained from time series data in which implicit are time lags, risk and uncertainty, and other behavioral factors that influence farmer's decisions to produce the output (Heady et al., 1961).

5.2 Normative Supply Function of Rice, Corn, and Cassava

In this section the supply functions for rice, corn, and cassava derived from the linear programming models described in Chapter III will be presented. Normative supply functions for the three crops were derived under traditional and new technologies with existing resource levels. The effects of releasing family labor constraints under the new technology were also examined. In the interpretation of the results caution must be taken since they were derived from one representative farm based on a purposive sample that was drawn from a limited number of samples and limited geographical areas. As a complete case only the analysis of the representative farm of North Lampung will be presented.

5.2.1 Rice Supply Function

In order to obtain the normative supply function for rice, the price of rice in the selling activities were varied over the range of Rp 100 per kilogram to Rp 300 per kilogram and then corresponding optimal solutions were obtained.[1] The quantity of rice produced at each price level was obtained from optimal solutions. The comparison of the results under traditional and new technologies within existing resource levels and new technology with labor increased is presented in Table 5.1. The comparison shows the likely impact of the new technology on the supply of rice on the representative farm in North Lampung.

The introduction of the new technology resulted in a shift in the supply curve outward to the right, indicating that the new technology has the effect of increasing the quantity of rice produced at each price. The increase of rice output comes from the expansion of acreage under cultivation of rice and an increase in rice yields.

The table also shows that the normative supply functions for rice under the new technology and increased availability of family labor increased the quantity of rice produced at each price level. The effectiveness of the new technology was enhanced by increasing the availability of family labor during the peak seasons. The effects of the new technology and the increase in availability of family labor are also shown in Figure 5.2.

The effect of relaxing credit constraints was not analyzed here, on the consideration that operating capital

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[1]The prevailing rice price in the study area is Rp 100 per kilogram. The price range used in the supply analysis may not represent the expected range of price increase, due to the government control on rice price.

Table 5.1.--A Comparison of Normative Supply Functions for Rice Under Traditional and New Technologies with Existing Resources of the Representative Farm in North Lampung.

Traditional Technology with Existing Resources		New Technology			
		Existing Resource		Labor Increased	
Price Range	Quantity	Price Range	Quantity	Price Range	Quantity
(Rp)	(Kg)	(Rp)	(Kg)	(Rp)	(Kg)
0-85	500	0-97	500	0-85	500
86-121	1144	100-121	1569	86-115	1602
122-257	1144	122-320	1569	116-363	1602
258-900	1153	321-666	1539	364-1326	1689

Source: Computed.

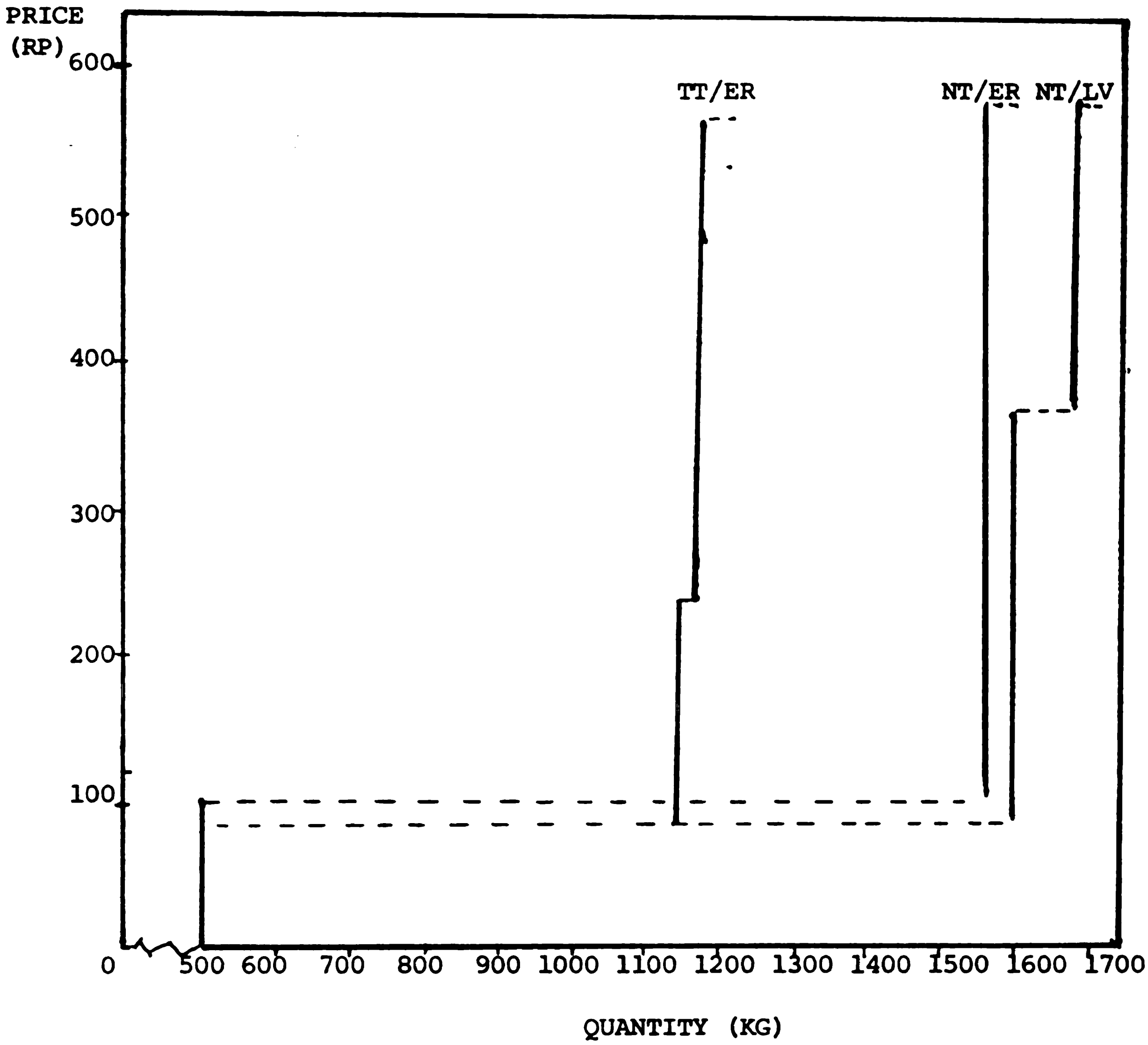

Figure 5.2. Normative Supply Functions for Rice Under Traditional and New Technologies of the Representative Farm in North Lampung.

Explanation of Abbreviations:

TT/ER = Traditional Technology with Existing Resources
NT/ER = New Technology with Existing Resources
NT/LV = New Technology with Increased Family Labor

Table 5.2.--A Comparison of Farm Income Under Traditional and New Technologies with Rice Price Varied on the Representative Farm in North Lampung.

Price	Quantity Sold (Kg)			Farm Income (Rp)		
(RP)	TT/ER	NT/ER	NT/LV	TT/ER	NT/ER	NT/LV
100	644	1069	1102	172302	283089	303314
115	644	1069	1102	181966	299118	319848
150	644	1069	1102	204514	336518	358418
400	653	1039	1089	366873	577925	611120

Source: Computed.

Explanation of Abbreviations:

TT/ER = Traditional Technology with Existing Resource

NT/ER = New Technology with Existing Resource Levels

NT/LV = New Technology with Increased Family Labor

Income = Gross Margin

is not a constraint due to a more even distribution of cash income to the farmers as they practiced multiple cropping.

Table 5.2 shows a comparison of farm income under traditional and new technologies under existing resources and with labor increased. Both rice production and farm income are increased under the new technology at all price levels. These increases are generated by the increase in the availability of family labor under the new technology. The implication is that the introduction of the new technology has a potential for increasing rice production and farm income. These increases are enhanced by the increase in the availability of family labor.

5.2.2 Corn or Maize Supply Functions

The normative supply functions for corn were also derived by variable price programming (parametrically varying the price of corn) over the range 60 Rupiah per kilogram to 561 Rupiah per kilogram, then obtaining the corresponding optimal solutions.[1] Table 5.3 shows a comparison of the quantity of corn produced at each price level under traditional and new technologies with existing resource levels and increased family labor under the new technology.

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[1]The prevailing price of corn in the study area is Rp 60 per kilogram, so this price range may be unrealistic. The price range should be wide in any case in order to see the effect of price changes on corn production.

Table 5.3.--A Comparison of Normative Supply Functions for Corn Under Traditional and New Technologies with Existing Resources and Labor Increased for the Representative Farm in North Lampung.

Traditional Technology Existing Resource		New Technology			
		Existing Resource		Labor Increased	
Price Range	Quantity	Price Range	Quantity	Price Range	Quantity
(RP)	(KG)	(RP)	(KG)	(RP)	(KG)
0-37	150	0-46	150	0-47	150
37-80	238	47-79	501	48-94	491
81-212	268	99-135	499	94-200	484
212-300	268	145-300	502	201-300	484
301-561	276	301-717	502	301-421	484

Source: Computed.

With results similar to the case of rice, the adoption of the new technology increased the quantity of corn produced at all price levels (shifted the supply curve outward to the right). The increase in corn production is the result of an increase in yields and the increase in the acreage under corn cultivation in a mixture. These supply functions are presented in Figure 5.3. An increase in family labor does increase in corn production and farm income.

The results of the analysis show that there is some potential for increasing corn production and farm income through the adoption of the new technology. The increase in family labor availability will enhance corn production and farm income. Under the new technology corn is produced in a mixed cropping system.

Table 5.4 shows a comparison of farm income under traditional and new technologies with existing resources and labor increased. Both production and farm income are increased under the new technology as in the case of rice. This is also true for corn. The increase in the availability of family labor enhances corn production and farm income. The implication is that the introduction of the new technology has a potential to increase both corn production and farm income. These increases are also enhanced by the increase in the availability of family labor.

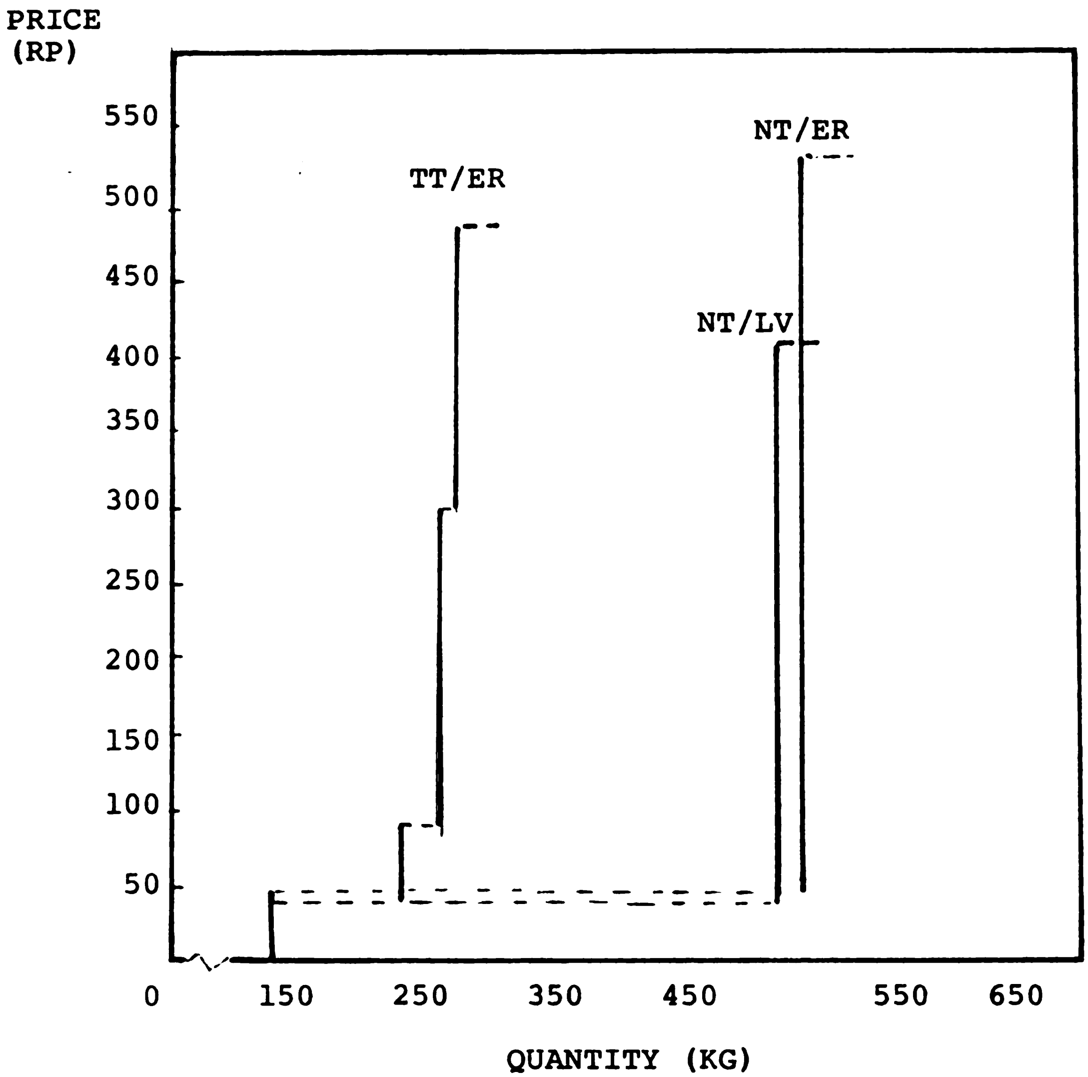

Figure 5.3. Normative Supply Functions for Corn Under Traditional and New Technologies of the Representative Farm in North Lampung.

Explanation of Abbreviations:

TT/ER = Traditional Technology with Existing Resources

NT/ER = New Technology with Existing Resources

NT/LV = New Technology with Increased Family Labor

Table 5.4.--A Comparison of Farm Income Under Traditional and New Technologies with Corn Price Varied for the Representative Farm in North Lampung.

Price	Quantity Sold (KG)			Farm Income (RP)		
(RP)	TT/ER	NT/ER	NT/LV	TT/ER	NT/ER	NT/LV
60	88	351	336	172302	283089	303658
100	113	349	334	176811	297032	316685
200	113	352	334	188081	332152	350113
300	113	352	334	199352	367352	383541
350	121	352	334	205402	384952	400255

Source: Computed.

Explanation of Abbreviations:

TT/ER = Traditional Technology with Existing Resources

NT/ER = New Technology with Existing Resource Levels

NT/LV = New Technology with Increased Family Labor

Farm Income = Gross Margin

5.2.3 Cassava Supply Functions

The normative supply functions for cassava were obtained by parametrically varying the price of cassava over the range of 17 Rupiah per kilogram to 60 per kilogram,[1] and then obtaining the corresponding optimal solutions. Table 5.5 shows a comparison of the quantity of cassava produced at each price level under traditional and new technologies and at an increased level of labor under the new technology. At all price levels the production of cassava is higher under the new technology than under the traditional technology. An increase of family labor availability has a positive impact on cassava production.

The supply curve of cassava under the new technology shift upward to the right as shown in Figure 5.4. The likely impact of the adoption of the new technology will increase cassava production and farm income. Table 5.6 shows a comparison of farm income under the traditional and new technologies. Farm income is higher under the new technology than under the traditional technology at all price levels. Increased family labor availability enhanced both cassava production and farm income.

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[1]The prevailing price of cassava in the study area is Rp 17 per kilogram, the price range is realistic since demand for cassava is strong due to a recent dramatic increase in the capacity of cassava processing industries in Lampung. Also the prospects for cassava prices are favorable in domestic markets and abroad.

Table 5.5.--A Comparison of Normative Supply Functions for Cassava Under Traditional and New Technologies with Existing Resource and Labor Increased for the Representative Farm in North Lampung.

Traditional Technology		New Technology			
Existing Resource		Existing Resource		Labor Increased	
Price Range (RP)	Quantity (KG)	Price Range (RP)	Quantity (KG)	Price Range (RP)	Quantity (KG)
0-11.0	3000	0-16	3000	0-7	3000
11-18.5	4314	16.2-18.3	9718	7-9	10384
19-21	5169	19.7-21.5	9720	19.5-20	11482
24-28	5380	24.3-31.6	9778	20-48	11482
28-34	6151	34-48.6	10729	48-168	13111
36-47	8415	48.6-79.6	13011	168-283	13111
47-90	8523				

Source: Computed.

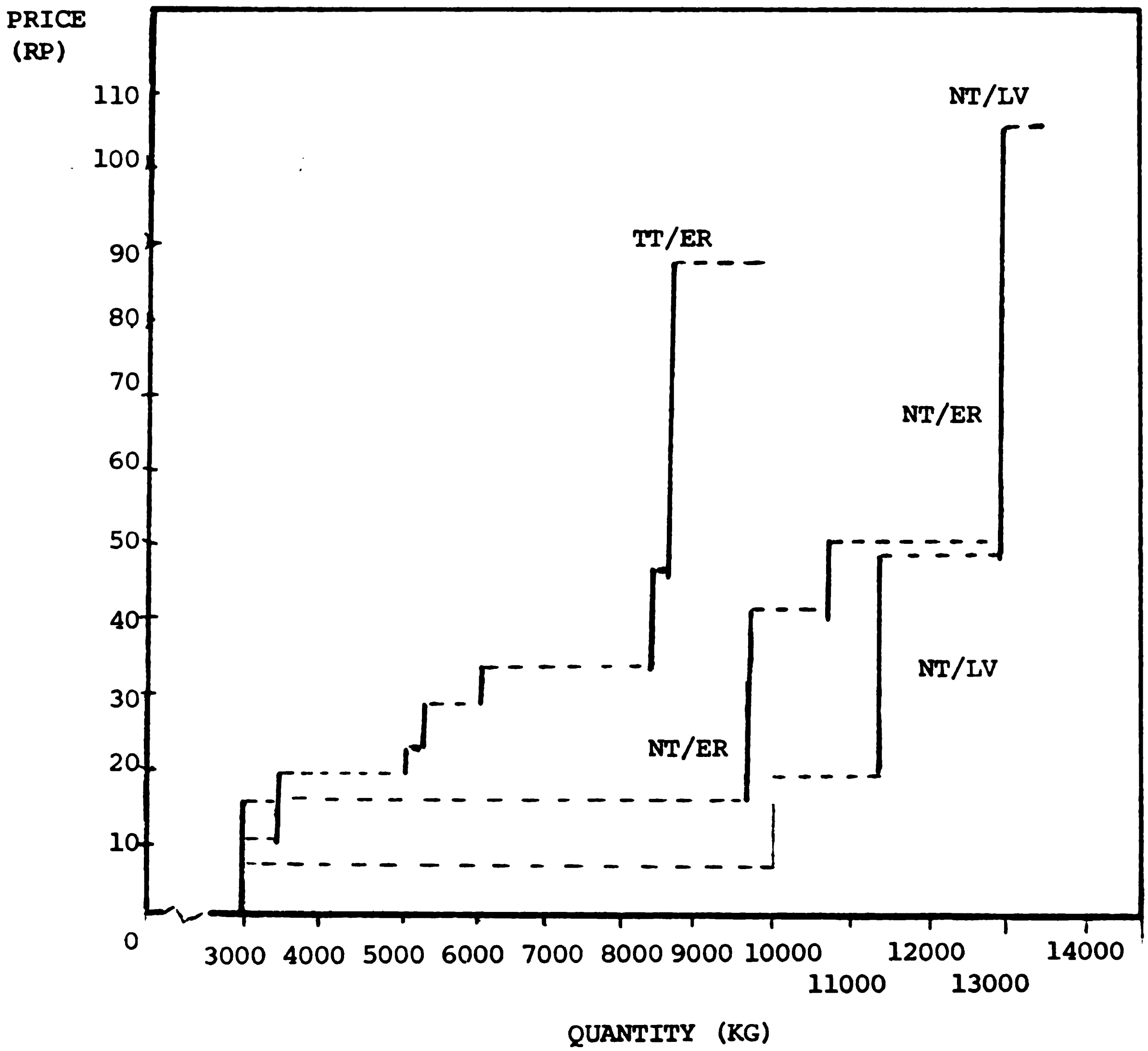


Figure 5.4. Normative Supply Functions for Cassava Under Traditional and New Technologies of the Representative Farm in North Lampung.

Explanation of Abbreviations:

TT/ER = Traditional Technology with Existing Resources

NT/ER = New Technology with Existing Resources

NT/LV = New Technology with Increased Family Labor

Table 5.6.--A Comparison of Farm Income Under Traditional and New Technologies with Cassava Price Varied for the Representative Farm in North Lampung.

Price	Quantity Sold (KG)			Farm Income (RP)		
(RP)	TT/ER	NT/ER	NT/LV	TT/ER	NT/ER	NT/LV
17	1314	6718	7384	172302	283089	303658
20	2169	6720	8482	176663	303237	325903
25	2380	6778	8482	188023	337076	368368
30	3151	6778	8482	201369	370925	410784
40	5415	7729	8482	249015	445598	495618
50	5523	7729	10111	303457	526166	583711
60	5523	7729	10111	358687	603458	684822

Source: Computed.

Explanation of Abbreviations:

TT/ER = Traditional Technology with Existing Resources

NT/ER = New Technology with Existing Resources

NT/LV = New Technology with Increased Family Labor

Farm Income = Gross Margin

The effects of commodity relative price increases under the new technology show that increases in relative price of cassava has the largest impact on farm income. For example a 50 percent increase in the relative price of cassava (from Rp 17 to Rp 25.50 per kilogram), ceteris paribus, farm income increases by 20 percent from Rp 283,089 to Rp 340,465. An increase in the relative price of corn by 50 percent (from Rp 60 to Rp 90 per kilogram), ceteris paribus, farm income increases by 4 percent from Rp 283,089 to Rp 293,542. An increase in relative price of rice by 50 percent (from Rp 100 to Rp 150), ceteris paribus, farm income increases by 19 percent from Rp 283,089 to Rp 336,518.

5.3 The Effects of the New Technology on the Price Elasticities of the Supply of the Major Food Crops

The ultimate purpose of the supply function analysis generally is the estimation of price elasticity. To complete the analysis of the supply functions of the major food crops, i.e., rice, corn, and cassava, the estimation of the price elasticities of these supply functions will proceed. For the "stepped" supply function, estimation of the price elasticity is not as clear-cut as the estimation of the price elasticity of smooth supply functions. Estimation of the stepped supply function is meaningless unless the function is transformed into a smooth or continuous supply curve.

Some methods are available to transform a "stepped" supply function into a smooth supply function. Krenz (1960) used optimum quantities and their corresponding prices as the observations to be used as data for a least square regression analysis to estimate price elasticity as in a continuous function. According to Burt (1964) the mid-points of the vertical portions of the steps are more stable with respect to price changes and therefore are used as values for price (independent variable). This method will be used in this section to estimate price elasticities of supply of the major food crops under traditional and new technologies.

A continuous supply function is fitted to the data presented as stepped supply functions in section 5.2. The model is based on only a single independent variable since it is assumed there are no changes in factors affecting supply except its price. The general functional form is as follows:

$$Q = f\ (P)$$

where:

Q = quantity of commodity produced in kilograms per crop year

P = price of commodity in Rupiah per kilogram

Each vertical part of the step function is treated as an observation on the dependent variable. It has been mentioned before that price production is stable at the midpoints of the vertical parts of the steps (and therefore these midpoints will be used as values for the independent variable). But it should be born in mind that the data generated by this procedure may not meet the normality and independence assumptions, so that statistical inferences and probability statements cannot be made.

Functional relationships to be considered are as in the following forms:

$$Q = \beta o + \beta 1\ P \qquad \text{(linear relationship)}$$

$$Q = \beta o + \beta 1\ P + \beta 2\ P^2 \qquad \text{(quadratic relationship)}$$

$$Q = \beta o + \beta 1 \log P \qquad \text{(semi-log relationship)}$$

$$\ln Q = \beta o + \beta 1 \log P \qquad \text{(double-log relationship)}$$

The criteria to be used for choosing the "best" fit of the functional relationship are: size of adjusted R square, the sign of the price coefficient ($\beta 1$) and F- value for the regression mean square. For estimating these functional relationships by using the SPSS (Statistical Package for Social Sciences) by Nie, 1975.

The estimated supply equations for these major food crops are presented in Table 5.7, Table 5.8, and Table 5.9 for rice, corn, and cassava respectively. For the rice supply equations the $\bar{R}^2$ are low and all coefficients are not significant at 5 percent level. Corn supply equation $\bar{R}^2$s are also low and all coefficients are not significant at the 5 percent level, except the corn supply equation under traditional technology. This equation has

Table 5.7.--Estimated Supply Functions for Rice Under Traditional and New Technologies for the Representative Farm in North Lampung.

Technology and Resource Level	Functional Form	β_0	β_1	$\bar{R}^2$	$F_{\alpha,\gamma}$
Traditional Technology and Existing Resources	Semi-log	-86.9	501.5	0.30	2.3
New Technology and Existing Resources	Double log	2.1	0.44	0.45	3.5
New Technology and Labor Increased*	Double-log	2.4	0.31	0.25	2.0

All of the coefficients are not significant at 5 percent level

Source: Computed.

*It was assumed that the family members are willing to work each month as long as in the months of the peak season.

Table 5.8.--Estimated Supply Functions for Corn Under Traditional and New Technologies for the Respresentative Farm in North Lampung.

Technology and Resource Level	Functional Form	β_o	β_1	$\bar{R}^2$	$F_{\alpha,\gamma}$
Traditional Technology and Existing Resources	Semi-log	60.9	87.0*	0.80	16.8
New Technology and Existing Resources	Smi-log	-47.0	232.1	0.43	4.0
New Technology and Labor Increased[a]	Double-log	1.76	0.40	0.56	6.1

Source: Computed.

*Significant at 5 percent.

[a]It was assumed that the family members are willing to work as long as in the months of peak season.

Table 5.9.--Estimated Supply Functions for Cassava Under Traditional and New Technologies for the Representative Farm in North Lampung.

Technology and Resource Level	Functional Form	β_o	β_1	$\bar{R}^2$	$F_{\alpha,\gamma}$
Traditional Technology and Existing Resources	Double-log	3.04	0.5**	0.95	111.2
New Technology and Existing Resources	Semi-log	-2909.0	8712**	0.82	28.8
New Technology and Increased Labor[a]	Semi-log	3055.9	4721.7**	0.57	

Source: Computed.

*Significant at 5 percent.

**Significant at 1 percent.

[a]It was assumed that the family members are willing to work as long as in the months of peak season.

$\bar{R}^2 = 0.80$ and the $\beta 1$ coefficient is significant at the 5 percent level. The $\bar{R}^2$ for the cassava supply equations are high at 0.95, 0.82, and 0.57 under traditional technology with existing resources, new technology with existing resources, and under the new technology with increased family labor respectively. All coefficients for cassava supply equations are significant at 1 percent and at 5 percent levels.

Elasticities of supply of the major food crops with respect to their own prices were calculated by using the following formula:

$$n_p = \frac{dQ}{dP} \cdot \frac{P}{Q}$$

Price elasticities for rice supply were calculated at various price levels ranging from 42.5 Rupiah to 579 Rupiah per kilogram. These calculated price elasticities for rice are shown in Table 5.10. All elasticities are positive and indicate the percentage increase in quantity of rice produced in response to a 1 percent increase in rice price. Under traditional technology, the price elasticity for rice supply varies from 1.0 at the price of 42.5 Rupiah per kilogram to 0.44 at the price of 579 Rupiah per kilogram. Price elasticities of rice are lower than one (except for rice price lower than the existing price of 100 Rupiah per kilogram). Rice supply functions can be considered inelastic.

Table 5.10.--Estimated Price Elasticities of Rice Supply Functions Under Traditional and New Technologies for the Representative Farm in North Lampung.

Price (Rp/KG)	Elasticities		
	Tradtional Technology and Existing Resources	New Technology and Existing Resources	New Technology and Increased Labor
42.5	1.00	0.44	0.31
103.5	0.44	0.44	0.31
139.5	0.44	0.44	0.31
579	0.44	0.44	0.31

Source: Computed.

The price elasticities of rice supply under traditional and new technologies with existing resources are constant at 0.44. Price elasticities of rice supply are also constant at 0.31 under the new technology with increased family labor. The supply of rice under the new technology is inelastic with constant elasticity irrespective of price levels (the best fit is the supply equation in double logarithmic form).

As family labor increased under the new technology, the supply of rice became more inelastic. This means that response of rice supply to a 1 percent change in the price of rice is lower under the new technology than under the traditional technology, but it is not necessarily true in terms of absolute changes of rice output, as can be seen later in this section. In all cases the price elasticities of rice supply functions are constant within the price range from 100 Rupiah per kilogram (existing rice price in the study area) to 579 Rupiah per kilogram.

Table 5.11 shows the price elasticities of corn supply functions. All coefficients are less than one except at a corn price at 18.5 Rupiah per kilogram under the new technology and existing resources. With current price of corn at 60 Rupiah per kilogram in the study area, it is likely that the supply of corn is inelastic. The supply of corn is more inelastic under traditional technology. So under the new technology, corn supply is more responsive to its price changes than under the traditional

Table 5.11.--Estimated Price Elasticities of Corn Supply Functions Under Traditional and New Technologies for the Representative Farm in North Lampung.

Price (RP/KG)	Elasticities		
	Traditional Technology and Existing Resources	New Technology and Existing Resources	New Technology and Increased Labor
18.5	0.58	1.54	0.40
63.0	0.37	0.46	0.40
146.5	0.32	0.46	0.40
256	0.32	0.46	0.40
476	0.32	0.46	0.40

Source: Computed.

technology. The effect of the adoption of the new technology on the price elasticity of corn supply is different from rice. Increases in the price of corn under the new technology is more effective in increasing production than is the case with rice.

Table 5.12 shows the price elasticities for cassava supply functions at the price range from 7.2 Rupiah per kilogram to 91 Rupiah per kilogram. All elasticities are less than one, except at the price level of 7.2 Rupiah per kilogram (which is much lower than the 17 Rupiah per kilogram existing price) under the new technology. So the supply of cassava is also inelastic but less inelastic than corn and rice supply curves. Supply of cassava is less inelastic under the new technology compared to the traditional technology. This implies that the increase in price of cassava is more effective in increasing its production under the new technology than under the traditional technology. In the case of the new technology, the price elasticities of cassava decreased as its price increased. This means that price increases for cassava is less effective to increase production at higher price levels.

In case the policy or program objective is to increase food production, the absolute increase in production in response to increases in crop prices is more relevant than the price elasticity itself as indication of the effectiveness of the price incentive. These absolute changes or increases in the major food crop production in

Table 5.12.--Estimated Price Elasticities of Cassava Supply Functions Under Traditional and New Technologies for the Representative Farm in North Lampung.

Price (Rp/KG)	Elasticities		
	Traditional Technology and Existing Resources	New Technology and Existing Resources	New Technology and Increased Labor
7.20	0.50	2.90	1.57
14.75	0.50	0.89	0.45
20.75	0.50	0.89	0.41
26.00	0.50	0.89	0.41
41.50	0.50	0.81	0.36
91.00	0.50	0.66	0.36

Source: Computed.

response to a 1 percent increase in its price are shown in Table 5.13, Table 5.14, and Table 5.15 for rice, corn, and cassava respectively.

Table 5.13 shows that the absolute increase of rice output in response to a 1 percent increase in its price is highest under the new technology. This implies that price increase is more effective to induce rice production in an absolute sense under the new technology with existing resources than under the traditional technology. Table 5.14 shows that the absolute increase in corn output in response to a 1 percent increase in its price is much higher than under traditional technology. This implies that price increase is much more effective to induce an increase in production of corn under the new technology than under the traditional technology.

Table 5.15 shows that the absolute increase in cassava output in response to a 1 percent increase in its price under the new technology with existing resource was more than triple the level under the traditional technology. Absolute increases in cassava output under the new technology and increase in labor availability is more than double the level of the traditional technology. These calculations imply that price increases are much more effective in expanding cassava production under the new technology than under the traditional systems. So even though the price elasticity of cassava supply under the new technology with increase in labor is lower than under the

Table 5.13.--Absolute Increases in Production of Rice in Response to a 1 Percent Increase in Its Price Under Traditional and New Technologies for the Representative Farm in North Lampung.

Price (Rp/KG)	Increase in Output (KG)		
	Traditional Technology and Existing Resources	New Technology and Existing Resources	New Technology and Increased Labor
42.5	5.00	2.20	1.55
103.5	5.03	6.90	4.97
139.5	5.03	6.90	4.97
579.0	5.07	6.77	4.93

Source: Computed.

Table 5.14.--Absolute Increases in Corn Production in Response to a 1 Percent Increase in Its Price Under Traditional and New Technologies for the Representative Farm in North Lampung.

Price (Rp/KG)	Increase in Output (KG)		
	Traditional Technology and Existing Resources	New Technology and Existing Resources	New Technology and Increased Labor
18.5	0.87	2.31	0.60
63.0	0.88	2.30	1.96
146.5	0.86	2.30	1.94
256.0	0.86	2.30	1.94
476.0	0.86	2.30	1.94

Source: Computed.

Table 5.15.--Absolute Increases in Cassava Production in Response to a 1 Percent Increase in Its Price Under Traditional and New Technologies for the Representative Farm in North Lampung.

Price (RP/KG)	Increase in Output (KG)		
	Traditional Technology and Existing Resources	New Technology and Existing Resources	New Technology and Increased Labor
7.20	15.0	87.0	47.1
14.75	21.6	86.5	46.7
20.75	25.8	86.5	47.1
26.00	26.9	87.5	47.1
41.50	30.7	86.9	47.2
91.00	42.1	85.8	47.2

Source: Computed.

traditional technology, the absolute increase in cassava production in response to a 1 percent increase in its price is higher.

In the next chapter the major findings from the empirical analysis on the effects of the new technology on the key farm variables will be summarized and policy implications of these findings will be discussed. The limitations of the study and suggestions for further study will be presented.

CHAPTER VI

SUMMARY, POLICY IMPLICATIONS, LIMITATIONS OF THE STUDY AND SUGGESTIONS FOR FURTHER RESEARCH

6.1 Summary

The present performance of Indonesian agricultural food crop subsector can be considered unsatisfactory. Food crop production is inadequate, resource productivity and farmers incomes are low. Food production has not kept pace with the growing population, so that Indonesia has to rely on food imports, especially rice. The problem of increasing food production is also aggravated by the concentration of population on the island of Java. These conditions hampered the capacity of the agricultural food crop subsector to contribute significantly to general economic development and especially to the industrial sector which relies on agriculture as a source of its raw materials.

The problems of unequal distribution of population and low farm income has been partly tackled by the transmigration program from Java to the outer islands, especially Lampung in South Sumatra. These programs are expected to have the dual strategies of easing Java's population pressure and also developing the outer islands. The intended impact is to increase food production, farm income, and growth centers outside Java which will then hopefully attract new migrants.

Traditional agriculture and traditional techniques have been identified as the primary causes of the poor performance of the agricultural food crop subsector. In order to increase food production, especially rice, the government has launched a series of programs aimed at increasing food production. The "BIMAS PROGRAM" (mass guidance for increasing rice production) has been underway since 1964/65 with special emphasis on irrigated rice production in Java. A major strategy for technological improvement has been the introduction of modern inputs such as chemical fertilizers, improved seed varieties, insecticides/pesticides and improved cultural practices. These programs to some extent have been successful and have been extended to other food crops such as corn, soybeans, and cassava in the upland farming in the outer islands.

Lampung province received considerable attention from the Central Government for its strategic location as a major recipient of the transmigrants from Java and for its great potential for food crop production. Programs for increasing upland food crop production such as upland rice, corn, and cassava have been carried out more intensively in Lampung compared to the other outer islands. Besides the BIMAS program there is a Japanese technical assistance program called "TANI MAKMUR PROJECT" in Lampung which is introducing new technology into the traditional cropping system. This project also enhances the farmer's organizational abilities to cope with the introduction of the new technology, especially farmer's training, distribution of agricultural inputs, and introduction of revolving funds. The Central Research Institute for Agriculture (CRIA) received technical assistance from the International Rice Research Institute (IRRI) and has conducted multiple cropping experiments in Lampung to provide information on the new highly potential cropping systems for the local area in order to increase food production and farm income.

Agricultural development theory focuses on the availability and introduction of new high return agricultural inputs. The use of these new inputs could significantly alter the resource use, crop enterprise combinations, as well as farm income. These new technological and economic conditions could have a significant impact on the key farm variables such as cropping patterns, crop enterprise combinations, farm income, employment, resource use and resource productivity.

This study was conducted in Lampung province where the transmigrants are concentrated and upland farming systems for upland food crop production are the main agricultural activities, and new technology for food crop production has been introduced. The study emphasis is on the small subsistence family farms based on the presumption that the development of small scale farms in Indonesia will be the necessary strategy for increasing food production and incomes of millions of small farmers. The large scale, highly mechanized commercial farms are important to increase agricultural production, but they are excluded in this study for the reasons discussed in the introduction.

This study was the first in Lampung with linear programming approach in which data was obtained from periodic visit survey on small farm operators. The ultimate objectives of the government program are to raise farm incomes, output and resource productivity. Quantitative information on the effects of technological changes on farm income, cropping patterns and crop enterprise combinations, resource use and productivity is needed. This information is useful as a basis for the evaluation of current agricultural policies and strategies.

The purpose of this study was to explore the extent to which new inputs have been incorporated on the small upland food crops farm and the changes in farm income, crop enterprise combinations, resource use and productivity, and to estimate price elasticities of the normative supply functions of the major food crops.

The linear programming approach was used as the framework for analyzing the economics of resource use under the traditional and new technologies. The linear programming structure is presented in Chapter III. The model was designed to maximize gross margins subject to meeting the minimum requirements for family food crop consumption. The activities in the model included crop production and selling activities, labor hiring activities, fertilizer and insecticide buying activities, food crop consumption and buying activities, capital borrowing activities, and transfer activities. Transfer activities are included in order to transfer surplus capital from one month to the next. This model was used to generate optimal plans both under the traditional and new technologies. A comparison of these two optimal plans was used to obtain the likely effects of the adoption of the new technology on the traditional farming system.

The data used for this empirical analysis was obtained from both secondary and primary sources but mostly from primary sources. The primary data were collected by interviewing a number of sample representative farmers. The sample farmers were selected by the stratified simple random sampling method. Four villages were selected and from each village twenty-three sample farms were selected at random, so we had ninety-two sample farms at the beginning of the interview. Due to several farms which dropped out for various reasons, there were only eighty-five sample farms used in the final analysis. These sample farms were interviewed every month from August through December 1979.

The unit of analysis was a representative farm based on average data from the sample farms from each village. The representative farm sizes were 1.48 hectares, 1.44 hectares, 1.45 hectares, and 1.38 hectares for Adiluih, Bulusari, Pugung Raharja, and Tatakarya villages respectively. About 1.27 hectares, 1.25 hectares, 1.10 hectares, and 1.38 hectares of these areas were devoted to food crop production respectively.

The family size on the representative farms was 5.3 persons, 5.9 persons, 5.6 persons, and 6.0 persons for Adiluih, Bulusari, Pugung Raharja, and Tatakarya villages respectively. The educational level of the household head of the representative farms was 3.4 years, 3.6 years, 3.0 years, and 3.2 years for these villages. The average family labor available including the farm operator were 2.8, 2.8, 2.9, and 2.t adult male equivalents for Adiluih, Bulusari, Pugung Raharja, and Tatakarya villages respectively.

The results of the analysis from the empirical data collected in the study area indicated that there is little potential to increase farm income and food production through the adoption of the currently available new technology on the representative farms in Central and South Lampung. Most of the currently available new technology has been adopted. Some potential was shown to be present for further adoption of currently available new technology for the representative farm in Tatakarya Village (North Lampung) a relatively newly settled transmigration area compared to the other two subregions of Central and South Lampung. This is maybe due to the lack of time for the representative farm to make the required adjustments toward the optimal farm organization.

The findings also indicated some of the cropping patterns have a better competitive position in the optimal plan after the introduction of the new technology than under the traditional technology. These are the mixed cropping of upland rice - soybeans in North Lampung, mixed cropping of corn + cassava - soybeans for Central Lampung, and mixed cropping of upland rice + corn - soybeans in South Lampung.

There is a comparative advantage in producing a specific crop with specific cropping patterns in each sub-region as shown by the results of the linear programming analysis under the new technology and by observations. North Lampung has a comparative advantage in producing cassava and upland rice with cropping patterns consisting of crop mixtures: corn + upland rice / cassava and upland rice - soybeans. Central Lampung has a comparative advantage in producing rice and cassava with crop mixtures: corn / cassava - soybeans and upland rice + corn / cassava. South Lampung has a comparative advantage in producing soybeans with crop mixtures: corn + upland rice - soybeans, upland rice - soybeans, and a triple crop of soybeans in sequence.

Turning to resource constraints, labor during peak demand months as expected is a major limiting factor in increasing crop production and farm income in the study area, especially for land preparation and weeding. The increase of family labor input by working more days and/or more hours in a day would increase farm income significantly. There is also a limited supply of hired labor during the peak seasons which may be due to the absence of landless farmers in the study area. The use of animal draft power may release part of this labor bottleneck for land preparation.

Long term credit may be required by the representative farms for investment in livestock such as cows or buffaloes for animal draft as additional source of power. The introduction of simple mechanical equipment for weeding operations need also to be considered to overcome labor bottlenecks for weeding. The analysis of representative farms shown no credit need for operating capital if they practice mixed cropping patterns which distribute their cash income more evenly by selling their products after harvest (cassava in September, soybeans in February, corn in March, and rice in May). The analysis shows that in production of rice, corn, and cassava a mixture of these crops is more profitable than sole crops under the new technology.

For estimation of the normative supply schedules of the three major food crops under traditional and new technologies variable price programming was used. The results of this price variable programming are the step supply functions. The results of the analysis for the representative farm in North Lampung show that the adoption of the currently available new technology resulted in a shift in the supply curves outward to the right, indicating that the new technology has the effect of increasing output of rice, corn, and cassava at each price level (shift in supply curves). For example with existing prices for these crops, adoption of new technology caused the supply of rice to increase by 37 percent, corn by 68 percent, and cassava by 123 percent, on the representative farm in North Lampung.

The effectiveness of the new technology to increase production would be enhanced by the increase in the availability of labor during the peak seasons.

In examining the supply response to a relative price change for each crop the step supply functions were transformed into smooth or continuous supply functions by means of regression analysis. From these continuous supply functions own price elasticities of the three major food crops were estimated. The results of the supply functions estimates show that double-logarithmic and semi-logarithmic forms of relationship were the best fitting for the three major food crops both under traditional and new technologies.

The following results should be interpreted with care since not all of the functional forms had a high R^2 and significant coefficients. For example rice normative supply functions had a low R^2 and insignificant coefficient. The analysis shows that the price elasticities for rice, corn, and cassava are less than one for price ranges up to three times the present price for both traditional and new technologies. Although the normative supply functions for the three major food crops are inelastic in all cases, the normative supply function for cassava is less inelastic. Rice price elasticities are equal under the traditional and new technologies with the existing resource levels. Corn price elasticities are higher under the new technology than under the traditional technology. This is also true for cassava. These results may imply that price increases would be more effective to increase the three major food crops production under the new technology. The results of the analysis also show that the price elasticities of the three major food crops are nearly constant even when their prices are tripled. Therefore relative price increases for these food crops as an incentive to increase food production appears likely to be effective for a broad range of prices.

6.2 Policy Implications

The policy implications derived from this study are limited to the assumptions made, data reliability, analytical framework used, and the construction of the representative farms. The quantitative estimates of the parameters may differ from their true magnitudes but at least this study has indicated the likely economic effects of the introduction of the new technology on traditional small upland farms in Lampung.

To release population pressure in Java, Lampung has a great potential as a transmigration area due to its strategic location and great potential for food crop production. Large areas still available are not yet farmed in Lampung province. The analysis of a small representative farm (1.38 hectares) in North Lampung which is a relatively newly settled transmigration area shows that there is potential to increase food production and farm income through the adoption of currently available new technology. Therefore, the development of small upland farm in the newly settled area in Lampung would partly tackle the problem of population distribution, and the problem of increasing food production and increasing small upland farm income.

For Central and South Lampung regions there is limited potential for increasing the output and farm income through the adoption of the currently available new technology. Therefore efforts should be emphasized on the production and the introduction of other new technology not currently available such as high yielding varieties, new cropping patterns and new crops.

The study also shows that an increase in the availability of labor could enhance the increase in output and farm income in the adoption of the new technology. Hired labor is also limiting since there are no landless farmers in the study area. The use of animal draft for land preparation could release part of the labor constraints in this peak period as could other sources of power such as tractors for land preparation. Other selective simple mechanization of some of the farm operations also need to be considered..

The analysis of the representative farm in Central Lampung, where irrigated rice production was also included in the model, shows that the marginal value product of irrigated land is much higher than the marginal value product of upland. Therefore it is important to explore the profitability of converting upland into irrigated land to increase both food production and farm income.

The planning of agricultural development should be continued toward the expansion of the adoption of the new technology on the small upland farm in the newly settled areas. To facilitate the process of diffusion of the new technology to the small upland farms, a number of programs were needed including research to produce new profitable inputs, farmer training for the use of these new inputs, farmers organization for the distribution of these new inputs and for marketing their agricultural products. The efforts such as of the Tani Makmur Project in this regard need to be continued and expanded.

The normative supply functions of the major food crops are inelastic, i.e., at the existing price levels the rice supply price elasticity is about 0.44 both under the traditional and new technologies; corn supply price elasticity is 0.37 under the traditional technology and 0.46 under the new technology; and cassava supply price elasticity is 0.50 under the traditional technology and 0.89 under the new technology.

The price elasticity of supply of cassava is less inelastic compared to rice and corn both under traditional and new technologies. This may imply that price incentive is more effective to increase cassava production than rice or corn.

The response of the output of corn and cassava to a 1 percent increase in their prices is higher under the new technology than under the traditional technology. This may imply that price incentive is relevant to increase food production in the areas where the new technology have been adopted.

The analysis also shows that the increase in the relative price of cassava by 50 percent (from Rp 17 to Rp 20.50 per kilogram, ceteris paribus), has the largest impact on farm income, i.e., an increase of 20 percent. This may imply that the most effective price policy to increase income of the small upland farmers in North Lampung is by increasing the relative price of cassava.

6.3 Limitations and Suggestions for Further Study

The effects of technological changes are locational and time specific due to differences in the physical, economic, and institutional environment in which the changes take place. The study only covered a one year crop cycle on the very limited representative areas. For better information of the effects of the new technology on the key farm variables, similar studies are needed on other regions and other cropping years in order to obtain a more comprehensive picture.

The linear programming approach is static in its nature while farming is dynamic. The linear programming approach is also within partial equilibrium conditions. The path of the technological diffusion from one equilibrium to another could not be identified by the static approach. This knowledge is important for policy makers as is the knowledge of the equilibrium conditions. The partial equilibrium conditions assumes that the price of one commodity can increase while the price of others are kept constant. This is an unrealistic situation, especially for crops which are competitive or complement any and supplementary in the production process.

For example the increase in the price of rice and an increase in its production will compete for the use of land and other resources with the production of corn and cassava. The increase in production of rice may be at the expense of the decrease in land devoted to corn production. As the supply of corn decreases, its price may rise. Hence there is a positive correlation between the rice price and the price of corn. A rise in the price of rice tends to pull the price of the competitive products in the same direction. This condition has obviously violated the analysis in this study, in which the price of one crop was increased while the price of its competitive crops are held constant.

The aggregate price effect of the technological changes is not considered. As the aggregate production increases the price of that crop may fall, so the price range used in the normative supply of the major food crops may be unrealistic. Perennial crops such as clove which recently experienced a dramatic increase in price is a strong competitor for land resources. This was not taken into consideration in this study. A study on the farming system which includes the perennial crops is needed.

On the input side, the circumstances of the technological change virtually guarantees that well established, well stocked and efficiently functioning input markets for the adoption of the new technology will take a considerable time to establish. Technical information that must accompany the sale of the new inputs is rarely possessed by the traditional shopkeeper. This is also not taken into consideration in this study.

The study does not take into account the distributive effect of the new technology. This is an important study to undertake in order to shed some light on the likely effect of the introduction of the new technology in achieving the equity objective of the government. Development strategies which are based only on economic efficiency may be disastrous in the long run.

To overcome the labor constraints in the peak seasons, the introduction of alternative sources of power is needed. For this purpose a study of the potential impacts of the alternative forms and level of mechanization on cropping patterns, output, labor and other resource use and productivity, as well as on farm income, is needed.

The last but possibly the most important limitation of the study is that the data obtained by interviewing the small number of sample farmers once a month within a half of a complete cropping cycle depended on the farmer's memory recall. To reduce this problem a larger number of sample farmers and more frequent interviews in a shorter period is needed. For example, future studies may well be designed for once or twice a week interviews covering the whole year of a cropping cycle. This method, called "cost route survey," has been used by some researchers in other developing countries, but has been very rare in Indonesia.

Most of the study limitations mentioned are not restricted to the farm planning and supply estimation technique used in this study. Other techniques of farm planning and supply estimates also face similar limitations. Despite these limitations, the study has shed some light on the likely effects of the technological change on the key farm variables of the small upland farm, and has broadened our knowledge concerning the role of the new technology as a strategy for the development of the traditional small upland farm in Lampung.

APPENDICES

APPENDIX A

MAPS OF INDONESIA AND LAMPUNG PROVINCE

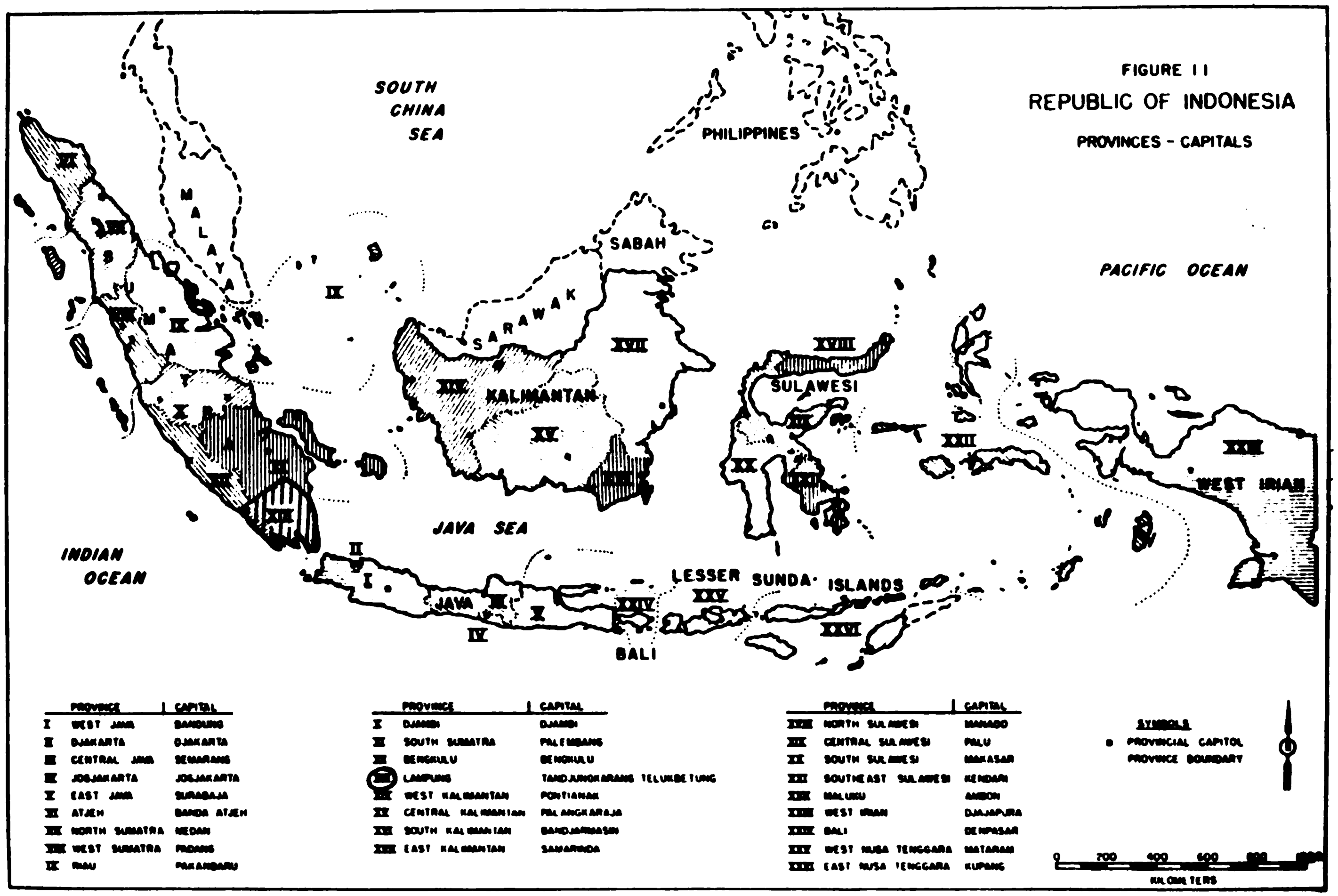
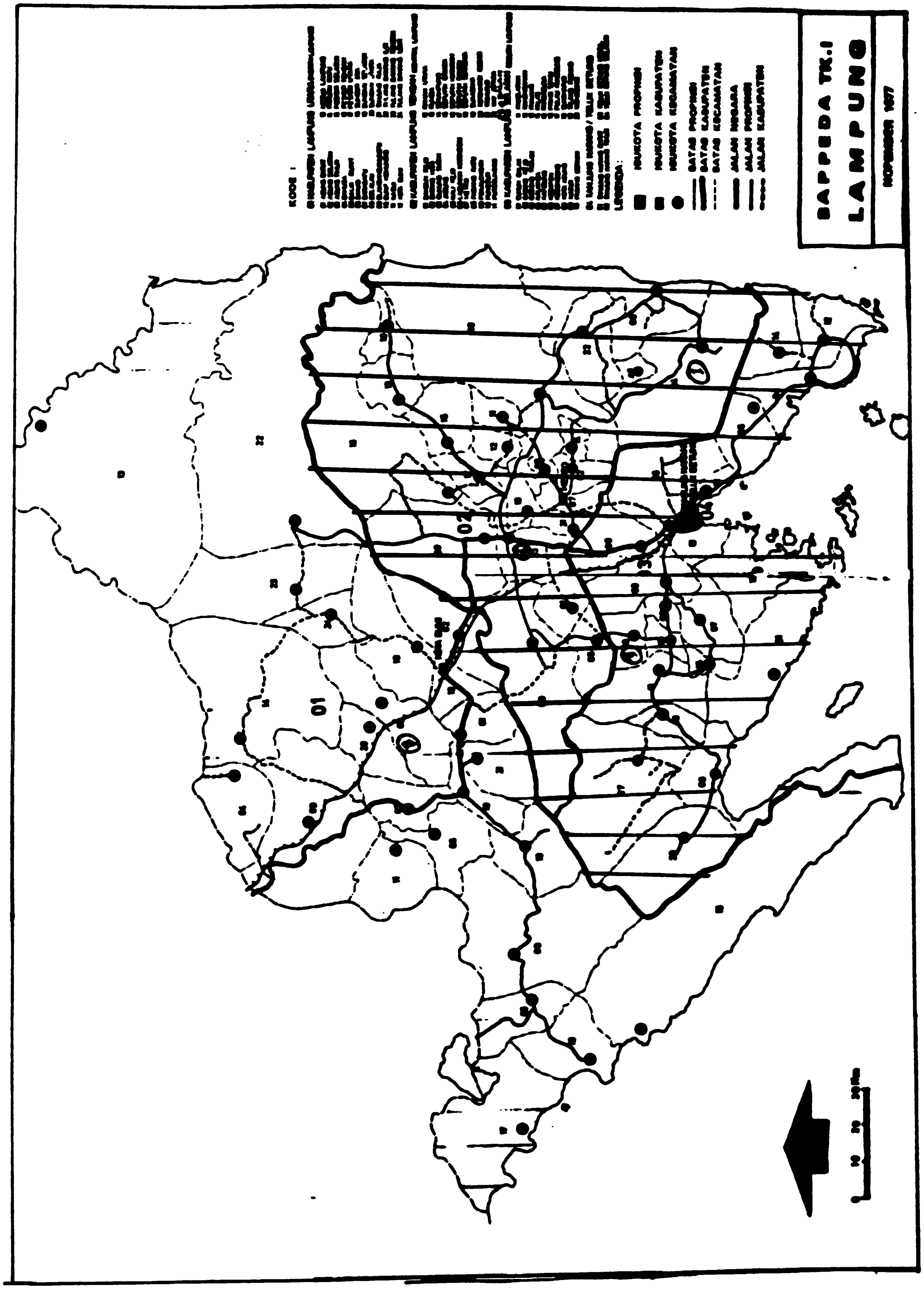


FIGURE 11
REPUBLIC OF INDONESIA
PROVINCES - CAPITALS
SOUTH CHINA SEA
PHILIPPINES
PACIFIC OCEAN
MALAYA
SABAH
SARAWAK
KALIMANTAN
SULAWESI
WEST IRIAN
JAVA SEA
INDIAN OCEAN
JAVA
BALI
LESSER SUNDA ISLANDS
PROVINCE | CAPITAL
I WEST JAVA | BANDUNG
II DJAKARTA | DJAKARTA
III CENTRAL JAVA | SEMARANG
IV JOGJAKARTA | JOGJAKARTA
V EAST JAVA | SURABAJA
VI ATJEH | BANDA ATJEH
VII NORTH SUMATRA | MEDAN
VIII WEST SUMATRA | PADANG
IX RIAU | PAKANBARU
PROVINCE | CAPITAL
X DJAMBI | DJAMBI
XI SOUTH SUMATRA | PALEMBANG
XII BENGKULU | BENGKULU
XIII LAMPUNG | TANDJUNGKARANG TELUKBETUNG
XIV WEST KALIMANTAN | PONTIANAK
XV CENTRAL KALIMANTAN | PALANGKARAJA
XVI SOUTH KALIMANTAN | BANDJARMASIN
XVII EAST KALIMANTAN | SAMARINDA
PROVINCE | CAPITAL
XVIII NORTH SULAWESI | MANADO
XIX CENTRAL SULAWESI | PALU
XX SOUTH SULAWESI | MAKASAR
XXI SOUTHEAST SULAWESI | KENDARI
XXII MALUKU | AMBON
XXIII WEST IRIAN | DJAJAPURA
XXIV BALI | DENPASAR
XXV WEST NUSA TENGGARA | MATARAM
XXVI EAST NUSA TENGGARA | KUPANG
SYMBOLS
PROVINCIAL CAPITOL
PROVINCE BOUNDARY
0 200 400 600 800
KILOMETERS


LEGENDA :
IBUKOTA PROPINSI
IBUKOTA KABUPATEN
IBUKOTA KECAMATAN
BATAS PROPINSI
BATAS KABUPATEN
BATAS KECAMATAN
JALAN NEGARA
JALAN PROPINSI
JALAN KABUPATEN
BAPPEDA TK.I
LAMPUNG
NOPEMBER 1977

APPENDIX B

MAJOR FOOD CROP PRODUCTION BY SUBREGIONS OF LAMPUNG

APPENDIX B

MAJOR FOOD CROP PRODUCTION BY SUBREGIONS OF LAMPUNG

Table B1.--Major Food Crop Production by Subregion in North Lampung for 1978.

Subregion/Kecamatan	Lowland Rice		Upland Rice		Corn		Cassava		Soybeans	
	Ha	Tons	Ha	Tons	Ha	Tons	Ha	Tons	Ha	Tons
1. Kotabumi	294	238	1873	3061	689	670	1194	22183	29	21
2. Abung Barat	257	867	2120	4464	35	23	215	2149	8	6
3. Abung Timur	67	71	3087	3802	1738	852	3890	46672	5	2
4. Abung Selatan	220	574	3250	4287	1352	1039	245	3189	12	7
5. Sungkai Utara	60	120	1879	2160	32	20	97	1341	4	3
6. Sungkai Selat	58	174	2965	5292	54	44	108	1452	-	-
7. Tulang Bawang Udik	73	128	4513	6681	756	1148	2449	34238	-	-
8. Tulang Bawang Tengah		121	8560	13690	395	257	3933	62190	-	-
9. Menggala	396	852	1712	2467	36	27	55	722	-	-
10. Mebuji	1022	2323	972	1494	20	14	10	116	-	-
11. Pakuan Ratu	-	-	965	868	343	197	35	620	395	107
12. Bahuga	1047	5508	379	1026	9	4	721	18050	42	62
13. Blambangan Umpu	264	672	2100	3800	210	110	110	963	58	28
14. Baradatu	225	562	2859	3334	193	168	1367	39374	25	25
15. Kasuy	50	155	2100	2700	38	30	65	842	6	4
16. Banjit	315	1061	1913	4060	46	35	76	1518	9	6
17. Bukit Kemuning	249	730	1598	2991	52	39	4	68	-	-
18. Tanjung Raja	208	777	2500	6425	152	100	247	5415	-	-
19. Sumber Jaya	2384	8231	2245	4245	40	37	33	391	-	-
20. Bilalau	865	3188	800	1941	316	378	45	655	-	-

Table B1.--Continued.

Subregion/Kecamatan	Lowland Rice		Upland Rice		Corn		Cassava		Soybeans	
	Ha	Tons	Ha	Tons	Ha	Tons	Ha	Tons	Ha	Tons
21. Balik Bukit	1170	4643	447	1182	20	26	4	110	-	-
22. PSS Tengah	1176	3499	275	575	178	160	74	872	-	-
23. PSS Utara	642	1714	86	172	9	10	11	139	-	-
24. PSS Selatan	1596	4090	500	920	30	10	11	168	4	3
Total	12718	41000	49698	83046	6733	5416	15001	243437	303	261

Source: Agricultural Extension Agency of Lampung Province.

Table B2.--Major Food Crop Production by Subregion in Central Lampung for 1978.

Subregion/Kecamatan	Lowland Rice		Upland Rice		Corn		Cassava		Soybeans	
	Ha	Tons	Ha	Tons	Ha	Tons	Ha	Tons	Ha	Tons
1. Metro	4968	15875	722	945	565	709	709	7090	6	4
2. Trimurjo	7037	21071	5	30	7	5	56	504	-	-
3. Batanghari	4515	14611	275	1635	236	180	875	11597	34	28
4. Sekampung	2560	8258	1255	1859	1892	1629	987	15581	464	347
5. Pekalongan	2328	9731	497	448	172	206	1902	19162	3630	2178
6. Sukadana	889	1459	3268	3171	3606	3371	4073	49870	4	2
7. Way Jepara	2487	8377	2765	5402	645	1161	685	9180	-	-
8. Lab. Maringgai	4433	8671	4199	8773	5484	10820	1325	23360	6807	2404
9. Jabung	1675	3643	7565	13617	6620	13681	135	2913	11975	11695
10. Purbolinggo	5805	18811	70	154	29	15	901	7868	-	-
11. Raman Utara	3178	11874	412	611	5	4	614	5362	-	-
12. Spt. Banyak	629	534	248	316	309	155	3005	27968	-	-
13. Spt. Raman	6303	22610	2092	1358	62	62	378	2681	-	-
14. Punggur	7740	28270	600	480	50	35	350	2950	-	-
15. Gunung Sugih	1905	5303	4424	7322	1822	1801	6525	61450	84	14
16. Terbanggi Besar	8069	31723	2986	4490	957	722	1975	21330	-	-
17. Padang Ratu	3250	9110	6140	8124	910	600	1150	12902	255	151
18. Kalirejo	2406	4922	1639	2459	400	574	4730	49139	180	95
19. Rumbia	245	334	45--	4342	1109	1047	6443	52744	-	-
20. Spt. Mataram	4623	14529	715	715	720	532	1525	17100	15	9
21. Bangun Rejo	1926	3472	1390	1251	663	643	1493	15576	23	12
22. Sukaraja	1837	7328	1400	1810	300	230	1750	11900	20	20
23. Spt. Surabaya	51	85	781	918	212	167	2811	24804	19	11
24. Gunung Balak	915	1638	1605	1766	5536	10297	875	9333	12204	10347
Total	80304	258569	49473	71995	32311	48817	43772	461663	35660	27312

Source: Agricultural Extension Agency of Lampung Province.

Table B3.--Major Food Production by Subregion in South Lampung for 1978.

Subregion/Kecamatan	Lowland Rice		Upland Rice		Corn		Cassava		Soybeans	
	Ha	Tons	Ha	Tons	Ha	Tons	Ha	Tons	Ha	Tons
1. Palas	3592	12326	1312	2302	183	240	650	7657	13	13
2. Penengahan	1553	5028	1060	2656	501	840	950	10486	94	66
3. Kalianda	1230	4037	60	135	35	42	90	956	-	-
4. Katibung	2789	8384	7638	14304	3424	3750	1529	2548	457	345
5. T. Bitung	429	1148	2000	5007	402	532	189	2987	46	39
6. Pd. Cermin	1587	5940	2435	4251	46	58	57	827	13	13
7. Kedaton	1942	5129	2093	3598	310	377	16845	183365	90	77
8. Natar	2108	6136	3500	8500	1625	2385	1810	18365	241	148
9. Gd. Tataan	3156	11306	3000	5340	675	1262	615	6915	25	39
10. Kedondong	5096	17639	1900	2500	75	95	30	363	-	-
11. Padasuka	2498	8737	442	996	68	91	109	1073	-	-
12. Gadingrejo	3001	11450	-	-	-	-	27	282	-	-
13. Pringsewu	3486	12370	-	-	-	-	-	-	-	-
14. Sukoharjo	1432	3595	720	1264	268	313	559	5642	207	103
15. Pagelaran	3769	11095	850	1275	140	161	165	2570	20	20
16. Talangpadang	8382	10686	340	840	232	264	23	270	-	-
17. Pulau Panggung	1463	4618	1750	2820	302	520	240	2617	-	-
18. Kota Agung	4391	13858	90	130	5	10	5	50	-	-
19. Wonosobo	4096	14369	1740	2700	75	91	185	2884	120	94
20. Cukuhbalak	720	1894	682	1625	24	24	172	1706	-	-
Total	51785	169747	31612	57065	8390	10422	24219	265883	1298	1021

Source: Agricultural Extension Agency of Lampung Province.

APPENDIX C

EXPLANATION OF ABBREVIATIONS USED IN CROPPING PATTERNS OF THE REPRESENTATIVE FARMS IN LAMPUNG

APPENDIX C

EXPLANATION OF ABBREVIATIONS USED IN CROPPING PATTERNS OF THE REPRESENTATIVE FARMS IN LAMPUNG

Cropping Patterns/ Abbreviations	Explanations
C+ULR≠CV	Corn and upland rice planted at the same time/or within a week and cassava planted one month later on the same piece of land.
ULR≠CV	Upland rice and cassava planted on the same piece of land but cassava planted a month later after rice.
ULR	Upland rice as a pure stand, only one crop a year.
CV	Cassava planted as a sole crop, only one crop a year.
LLR	Lowland rice as a sole crop planted in fully or partly irrigated land. Two crops a year is usually the practice.
ULR-SB	Upland rice and soybeans planted on the same piece of land, but soybeans planted after upland rice harvested.
C+SB≠CV	Corn and soybeans planted at the same time/or within a week and one month later cassava planted on the same piece of land.

Cropping Patterns/ Abbreviations	Explanations
C+ULR/CV	Corn and upland rice planted at the same time or within a week and after one month cassava planted surrounding each block of land where corn and upland rice planted.
SB-SB-SB/CV	Three crops of soybeans planted in sequence, after one crop harvested the second crop planted and the third soybean crop planted after the second crop harvested. Cassava was planted a month later after the first crop planted surrounding every block of land.
C/COC	Corn is planted between coconut trees.
GNDT	Groundnut as a sole crop.
PEP	Pepper (perennial) crop as a sole crop.
C/CV	Cassava is planted after one month later after corn planted on the same piece of land.
ULR-SB/COC	After upland rice harvested then soybeans planted and these two crops were planted between coconut trees.
COF+COC	Coffee and coconut both are perennial crops planted together on the same piece of land arranged in rows.
CLO+COC	Clove planted between coconut trees.
COC/FC	Food crops were planted between coconut trees.
COF/FC	Some food crops planted between coffee trees.
PEP+CLO	Pepper and clove planted together on the same piece of land.

Cropping Patterns/ Abbreviations	Explanations
CLO/FC	Some food crops were planted between clove trees.

APPENDIX D

EXPLANATION OF ABBREVIATIONS USED IN THE LINEAR PROGRAMMING TABLE OF THE REPRESENTATIVE FARMS IN LAMPUNG

APPENDIX D

EXPLANATION OF ABBREVIATIONS USED IN THE LINEAR PROGRAMMING TABLE OF THE REPRESENTATIVE FARMS IN LAMPUNG

Row No./ Column No.	Abbreviations	Complete Headings
Restrictions		
1.	Land	Land operated/under cultivation
2.	FLXAUG	Family Labor in August
3.	FLXSEP	Family Labor in September
4.	FLXOCT	Family Labor in October
5.	FLXNOV	Family Labor in November
6.	FLXDEC	Family Labor in December
7.	FLXJAN	Family Labor in January
8.	FLXFEB	Family Labor in February
9.	FLXMAR	Family Labor in March
10.	FLXAPR	Family Labor in April
11.	FLXMAY	Family Labor in May
12.	FLXJUN	Family Labor in June
13.	FLXJUL	Family Labor in July
14.	HLXAUG	Hired Labor in August
15.	HLXSEP	Hired Labor in September
16.	HLXOCT	Hired Labor in October
17.	HLXNOV	Hired Labor in November
18.	HLXDEC	Hired Labor in December
19.	HLXJAN	Hired Labor in January
20.	HLXFEB	Hired Labor in February
21.	HLXMAR	Hired Labor in March

Row No./ Column No.	Abbreviations	Complete Headings
22.	HLXAPR	Hired Labor in April
23.	HLXMAY	Hired Labor in May
24.	HLXJUN	Hired Labor in June
25.	HLXJUL	Hired Labor in July
26.	AHXAUG	Animal Hired in August
27.	AHXSEP	Animal Hired in September
28.	AHXOCT	Animal Hired in October
29.	AHXNOV	Animal Hired in November
30.	SEEDRC	Quantity of Rice Seed Used
31.	SEEDXC	Quantity of Corn Seed Used
32.	SEEDSB	Quantity of Soybean Seed Used
33.	SEEDCV	Quantity of Cassava Stick Used
34.	FERTXN	Quantity of Fertilizer-N Used
35.	FERTXP	Quantity of Fertilizer-P Used
36.	INSECTD	Quantity of Insecticides Used
37.	OCXAUG	Operating Capital in August
38.	OCXSEP	Operating Capital in September
39.	OCXOCT	Operating Capital in October
40.	OCXNOV	Operating Capital in November
41.	OCXDEC	Operating Capital in December
42.	OCXJAN	Operating Capital in January
43.	OCXFEB	Operating Capital in February
44.	OCXMAR	Operating Capital in March
45.	OCXAPR	Operating Capital in April
46.	OCXMAY	Operating Capital in May
47.	OCXJUN	Operating Capital in June
48.	OCXJUL	Operating Capital in July
49.	OPTRICE	Quantity of Rice Produced
50.	OPTCORN	Quantity of Corn Produced
51.	OPTSOBN	Quantity of Soybeans Produced

Row No./ Column No.	Abbreviations	Complete Headings
52.	OPTCASV	Quantity of Cassava Produced
53.	CONSRICE	Minimum Quantity of Rice for Household Consumption
54.	CONSCORN	Minimum Quantity of Corn for Household Consumption
55.	CONSCASV	Minimum Quantity of Cassava for Household Consumption
56.	AMT-BC	Total Amount Borrowed
57.	LMT HL-AUG	Limited Hired Labor Available in August
58.	LMT HL-SEP	Limited Hired Labor Available in September
59.	LMT HL-OCT	Limited Hired Labor Available in October
60.	LMT HL-NOV	Limited Hired Labor Available in November
61.	LMT HL-DEC	Limited Hired Labor Available in December
62.	LMT HL-JAN	Limited Hired Labor Available in January
63.	LMT HL-FEB	Limited Hired Labor Available in February
64.	LMT HL-MAR	Limited Hired Labor Available in March
65.	LMT HL-APR	Limited Hired Labor Available in April
66.	LMT HL-MAY	Limited Hired Labor Available in May
67.	LMT HL-JUN	Limited Hired Labor Available in June
68.	LMT HL-JUL	Limited Hired Labor Available in July
69.	LMT AH-AUG	Limited Hired Animal Available in August
70.	LMT AH-SEP	Limited Hired Animal Available in September
71.	LMT AH-OCT	Limited Hired Animal Available in October
72.	LMT AH-NOV	Limited Hired Animal Available in November
73.	LMT BCAUG	Limited Borrowed Capital in August
74.	LMT BCSEP	Limited Borrowed Capital in September

Row No./ Column No.	Abbreviations	Complete Headings
75.	LMT BCOCT	Limited Borrowed Capital in October
76.	LMT BCNOV	Limited Borrowed Capital in November
77.	LMT BCDEC	Limited Borrowed Capital in December
78.	LMT BCJAN	Limited Borrowed Capital in January
79.	LMT BCFEB	Limited Borrowed Capital in February
80.	LMT BCMAR	Limited Borrowed Capital in March
81.	LMT BCAPR	Limited Borrowed Capital in April
82.	LMT BCMAY	Limited Borrowed Capital in May
83.	LMT BCJUN	Limited Borrowed Capital in June
84.	LMT BC JUL	Limited Borrowed Capital in July

Activities

1.	A1C+ULR≁CV (TT1)	Produce Corn, Upland Rice and Cassava in Mixture with Manual Labor for Land Preparation
2.	A2C+ULR≁CV (TT2)	Produce Corn, Upland Rice and Cassava in Mixture with Animal Power for Land Preparation
3.	A3C+ULR≁CV (NT1)	Produce Corn, Upland Rice and Cassava in Mixture with Use of Fertilizer Level 1 and Use of Insecticides as Recommended.
4.	A4C+ULR≁CV (NT2)	Produce Corn, Upland Rice and Corn in Mixture with Use of Fertilizers Level 2 with Use of Insecticides at Recommended Level
5.	A5ULR+CV (TT)	Produce Upland Rice and Cassava with Traditional Technology

Row No./ Column No.	Abbreviations	Complete Headings
6.	A6ULR+VC (NT)	Produce Upland Rice and Cassava in Mixture with the Use of Fertilizers (New Technology)
7.	A7C+CV (TT1)	Produce Corn and Cassava in Mixture with Manual Labor for Land Preparation and no Use of New Inputs (Traditional Technology)
8.	A8C+CV (TT2)	Produce Corn and Cassava in Mixture with Animal Power for Land Preparation, no Use of New Inputs (Traditional Technology)
9.	A9C+CV (NT)	Produce Corn and Cassava in Mixture with the Use of the New Inputs (New Technology)
10.	A10ULR-SBT	Produce Upland Rice and Soybeans in Sequence with no Use of New Inputs (Traditional Technology)
11.	A11ULR-SBN	Produce Upland Rice and Soybeans in Sequence with Use of New Inputs (New Technology)
12.	A12CVTT1	Produce Cassava with Manual Labor for Land Preparation, no Use of New Inputs (Traditional Technology)
13.	A13CVTT2	Produce Cassava with Animal Power for Land Preparation, no Use of New Inputs (Traditional Technology)
14.	A14CVNT	Produce Cassava with the Use of New Inputs (New Technology
15.	A15HLXAUG	Hiring Labor Activities in August
16.	A16HLXSEP	Hiring Labor Activities in September

Row No./ Column No.	Abbreviations	Complete Headings
17.	A17HLXOCT	Hiring Labor Activities in October
18.	A18HLXNOV	Hiring Labor Activities in November
19.	A19HLXDEC	Hiring Labor Activities in December
20.	A20HLXJAN	Hiring Labor Activities in January
21.	A21HLXFEB	Hiring Labor Activities in February
22.	A22HLXMAR	Hiring Labor Activities in March
23.	A23HLXAPR	Hiring Labor Activities in April
24.	A24HLXMAY	Hiring Labor Activities in May
25.	A25HLXJUN	Hiring Labor Activities in June
26.	A26HLXJUL	Hiring Labor Activities in July
27.	A27AHXAUG	Hiring Animal for Land Preparation in August
28.	A28AHXSEP	Hiring Animal for Land Preparation in September
29.	A29AHXOCT	Hiring Animal for Land Preparation in September
30.	A30AHXNOV	Hiring Animal for Land Preparation in November
31.	A31BFERT-N	Buying Fertilizer Activities in October
32.	A32BFERT-P	Buying Fertilizer Activities in October
33.	A33BPSTD	Buying Insecticide Activities in October
34.	A34BRCXSEP	Buying Rice Activities for Consumption in September
35.	A35BRCXOCT	Buying Rice Activities for Consumption in October
36.	A36BRCXNOV	Buying Rice Activities for Consumption in November
37.	A37BRCXDEC	Buying Rice Activities for Consumption in December

Row No./ Column No.	Abbreviations	Complete Headings
38.	A38BRCXJAN	Buying Rice Activities for Consumption in January
39.	A39BOYXFEB	Buying Oyek Activities for Consumption in February
40.	A40BOYXMAR	Buying Oyek Activities for Consumption in March
41.	A41CONSRICE	Family Household Rice Consumption
42.	A42CONSCORN	Family Household Corn Consumption
43.	A43CONSCASV	Family Household Cassava Consumption
44.	A44SRCMAY	Selling Rice Activities in May
45.	A45 SCMAR	Selling Corn Activities in March
46.	A46SSBFEB	Selling Soybeans Activities in February
47.	A47SCVSEP	Selling Cassava Activities in September
48.	A48ORCTOSSRC	Rice Seed from Own Production
49.	A49OCTOSSC	Corn Seed from Own Production
50.	A50OSBTOSSB	Soybean Seed from Own Production
51.	A51FL/NOVTOSSCV	Family Labor Activities in November to Produce Cassava Sticks
52.	A52BCAUG	Borrowing Capital Activities in August
53.	A53BCSEP	Borrowing Capital Activities in September
54.	A54BCOCT	Borrowing Capital Activities in October
55.	A55BCNOV	Borrowing Capital Activities in November
56.	A56BCDEC	Borrowing Capital Activities in December
57.	A57BCJAN	Borrowing Capital Activities in January
58.	A58BCFEB	Borrowing Capital Activities in February

Row No./ Column No.	Abbreviations	Complete Headings
59.	A59BCMAR	Borrowing Capital Activities in March
60.	A60BCAPR	Borrowing Capital Activities in April
61.	A61BCMAY	Borrowing Capital Activities in May
62.	A62BCJUN	Borrowing Capital Activities in June
63.	A63BCJUL	Borrowing Capital Activities in July
64.	A64TC-AS	Transfer Capital from August to September
65.	A65TC-SO	Transfer Capital from September to October
66.	A66TC-ON	Transfer Capital from October to November
67.	A67TC-ND	Transfer Capital from November to December
68.	A68TC-DJ	Transfer Capital from December to January
69.	A69TC-JF	Transfer Capital from January to February
70.	A70TC-FM	Transfer Capital from February to March
71.	A71TC-MA	Transfer Capital from March to April
72.	A72TC-AM	Transfer Capital from April to May
73.	A73TC-MJ	Transfer Capital from May to June
74.	A74TC-JJ	Transfer Capital from June to July
75.	A75PY OFF	Pay Off Activities in July

APPENDIX E

MONTHLY MAJOR FOOD CROPS PRICES AT THE NEAREST MARKET TO THE REPRESENTATIVE FARMS IN LAMPUNG

APPENDIX E

MONTHLY MAJOR FOOD CROPS PRICES AT THE NEAREST MARKET TO THE REPRESENTATIVE FARMS IN LAMPUNG

Table E1.--Monthly Major Food Crop Prices in Sungkai Selatan (North Lampung) and Sukoharjo (South Lampung) for 1979.*

Subdistrict and Commodities	Average Monthly Price (RP/KG)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
I. Sungkai Selatan												
1. Hulled Rice	178	180	175	173	178	200	225	210	210	215	215	215
2. Unhulled Rice	100	100	95	97	100	105	110	110	110	110	110	110
3. Corn	70	74	83	93	93	110	115	110	110	110	110	110
4. Cassava	7	9	13	15	15	19	20	20	20	20	23	25
5. Soybean	218	227	235	253	258	263	236	243	243	310	310	310

Table E1.--Continued.

Subdistrict and Commodities	Average Monthly Price (RP/KG)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
II. Sukoharjo												
1. Hulled Rice	170	165	160	165	175	200	200	200	205	205	205	200
2. Unhulled Rice	95	92	90	90	95	95	100	100	100	100	100	100
3. Corn	51	50	50	75	78	75	95	105	110	110	110	110
4. Cassava	12	15	15	15	17	15	20	25	15	20	25	25
5. Soybean	225	260	260	250	275	275	275	275	275	300	310	315

Source: Agricultural Extension Agency of Lampung, Indonesia.

*Sungkai Selatan is the nearest producer's market for Tatakarya Village (North Lampung). Sukoharjo is the nearest market for producers for Adiluih Village (South Lampung).

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