THE UNIVERSITY OF MANITOBA

THE EFFECTS OF SMALL FARM MECHANIZATION ON PRODUCTION, INCOME AND EMPLOYMENT IN SELECTED RICE-GROWING AREAS IN THE PHILIPPINES

by

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ABSTRACT

JEROME FRONDA SISON, University of Manitoba, November, 1982. The Effects of Small Farm Mechanization on Production, Income and Employment in Selected Rice-growing Areas in the Philippines. Major Adviser: Dr. Charles F. Framingham.

The issue of farm mechanization in small rice farms in the Philippines has been the center of controversy since the 1960's. Aside from whether farm mechanization has increased farm output and/or income, questions with regard to its effects on farm labor utilization and employment have been raised and studied in many rice producing countries.

The use of mechanical power in certain farm operations has resulted in the development of two schools of thought regarding labor effects of mechanization. Proponents of the net contribution school of thought argue that mechanization increases land preparation efficiency, positively affects yields, allows for greater intensity of land use and thereby increases labor requirements of certain farm activities offsetting the land preparation labor displaced through mechanization. On the other hand, the substitution school proponents argue that farm machinery merely substitutes for and displaces labor which is undesirable under conditions of abundant labor supply. These schools of thought provided the background for this study which investigates the effects of mechanization of certain farm operations in selected rice-growing areas in the Philippines, using cross-section data.

Mechanization of small rice farms may be assessed in terms of its impact on land preparation and post-production labor requirements. Although it is difficult to solely attribute the findings to mechanization alone, covariance analysis shows that mechanized farms exhibited significant reductions in labor use for land preparation and post-production operations. This decline implies that no offsetting positive effects in labor utilization occur in spite of higher yields produced by mechanized farms. In addition to casting serious doubt to the 'net contribution' school of thought, the study indicates that it is inappropriate to ascribe the yield increase on mechanized land to mechanization since a variety of factors, including higher levels of chemical and fertilizer application and significant responses to such inputs may account for this difference.

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THE EFFECTS OF SMALL FARM MECHANIZATION ON PRODUCTION, INCOME AND EMPLOYMENT IN SELECTED RICE-GROWING AREAS IN THE PHILIPPINES

Chapter I

Introduction

A Short Background on the Philippines

The Philippines, composed of approximately 7,100 islands, is one of the largest archipelagos in the world. The country's total land area is estimated to be about 115,830 square miles. Referring to Figure 1.1, it may be seen that to the west of the Islands lies the South China Sea while the Pacific Ocean and the Celebes Sea boarder its eastern and southern shores. Known as a tourists's paradise, it is strategically located within the other Asian countries. The northern most islands of the archipelago lie within 65 miles from the southern tip of the island of Taiwan while its southern most island is at least 30 miles from Borneo.[1]

Eleven of the largest islands make up 95 percent of the total land area with Luzon and Mindanao being the largest, respectively. Most of the islands are mountainous, with isolated alluvial plains, resulting from volcanic activities and other earth movements. The abundance of water resources have made most of the large islands suitable for agricultural production.[2]

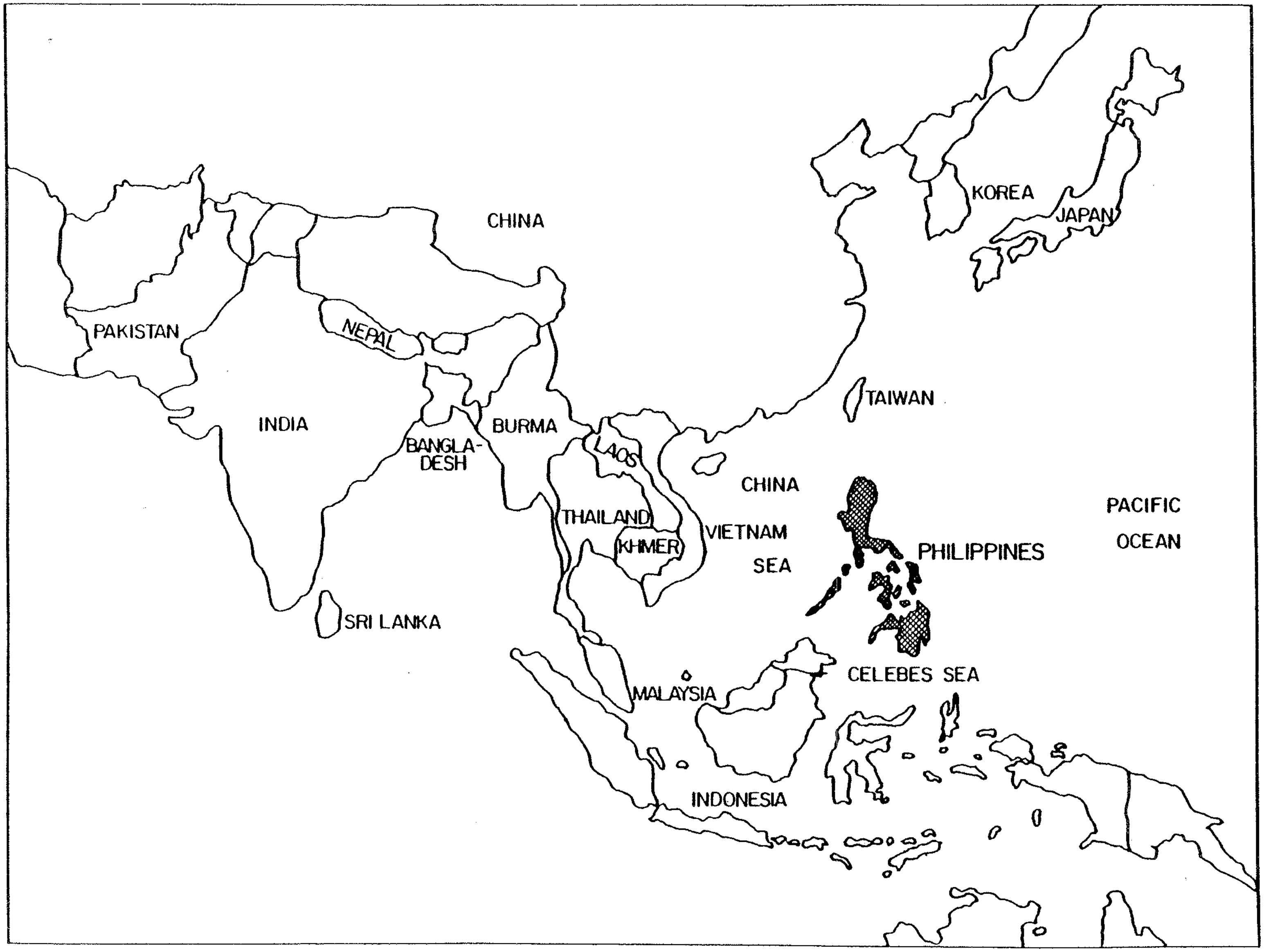

Figure 1.1 Map showing the location of the Philippines.

In general, the country has tropical weather conditions. Rainfall throughout the archipelago is generally adequate but varies regionally from distinct wet and dry seasons to an even monthly distribution. This is mainly attributed to typhoons and local tropical thunderstorms, the frequency of which increases from south to north. The annual temperature, however, averages around 27°C thus making all parts of the country suitable for year-round agricultural production.[3]

The Agricultural Economy of the Country

Philippine agriculture is divided into two sectors, the export sector and the food-crop sector. The major crops produced by the export sector are coconuts, sugar, abaca, pineapples, bananas and fiber crops planted over an area of approximately 3.1 million hectares or 29 percent of the total cultivated land area.[4]

On the other hand, the food-crop sector, with an area of 7.6 million hectares, produces agricultural commodities generally for domestic consumption. The principal crop of this sector is rice which in 1975 was planted on 3.6 million hectares or approximately 33 percent of the total 10.8 million hectares of agricultural land. Closely competing with rice with regard to land usage is corn which accounts for at least 3.0 million hectares or an equivalent of 28 percent of agricultural land. At least 47 percent of the total land area of the food-crop sector is devoted to rice production.[5]

The Importance of Rice in Philippine Agriculture

The importance of rice as a major staple crop may be observed from the fact that rice production constituted 42 percent of the total food-crop production in 1975. The value equivalent of the total rice produced during the same year amounted to 5.3 billion pesos which was approximately 40 percent of the total crop value produced by the food-crop sector which amounted to 13.3 billion pesos.[6]

In terms of employment generated by the rice industry, at least 45 percent of the total available labor force is involved rice production. Most of the farm units operated on, however, are small farms. The Bureau of Agricultural Economics (BAEcon) estimated that there were 1.69 million rice farms operating in the country during 1972 with a total cultivated area of about 2.63 million hectares. These data implied that the average size of rice farm was less than 2.0 hectares.[7]

It should be noted that the dominance of small farms in rice production is one of the most important characteristics of Philippine agriculture. According to a World Bank study,[8] historical data, based on the period 1960-1972, have shown a declining trend in farm size. To illustrate, in 1960, about 77 percent of all rice farms were less than four hectares. However, this percentage increased in 1972 where the proportion of farms having less than four hectares amounted to 94 percent. It was further noted that approximately 70 percent were less than two hectares. The study attributed the decrease in rice farm sizes mainly to two factors: a) the steadily increasing pressure of population on the available arable land and b) the shift to sugar production which is a more profitable export product. This finding is further supported by the "loop" survey of rice farms conducted by the International Rice Research Institute in Central Luzon for the years 1970, 1974 and 1979. The data indicated that during the last decade, farm size exhibited a decreasing trend — from 2.47 hectares in 1970 to 2.43 hectares in 1974 and finally to 2.14 hectares in 1979.[9]

With this decreasing trend in the size of rice farms, rice producers have resorted to farm methods and practices which would increase production as well as the efficiency and intensity of land use. This is especially evident in farms located in the Central Luzon area, the major rice producing region of the Philippines, where high yielding rice varieties or modern rice varieties, fertilizers and chemicals are widely used in order to enhance rice production. Furthermore, substantial mechanization of certain farm operations in this region have been observed by Barker et al.[10] as a means of improving production efficiency and intensity of land use.

The Problem

The issue of farm mechanization on small farms has been the center of controversy since the 1960's. Aside from whether farm mechanization has increased farm output significantly and subsequently farm incomes, questions have to be answered with regard to its effects on rural employment. There is an immediate need to search for answers to these questions, especially in the context of a developing country like the Philippines.

Although government policies directly affect the direction and rate of farm mechanization of a particular developing country, the adoption of farm mechanical power as a substitute for manual and/or animal power poses a paradox. Several researchers have indicated that mechanization of certain farm operations have resulted in the replacement and displacement of labor which is undesirable in countries where manual power is abundant and farming operations are labor intensive. However, other studies (see Chapter III) have shown that farm mechanization allows for more efficient farm operations which contribute to increases in yields as well as greater intensity of land use. As a result of higher production and greater intensity of land cultivation, proponents of farm mechanization showed that the increase in the labor requirements of certain farming activities, i.e., harvesting, had an offsetting effect on the amount of labor displaced from other farm operations, land preparation for example. This implies that under conditions of increasing demand for food products, resulting from a rapidly increasing population, farm mechanization may alleviate the food problem that is common in most developing countries, like the Philippines, and at the same time provide job opportunities to the rural labor force.

It should be noted, however, that the proponents of the latter school of thought failed to separate the benefits accruing to mechanical power from the benefits attributed to high-yielding variety seeds, fertilizer and other inputs. It would have been more appropriate and economically meaningful to investigate whether the increases in output, and subsequently in the labor requirements of certain farm operations, resulted from mechanization or from other factors of production.

In spite of the fact that the sugar industry in the Philippines had been using mechanical power since the late 1960's, substantial mechanization of certain rice farm operations only occurred in the middle part of the following decade. This indicated the government's shift in its emphasis from export to domestic oriented agricultural food production, with rice being the major crop concerned. During the same period, modern rice varieties were introduced to the farmers in the major rice producing regions of the country. These new rice varieties required a shorter time interval from planting to harvesting, as compared to traditional varieties, which facilitated a higher degree of land usage in rice production. However, it was soon learned, that this modern rice technology package required high levels of input utilization as well as intensive cultural practices in order to attain a profitable level of output. In this regard, the government stepped up its efforts to make the necessary inputs, such as chemicals, fertilizers and irrigation water, easily available to the Filipino farmers through the Masagana 99 program as well as the construction of irrigation facilities in strategic rice producing areas. Furthermore, in order to facilitate land tillage within individual farms, thus shortening the turn-around time between each crop of rice, the Philippine government negotiated two loans with the World Bank. These loans were administered through the local rural banking system in order to encourage mechanization in small farms as a part of the country's "Green Revolution" program geared toward increasing agricultural output through a more intensive land utilization scheme.

Although the shift from animal to mechanical power came about gradually, a decreasing trend in rural employment was observed during the first ten years of mechanization. According to a study conducted by the International Labor Office, United Nations, the total labor force employed in agriculture in 1960 was approximately 61.2 percent.[11] However, in 1978, this figure declined to 47 percent, a reduction of 14.2 percent.[12] With these preliminary statistics at hand, it is necessary to investigate whether the use of mechanical power in rice production operations has resulted in the reduction of employment opportunities in rural areas of the Philippines.

In addition, it is worth noting that the total rice production in the Philippines increased from 4.073 million metric tons (or 1.31 metric tons per hectare) in 1966 to 7.604 million metric tons (or 2.17 metric tons per hectare) in 1980.[13] It is worthwhile to mention that this period may be characterized by the prevalent cultivation of improved rice varieties, intensive use of fertilizer and chemicals as well as increased dependency on farm machinery for land preparation. However, the investigation of the yield impact of mechanizing land preparation operations is a necessary undertaking in order to guide policy-makers with regard to designing production programs involving the utilization of farm machinery. This is specially true in the light of increased sales of four-wheel tractors and two-wheel tractors from 1966-1980.[14] Another dimension that has to be considered is the effect of the adoption of mechanical power on farm income in the light of increasing input prices, particularly energy price, as well as on farmers' decisions to mechanize their farm operations.

Whatever information are obtained from such investigations may provide policy makers valuable answers for the solution of the major economic problems besetting the Philippine rice industry regarding employment, income distribution and productivity.

Objectives and Scope of the Study

The following are the objectives of this research:

1. To develop a working definition of a mechanized rice farm operating under the conditions prevailing in the Central Luzon region, particularly Nueva Ecija, based on the types of farms within this area.
2. To determine whether significant differences between mechanized and non-mechanized rice farms, as well as among mechanized farm-types, exist.
3. To determine how various factors, including farm machinery, affect the production, employment and income of small rice farms in Nueva Ecija.
4. To indicate the policy implications of such mechanization effects.

The scope of this research will be limited to the analysis of the above-mentioned objectives and will indicate the policy implications arising therefrom.

Organization of Remainder of the Paper

This section indicates the topics discussed in the following chapters of the paper. The next chapter, Chapter II provides a brief historical review of farm machinery adoption in the Philippines. Chapter III discusses earlier research studies related to farm mechanization effects that were conducted in different Asian countries. It also presents the general viewpoints of researchers with regard to the effects of mechanization on farm production, employment, output and income. Chapter IV presents the theoretical framework used to analyze the effects of mechanical power adoption on farm employment and income. The succeeding chapter, Chapter V, discusses the models, the specification of variables and the methodology to be used in the analysis while Chapter VI, describes the project site from which pertinent data for this research were gathered. Discussion of the analytical results, as well as their interpretation, are undertaken in Chapter VII. These serve as the basis for policy implications, an attempt of which is undertaken in Chapter VIII.

Footnotes

Chapter I

[1]World Bank, The Philippines: Priorities and Prospects for Development, Washington, D.C., June, 1976, p. 3.

[2]Ibid., pp. 3-4.

[3]Ibid., p. 4.

[4]Bureau of Agricultural Economics, Crop Statistics 1975, Manila, Philippines, 1977, pp. 1-10.

[5]Ibid.

[6]Ibid.

[7]World Bank, The Philippines: Priorities and Prospects for Development, op. cit., p. 100.

[8]Ibid., pp. 100-102
101.

[9]J. Lingard, L. Castillo, S. Jayasuriya and L. Garcia, "Comparative Efficiency of Rice Farms in Central Luzon: Production Function Estimation Using Matched Farm Data 1970-1979," Economics Section, Agricultural Engineering Department, The International Rice Research Institute, Los Baños, Laguna, Philippines, 1981.

[10]Randolph X. Barker, W. H. Meyers, C. M. Crisostomo and B. Duff, "Employment and Technological Change in Philippine Agriculture," International Labor Review (Reprint), CVI, 2-3, August-September, 1972, pp. 3-31.

[11]International Labor Office, Sharing in Development, Manila, Philippines, 1974, p. 12.

[12]Adelita C. Palacpac, World Rice Statistics, Agricultural Economics Department, The International Rice Research Institute, Los Baños, Laguna, Philippines, 1980, p. 72.

[13]Bureau of Agricultural Economics, Philippines (as obtained from a mimeographed handout).

[14]Virgilio S. Monge, "Analysis of Factors Affecting the Demand of Tractor and Power Tiller Services in Nueva Ecija, Philippines," Master of Science Thesis, University of the Philippines at Los Baños, College, Laguna, Philippines, March, 1980, p. 15.

Chapter II

Brief Historical Review of Farm Machinery Adoption in the Philippines

This chapter provides a brief historical review of farm machinery adoption in the Philippines by describing the two main periods of Philippine farm mechanization during the past century. It also accounts for the major factors which have influenced the direction of government policies as far as facilitating the dissemination and utilization of tractors in Philippine farms.

The history of farm machinery adoption may be divided into two major periods: the Pre-World War II and the Post-World War II periods.[15] The former may be described as the "introductory phase" which began during the latter part of the Spanish regime and lasting until the early 1940's, while the latter as the "government intensification phase" which was initiated during the late 1940's and extending through the present.

Mechanical power, as an alternative source to human and/or animal power for land preparation, was first introduced in the Philippines by the Spaniards in 1896.[16] Aside from tractors, the use of other mechanical implements such as disc harrows, cultivators and gang plows were initiated during the latter part of the nineteenth century but with very little success. After the decline of the Spanish regime, the Americans continued the task of mechanizing Philippine farms with similar results. The main reason for these failures is that the machines introduced in the country during this period were not suited to local conditions.[17] However, some success was attained in the 1930's during which four-wheel tractors, mostly imported from the United States, were satisfactorily adopted in sugar plantations. Sugar, being a significant foreign exchange earner for the Philippines, became the main thrust of farm mechanization up to the 1940's.[18]

Although an intensified mechanization scheme was initiated by the Philippine government during the early years of the Post-World War II period, the emphasis was still on the sugar industry. This continued until the 1950's and the early 1960's due to the boom in this sector resulting from the higher price obtained from Philippine sugar exports after the United States embargoed Cuban imports. The main farm machinery used in the major sugar plantations of the country were four-wheel tractors.[19] The 1960 Census reported that 35 percent of the more than 5,000 tractors in the country were located in the Western Visayas and Pampanga provinces, the major sugar producing areas of the Philippines.[20]

However, during the early 1960's there was a shift in tractor utilization toward rice mainly due to government programs geared toward the development of agriculture and the implementation of financing schemes to encourage farm machinery adoption. Although four-wheel tractors were found to be appropriate for upland farming, such as on sugar plantations, they were not suitable for small, fragmented irrigated rice fields. Realizing this situation, as well as the limited capital funds of rice farmers, the government initiated a credit program directed toward the attainment of modernizing the rice sector of the Philippines through mechanization of small rice farms. In order to fulfill this objective, the Central Bank (CB) of the Philippines negotiated a series of loans with the International Bank for Rural Reconstruction and Development (IBRD) for financing farmer purchase of four-wheel tractors and two-wheel tractors. This is known as the CB-IBRD credit project and has been the main source of institutional credit for farm machinery, administered through the local rural banking system, since 1966 in the Philippines.[21]

Studies conducted by Duff[22], Sanvictores[23] and SGV[24] indicated that the major factor affecting the sales of four-wheel and two-wheel tractors was the CB-IBRD program. This is reflected by Figure 2.1 which indicated that during a span of fourteen years, four-wheel and two-wheel tractor sales exhibited a positive relationship with the total number of loans availed of through the CB-IBRD program.

In order to better understand the trend of tractor sales during the years following 1965, Gonzales et al.[25] divided the fourteen-year period, 1966-1980, under the credit program into four-sub periods: the initial phase (1966-1968); the peso devaluation phase (1969-1971); the recovery phase (1972-1975) and the high fuel cost phase (1975-1980).

The authors indicated that during the initial phase, total tractor sales exhibited an increasing trend with two-wheel tractors showing higher sales than four-wheel tractors (Table 2.1) primarily due to the introduction of high yielding rice varieties. This is in contrast to the period prior to the mid-sixties during which four-wheel tractors dominated industry sales due to the export boom in the sugar industry.[26]

Unfortunately, a slack in the total sales of the tractor industry

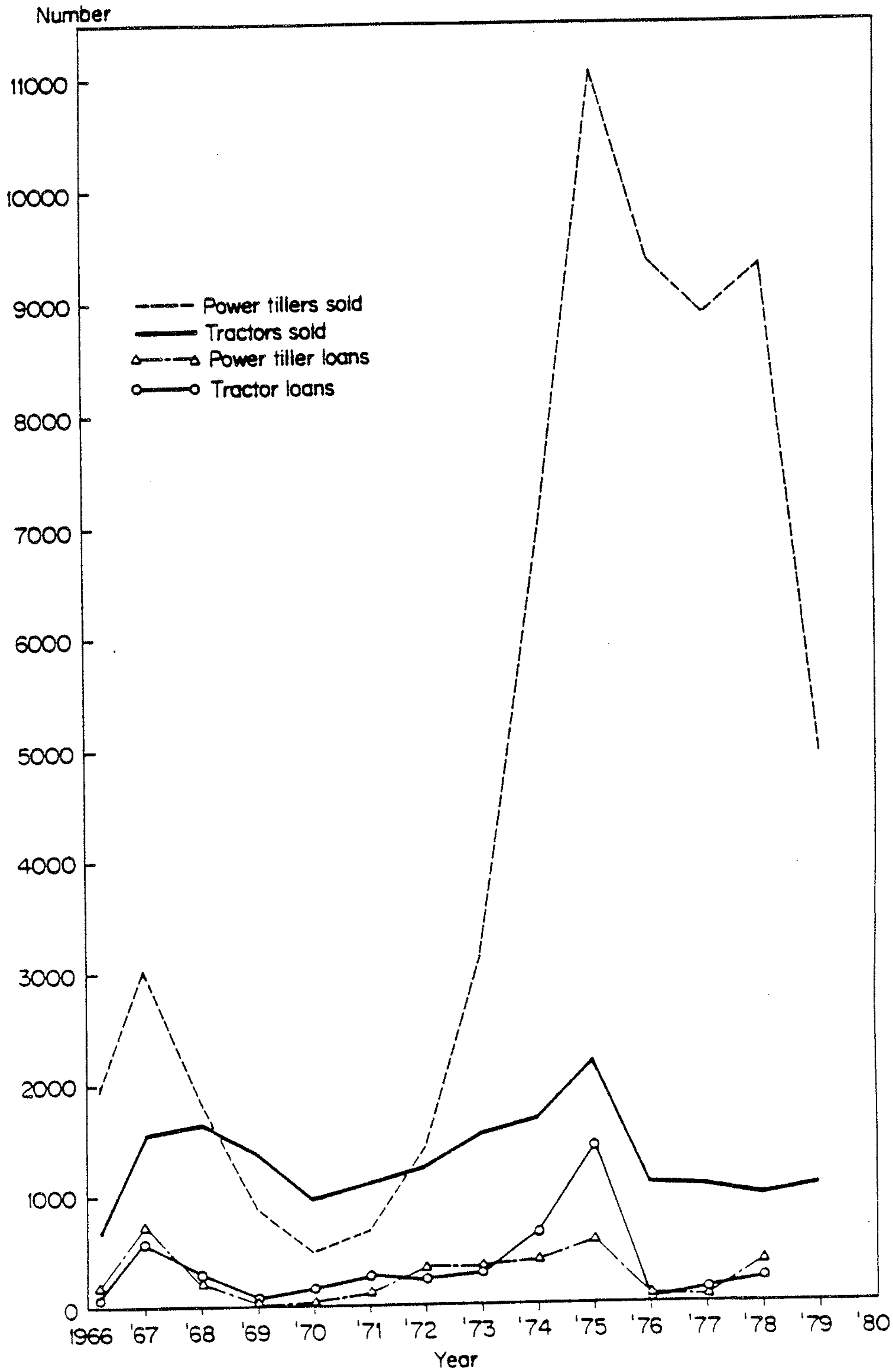

Figure 2·1. Annual sales of tractors and tillers and number of loans granted under the CB-IBRD rural credit projects, 1966-79.

Table 2.1. Tractor sales and loans under the CB:IBRD Credit Program, 1966-1980.

Year	4-wheel Tractors		2-wheel Tractors		Total	
	Sales	No. of Loans	Sales	No. of Loans	Sales	No. of Loans
	(pesos)		(pesos)		(pesos)	
1961	813	-	-	-	-	-
1962	994	-	-	-	-	-
1963	863	-	-	-	-	-
1964	950	-	-	-	-	-
1965	607	-	1,505a	-	-	-
1966	644	72	1,932	126	2,576	198
1967	1,534	560	3,058	724	4,592	1,284
1968	1,630	265	1,873	228	3,503	493
1969	1,350	54	910	34	2,260	88
1970	978	150	475	42	1,450	192
1971	1,086	251	680	109	1,766	360
1972	1,216	472	1,408	330	2,624	802
1973	1,517	534	3,120	322	4,637	856
1974	1,666	641	6,721	377	8,387	1,018
1975	2,176	1,390	11,077	805	13,253	2,195
1976	1,076	46	9,352	52	10,428	98
1977	1,057	100	8,865	95	9,922	195
1978	971	458	9,313	619	10,284	1,077
1979	1,086	-	4,936	-	6,022	-
1980	667	-	2,993	-	3,660	-

[a]Estimated cummulative total of power tiller sold between 1960 and 1965.

Source: Bureau of Census and Statistics, Central Bank of the Philippines, Agricultural Machinery Manufacturers and Distributors Association (AMMDA).

occurred from 1969 to 1971 due to the peso devaluation which allowed the exchange rate of the peso to seek its own equilibrium level relative to the U.S. dollar.[27] This, in effect, made the imported tractors relatively more expensive to buy compared to previous years. In addition, with the stricter collateral requirements imposed by the rural banks on loans, fewer loans were made during this period. Thus, further contributing to the decrease in total tractor sales.

The period of 1972 to 1975, described as the recovery phase, exhibited increasing sales of both four-wheel and two-wheel tractors. This is particularly true for two-wheel tractors which showed doubling of sales for each year of this sub-period. The factors which played important roles in influencing the trend and pattern of tractor sales during these years are summarized below:

> "Several factors could account for the upsurge of machine sales during this sub-period. One was the land reform program which parceled out rice landed estates into small units. This resulted in large income gains to former share tenants and increased the demand for power tillers. Another was the incidence of hoof and mouth disease that afflicted thousands of work animals in 1975. This led to the creation of a special financing program for tillers and tractors under the Land Bank of the Philippines and the Development Bank of the Philippines. The introduction of IRRI designed power tillers and the availability of financing support for locally built farm equipment also affected the increase of machine sales during this phase. Finally the promulgation of the General Order 47 in 1974 also created an additional market for large machinery like tractors and threshers."[28]

The fourth sub-period or the high fuel cost phase, which covers the years 1975-1980, exhibited annual declines of 15 percent and 16 percent in the sales of (four-wheel) tractors and tillers (or two-wheel tractors) respectively. Although, annual sales averaged 1,061 tractors and 8,708 tillers, the high cost of fuel seems to explain the downward trend in the sales of machinery.[29] Table 2.2 presents fuel price data from 1966 to 1980, which exhibits increasing fuel price from 1975 to 1980.

Aside from the CB-IBRD Credit Program, the current government tax/tarriff policy has had significant effects on the total supply pattern of farm machinery in the Philippines during the 1970's. Its objective is to increase government revenues and to protect the local farm machinery manufacturers by discouraging imports.[30] The effect of such policy may be observed in Table 2.3. In 1972, of the total 1,409 units of two-wheel tractors sold, 24 percent were locally manufactured while 76 percent were imported. However, with the imposition of an effective tax rate of 16 percent on two-wheel tractors in 1972, a decline in the importation of this type of farm machinery may be observed over the following years until 1978. In 1978, locally manufactured two-wheel tractors captured 70 percent of the market while imports covered only 30 percent.

It is worthwhile to mention that all four-wheel tractors in the Philippines are imported, with firms in the domestic market merely acting as distributors of this type of machinery.

As indicated by Monge,[31] the largest percentage of two-wheel tractors are located in the rice producing areas of Central Luzon region with Nueva Ecija having the largest share of the total regional distribution. As of 1976, 26 percent or 6,747 two-wheel tractors were in Central Luzon. On the other hand, four-wheel tractors were mainly concentrated in the Western Visayas region, the principal sugar producing area of the Philippines.

It is noteworthy that for the same year, "regions with high

Table 2.2. Fuel prices, 1966-1980, Philippines.

Year	Fuel Price
	(pesos/liter)[a]
1966	0.19
1967	0.19
1968	0.19
1969	0.19
1970	0.19
1971	0.30
1972	0.30
1973	0.58
1974	1.09
1975	1.22
1976	1.40
1977	1.66
1978	1.66
1979	2.80
1980	4.30

[a]Regular gasoline prices

Source: R. W. Herdt and L. A. Gonzales, "The Impact of Rapidly Changing Prices on Rice Policy Objectives and Instruments in the Philippines." A paper presented at the National Rice Strategy Seminar, September 22-24, 1980, Los Baños, Laguna, Philippines.

Table 2.3. Sales of two-wheel tractors by source, 1972-1978.

Year	Total Number of Units Sold	Percent by Source Local	Imported
1972	1,409	24	76
1973	3,120	66	34
1974	6,721	35[a]	65
1975	11,077	47[a]	53
1976	9,352	61	39
1977	8,865	70	30
1978	9,313	70	30

[a]There were low percentage sales for local and gasoline type tiller in 1974 and 1975 because of the high number of imported Kubota sales (around 5,000 units) to the Department of Agrarian Reform as part of cash programs during these periods. Without these Kubota sales, however, local tillers accounted for 63% in 1974 and 58% in 1975 while gasoline tillers accounted for 86% in 1974 and 77% in 1975.

Source: Firm sales reports submitted to AMMDA and NFAC, 1975, and IRRI interview of firms, 1976 to 1978.

(From L. A. Gonzales, et al. as obtained from Monge, 1979) machine concentrations did not necessarily have the lowest carabao numbers ... (suggesting) that animal power remains an important resource in agricultural production despite widespread use of machines."[32]

Based on such a historical background, it may be concluded that the adoption of farm machinery in Philippine rice farms was greatly affected by government policies during the past two decades, the impact of which necessitates the undertaking of this research.

Footnotes

Chapter II

[15]Ibid., pp. 10-12.

[16]G. Santos, "Mechanization in the Philippines," Master of Arts Thesis, University of Sto. Tomas, Manila, Philippines, 1946.

[17]C. Piputsitee, "An Economic Analysis of Manufacturing and Distribution Activities in the Farm Machinery Industry in the Philippines," Master of Arts Thesis, University of the Philippines, Diliman, 1976.

[18]Virgilio S. Monge, op. cit., p. 11.

[19]Randolph X. Barker, W. H. Meyers, C. M. Crisostomo and B. Duff, op. cit.

[20]Bart Duff, "Output, Employment and Mechanization in Philippine Agriculture," The Effects of Mechanization on Output, Employment and Welfare, FAO, Rome, February 4-7, 1975, p. 117.

[21]L. A. Gonzales, R. W. Herdt and J. P. Webster, "Evaluating the Sectoral Impact of Mechanization on Employment and Rice Production in the Philippines: A Simulation Analysis." A paper presented at the

joint ADC/IRRI Workshop on the Consequences of Small Rice Farm Mechanization in Asia, The International Rice Research Institute, Los Baños, Laguna, Philippines,14-18 September 1981.

[22]Bart Duff, op. cit.

[23]H. Sanvictores, "Status of Agricultural Mechanization in the Philippines." A paper presented at the International Agricultural Machinery Workshop, The International Rice Research Institute, Los Baños, Laguna, Philippines, 2-5 November 1977.

[24]Sycip, Gorres and Velayo, "CB:IBRD Mechanization Study Final Report Draft," Vol. 1, Central Bank of the Philippines, Manila, Philippines, 1980.

[25]L. A. Gonzales, R. W. Herdt and J. P. Webster, "Evaluating the Sectoral Impact of Mechanization on Employment and Rice Production in the Philippines: A Simulation Analysis," op. cit.

[26]Ibid.

[27]Ibid.

[28]Ibid.

[29]Ibid.

[30]Ibid.

[31]Virgilio S. Monge, "Analysis of Factors Affecting the Demand of Tractor and Power Tiller Services in Nueva Ecija, Philippines," op. cit., p. 12.

[32]Ibid.

Chapter III

Review of Related Studies

Mechanization of agriculture in low-wage countries has been the center of controversial debates during the past two decades. The studies conducted in these countries indicate this situation. The debate about the effects accruing to mechanization has essentially been between two different views.

The first view concerns the concept that mechanical power and animal power are perfect substitutes. In this school of thought, any farm operation which is performed by machinery together with its implements is assumed to be also feasible by a combination of animal and manual power. The implication of this concept is that the introduction of any type of machinery in agricultural production would have a considerable impact on rural employment as far as displacing farm labor is concerned. This is especially true for less developed countries where there is surplus farm labor.[33]

Another view argues that mechanization allows for more efficient farm operations which, in turn, positively affect yields as well as allows for greater intensity of land use. As a result of higher production and greater intensity of land cultivation, proponents of farm mechanization showed that the increase in the labor requirements of certain farming activities, i.e., harvesting, had an offsetting effect on the amount of labor displaced from other farm operations, such as land preparation. Therefore, this implies that mechanizing certain farm operations could contribute to increased production without necessarily displacing labor.[34]

The views just presented imply that mechanization has two major effects. They are: (1) labor effect — resulting from the substitution of farm mechanical power for manual and/or animal power and (2) output effect — resulting from the upward shift of the farm-specific total product curve. The latter, however, further implies a third effect — the cost effect, which arises from the downward shift of the average and marginal cost curves which, in turn, results in higher farm incomes at given input and output prices.

In order to place these effects into proper perspective, this chapter reviews some recent studies in relation to the impact of small farm mechanization in Southeast Asian and South Asian countries. The main thrust of this review will be geared toward those studies concerning rice farming, particularly in Southeast Asia. For additional information, studies involving the impact of farm machinery adoption on farms growing other agricultural crops such as in those countries in South Asia, are included.

Labor Effect. In a review of studies of mechanization in developing countries, Merrill[35] concluded in part that a reduction in labor inputs usually results from mechanization which replaces animal power. However, "the amount of the reduction in labor inputs depends on the particular crops, farm size and extent (as well as type) of mechanization." He further indicates that the "mechanization of agriculture is a continuous and inevitable process in economic development but one whose speed and direction can be altered by public policies and programs." This implies that "government policies and programs to promote mechanization through subsidized interest rates, favorable import arrangements, or increased credit availability can cause a significant increase in the rate of mechanization."

A study conducted in the Philippines by Barker et al.[36] exemplifies this mechanization process. They indicated that the initial introduction of tractors was mainly concentrated in the sugar industry, due to the boom in this sector resulting from the high price obtained for Philippine sugar exports after the United States embargoed Cuban imports. However, during the late 1960's there was a shift in tractor utilization towards rice, largely because the government adopted a credit program to encourage mechanization.

The authors observed that factors which generally affected the adoption of mechanical power in the study regions, (i.e., Central Luzon and Laguna) were social, economic and institutional. The social factor includes land tenure and farm size. It was found that farmers who owned the land that they were farming, as well as those who have large farmholdings, tended to mechanize more of their farm operations. Another social factor is the issue of maintaining a water buffalo (carabao). In a survey of 150 farmers in Laguna province, ninety of the respondents indicated their problems of keeping a carabao: they are usually stolen or poisoned, and their care and feeding are a niusance.[37]

The economic reasons for the purchase of tractors were: "it saves time in land preparation, it can work faster, it is easier and cheaper to operate and it can work continuously".[38] These responses imply that mechanization has the potential of increasing land productivity by enabling farmers to prepare their land more quickly and efficiently. This in turn reduced the time interval between crops which facilitates double cropping.

Institutional factors which affected mechanization included government policies directed toward the attainment of modernizing the rice sector of the Philippines. In order to fulfill this objective, the Central Bank (CB) of the Philippines negotiated loans with the International Bank for Reconstruction and Development (IBRD). These loans were administered through the local rural banking system in order to encourage mechanization in small farms.[39]

The tractor sales pattern in the Philippines during the period covered by these two CB-IBRD loans is summarized below:

> "In the middle 1960's rapid tractorization took place after the Central Bank began to provide credit from a World Bank loan in April 1966. The demand for machines fell off sharply with the exhaustion of the World Bank funds in 1968. A subsequent credit scheme financed from the same source and launched in September 1969 was much less effective in promoting the sale of tractors. The reasons appear to be a combination of the more rigid conditions imposed by the rural banks for lending funds, the requirement that the rural banks themselves provide counterpart financing amounting to at least 10 percent, and in 1970, the devaluation of the peso. (The last factor was undoubtedly the most significant). As a result the retail price of imported farm machinery increased by 40 to 50 percent, and sales dropped in almost equal measure."[40]

Barker, et al. also investigated the employment effects of using mechanical technology on the different types of farm operations in the two study areas. These are summarized in Table 3.1.

Based on Table 3.1, considering all farms in both the Central Luzon and Laguna survey areas, it was indicated that tractor users increased from 14 to 48 percent and the labor input for land

Table 3.1. Changes in total and hired labor use in the wet season and concurrent changes in technology between 1966 and 1970 in selected areas of the Philippines with high rates of mechanization.

	Labor Use					
	1966			1970		
	Man-days per hectare		Percentage Hired	Man-days per hectare		Percentage Hired
	Total	Hired		Total	Hired	
Central Luzon-Laguna						
Land preparation	17	3	18	10	2	23
Pulling and transplanting	15	14	96	17	16	99
Weeding	5	2	36	11	3	31
Other pre-harvest	8	2	19	8	1	15
Harvesting and threshing	18	16	86	21	18	85
Total	64	37	58	67	41	62
Laguna						
Land preparation	20	4	18	11	4	37
Pulling and transplanting	10	9	95	10	10	99
Weeding	16	2	16	18	10	56
Other pre-harvest	8	1	10	10	1	14
Harvesting and threshing	32	32	100	31	31	100
Total	86	48	57	80	57	72

	Technology	
	1966	1970
Central Luzon-Laguna		
Tractor users (%)	14	48
Area planted to HYVs (%)	0	67
Yield (metric tons/hectare)	1.9	2.7
Laguna		
Tractor users (%)	37	76
Area planted to HYVs (%)	1	93
Yield (metric tons/hectare)	2.4	3.4

Source: Unpublished data from surveys conducted in the Central Luzon region and Laguna province, as obtained from the study by Randolph X. Barker, W. H. Meyers, C. M. Crisostomo and B. Duff, "Employment and Technological Change in Philippine Agriculture," International Labor Review (Reprint), CVI, 2-3, August-September, 1972, pp. 3-31.

preparation declined from 17 to 10 man-days per hectare. The Laguna survey, on the other hand, showed an even greater increase in tractor users, from 37 to 76 percent. This is a case of capital being substituted for labor but there is no clear evidence that land productivity increased as a result of this substitution alone. Table 3.1 shows that in both survey areas, there was little if any decline in hired labor for land preparation as tractor use increased. However, it can be noted that total hired labor increased as a proportion of the total labor requirement.

Mechanical weeders have a different relationship to labor input. The use of mechanical weeders and the labor input for weeding increased simultaneously. This increase in weeding labor could have been brought about by any combination of the following three factors: the high-yielding varieties made intensified weeding profitable; increased fertilizer use made increased weeding necessary; or the efficiency of the rotary weeder increased marginal returns to weeding labor.[41]

The impact of mechanization on employment may be summarized in the following table (Table 3.2). This table is based on the Central Luzon - Laguna data and illustrates the major change that has been brought about in the use of labor for specific farm operations.

Although there was an indication of an increase in labor requirements (with direct effects on the total hired labor in rice production) resulting from the introduction of farm machinery in the major rice areas in the Philippines, the authors did not foresee any "likelihood that labor will be displaced rapidly in the Philippine

Table 3.2. Change in the distribution of labor requirements on survey farms in Central Luzon Region and Laguna Province in the Philippines, 1966 vs. 1970.

Farm Operation	Distribution of Labor Requirements (percent) 1966	1970
Land preparation	27	15
Weeding	8	17
Other pre-harvest operations	36	37
Harvesting and threshing	29	31
Total labor requirement (percent)	100	100

Source: Randolph Barker, et al., "Employment and Technological Change in Philippine Agriculture," International Labor Review (Reprint), Vol. 106, Nos. 2-3, August-September 1972, p. 25.

rice sector."[42] This is supported by the fact that even on those farms that are mechanizing, labor requirements per hectare have not changed significantly, as observed in Tables 3.1 and 3.2.

Smith and Gascon[43] found similar labor utilization trends in their study conducted in Laguna, Philippines. During the period 1965-1978, they observed that land preparation labor declined steadily as a result of increased mechanical power adoption. For example, "in 1965, plowing was universally done by carabao and only 24 percent of the farmers harrowed with a tractor. In contrast, in 1978 harrowing was almost completely mechanized and 47 percent of the farmers used tractors for plowing. (However), the decline in land preparation labor was more than offset by the increase in weeding labor."[44] This was true until 1975. After 1975, an increase in the use of herbicides resulted in a reduction in weeding labor. According to the authors, this shift to intensive chemical usage, as a measure to control weeds, was an attempt by the farmers to adapt to changing relative factor prices. "From 1970 to 1975, as herbicide prices increased and real agricultural wages fell, farmers' weed control was mainly by hand weeding. From 1975 to 1978 real wages increased and herbicide prices stabilized (due to government control) and farmers increased use of herbicides."[45]

In a similar note, Duff's study[46] in 1971, also conducted in the Philippines, showed that the use of two-wheel (or hand tractors) and four-wheel tractors in rice production reduced the amount of labor used for land preparation. "Most of the labor that has been replaced by mechanical power comes from family sources." However, he further states that "this decline in labor used for this task ... was more than offset by an increase in the labor used for weeding and harvesting/threshing operations." As a result, the overall labor utilization for rice production increased slightly.

In a later study, 1978, Barker and Cordova[47] attempted to identify the contribution of modern technology and other factors to the change in labor input in rice farms in the Philippines, specifically, in the Central Luzon area and Laguna province. They observed that "there appears to be ... a decline in labor input due to mechanization (particularly in land preparation operations). Since the general practice is to rent tractor services for ... land preparation tasks, the result has been fairly substantial gain in hired labor utilization, but a tendency for family labor to decline."[48]

The authors also tried to trace the changing pattern of mechanical thresher use in both study areas and its effect on post-production labor. This is summarized below:

> "Threshing is mechanized in Central Luzon, but not in Laguna. Its mechanization in Central Luzon occurred long before 1966 and is associated with the landlord-tenant system in the region. Landlords in Central Luzon frequently have large holdings—100 hectares or more—operated by a large number of tenants. Landlords in Laguna, on the other hand, typically owned 10 to 20 hectares operated by just a few tenants. In Central Luzon, the introduction of threshers was encouraged by the landlords, who saw them as a means of better control over the sharing of the crop at the time of the harvest. The primary purpose was not to save labor.
>
> The use of the large mechanical threshers underwent a substantial decline between 1966 and 1974. Of the 44 farmers using threshers in the 1970 wet season, 15 discontinued the practice in 1974. Thirteen of the 15 farmers were asked why they stopped using threshers. Their main reasons were the desire to provide work for landless laborers, and the difficulty of using the heavy threshing machines in the field during the wet season. However, it should also be noted that there was a shift from share-tenancy to leasehold (fixed rent) under the land reform program implemented since 1972, and thresher use by landlords to control the sharing of the

> crop was no longer necessary.
>
> Since the 1974 and 1975 surveys a number of small threshers have been introduced into Central Luzon and Laguna. These threshers are easy to move from one field to another and require only two or three men to operate.
>
> The decline in labor use due to mechanical threshing (however), has been fairly modest."[49]

In a study involving twelve villages in two provinces in the Philippines, i.e., Iloilo and Laguna, Juarez and Duff[50], on the other hand, observed significant reductions in labor requirement during post-production operations due to mechanical thresher adoption. With a mechanical thresher, harvesting and threshing labor requirements are 18.4 man-days/hectare in contrast to 42.6 man-days/hectare using traditional methods. For threshing task alone, machine threshing requires only 1.4 man-days/hectare compared to 26.0 man-days/hectare using traditional methods. Furthermore, the authors indicated that the total labor input per hectare per year for harvesting and threshing is higher in irrigated areas due to higher yields. This is largely due to the planting of modern varieties and double cropping practices in these areas. However, thresher use was found to have no influence on cropping patterns and intensity.

Deviating from the farm level analysis, as exemplified by the above studies, Gonzales, Herdt and Webster[51] used a sectoral simulation model to evaluate the impact of mechanization on employment and rice production in the Philippines. Based on assembled data from several studies, the authors assumed that two-wheel tractors and four-wheel tractors displace "approximately 25 and 28 man-days family labor per hectare, respectively, each season. On the other hand, portable rice threshers ... displaced hired labor by approximately 26 man-days per hectare."[52]

Furthermore, studies conducted in specific rice-growing areas in the Philippines indicated that tractor usage is more common in medium (1.6 - 2.5 hectares) and large (above 2.5 hectares) farms for both Central Luzon and Laguna areas[53] as well as in irrigated areas.[54]

In a study by Inukai[55] concerning rice production, the level of mechanization in Thailand varies widely by region, type of machinery, size of land holding and system of tenure. These variations were examined in an attempt to discover what factors determine the degree of popular use of different farm machines.

As far as regional variations in the level of farm mechanization are concerned, Inukai indicated that these can be attributed to a number of factors. To facilitate explanation, data representing the regional variations in the level of farm mechanization in Thailand are represented in Table 3.3.

First of all, the infrastructure of water utilization must be mentioned. The Central Region includes the entire Bangkok Plain, along with the Chao Phya, Mekong and Prachin rivers. The construction of irrigation facilities was mostly concentrated in this region. These irrigation facilities are on relatively low land and the water level in distribution channels is often lower than the paddy fields. Therefore, one may observe more utilization of diesel engines or electric motors for pumping in the Central Region.

Secondly, the average income of a farm household in the Central Region is considerably higher than the other three regions. Based on Table 3.3, one may observe that this region has a greater proportion of all types of machinery compared to the Northeast, North and South

Table 3.3. Percentages of farm holdings reporting the use of machinery by region and type of machine, Thailand, 1963.

Type of Machine	Whole Kingdom	Central Region	Northeast Region	North Region	South Region
Electric motors or diesel engines	7.3	24.2	1.3	5.1	0.9
Tractors	5.9	14.2	0.5	5.9	7.5
Sprayers	4.4	10.0	0.7	7.5	0.8
Threshers	1.9	3.5	0.3	4.2	0.1

Source: Census of Agriculture, 1963: Whole Kingdom (Bangkok, National Statistical Office, Office of the Prime Minister, 1965), p. 36; Ibid., Central Region, p. 36; Ibid., Northeast, p. 35; Ibid., South Region, p. 33. As presented by I. Inukai, "Farm Mechanization Output and Labor Input: A Case Study in Thailand", International Labor Review, CI, 5 (May, 1970).

Regions. This implies that farmers with higher incomes are more inclined to invest in farm machinery since they have more financial resources.

A third reason for the variation in the level of mechanization in the four regions may be attributed to the size of landholdings of farmers. It was indicated that on the average, farm land per operator was far greater in the Central Region than in the other regions which would imply that the utilization of mechanical power facilitates operations in large farms.

Another factor which may have contributed to the concentration of most of the farm machinery in the Central Region is the number of landlords in this region. It was observed by Inukai that there were more large landowners in this region compared to the other regions.

With regard to the effects of mechanization on rural employment in Thailand, the author concluded that "tractor farming can lead to more intensive utilization of the labor force in a dynamic setting of changing land utilization."[56] This was illustrated by the fact that a shift from broadcasting with buffalo farming to transplanting accompanied by tractor plowing will increase labor requirements for land preparation and care operations by 233 percent. Furthermore, the total labor requirements for all operations also increased by at least twice that required under buffalo farming. However, the author failed to explain the reason why the harvesting and threshing labor requirements remained the same for both types of farming techniques. The constancy in the required labor input for both techniques seem to imply that no increase in output have occurred due to mechanization. This seems to be a contradiction to his conclusion regarding the positive effects of mechanization on the output.

Sukharomana's study concerning "The Impact of Farm Mechanization on Employment in Thailand"[57], on the other hand, showed that farms using two-wheel tractors for land preparation required less labor input than farms using water buffaloes. However, it was concluded that the use of such machines increased labor efficiency as well as released the farm operator's labor from the care of draft animals to do other productive tasks. The same was concluded with regard to the use of mechanical threshers.

Bernsten[58] arrived at similar results, in a study conducted in South Sulawesi, Indonesia. He indicated that while mechanization reduced human/animal land preparation labor requirements, it is primarily family labor that is affected. As a result, mechanization improves farmers' welfare by freeing family labor for alternative work opportunities or leisure activities.

Other studies in Indonesia have been conducted by Bagyo and Lingard[59] (in West Java) and Santoso[60] (in East Java). In the former study, the authors observed that the labor use per hectare per season was lower on mechanized than on non-mechanized farms. However, the total annual labor use per farm was higher for mechanized farms due to larger land area. Therefore, in an area which has an extremely high labor-land ratio, such as in Java, the impact of farm size is greater than the impact of farm mechanization on labor utilization. Furthermore, as concluded by Santoso, "the development of agricultural mechanization will cause little unemployment (in the rural areas) because of opportunities outside the agricultural sector."[61] This in effect may facilitate economic growth within the region.

However, in the case of South Asia, in which Binswanger[62] reviewed several earlier empirical studies on the economics of tractors and compared the reported results of 358 samples of bullock and tractor operated farms, a different view was presented. The author concluded:

> "Indeed, the fairly consistent picture emerging from the surveys largely supports the view that tractors are substitutes for labor and bullock power, and thus implies that, at existing and constant wages and bullock costs, tractors fail to be a strong engine of growth. They would gain such a role only under rapidly rising prices of those factors of production which they have the potential to replace."[63]

Binswanger goes on further by saying:

> "...it must be stressed that tractorization of agriculture in the subcontinent ...has been confined to the higher wage areas, such as the Punjab, or to the more prosperous coastal areas of Tamil Nadu and Andhra Pradesh. There is no evidence ...that tractors have high benefit-cost ratios in semi-arid zones or even in the eastern rice belt of the subcontinent. Tractorization has further been largely confined to operations such as tillage and transport of all kinds in which either power or running speed give it a substantial comparative advantage. In particular it has not yet been used for a host of highly labor intensive operations such as transplanting or weed control (in conjunction with herbicides). Nevertheless the potential for such uses is there, as are other potential labor-saving innovations such as combine harvesters, threshers, or herbicides. Many of these innovations may be unprofitable or only marginally profitable at present, but may quickly obtain a cost advantage after fairly modest labor cost rises. Taken together, the potential mechanical and chemical labor-savings innovations will ensure a highly elastic labor supply from agriculture should wage rates in the subcontinent start to rise due to vigorous non-agricultural labor demand.
>
> We therefore must expect that, even with rapidly growing labor demands from the non-agricultural sectors, wages for unskilled labor will rise slowly. After wage rises we must expect substantial shifts of private investment by farmers into labor-saving technology. This investment process is likely to generate a series of ceilings on wage rates. At each of these ceilings the agricultural sector will be able to release massive amounts of labor without rapid rises in wage rates."[64]

It appears that later studies conducted in the subcontinent region showed that the mechanization of certain farm operations brought about negative effects to some farmers which substantiated Binswanger's claim that farm machinery "fail to be a strong engine of growth". This is exemplified by a study in Bangladesh in which the authors concluded that:

> "(Although) tiller-use significantly increased the size of cultivated holding, (the use of such machinery resulted in) decreased regular labor, evicted tenants, changed tenure status (and increased costs of repairs and maintenance) ... The findings indicated that mechanization of tillage would largely benefit rich farmers at the expense of small and marginal farmers."[65]

A study by A. H. M. Mahbudul Alam[66] in the same country arrived at a similar conclusion but added that aside from the displacement of marginal farmers, the employment opportunities of landless laborers in agricultural endeavors were negatively affected.

Such conclusions imply that the adoption of farm machinery may be more prevalent among large landowners, as found by Munir[67] (in Pakistan) and Abraham and Rao[68] (in India) since they have more resource endowments and are able to cover the costs of unexpected machine breakdowns and regular repair and maintenance.

Output Effect. Advocates of using farm machinery, particularly for land preparation operations, consider this as an important imput for increasing current farm output. One of these advocates, Kudo Zyuro,[69] considers farm mechanization as one of the most important steps in raising levels of agricultural productivity, especially in the developing countries where farm size is small. In Taiwan, Lee emphasized farm mechanization as a pre-requisite for the country's agricultural development, as well as for its development as a whole.[70]

The yield-increasing effects of mechanization are based on the assumption that it enhances better land preparation, enables early planting and reduces weed population. However, Deomampo[71] observed that in experiments done at IRRI which compared the use of a carabao with the use of a hand tractor in land preparation for two seasons showed that there were no significant differences in yield resulting from the use of tractor over that of carabao.

In a review of previous IRRI studies Duff[72] attempted to generate evidence on the degree of mechanization it required to realize the production potential of modern rice varieties. He concluded that "there is little evidence to indicate a strong causal relationship between the adoption of modern varieties and use of mechanization, particularly tractors. Adoption of tractors for land preparation appears to be primarily a result of economic factors such as credit availability and distortions in relative factor prices ... (However), mechanical land preparation does not appear to increase yields as compared with traditional land preparation. On the other hand, mechanization of post production operations significantly reduces grain losses ... (and) results in significant improvement in grain quality as reflected in higher head rice recoveries."[73]

In order to show the effects of farm mechanization on output in Thailand, Inukai[74] assumed a linear relationship between yields per rai and the level of farm mechanization. Regressions were tested in accordance with the following equation:

$$Y = a + bX$$

where Y is the yield per rai (harvested land) and X is the index of farm mechanization. Based on the regression results, the author indicated that higher yields may have resulted from mechanization. The reason for this is that buffalo plowing is subject to diminishing efficiency as land area plowed is increased. On the other hand, tractors permit timely plowing as well as greater efficiency in deep plowing. This in turn improves soil fertility and root growth of rice plants which could have a positive effect on land productivity.

The limitation of this line of reasoning is that the author neglected to separate the effects of other inputs such as fertilizers, chemicals and high-yielding seed varieties as well as the weather factor on farm output. In doing so, he has attributed all changes in output to changes in farm mechanization.

Another study conducted in the same country by Wongsangaroonsri[75] showed that output differences between mechanized farms and non-mechanized farms were due to different planting methods, i.e., transplanting versus broadcast planting method. The author observed that farms which used machinery (i.e., two-wheel tractors) for land preparation and employed the method of transplanting attained higher yields compared to those which relied on bullocks and used the broadcast method of planting rice. However, he pointed out that two-wheel tractor farms consumed twice as much fertilizer per unit of land (rai) than bullock farms.

In Indonesia, it was observed that the "yield differences can be largely explained by differences in the amount of fertilizer applied—mechanized farmers used about twice as much fertilizer as non-mechanized."[76] This is verified by Al-Sri Bagyo and John Lingard in their study in West Java.[77]

Not surprisingly, Binswanger also concluded that "the tractor surveys fail to provide evidence that tractors are responsible for substantial increases in intensity, yields, timeliness and gross returns on farms in India, Pakistan and Nepal."[78]

Although some studies have shown that mechanization has some effect on yield, as indicated by Tan and Wicks[79] and Bagyo and Lingard[80] using production function estimation and decomposition analysis, the difficulty to ascribe the yield-difference between non-mechanized and mechanized farms is summarized below:

> "The impact of agricultural mechanization on output will vary with the form of machine, the on-farm resource situation, season, region, soil type, etc. and the institutional structure (pricing conditions) of agriculture. The primary impact of mechanization will manifest itself in a changed farm input structure leading to possible output differences between mechanized and non-mechanized farms. Attributing that part of the amount difference due to mechanization alone is however difficult for there are many confounding factors."[81]

Cost/Income Effect. Mechanization, in order to be profitable, must lower the cost of production of a particular commodity. Reductions in cost may be achieved either by (1) expanding output for a given set of resources or (2) producing a given output with a reduced level of inputs. In agriculture, the former increases the productivity of land, and of labor as well, while the latter normally increases labor productivity by substituting capital (machinery) for labor.[82]

According to Duff, "the economic advantage of mechanization differs from crop to crop. Rice clearly does not offer the same economic advantage to mechanization as is found in upland crops such as sugarcane. First, there are some technical difficulties involved in the mechanization of certain tasks in rice production. Tractors do not operate efficiently in deep mud and can frequently be used only for plowing, with water buffalo doing the harrowing. Second, the institutional and social structure of Philippine rice farming is not conducive to certain types of mechanization, at least with currently available technologies. Farm operating units are small and the arrangement for the sharing costs between tenants and landlords (particularly land preparation where the tenant pays the entire costs) often makes ownership of presently available machinery an uncertain and unattractive investment."[83] In another study conducted prior to the implementation of land reform in the Philippines, Deomampo and Torres[84] indicated that although the use of tractor in land preparation reduces man and animal labor requirements (thus resulting in increased labor efficiency) such practice is more expensive due to the higher cost of fuel and repairs. Furthermore, for farmers owing a tractor, it was observed that they are worse off without using such machine for customwork.

In Indonesia, specifically South Sulawesi and West Java,[85] it was observed that it was difficult to isolate the independent effect of mechanization on farm profits. However, in general, mechanized farms realized larger profits than those which were non-mechanized due to higher yields which in turn may be attributed to higher levels of fertilizer application by mechanized farms.

In South Asia, Binswanger indicated that the tractor surveys do not show a substantial cost advantage of tractors as verified by the benefit-cost studies. "The overall conclusion from the benefit-cost analysis is that ... most rates of returns and benefit-cost ratios are overestimates of the true rate of returns to tractors ... Furthermore, the benefit-cost studies are also unanimous in that profitability of tractors on small farms is very low. Small (tractor-owning) farm could increase benefits by hiring out the tractors..."[86]

<u>Other Studies</u>. In a comprehensive review of mechanization in less developed countries in Asia, Africa and Latin America, Gemmill and Eicher showed "that economists have reached divergent conclusions because of their alternative assumptions and because they have made somewhat speculative policy prescriptions based on small scale analysis.[87] In addition, they distinguished studies with short term static frameworks, which include most cost-benefit studies of particular machines, from medium term dynamic studies, generally conducted at a regional or national level, and a third category of long-term perspective studies. Based on their insightful, juxtaposition of engineers' and economists' views on mechanization, which covered a diversity of countries such as Pakistan, Ghana, India, West Pakistan and Colombia, they concluded that "the mechanization question is an empirical one which cannot be solved with rules of thumb or cursory analysis. Economists often condemn agricultural engineers for using such rules of thumb as '0.2 hp. per acre is the minimum acceptable level, or the concept of a 'mechanization ladder' as guidelines for policy making, but the economists are equally guilty of reaching conclusions in the absence of thorough empirical analysis."[88] One of the reasons for these divergent positions may be due to the fact that research on mechanization has at least three different aspects: technical, economic and sociological. Since the

engineer, economist and sociologist have different disciplinary objectives, the conclusions they derive very often differ from each other.[89]

Even among economists, differences in opinion arise with regard to the approach that current mechanization researchers have adopted. Roumasset[90] cautioned researchers regarding the "consequences of mechanization" mentality. He indicated that "the consequences mentality misleads analysts into regarding new technology, including mechanization, as exogenous...(which) in turn leads to invalid policy conclusions."[91] Using data obtained from Nepal, Roumasset and Thapa[92] developed a methodology and identified a behavioral model which explained tractor choice based on the premise that tractors, like other inputs, are used in a way that is consistent with rational choice. Such an approach provides valuable insight on how farmers choose to adopt mechanical power as well as serves as a basis for policy-makers with regard to deciding which strategy to use in promoting mechanization in a particular agro-economic setting.

In spite of this interdisciplinary disagreement, a massive amount of research, particularly in agricultural economics, has been undertaken concerning the mechanization issue in developing countries in order to provide a much clearer perception of the policy options available to these countries. This is exemplified by Binswanger's review of over twenty empirical studies on the economics of tractors on the Indian Subcontinent[93] as well as studies conducted by the International Rice Research Institute in various Southeast Asian countries.

Although these studies indicated that evidences have been obtained concerning the substitutability of mechanical power for labor and/or animal power, certain problems arise in analyzing mechanization effects on employment. In his essay, "Some Effects of Farm Mechanization", Anker states the dilemma confronting researchers with regard to this type of studies:

> "When one attempts to estimate the influence of mechanization on employment in agriculture as a whole, the causal relationship is much more difficult to establish, since a whole complex of factors influences the size of the agricultural labor force, and the importance of any one of them can be assessed only approximately. In most industrial countries and those where economic development is in progress, there has been for many years a constant decline in the agricultural labor force. However, though a correlation may be established between the degree of mechanization and employment in agriculture, it is hard to generalize as to which is cause and which is effect. In some cases farmers have taken to mechanization because labor is too expensive or too difficult to find. Some governments have even adopted a definite policy of promoting mechanized agriculture in order to maintain agricultural production in the face of a declining farm population. What can be said without hesitation is that mechanization permits a given level of agricultural production to be maintained with a smaller labor force, and that in many countries where mechanization is far advanced the labor force in agriculture has declined sharply."[94]

It may be concluded from these studies that the utilization of farm machinery in agricultural production, as a substitute for animal and/or manual power, has three major effects. These are (1) labor effect, (2) output effect and (3) cost/income effect.

Footnotes

Chapter III

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Chapter IV

Theoretical Framework

This chapter discusses the theoretical framework which will serve as the basis for the analysis of the effects of small farm mechanization on production, income and employment. However, before discussing the relevant economic theories, it is necessary to define what a mechanized rice farm is. For the purpose of this study, the utilization of mechanical power in land preparation, i.e., seedbed preparation, plowing, harrowing and levelling, as well as in postproduction activities, i.e., threshing, defines a mechanized rice farm. It is generally thought that farm mechanization (or mechanical technology), like biological and chemical technologies, may be considered as a form of technical change which, it turn, may enhance agricultural output growth. This implies an upward shift in the total product curves of mechanized farms, a downward shift in their cost curves and a downward pressure on farm employment due to factor substitution. These are fully discussed in the following section.

Effects of Farm Mechanization Analysis

Based on traditional production theory, the total amount of a particular output produced by a farm is determined by the amounts of inputs it utilizes in producing that output with a given level of technology. This relationship could be expressed in the following relationship:

(4.1) $$Q = f(X_1, X_2, X_3, \ldots, X_n|T)$$

where: Q is the level of rice output produced.

X_1 is the level of labor input employed to produce Q.

X_i's are the amounts of inputs other than labor.

utilized to produce Q. $i = 2, 3, \ldots, n$

T is a given level of technology.

This functional relationship suggests that as a farm varies its utilization of the necessary inputs in producing a particular output, there results a corresponding variation in the total output produced.

By varying the utilization of one input, say labor in terms of total man-hours per hectare, while holding the level of other inputs utilized constant at a given level of technology, the familiar production function (presented in Figure 4.1b by TP_L) may be obtained. In functional form, this relationship may be expressed as:

(4.2) $$Q = f(X_1|X_2, X_3, \ldots, X_n)$$

Consider first the total product curve, TP_L, and assume that this represents the input-output relationship of a non-mechanized rice farm. Assuming that the price of labor is given, the average and marginal cost curves corresponding to this total product curve are indicated by AC_1 and MC_1, respectively, as seen on Figure 4.1a. In a situation where the farm employs L_2 level of labor, the total output that will be produced by this level of employed labor is indicated by q_2. The average cost corresponding to this amount of output produced is AC_2. Suppose the amount of labor utilized by the farm is L_1, the total output produced will be q_1 while the average cost incurred in producing this level of output will be AC_1.

Let us now investigate the possible effects of mechanization in

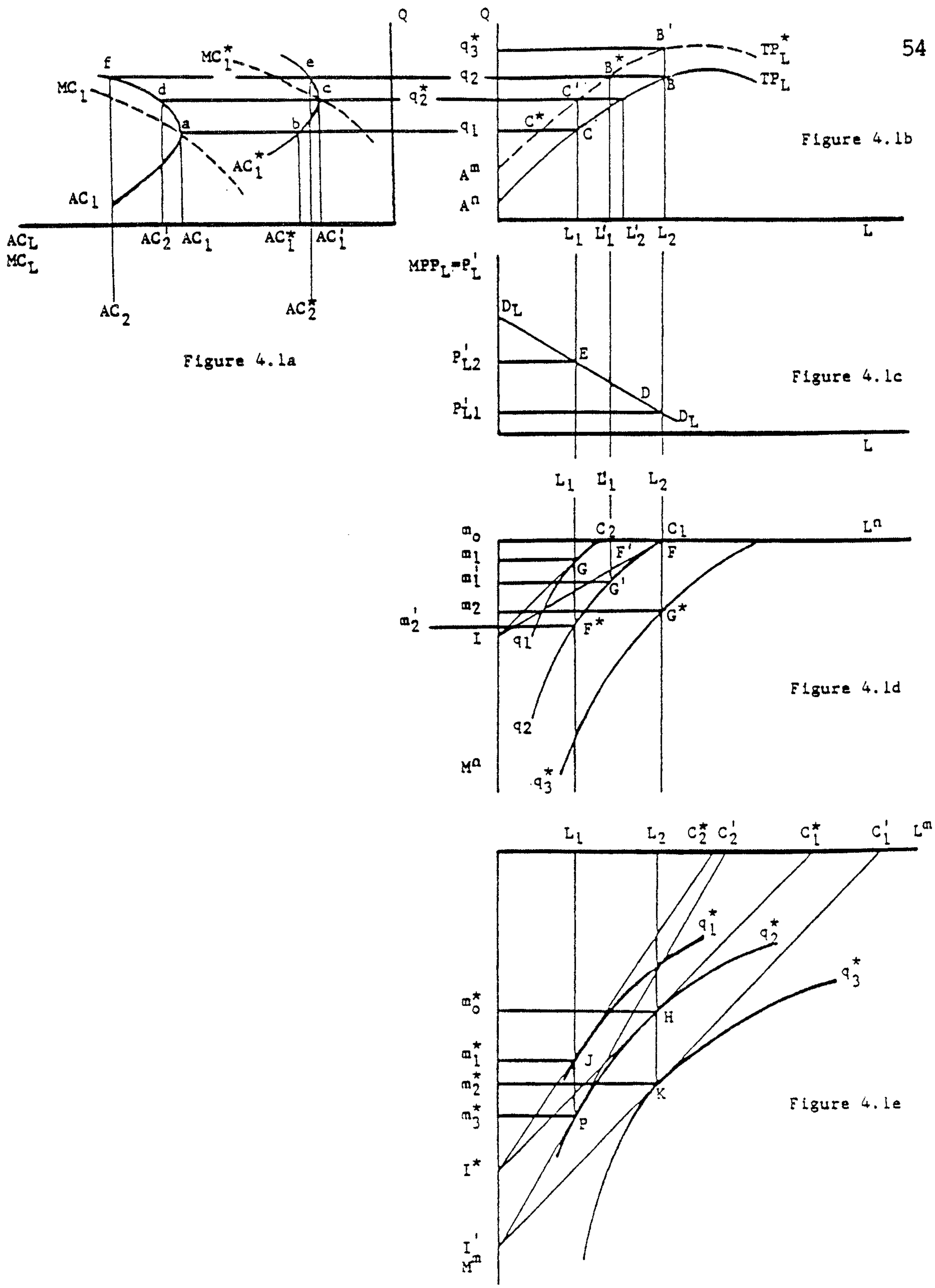

Figure 4. A graphical illustration for explaining the theoretical framework for analyzing the impact of mechanization on farm labor employment, output and income.

the model by introducing the assumption that the same farmer has mechanized some of his farm operations such as land preparation and harvesting. By doing so, his total product curve shifts upward (from TP_L to TP_L^*) which in turn results in a downward shift in the cost curves. In Figure 4.1a, this shift is indicated by the movement of AC_1 to AC_1^*, implying greater efficiency in farm operations derived from mechanization, and MC_1 to MC_1^* which implies an increase in farm output supply. It should be noted that the adoption of farm equipment as a substitute for manual/animal power has three possible effects: output, cost and labor effects.

To illustrate the output effect, refer to Figure 4.1b. Assume that prior to mechanization the amount of labor utilized by the farm is L_2. This amount of labor will produce q_2 level of output. With the introduction of farm machinery, more output can be produced with this same amount of labor input as indicated by q_3^*. The effect of mechanization on output, therefore, is an increase in the amount of rice produced by the farm which is equivalent to $q_2q_3^*$. Using the same line of reasoning, at L_1 level of labor input the increase in output due to mechanization is $q_1q_2^*$.

The cost effect (refer to Figure 4.1a) may be derived by considering a particular level of output, say q_2. Note that without mechanization, the average cost of producing this level of output is represented by AC_2. For the sake of illustration, assume that the farm under consideration adopts farm machinery for the purpose of improving the efficiency of certain farm operations. As a result, the average cost of producing the same level of of output (q_2) under a mechanized scheme decreases to AC_2^*. This decrease, equivalent to

$AC_2AC_2^*$ or fe is the cost effect of mechanization. Under conditions of constant output and factor prices, this would imply an increase in net farm income. It should be noted, however, that the upward or downmward shift of the cost curves largely depend on the relative investment a particular farm has made on farm machinery.

The effect of mechanical power adoption on farm labor employment is illustrated in Figure 4.1d. With the aid of isoquants, which show the different level combinations of labor and mechanical power in producing a given level of output, a theoretical relationship may be established between these two factors of production. With a given level of output, such as q_2, the amount of labor input required to produce this amount is L_2 under non-mechanized operations. The introduction of farm machinery into the farm operations will have a considerable impact on the level of farm employment which may be observed from the labor effect of mechanization, as shown in Figure 4.1d.

It has been established that prior to mechanization, the labor-mechanical power combination needed to produce output q_2 is L_2m_o. This relationship is shown in Figure 4.1d by point F on isoquant q_2. However, under a mechanized scheme, to produce the same level of output, the total labor requirement is L_1' while the mechanical power requirement is m_1' as indicated by point G' on isoquant q_2. This implies a decrease in labor employed in the farm by as much as $L_1'L_2$ and an increase in mechanical power requirement amounting to m_om_1'.

Based on this argument, it may be hypothesized that mechanization in small rice farms will result in:

1. an increase in farm output,

2. an increase in net farm income under conditions of constant output and factor prices and

3. a decrease in farm labor requirements.

However, before conducting any analysis, it is worthwhile to relate the above theoretical framework to the two schools of thought regarding the impact of farm mechanization. Consider first the argument regarding farm machinery as a net contributor to total output produced as well as to total labor usage.

It was illustrated that at initial labor input, L_2, the level of output produced under a mechanization scheme is q_3^*. As a result, output increased from q_2 to q_3^* — an increase of $q_2q_3^*$. This may be observed in Figure 4.1b. It may be noticed that in Figure 4.1d, to produce q_3^* output, the labor-mechanical power combination is L_2 and m_2 which is indicated by point G*. This implies that in spite of farm machinery adoption, the same amount of labor is required at a higher output level. This is in line with the net contributory school of thought — that higher production results in an increase in harvesting labor requirements which, in turn, offsets the amount of displaced labor by mechanized land preparation operations.

By assuming that the adoption of mechanical technology, like biological and chemical technologies, results in shifts in a farm's production and costs curves, the substitution view regarding farm machinery adoption may be illustrated. Holding the level of output at q_2, the labor-mechanical power combination under a non-mechanized scheme is L_2m_0. However, by introducing mechanical power (an amount equal to m_1') into certain farm operations, such as land preparation, less labor input is required, i.e., L_1', to produce q_2 output. This is indicated by point G' on isoquant q_2 in Figure 4.1d. In effect, an increase in mechanical power utilization of m_0m_1' resulted in a decrease in labor input usage by an amount equal to $L_1'L_2$. This is the substitution effect of farm machinery adoption.

In order to show the effect of factor price changes on the substitution of mechanical power for animal/manual power, it is necessary to consider the following production functions pertaining to two different farm-types, i.e., mechanized and non-mechanized farms, similar to that expressed in (4.2):

(4.3) $$Q^m = A^m f(X_1^m, X_i^m | T^m)$$

(4.4) $$Q^n = A^n f(X_1^n, X_i^n | T^n)$$

where: m refers to mechanized farms.

n refers to non-mechanized farms.

T refers to a given level of technology in each farm-type.

Q is the output produced by each farm-type.

X_1 is the labor input level utilized by each farm-type to produce output Q.

X_i are the other inputs used by each farm-type.

Referring to the total product curves of labor, TP_L in Figure 4.1b refers to the total product curve of a non-mechanized farm while TP_L^* pertains to that of a mechanized farm. However, for preliminary discussion purposes, first assume that both mechanized and non-mechanized farms have the same technical efficiency which implies that $A^m = A^n = A^o$ and that the slopes at any point of the total product curve are the same for both farms.[96] This implies that both farm-types operate along the same production function curve (TP_L, for discussion purposes). Furthermore, assume both farm-types are price efficient since they are able to equate their respective value marginal product of labor to the wage rate as indicated by points D and E (as seen in Figure 4.1c) which are points on the labor demand curve for both firms. It should be noted that the farms may not necessarily face the same input and output prices but are assumed to be able to equate the value of the marginal product of labor (or any other factor) to its farm-specific opportunity cost.

Under conditions of homogeneous output (or technology) and profit maximization under perfect competition, subject to a set of exogenous variables such as input and output prices, the labor demand curve, D_LD_L, may be derived from the profit maximization condition:

$$VMP_L = P_L \tag{4.5}$$

$$(P_q)(MPP_L) = P_L \tag{4.6}$$

where: VMP_L is the value marginal product of labor.

P_L is the price of labor.

P_q is the price of output.

MPP_L is the marginal physical product of labor.

Equation (4.6) implies that a firm is price-efficient if it equates the value of marginal product of labor (or of each variable input) to its price. It should be noted that (4.6) may be further expressed as:

$$MPP_L = \frac{P_L}{P_q} = P_L' \tag{4.7}$$

where: P_L' is the labor price normalized by the output price.

Equation (4.7) defines the labor demand curve as shown in Figure 4.1c, which implies that an increase (decrease) in the price of labor relative to the output price results in a decrease (increase) in the labor utilization by both farms. To illustrate, assume that at output price, P_q, and labor price, P_{L1}, both farms maximize profit at point D where $VMP_{L1}=P_{L1}$ or $MPP_{L1}=P_L'$. The amount of labor utilized by each farm at this labor price is L_2 while the amount of output produced is q_2. An increase in the price of labor from P_{L1}' to P_{L2}' will result in a reduction in labor utilization in both farm-types, which will decrease from L_2 to L_1. This reduction in labor input utilization, in turn, results in a decrease in output produced, from q_2 to q_1, for both farms.

In order to illustrate the effect of factor price changes on the substitution of mechanical power for animal/manual power, consider Figures 4.1d and 4.1e which depict the profit maximizing condition of a non-mechanized and mechanized farm, respectively, with the use of isocost and isoquant curves.

Consider first the profit maximizing output and labor input levels, q_2 and L_2 in Figure 4.1b. At these levels, both farm-types are able to maximize profit since their respective $VMP_L=P_L$ (Figure 4.1c). This profit-maximizing condition for both farms is depicted in Figures 4.1d and 4.1e. In Figure 4.1d, the non-mechanized farm is said to be maximizing at point F where its isocost line, IC_1, is tangent to isoquant, q_2. At this level of output, the total labor utilized is L_2 while the total mechanical power usage is zero. This is indicated by m_0 level of mechanical power utilization in Figure

4.1d. On the otherhand, the profit-maximizing condition for the mechanized farm is indicated by point H, in Figure 4.1e, where the isocost curve $I^*C_1^*$ is tangent to isoquant curve q_2^*.

It should be noted that tangency of the isocost line to a particular isoquant implies equality in the slopes of the isocost and the isoquant. This may be expressed as:

$$(4.8) \qquad -\frac{\partial L}{\partial M} = \frac{P_M'}{P_L'}$$

where: $\frac{\partial L}{\partial M}$ is the slope of the isoquant curve.

P_M' is the price of mechanical power normalized by output price.

P_L' is the price of labor normalized by the output price.

$\frac{P_M'}{P_L'}$ is the slope of the isocost line.

Recall from basic economic theory that the slope of the isoquant indicates the marginal rate of technical substitution of a particular input for another. In otherwords:

$$(4.9) \qquad -\frac{\partial L}{\partial M} = \frac{MPP_M}{MPP_L} = MRTS_{ML}$$

where: MPP_M is the marginal physical product of farm machinery.

MPP_L is the marginal physical product of labor.

$MRTS_{ML}$ is the marginal rate of technical substitutiion of mechanical power for manual labor.

Substituting (4.8) into (4.9), the following expression may be obtained:

$$(4.10) \qquad \frac{P'_M}{P'_L} = \frac{MPP_M}{MPP_L} = MRTS_{ML}$$

Equation (4.10) implies that the price ratio of two inputs (in this case, mechanical power and labor) is equal to the marginal rate of technical substitution of these two inputs.

In order to find out the effect of a price change on the $MRTS_{ML}$, assume an increase in the price of labor from P'_{L1} to P'_{L2} while holding the price of mechanical power constant at P'_M. At P'_{L1}, the $MRTS_{ML}$ is equal to (P'_M/P'_{L1}) and at P'_{L2}, the $MRTS_{ML}$ is equal to (P'_M/P'_{L2}). Since $P'_{L2}>P'_{L1}$, labor utilization in both farms will decrease from L_2 to L_1 with a tendency toward increased mechanical power utilization, as indicated by the increase in mechanical power utilization in Figure 4.1d, from m_0 to m_1, and in Figure 4.1e, from m_0^* to m_1^*. This implies an increase in the MPP_L and a decrease in the MPP_M which, in turn, results in a decrease in the $MRTS_{ML}$ (or a decrease in the slope of the isocost curve) for each farm-type. In Figures 4.1d and 4.1e, this is indicated by the rotation of the isocost curve to the left, i.e., from IC_1 to IC_2 for the non-mechanized farm, and from $I^*C_1^*$ to $I^*C_2^*$ for the mechanized farm. As a result, a new profit-maximizing condition is obtained for both farms. This is indicated by points G and J for the non-mechanized and mechanized farms, respectively.

It may be observed that due to the labor price increase, both farms are maximizing profits at a lower output level, q_1 for the non-mechanized farm, and q_1^* for the mechanized farm. Furthermore, although both farms are producing lower levels of output, they are still at equilibrium.

It is worthwhile to mention that even if the technical efficiency parameters of the two farm-types are different, i.e., $A^m > A^n$, both farm-types may still experience this equilibrium condition given their respective technology. To illustrate, assume that at each level of labor input, more output is produced by a mechanized farm. This is depicted in Figure 4.1b where TP_L^* refers to the total product curve of a mechanized farm while TP_L refers to that of a non-mechanized farm. This implies that the mechanized farm produces output, q, more efficiently. It should be noted that a maintained hypothesis in this analysis is that the production function is identical for both mechanized and non-mechanized farms up to a neutral efficiency parameter. This means that although the efficiency parameter differs between the two farm-types, the marginal physical product of a particular input, say labor (L), will be the same for both farms. This is indicated in Figure 4.1c, in which the demand curve (or the MPP_L) remains unchanged for both mechanized and non-mechanized farms, although the efficiency parameter of the former is greater than that of the latter, i.e., $A^m > A^n$.

At initial prices of P'_{L1} and P'_{M1} the profit-maximizing condition for the two farm-types is at point D in Figure 4.1c. With the aid of isocost and isoquant curves, the profit-maximizing condition for both non-mechanized and mechanized farms at these initial prices is depicted in Figures 4.1d and 4.1e, respectively. As illustrated, it may be observed that the non-mechanized farm employs L_2 level of labor input and m_o (or zero) level of mechanical power to produce output q_2. On the otherhand, the mechanized farm utilizes the same level of labor input (L_2) and m_2^* mechanical power to produce q_3^* output. The non-mechanized farm is said to be at equilibrium at point F (Figure 4.1d), the point of tangency of the isocost line IC_1 and isoquant curve q_2 while the mechanized farm is at equilibrium at point K (Figure 4.1e).

In order to investigate the effects of a price change, assume an increase in the price of labor from P'_{L1} to P'_{L2}. This change in the labor price will result in a decrease in the amount of labor utilized by the non-mechanized farm (and by the mechanized farm), from L_2 to L_1. The profit-maximizing condition at labor price P'_{L2} and labor usage L_1 is indicated by point E on the demand curve D_LD_L, in Figure 4.1c. It should be noted that this decrease in the quantity of labor demanded also results in a decrease in the amount of output produced by each farm-type, i.e., from q_2 to q_1 for the non-mechanized farm and from q_3^* to q_2^* for the mechanized farm (Figure 4.1b).

Referring to Figure 4.1d, prior to the labor-price increase, the non-mechanized farm is at equilibrium at point F. At this equilibrium condition, the farm utilizes L_2 amount of labor and m_o level of mechanical power. The profit-maximizing output at these input levels is q_2. It may be observed that an increase in the price of labor decreased labor utilization from L_2 to L_1 and increased mechanical power usage from m_o to m_1. As a result of these changes in the input levels, a reduction in the $MRTS_{ML}$ is observed. This is attributed to the decrease in the MPP_M (due to increased mechanical power utilization) and the increase in the MPP_L (due to decreased labor utilization), thus causing the isocost line IC_1 to rotate to the left. These adjustments bring about a new equilibrium condition for the non-mechanized farm which is indicated by point G, where the new isocost line IC_2 is tangent to isoquant curve q_1. Note that point G indicates the new profit-maximizing condition at lower levels of output and labor utilization and at a higher level of mechanical power usage.

Similar changes and effects occur in the mechanized farm. At the initial labor price P'_{L1} this farm maximizes profit at L_2 and m_2^* levels of labor and mechanical power, respectively. The amount of output produced by these levels of input is q_3^*. The equilibrium condition at these input-output levels is depicted by point K in Figure 4.1e. Due to the increase in the labor price, a decrease in labor utilization from L_2 to L_1 may occur. Since mechanical power becomes relatively less expensive (its price does not change), the usage of this input increases from m_2^* to m_3^*. This substitution of mechanical power for labor results in adjustments which give rise to a new profit-maximizing condition for the mechanized farm at point P. This is indicated by the point of tangency of isocost line $I'C'_2$ and isoquant curve q_2^*.

From the above discussion, it may be observed that if both farms are price efficient, a farm which is technically more efficient will realize more profit than another farm which is less technically efficient. In the present example, the mechanized farm will then be more profitable than one which is non-mechanized since $A^m > A^n$.

The theoretical framework just discussed serves as a guide for the analysis of the effects of mechanization in small rice farms in the Philippines. It provides the researcher a theoretical explanation regarding the possible effects of mechanical power adoption as well as a basis for comparing mechanized versus non-mechanized farms. However, due to the difficulties involved in establishing the costs, which takes into account investment in farm machinery, as well as problems in accounting for all the items that must be included in the price of man-animal and man-machine services of each individual farm-type, the analysis undertaken in this thesis will concentrate mainly on the production effect of mechanization.

Footnote

Chapter IV

95The assumptions used in the succeeding discussion follow that of Lau and Yotopolous in their paper, "Profit, Supply and Demand Functions", as found in the American Journal of Agricultural Economics, 54, February, 1972, pp. 11-18.

Chapter V

Model Specification

The Model

This section of the thesis deals with the discussion of the factors that affect the aspects of farm output, profit, the level of farm mechanization and labor employment. It attempts to explain their relationships through the various variable factors that may have direct and/or indirect effects on these aspects. In order to facilitate explanation, a model is presented in Figure 5.1.

Consider first the factors that affect farm output. Based on the diagram, it may be observed that the level of farm production (Q) is influenced by the amount of input (X) utilized by the farm. However, the level of input usage may be affected by factors such as credit availability (C), the price of output (P_q), the relative input prices (R_i) as well as the economic efficieny (Ef) of the individual farm. Farm output is further affected by the size of farm area (H), the type of technology (Tc) which has been adopted by the farm, the farm's cropping pattern and intensity (CPI), land tenure (T), the experience (Ex) and educational level attained (Ed) by the farmer operator as well as the farm's resource endowments (R) which are relevant to the production of its output. Other factors such as government policies (GP), the quality of extension services (ES), soil characteristics of the farm (S), weather (We), irrigation (I), the level of mechanization (M) and total farm labor employment (L) also play important roles in influencing farm output fluctuations.

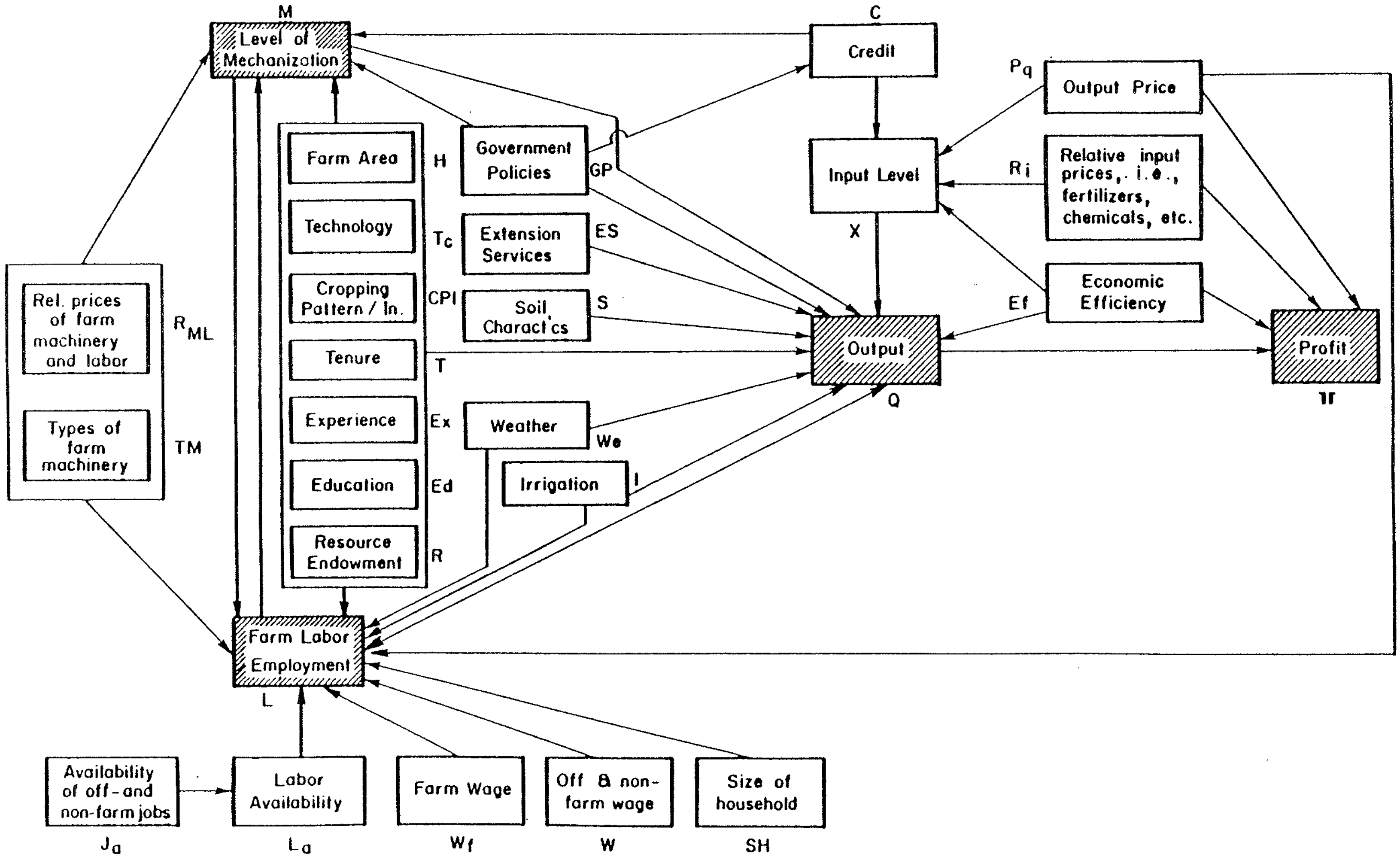

Figure 5-1. A model for explaining the impact of mechanization on labor employment, output and income.

It should be noted that the level of farm machinery adoption (M) and labor employment (L) are, likewise, jointly affected by the total farm area (H), the technology (Tc) adopted by the farm (as reflected by the elasticity of substitution between mechanical power and labor), the farm's cropping pattern and intensity (CPI), land tenure (T), the farmer's experience (Ex) and educational level attainment (Ed) as well as the resource endowments (R) of the farm. The relative prices of farm machinery and labor (R_{ML}) is also another important factor which influences a farmer's decision whether or not to adopt mechanical power for certain farm operations. In this connection, it may be argued that the different types of machinery (TM) utilized in a farm (i.e., tractors for land preparation and mechanical threshers for threshing) will, therefore, have a significant impact on the farm's degree of mechanical power adoption (M) as well as on its level of labor input utilization (L).

It cannot be denied that certain government policies (GP) may also encourage machinery adoption in farms. This may be done through a credit program (C) which enables farmers to acquire financial assistance, at reasonable interest rates, for the purpose of purchasing farm machinery.

Aside from the above-mentioned variable factors that affect farm labor employment (L), other variables such as farm household size (SH), the price of output (P_q) off-and non-farm wages (W), as compared with farm wages (W_f), together with the availability of farm labor (La) in the rural areas also cause fluctuations in the total labor utilization at the farm level. It should be noted that the availability of farm labor (La) largely depends on the availability of off-and non-farm jobs (Ja).

Farm profit (II), on the other hand, is affected by the total output (Q) of the farm as well as by the output price (P_q), relative input prices or R_i (i.e., fertilizer, chemicals, seeds, etc.), and the economic efficiency (Ef) of the farm.

We have, so far, established the interrelationships of the factors that create changes in the levels of the different farm dimensions, i.e., output, profit, levels of mechanization and labor employment. Based on the above-discussion, it may therefore, be inferred that farm differences may arise due to variations in the level of mechanical power usage.

For the purpose of this thesis, the main focus will be on the farm labor employment, output and profit (or income). In this connection, a simplified version of Figure 5.1 is presented in Figure 5.2 which will serve as the basis for analyzing the impact of farm machinery adoption on these three dimensions of rice production. To facilitate analysis, only selected variables (as indicated in Figure 5.2) are utilized in the analysis.

In order to facilitate such an analysis, a methodology is developed in the following section.

Methodology

Preliminary analyses for comparing mechanized farms to non-mechanized farms. In order to investigate whether differences exist among farm groups with varying degrees of farm mechanization and to test whether the group differences are statistically significant, the following preliminary test procedures will be used.

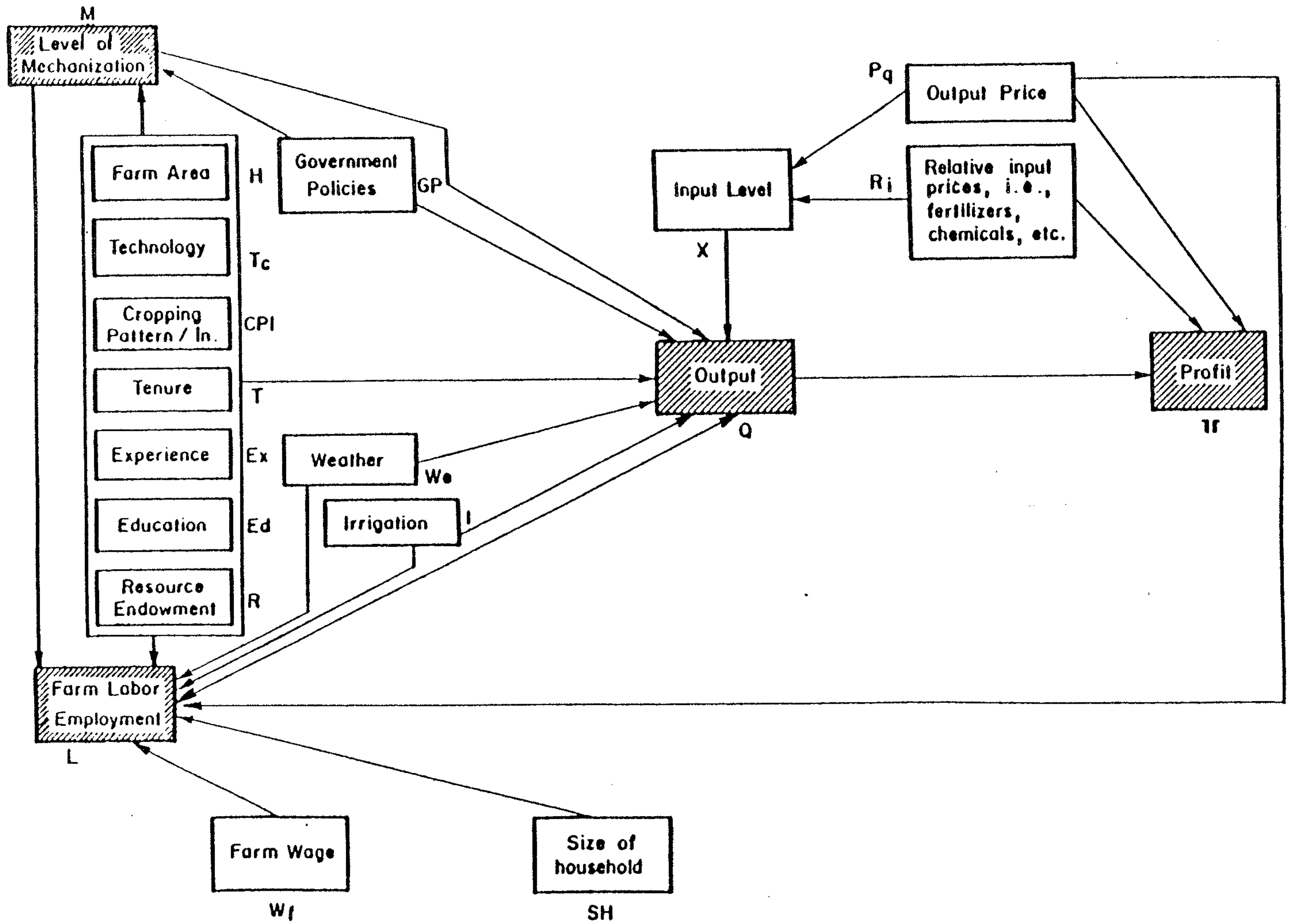

Figure 5.2. A simplified model for explaining the effects of mechanization on labor employment, farm output and income using selected variables.

1. Tabular analysis. This type of analysis requires the construction of a system of farm classifications in order to be able to make certain distinctions between small rice farms with different modes of mechanization. However, before one is able to undertake this task, it is necessary to define a mechanized farm as well as develop a working classification of farm groups with different modes of mechanization.

For the purpose of this study, the utilization of mechanical power in land preparation, i.e., seedbed preparation, plowing harrowing and levelling, as well as in post-production activities, i.e., threshing, defines a mechanized rice farm. In this respect, farms using carabao power for land tillage and manual labor for threshing are classified as non-mechanized farms (or C). On the other hand, farms which avail of the services of two-wheel tractors (or a combination of two-wheel tractor and carabao power) as well as the services of mechanical threshers are defined as mechanized farms. Within the classification of mechanized farms, five types are defined. They are:

a. Carabao/thresher farms (CT) - those that utilize carabao power for land preparation and mechanical thresher for post-production operations,

b. Two-wheel tractor farms (TW) - those that utilize two-wheel tractors for land preparation and manual labor for post-production operations,

c. Two-wheel tractor/thresher farms (TWT) - these are rice farms which use two-wheel tractors for land preparation and mechanical threshers for post-production operations,

d. Two-wheel tractor/carabao farms (TWC) - these are rice farms which use a combination of two-wheel tractor and carabao power for land preparation and manual labor for post-production operations, and

e. Two-wheel tractor/carabao/thresher farms (TWCT) - these are farms which use two-wheel tractor and carabao power for land preparation and mechanical thresher for post-production operations.

The above classifications are then utilized in constructing tables for analyzing labor differences among the farm groups for different rice production operations such as land preparation, planting, care/cultivation and post-production. For analytical purposes, labor is expressed in man-hours per hectare. Furthermore, the tables are constructed for both wet and dry seasons in order to obtain information whether the same farm classifications differ in the amount of labor requirements between seasons.

2. <u>Covariance analysis</u>. This approach is a quantitative assessment of mean labor utilization by mechanization groups. The basic advantage of this method of analysis is that it incorporates corrections for differences in other factors which may have significant effects on labor employment at the farm level. The basic models that will be used for this analysis are the following:

a. Total labor for all operations

(5.1a) $L_i = A_0 + A_1M_1 + A_2M_2 + A_3M_3 +$
$A_4M_4 + A_5M_5 + A_6S + A_7I +$
$A_8T + A_9HM + A_{10}Q + A_{11}Ex +$
$A_{12}Ed + A_{13}WRP + A_{14}CPI +$
$A_{15}NW + e$

b. Labor for land preparation operations

(5.1b) $L_i' = A_0' + A_1'M_1 + A_2'M_2 + A_3'M_3 +$
$A_4'M_4 + A_5'M_5 + A_6'S + A_7'T +$
$A_8'HM + A_9'Ex + A_{10}'Ed + A_{11}'WRP +$
$A_{12}'CPI + A_{13}'NW + e'$

c. Labor for post-production operations

(5.1c) $L_i^* = A_0^* + A_1^*M_1 + A_2^*M_2 + A_3^*M_3 +$
$A_4^*M_4 + A_5^*M_5 + A_6^*S + A_7^*T +$
$A_8^*HM + A_9^*Q + A_{10}^*Ex + A_{11}^*Ed +$
$A_{12}^*WRP + A_{13}^*CPI + A_{14}^*NW + e^*$

where: L_i, L_i' and L_i^* refer to the total man-hours in terms of either (a) total hired labor, (b) total family labor or (c) total labor for their respective farm operations.

M_i refers to a mechanization dummy which takes a value of unity if the farm belongs to mechanization group i, such as: M_1 = TW, M_2 = TWC, M_3 = CT, M_4 = TWT and M_5 = TWCT. The reference group is the carabao farm category or C.

S is a season dummy which takes a value of unity for dry season and zero for wet season.

I is an irrigation dummy which takes the value of unity for irrigated farms and zero for non-irrigated farms.

T is a tenure status dummy which takes the value of unity for farmer-owned farms and zero, otherwise.

HM is the total number of household members per farm above ten years old.

Q is kilogram rough rice per hectare.

Ex is the total number of years of farming experience of the farm operator.

Ed is the number of years education the farm operator had.

WRP is the ratio of the average wage rate per hour for all farm operations and the average price per kilogram of rough rice.

CPI is cropping intensity, computed as follows:

$$CPI = \frac{\text{wet season rice farm area} + \text{dry season rice farm area}}{\text{total available area per farm}}$$

NW is the farm networth, expressed in pesos.

e is the residual term.

It should be noted that such models will be utilized for analyzing labor differences among the specified farm categories on a per hectare basis.

The coefficients of the mechanization dummies measure group differences between mechanized and purely non-mechanized farms. For example, A_1 reflects how much more (if $A_1 > 0$) or less (if $A_1 < 0$) total labor hours were utilized by M_1 farm group (or TW farms) relative to the reference farm group, C. To illustrate, if L refers to total labor input, then A_1 measures the difference in the total labor use between C farms and TW farms. With regard to the analysis on a per hectare basis, the regression constant or intercept A_o carries a definite interpretation. Ignoring the influence of farm size on the labor input use, A_o measures the average man-hours utilized on non-irrigated carabao farms during the wet season.

Dummy variables M_1, M_2, M_4 and M_5 are expected to exhibit negative regression coefficients for land preparation labor covariance analysis due to the fact that these farm groups utilize two-wheel tractors soley or in combination with carabao power. The carabao/thresher farms group or CT, as represented by dummy variable M_3, is not expected to show any significant difference from the reference farm group, C, in terms of land preparation labor utilization (on a per hectare basis). The reason for this is that both farm-types mainly rely on carabao power for primary tillage. However, for post-production labor covariance analysis, only farms using mechanical threshers such as CT, TWT and TWCT (represented by M_3, M_4 and M_5, respectively) are expected to exhibit negative regression coefficients due to the displacement of some post-production labor by mechanical threshers.

The season dummy should exhibit a positive regression coefficient, i.e., $A_6 > 0$, which implies that more labor is used during the dry season than in the wet season. This is particularly true for the land preparation labor covariance analysis since the dry condition of the soil requires more effort and time for land preparation operations. Post-production operations, likewise, should require more labor employment during the dry season since the ideal growing conditions, i.e., absence of strong winds and prolonged cloudy and rainy days, result in higher yields. This, in turn, results in higher post-production labor utilization.

The irrigation variable, I, should also exhibit a positive regression coefficient since water management requires additional labor, particularly from the farm operator.

It is maintained that farmers who own the land they are cultivating are financially better-off compared to those farmers who rent, lease or borrow the land they are farming on. This hypothesis is based on Table 5.1 which shows that farm owners under all the farm categories have higher networth values than those who are non-farm owners. With this information, it is hypothesized that farm owners utilize more hired and less family labor, compared to those who do not own the land they are tilling, since they are more financially capable of hiring additional off-farm labor. This implies that the regression coefficient of the tenure dummy variable, T, will be positive.

Table 5.1. Financial condition of farmers with different land tenure status under the different farm categories, crop year 1979-1980.

Farm Classification		Total Assets	Total Liabilities	Total Net Worth
		(pesos)	(pesos)	(pesos)
Carabao	(C)			
Rented		5,917	1,779	4,138
Owned		12,277	2,575	9,702
Carabao/thresher	(CT)			
Rented		4,708	3,663	1,045
Owned		18,233	2,918	15,315
Two-wheel	(TW)			
Rented		9,477	2,585	6,892
Owned		33,735	4,485	29,250
Two-wheel/thresher	(TWT)			
Rented		7,503	4,637	2,866
Owned		26,083	3,530	22,553
Two-wheel/carabao	(TWC)			
Rented		7,699	1,603	6,096
Owned		23,280	3,689	19,591
Two-wheel/carabao/ thresher	(TWCT)			
Rented		6,678	2,393	4,285
Owned		35,194	3,682	31,512

Output, Q, should have positive effects on the amount of labor used in a farm or in a hectare of land.

The inclusion of the variable referring to the total number of household members per farm, HM, is only applicable for the hired labor covariance analysis model in order to find out whether an inverse relationship exists between the potential source of family labor and the amount of hired labor utilized by the farm.

It is difficult to predict the signs of the regression coefficients of the variables representing the number of years farming experience (Ex) and number of years education of the farmer (Ed) since these variables imply certain inherent managerial qualities of the farm operator. In terms of the covariance model, these two variables pertain to the farm operator's ability to manage labor utilization based on his farming and educational experiences. Since the employment of more (or less) labor does not imply good (or bad) management, the regression coefficients of Ex and Ed will only be tested for its significance with regard to their effect on labor utilization. However, the cropping intensity variable (CPI) is expected to exhibit a positive regression coefficient.

It should be noted that the labor wage rate per hour varies depending on the type of farm operation labor is being hired for. This being the case, the wage rate for land preparation differs from that for planting, care/cultivation and post-production operations. Furthermore, not all farms face the same wage rates for similar farm operations due to variations in labor demand during the rice production period. Due to the heterogeneity of the labor wage rate among farm operations and individual farms within each farm classification, it is deemed necessary to specify an average labor wage rate which will reflect the wage rate of all farm operations in each farm classification. For analytical purposes, the farm-specific average labor wage rate is calculated as:

$$\frac{(HLP_{ij})(WLP_{ij})+(HP_{ij})(WP_{ij})+(HCC_{ij})(WCC_{ij})+(HPP_{ij})(WPP_{ij})}{T_{L_{ij}}}=P_{L_{ij}} \quad (5.2)$$

where: i is the ith farm in the jth farm classification.

j is the jth farm classification.

HLP is the total hired labor hours utilized for land preparation operations per hectare.

HP is the total hired labor hours utilized for planting operations per hectare.

HCC is the total hired labor hours utilized for care/cultivation operations per hectare.

HPP is the total hired labor hours utilized for post-production operations per hectare.

WLP is the actual wage rate per hired man-hour for land preparation operations.

WP is the actual wage rate per hired man-hour for planting operations.

WCC is the actual wage rate per hired man-hour for care/cultivation operations.

WPP is the actual wage rate per hired man-hour for post-production operations.

$P_{L_{ij}}$ is the farm-specific average labor wage rate of the ith farm in the jth farm classification.

Having calculated the farm-specific average labor wage rate ($P_{L_{ij}}$), the wage:rice price ratio (WRP) is then specified by using the average price per kilogram of rough rice received by the ith farm in the jth farm classification ($P_{q_{ij}}$) as the denominator.

The wage:rice price ratio (WRP) is expected to be negative for the labor covariance models which analyze the hired labor component of each farm operation. This implies that higher increases (or decreases) in the labor wage rate relative to the increases (or decreases) in the price per kilogram of rough rice results in a decrease (or increase) in the amount of hired labor employed for a particular farm operation. In analyzing the total labor demand, this ratio is also expected to exhibit a negative sign. However, for the family labor covariance analysis, the variable WRP is expected to be positive—meaning that higher increases (or decreases) in the labor wage rate relative to the increases (or decreases) in the price per kilogram of rough rice results in an increase (or decrease) in the amount of family labor utilized in a particular farm operation. This phenomenon is expected to occur since hired labor becomes more (or less) expensive, thus forcing the farm household to rely more on its family labor resource.

Since networth (NW) reflects the financial status of a particular farm, farms with high networth values, i.e., well-to-do farm households, are expected to utilize more labor than those with low networth. Therefore, the regression coefficient of NW is expected to exhibit a positive sign.

Farm budget analysis. In order to evaluate differences in farm performance between mechanized and non-mechanized farms, as well as among farms with different modes of mechanization, an analysis of the farm budget of each farm classification will be conducted. This method not only provides information regarding revenues and expenditure of each farm group but also facilitates the identification of specific variables which differentiate one farm classification from another.

Net farm income, as a measure of farm performance, may be calculated by accounting for the value of cash and non-cash farm transactions as well as the changes in farm assets over the accounting period under consideration.[96] This generally involves comparing the total value of output and total expenditures incurred during the production process of a particular commodity (or a set of commodities) within a specific production period.

1. Farm revenue. In this thesis, the main commodity considered is rice. Furthermore, in order to eliminate the effect of farm size on net farm income and facilitate comparative budget analysis among the different farm groups, the budgets are constructed on a per hectare basis. Therefore, the total revenue per hectare of each farm classification is the average actual yield per hectare of a specific farm classification (i.e., C, CT, TW, TWT, TWC and TWCT) multiplied by the "farm gate" price of rough rice received by farmers.

2. Total gross benefits. However, a portion of this total revenue is generally paid in kind to harvesters and threshers for their services and to landowners as payment for the use of the

land. This portion is called "output share" and is valuated in terms of the farm gate price. Subtracting the value of output share from the total revenue (or the total value of output) gives total gross benefits which is the value of the rice crop that is left with the farmer after paying in-kind harvesting costs and rent paid to landlord.

It is important to note that not all farms within each specific group incur land rent as an expense. For rice farms owned by the farmer operator, the opportunity cost of land will have to be calculated in order to impute the value of land rent for these farm-operator-owned farms. The imputed land rent is calculated as the average rent paid by all farmers within each farm group who rented land.

3. <u>Farm paid-out costs</u>. Paid-out costs include those expenses for hired labor, production material inputs and other miscellaneous variable expenses, i.e., tractor rent, repairs and maintenance and marketing costs. It should be noted that difficulties arise in separating current farm debt from previous debts as well as in estimating the actual portion of each specific farm loan that was actually used for production, education and home consumption. In order to facilitate analysis, it is assumed that farmers in all farm categories rely on credit for financing production expenses. Interest expense is computed at 30% per annum or 15% per season.[97]

a. <u>Hired labor expense</u>. The average hired labor expense for each farm classification is computed by estimating the average number of man-hours utilized for each farm operation.

Having done this, the labor hours spent for a particular operation is multiplied by the average wage rate per hour that is charged for that particular farm operation within a specific farm classification. The total hired labor expense is calculated by summing the cost of hired labor for all operations.

b. Production materials expense. Five major items are considered in this expense category. These are:

(1) Seeds expense - Due to limited information regarding the amount of rice seed utilized by each farm household in each farm classification, it is assumed that the seeding rate per hectare is 50 kilograms. Seeds expense is arrived at (for each farm classification) by multiplying this assumed seeding rate by the actual average price of rice seed that was calculated for each farm classification.

(2) Fertilizer expense - This expense is computed by estimating the average value of fertilizer expense for each farm classification. No attempt was made in disaggregating this expenditure into expenses incurred for different types of fertilizer due to data limitations. This is reflected by the fact that the amount of fertilizer, in kilogram/hectare, is expressed in aggregate form.

(3) Chemicals expense - Similarly, this expense is computed by obtaining the average value of chemicals expense for each farm classification due to

disaggregation difficulties.

(4) Irrigation expense - This is also the average value of irrigation expense for each farm classification. It should be noted that such expense includes fuel and oil.

(5) Expenditure on sacks - Since each rice sack holds 50 kilograms of paddy rice, the number of sacks per production period is calculated by dividing the average total yield per hectare of each farm classification by this value. This is then multiplied by one peso which is the assumed price per sack.

c. Miscellaneous variable expenses. This is composed of the following items:

(1) Tractor rent - In the two major municipalities considered in the study, tractor services may be hired in two possible alternatives. The first is on a daily basis at 100 pesos per day or approximately 12.50 pesos per hour for an eight-hour day. This includes payment to the two-wheel tractor operators who pocket 40 percent of the two-wheel tractor rented rate. The second is on a per hectare basis which ranges from 250 to 350 pesos per hectare. This includes at least one plowing and three harrowings, depending on the village under consideration as well as on the arrangements agreed upon by the farmer and the two-wheel tractor owner. In order to simplify the estimation of tractor rental expense, the first alternative was chosen and it was assumed that 60 percent of the man-machine hour rate for land

preparation (for each farm category) approximates the hourly tractor rent. Multiplying this value by the total family labor hours devoted to land preparation using a two-wheel tractor, the total tractor rent per farm category is arrived at.

(2) Repairs and maintenance - This is expressed as the average value of repairs and maintenance expense of each farm category.

(3) Marketing costs - This expense includes all the costs of transportation and hauling the harvested rice to the rice mill.

4. Gross farm family income. By subtracting total paid-out costs from total gross benefits, gross farm family income is obtained. This represents the return to family labor, capital and management.

5. Net farm family income. This is obtained by calculating for the difference between gross farm family income and depreciation. It is the return to family labor and management. Depreciation is based on a ten-year straight line method which takes into account the wear and tear of such assets as draft animals, farm tools and implements and farm machinery.

6. Imputed value of farm family labor. Of all the items of the farm budgets, the imputed value of family labor is the most difficult to estimate. This is because family labor may not enter the market in a general sense, so a direct cash cost of household labor may not exist. In order to understand the behavior of subsistence and/or semi-subsistence farmers who combine a farm

business with "a way of life", the concept of opportunity cost must be given considerable attention. Opportunity cost, generally defined, is the value of a resource in its best alternative use. In terms of farm labor, this definition implies two things, (1) that the farmer has other skills aside from farming and (2) that the farmer posseses a scarce resource known as time for which he has opportunity costs. For the purpose of this thesis, it is maintained that all the farmer operators possess the same skills, that is only farming skills. It would seem that this is realistic since, in general, farmers in the survey areas mainly rely on rice farming as a major source of income. However, more importance is extended to the opportunity costs of their time. The reason for this is that they have the choice of intensively cultivating their ricefields, or doing a less intensive job and enjoying more leisure time, or working for some other farmer.

Having established that farmers have opportunity costs for their time, the next consideration is the method of imputing the value of family labor. When imputing family labor value, one must take into consideration the labor demand situation at a specific point in time. During peak periods of land preparation, planting and post-production operations, high demands for hired labor result in farm labor shortages which in turn causes the wage rate to increase. However, during slack periods, farm labor wage rates become stable at a low level. Therefore, if the value of family labor is imputed during peak demands for farm labor, estimates will be at a higher level while during slack periods, the estimates will be at a lower level. In order to simplify the estimation, an average hired labor wage rate for each farm activity is used in order to establish values for family labor utilized in specific farm activities for each farm observation. Such values are then used to estimate the weighted average value of imputed family labor, the formula of which is presented below:

(5.3) $$WR_i^v = IFLV_i^f$$

where: i pertains to specific farm operations such as land preparation, planting, care/cultivation and post-production.

WR_i^v refers to the estimated average wage rate for the ith operation in a particular village.

$IFLV_i^f$ refers to the imputed family labor value for the ith farm operation for a particular farm.

7. Net farm income. This is obtained by subtracting the opportunity costs of family labor (or the imputed value of family labor) from net farm family income. This represents the return to management for each farm classification.

It is worthwhile to mention that the above analysis provides information with regard to intensity differences in input utilization among farms with different modes of mechanization. This information, in turn, is very useful for constructing a production function for the purpose of identifying the inputs, i.e., land, labor, fertilizer, chemicals, irrigation, which exert significant influences on rice output variations for each farm classification.

Production function analysis. A farm may be defined as a technical unit which transforms inputs into outputs subject to the technical rules of its production function and the random effects of uncontrollable factors such as weather, pests and diseases. The decision-making unit of the technical unit is the farm operator who decides "what to produce", "how much to produce" and "how to allocate his limited resources in the production of the commodity to produce". The quality of the decision-making ability of the farm operator is, in turn, reflected by profit he realizes or by the loss he incurs as a result of his decisions involving the overall farm operations. With this farmer behavioral background, it seems realistic to assume that a farming entity attempts to maximize its profits.

However, in its process of maximizing profits, the firm is faced with two constraints — (1) market constraints and technological constraints.[98] For the purpose of this paper, each farm unit, i.e., rice farm unit, is assumed to be a price taker with respect to input and output prices. This implies that the farm is one of the many rice producers in a competitive rice industry — which is just the case in the Philippine rice industry. "Technological constraints are simply those constraints that concern the feasibility of the production plan".[99] In a broad sense, this may involve the level of technology on hand, the amount of resources a farm is able to readily utilize in the production process and the various uncontrollable factors which may affect both the amount of resources used and the amount of output produced. For the purpose of developing a production function model, consider the short-run production function of the jth farm group with the following relationship:[100]

(5.4) $Q_j = f(X_{1j}, X_{2j}, X_{3j})$

where: Q_j is the output produced by farm j.

X_{1j} and X_{2j} are the variable inputs employed by the jth farm in the production of Q_j.

X_{3j} is a fixed input where the maximum level X_{3j} is given by $\bar{X}_{3j}$.

Expressing the above expression in a Cobb-Douglas production function form, the following is obtained:

(5.5) $Q_j = A_j X_{1j}^{a} X_{2j}^{b} X_{3j}^{c} e^{u_j}$

where: $X_{1j}, X_{2j} > 0$

$\bar{X}_{3j} > X_{3j} > 0$

$1 > a,b,c > 0$

A_j is the technical efficiency parameter of the jth farm.

a,b and c are the elasticities of output with respect to the individual inputs employed which also indicate the relative share of each input in the total product.[101]

The estimation of a single equation production function, as expressed by equation (5.5), often gives rise to such problems of simultaneous equation bias and specification bias. The latter arises out of omitting farm-specific factors from the production function model. On the otherhand, simultaneous equation bias results from the estimation of only one equation which is embedded in larger system of equations[102] — "the system is such that some of the independent variables, as well as the dependent variable, are functions of the disturbance term in the given equation. This contradicts the assumptions underlying single equation regression since the presumed independent variables are in fact correlated with the disturbance."[103] The succeeding discussion provides information on how to avoid the problem of simultaneous equation bias.

It is conventional to assume that the production function of the jth farm group is stochastic. Furthermore, the random error u_j is assumed to have the usual classical properties and can be rationalized as being due to random error, i.e., unpredictable variations in other factors which affect output but not included in the specified production function. Since the effect of the random error on output is not known until after the factors of production have been committed, farmers undertake decisions regarding input utilization under conditions of uncertainty. Under such conditions, it is realistic to assume that the main objective of farmers is to maximize expected output and, subsequently, their expected profit. In mathematical terms, this is expressed by the following:

(5.6) $\text{Max } E[\Pi_j] = \text{Max } P_q \cdot E[Q_j] - P_1X_{1j} - P_2X_{2j} - F_j$

subject to:

$$X_{1j} > 0$$

$$X_{2j} > 0$$

$$X_{3j} = \bar{X}_{3j}$$

where: $E[\Pi_j]$ is the expected profit of the jth farm.

P_q is the price of output.

$E[Q_j]$ is the expected output of the jth farm.

P_1 is the price of input X_{1j}.

P_2 is the price of input X_{2j}.

F_j is the cost of fixed input X_{3j}.

The first order, necessary conditions for a maximum for a price-taking farm are:

$$\frac{E[\Pi_j]}{X_{1j}} = P_q \cdot a \frac{E[Q_j]}{X_{1j}} - P_1 = 0$$

(5.7a)
$$P_q \cdot a \frac{E[Q_j]}{X_{1j}} = P_1$$

$$\frac{E[\Pi_j]}{X_{2j}} = P_q \cdot b \frac{E[Q_j]}{X_{2j}} - P_2 = 0$$

(5.7b)
$$P_q \cdot b \frac{E[Q_j]}{X_{2j}} = P_2$$

Equations (5.7a) and (5.7b) imply that if a profit maximizing farm uses both X_1 and X_2 inputs, then each should be utilized until the input price of X_1 (or X_2) is equal to the expected marginal value product of X_1 (or X_2).

The second-order, sufficient conditions for a maximum will always be satisfied if the production function is strictly concave for all positive values of X_1 and X_2. This implies that $(a + b) < 1$ or decreasing returns which, in turn, implies the operation of variable proportions.[104]

Taking the logarithm of equations (5.5), (5.7a) and (5.7b) and expressing the system of equations in matrix form, the following is obtained:

$$(5.8) \quad \begin{bmatrix} 1 & 0 & -a & -b \\ 0 & 1 & -1 & 0 \\ 0 & 1 & 0 & -1 \end{bmatrix} \begin{bmatrix} \ln Q_j \\ \ln E[Q_j] \\ \ln X_{1j} \\ \ln X_{2j} \end{bmatrix} = \begin{bmatrix} \ln A + c \ln X_{3j} \\ \ln (P_1/P_q) - \ln a \\ \ln (P_2/P_q) - \ln b \end{bmatrix} + \begin{bmatrix} u_j \\ 0 \\ 0 \end{bmatrix}$$

From the above relationship, it may be observed that inputs X_1 and X_2 are independent of the random error term, u_j, in the production function. This implies that "shifts in the production relation affect actual output, Q_j, but not expected output, $E[Q_j]$, and hence, when these shifts occur, the level of input is not affected."[105] Therefore, ordinary least squares estimates of the parameters of the production function are unbiased and consistent.

In the process of developing a model, in this case a production function model, the researcher tends to omit variables due to (1) data limitations, (2) lack of knowledge regarding the factors that determine the phenomenon being studied, (3) problems of multicollinearity, since economic variables tend to be correlated with each other, and (4) the desire to simplify the model in order to facilitate statistical analysis and/or to permit data collection feasible. To minimize the occurrence of specification bias due to the omission of relevant variables, other factors that exert their influence on output variations are included in the model. Based on a priori knowledge, unquantifiable variables such as irrigation and weather are included, aside from those that are quantifiable such as labor hours, amount of fertilizer and chemical expenditure. Furthermore, an attempt is made to incorporate other demographic variables (such as years of education and experience of farmer) and institutional variables (such as the quality of extension services and membership in farmers' organization) in the estimated production in order to investigate whether such variables play important roles in output variations.

Production function statistical model. This section discusses the specified production function model used for investigating which factors of production play significant roles in rice output variations. The rice production function for the farms considered in the study, with the usual neoclassical properties, is specified as:

$$(5.9) \quad Q_{ij} = f(L_{ij}, F_{ij}, Ch_{ij}, I_{ij}, Ed_{ij}, Ex_{ij}, ES_{ij}, FO_{ij}, S)$$

where: j refers to farms with different modes of mechanization such as C, CT, TW, TWT, TWC and TWCT farms which have been previously defined.

i refers to the individual farm belonging to farm group j.

Q is farm output per hectare of the ith farm belonging to the jth farm group which is measured in terms of total kilograms.

L is the total man-labor hours utilized for rice production per hectare.

F is the total amount of fertilizer used per hectare, in kilograms.

Ch is the total expenditure per hectare on weedicides/herbicides, insecticides and other chemicals used for rice production, in pesos.

I is an irrigation dummy which takes the value of one if the farm is irrigated and zero if it is rainfed.

Ed is the total number of schooling years the farm operator has had.

Ex is the number of years experience the farmer has in farming.

ES is the quality of extension services provided to the farmer which is a subjective assessment by the farmer himself, i.e., it takes the value of one if the farmer thinks that the extension services provided are adequate and zero if not.

FO is a dummy variable representing government policies. This tries to measure the effect of institutional factors such as membership in a village organization, i.e., Samahang Nayon. This takes the value of one for members and zero, otherwise.

S is a season dummy variable which takes the value of zero wet season and one for dry season.

Expressing (5.9) in terms of a Cobb-Douglas production function, the following is obtained:

$$(5.10) \quad Q_{ij} = A_j \, L_{ij}^{a_l} \, F_{ij}^{a_f} \, Ch_{ij}^{a_c} \, e^{b^*}$$

where: A_j is the technical efficiency parameter of the jth farm.

$b^* = (b_i I_{ij} + b_{ed} Ed_{ij} + b_{ex} Ex_{ij} + b_{es} ES_{ij} + b_{fo} FO_{ij} + b_s S + u)$

The estimating equation is:

$$(5.11) \quad \ln Q_{ij} = \ln A_j + a_l \ln L_{ij} + a_f \ln F_{ij} + a_c \ln Ch_{ij} + b_i I_{ij} + b_s S + b_{ed} Ed_{ij} + b_{ex} Ex_{ij} + b_{es} ES_{ij} + b_{fo} FO_{ij} + u'$$

where: a_i's and b_i's are the regression coefficients.

u' is the residual term.

It should be noted that equation (5.11) will be estimated on a per hectare basis.

Recall that the regression coefficients, a_h, a_l, a_f and a_c, indicate the relative share of each input in the total product. Such estimates, together with the coefficient of the irrigation dummy variable, may be useful in disaggregating the effects of factors such as fertilizer, chemicals, irrigation and season on rice output in order to arrive at the net effect of mechanical power adoption. The adjustment of the rice output of each farm classification is given as follows:

$$(5.12) \qquad Q_j^* = A_j \, L_{ij}^{a_{lj}} \, F_k^{a_{fj}} \, Ch_k^{a_{cj}} \, e^{b_i I_{ij} + b_s S}$$

where: j refers to a particular farm classification, i.e., C, CT, TW, TWT, TWC and TWCT.

Q_j^* refers to the adjusted yield per hectare of a particular farm classification.

A_j is the technical efficiency parameter of the jth farm classification.

a_{lj} is the regression coefficient of the labor variable L_{ij}.

a_{fj} is the regression coefficient of the fertilizer variable F_j.

a_{cj} is the regression coefficient of the variable representing chemicals expense, Ch_j.

b_i is the regression coefficient of the dummy variable representing irrigation, I_{ij}.

b_s is the regression coefficient of the season dummy variable S.

L_{ij} is the average labor hours utitlized by the ith farm in the jth farm classification.

F_k is the average amount of fertilizer, in kilograms, that the carabao farm classification applied during a production season.

Ch_k is the average expenditure that the carabao farm classification incurred for chemicals.

I_{ij} is an irrigation dummy variable which is unity for irrigated farms and zero, otherwise. To adjust for the effect of irrigation, I_{ij} will take the value of zero.

S is a season dummy which takes the value of unity for wet season and zero, otherwise. In computing for the adjusted yield, S will be given a zero value.

Footnotes

Chapter V

[96]John L. Dillon and J. Brian Hardaker, Farm Management Research for Small Farms Development, FAO Agricultural Services Bulletin (41), Food and Agriculture Organization of the United Nations, Rome, 1980, p. 43.

[97]This is the same interest rate assumed by R. W. Herdt and L. A. Gonzales in their paper entitled, "The Impact of Rapidly Changing Prices on Rice Policy Objectives and Instruments in the Philippines, 1980," a paper prepared for the National Rice Strategy Seminar, September 22-24, 1980, Los Baños, Philippines. Agricultural Economics Department Paper No. 80-16, The International Rice Research Institute,

Los Baños, Laguna, Philippines.

98Hal R. Varian, Microeconomic Analysis, W. W. Norton and Company, New York, 1978, p. 3.

99Ibid., p. 2.

100The discussion in this section follows that of J. Lingard, L. Castillo, S. Jayasuriya and L. Garcia in their paper entitled, "Comparative Efficiency of Rice Farms in Central Luzon: Production Function Estimation Using Matched Farm Data 1970-1979," The International Rice Research Institute, Los Baños, Laguna, Philippines.

101Alpha C. Chiang, Fundamental Methods of Mathemathical Economics, 2nd Edition, McGraw-Hill Book Company, New York, 1974, p. 409.

102J. Lingard, L. Castillo, S. Jayasuriya, and L. Garcia, "Comparative Efficiency of Rice Farms in Central Luzon: Production Function Estimation Using Matched Farm Data 1970-1979," op. cit., p. 3.

103I. Hoch, "Simultaneous Equation Bias in the Context of the Cobb-Douglas Production Function," Econometrica (26), 1958, p. 568.

104J. Lingard, L. Castillo, S. Jayasuriya, and L. Garcia, op. cit., p. 6.

105I. Hoch, "Simultaneous Equation Bias in the Context of the Cobb-Douglas Production Functions," op. cit., p. 569.

Chapter VI

Project Site Description

The data for this study was obtained from the farm survey conducted by the International Rice Research Institute in the province of Nueva Ecija for the "Consequences of Small Rice Farm Mechanization Project." The province is located in the Central Luzon region which is considered as the rice granary of the Philippines. The labelled area in Figure 6.1 indicates this region. The Central Luzon region is composed of the following provinces: a) Bataan, b) Bulacan, c) Pampanga, d) Tarlac, e) Zambales and f) Nueva Ecija. Referring to Table 6.1 it may be observed that, relative to the other regions, Central Luzon has the highest share of the nation's actual total rice production. Its share for the 1979 production year was 16.8 percent while for 1980 it was 16.5 percent. Although the region only ranks third (as of 1980) in total rice area (Table 6.2), it exhibits the highest yield per hectare as compared to the other regions as seen in Table 6.3. Furthermore, it may be observed that Central Luzon's average yield per hectare is comparatively higher than the national average for both 1979 and 1980 cropping seasons.

The prevailing climate in this region is tropical, characterized by a distinct wet season during the months of May through October and a dry season from November through April. Most farmers with accessible irrigation facilities are able to plant two crops of rice a year. For the wet season, land preparation is usually initiated in June extending through July depending on the availability of water.

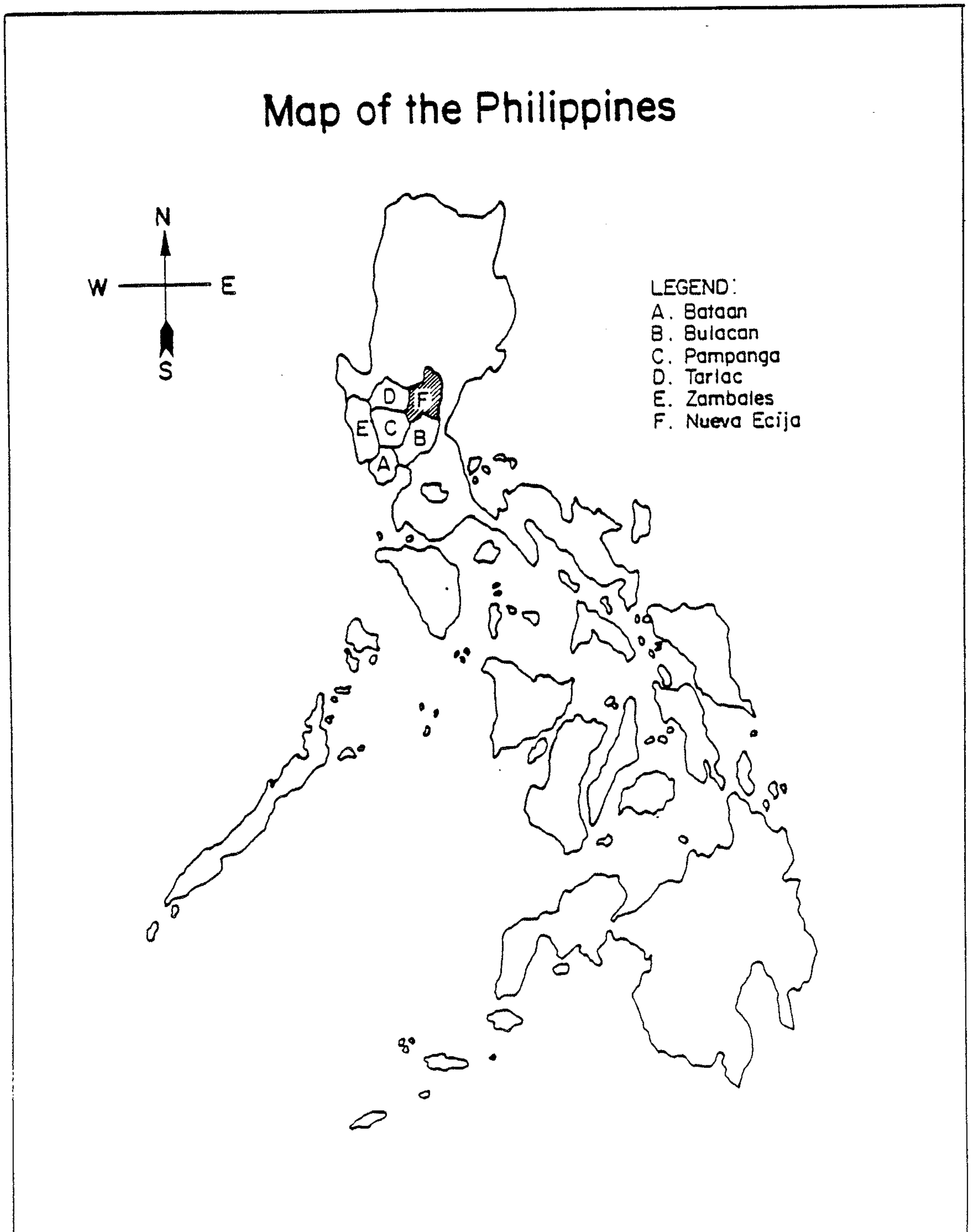

Figure 6.1 Location of the Central Luzon Region and its provinces.

Table 6.1. Regional distribution of rice production, Philippines, 1979-1980.

Region	1979		1980	
	Metric Tons	% Share	Metric Tons	% Share
Ilocos	638,650	8.9	647,150	8.5
Cagayan Valley	847,745	11.8	785,580	10.3
Central Luzon	1,208,740	16.8	1,255,610	16.5
Southern Tagalog	813,985	11.3	774,385	10.2
Bicol	598,785	8.3	635,955	8.4
Western Visayas	935,755	13.0	1,081,060	14.2
Central Visayas	125,655	1.7	162,800	2.1
Eastern Visayas	254,810	3.5	281,170	3.7
Western Mindanao	409,865	5.7	363,295	4.8
Northern Mindanao	265,670	3.7	264,695	3.5
Southern Mindanao	435,150	6.1	568,805	7.5
Central Mindanao	662,740	9.2	783,825	10.3
PHILIPPINES	7,197,550	100.0	7,604,330	100.0

Source: Bureau of Agricultural Economics, Manila, Philippines.

Table 6.2. Regional distribution of rice area, Philippines, 1979–1980.

Region	1979	1980
	(hectares)	
Ilocos	321,480	311,410
Cagayan Valley	416,100	369,650
Central Luzon	399,590	409,630
Southern Tagalog	425,240	424,480
Bicol	286,030	314,350
Western Visayas	468,360	518,660
Central Visayas	73,940	109,850
Eastern Visayas	171,360	173,240
Western Mindanao	147,090	141,300
Northern Mindanao	164,290	128,370
Southern Mindanao	176,880	209,020
Central Mindanao	418,540	393,090
PHILIPPINES	3,468,900	3,503,050

Source: Bureau of Agricultural Economics, Manila, Philippines.

Table 6.3. Average rice yield per hectare, Philippines, 1979-1980.

Region	1979	1980
	(metric tons per hectare)	
Ilocos	1.99	2.08
Cagayan Valley	2.04	2.13
Central Luzon	3.02	3.07
Southern Tagalog	1.91	1.82
Bicol	2.09	2.02
Western Visayas	2.00	2.08
Central Visayas	1.70	1.48
Eastern Visayas	1.49	1.62
Western Mindanao	2.79	2.57
Northern Mindanao	1.62	2.06
Southern Mindanao	2.46	2.72
Central Mindanao	1.58	1.99
PHILIPPINES	2.07	2.17

Source: Bureau of Agricultural Economics, Manila, Philippines.

Planting is usually done in July until August while harvesting generally starts in October and peaking in November. Dry season land preparation starts in late December or early January or when sufficient water is available. During the period of mid-January up to the end of February, planting operations are usually undertaken so that the dry season crop is ready for harvest during the months of April and May.

The project site consists of two municipalities, Cabanatuan City and the town of Guimba, from which eight sample villages — four from each municipality — were selected for farmer interviews. Figure 6.2 presents the map of Nueva Ecija province indicating the survey areas. The interviews conducted by the International Rice Research Institute for the "Consequences of Small Rice Farm Mechanization Project" were initially undertaken within the period of March-April 1979 during which a mini-census of the entire eight villages was undertaken. For additional information, a survey of sample farm households was conducted during the wet season of 1979 and the dry season of 1980. This survey covered stratified randomly selected households in all villages.

Sampling Procedure

Since the data for this research were based on the farm household survey of the "Consequences of Small Rice Farm Mechanization Project", this section describes the sampling procedure used in the project for collecting relevant data.

Village level. The first step was to identify the rice region in the Philippines where machinery has been adopted in sufficient levels

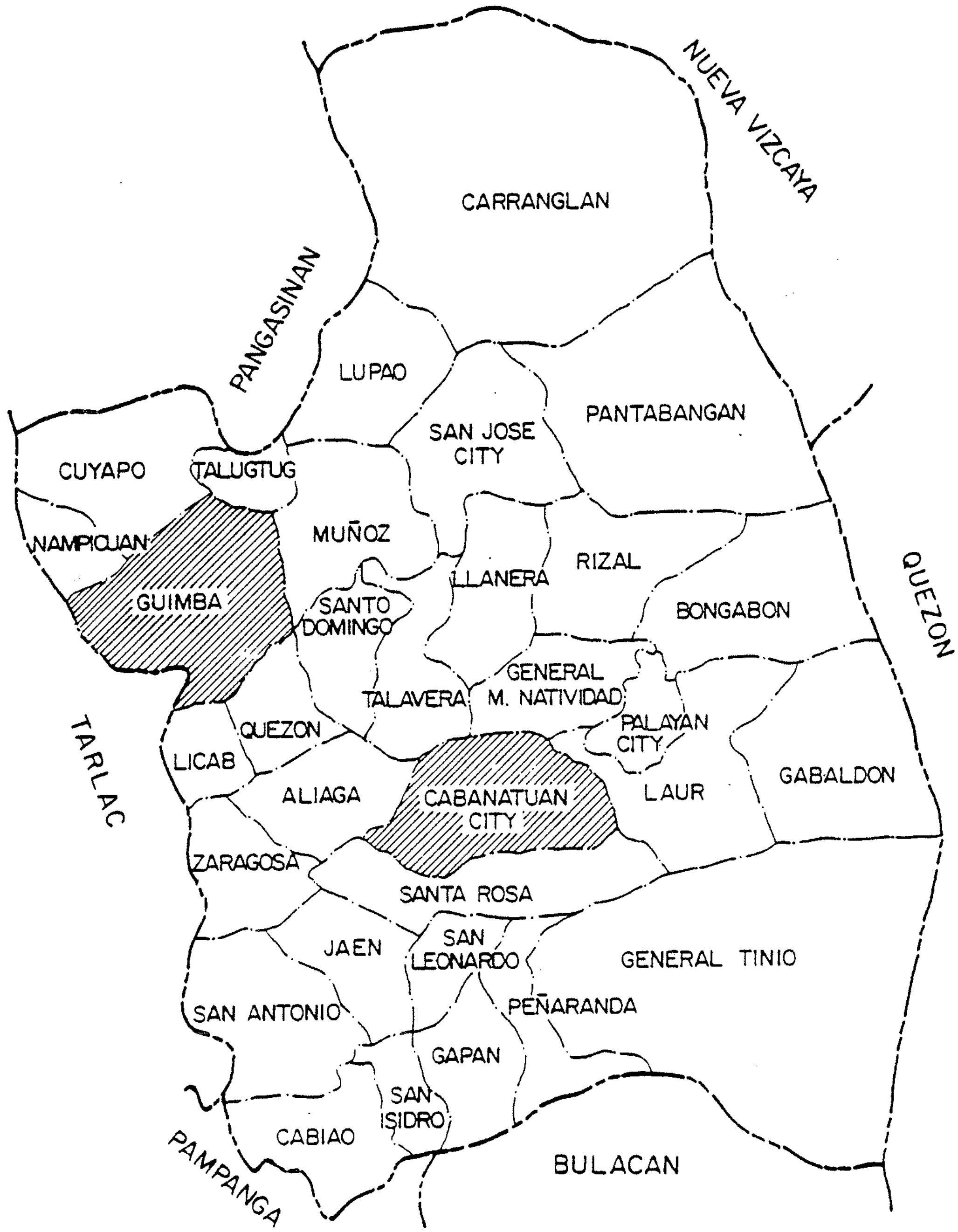

Figure 6.2 Map of Nueva Ecija province showing the sample areas.

in order to make such an inquiry meaningful. The second step was to identify villages or groups of villages where farmer household interviews may be conducted. For this purpose, the municipalities of Cabanatuan City and Guimba were chosen. Selection of the two municipalities was based on: "the type and extent of irrigation available and degree of mechanization in land preparation. Additional considerations include: accessibility by transportation, proximity of the municipalities to each other and availability of secondary data describing each district. To select the sample villages, the villages in each municipality were grouped into the following categories using current secondary data: (1) rainfed, low level of mechanization, (2) rainfed, high level of mechanization, (3) irrigated, low level of mechanization and (4) irrigated, high level of mechanization. The mechanization index was portrayed by the number of four-wheel/two-wheel tractors found in each village (used mainly for land preparation). Since the average number for all villages was five, this number was a cut-off point and villages with five or more were considered to have high level of mechanization while those with less than five were considered to have a low level."[106]

A census of all farm households in the selected villages was taken. The information derived from this village census provided important information for the purpose of drawing a stratified random sample from the household list.

Farm household level.[107] Based on the household census, households[108] were grouped into rice farm households,[109] field labor households (landless)[110] and non-farm households.[111] A total enumeration of the sample villages was undertaken since the number of households in each village was rather small, ranging from 100 to 400 households per village. Having identified the three major household categories, the rice farm households were further stratified into different groups based on the type of irrigation and power used for land preparation. These groups are the following:

1. rainfed — animal power
2. rainfed — two-wheel tractor
3. rainfed — four-wheel tractor
4. irrigated one cropping season — animal power
5. irrigated one cropping season — two-wheel tractor
6. irrigated one cropping season — four-wheel tractor
7. irrigated two or more cropping seasons — animal power
8. irrigated two or more cropping seasons — two-wheel tractor
9. irrigated two or more cropping seasons — four-wheel tractor

It should be noted that the field labor households were placed into a separate stratification grouping (the landless labor cell), thus making a total of ten different stratification cells. The non-field labor household group was dropped from the sample.

For the rice farm households, the stratification unit used was the parcel[112] not the total farm-holding. Excluded from the stratification exercise were parcels located outside the sample villages. Parcels or total farm-holdings of more than 10 hectares were also excluded since this size category is outside the definition of small farm. In the case of farmers with more than one parcel, stratification was based on the parcel with the largest area planted to rice. If the largest parcel was located outside the sample village, the largest among parcels within the village was chosen to characterize the total farm-holding.

After all rice farm households and field labor households had been placed in representative stratification cells, 40 households were randomly drawn from each of the first 9 cells, with the last 5 households serving as substitutes or replacements in case of dropouts. For the landless labor classification, 60 samples were drawn, with the last 10 serving as replacements. In the case of cells with census populations with less than the required number of observations, a total enumeration of that classification was taken.

Demographic Characteristic of Villages

As obtained from the household census, most of the household heads in the villages were farmers, with Guimba exhibiting a higher percent distribution of farmer operators than Cabanatuan City (Table 6.4). On the otherhand, Cabanatuan City exhibited a higher percent distribution of household heads which derive income from non-agricultural sources. This may be attributed to the villages' proximity to the city proper where a variety of non-farm employment opportunities are available. Landless household heads, which are potential sources of farm labor, varied from five to eighteen percent across the villages.

Table 6.5 presents some demographic characteristics of the sample households by village. From this table, it may be observed that, across villages, the households are relatively homogeneous in terms of the average age, education and experience of farm operator as well as the average total number of members per household.

Table 6.4. Distribution of households by occuptional group in selected villages of Cabanatuan City and Guimba, Nueva Ecija, March 1979.

Village	Total Number of Households	Distribution by Occupational Group (%)		
		Farm Operator	Landless Laborer	Non-agricultural Worker
Cabanatuan				
San Isidro	200	55.5	15.5	29.0
Lagare	153	69.9	18.3	11.8
Kalikid Sur	282	48.9	5.3	45.7
Caalibang-bangan	410	48.3	17.1	34.6
Guimba				
Galvan	134	80.6	14.2	5.2
Narvacan I	89	80.9	7.9	11.2
San Andres	125	87.2	11.2	1.6
Bunol	283	70.3	17.3	12.4
Total	1676	62.2	13.9	23.9

Source: Household Census, 1979, as presented by Presentacion B. Moran and Edith C. Camacho in their report on the "Consequences of Farm Mechanization Project Site Description: Philippines." A paper presented at the Joint ADC/IRRI Workshop on the Consequences of Small Rice Farm Mechanization in Asia, The International Rice Research Institute, Los Baños, Laguna, Philippines, 14-18 September 1981.

Table 6.5. Demographic characteristics of selected villages in Nueva Ecija, Philippines, wet season 1979.

Item	Cabanatuan City				Guimba			
	San Isidro	Lagare	Kalikid Sur	Caalibangbangan	Galvan	Narvacan I	San Andres	Bunol
Number of households	49	47	24	77	35	39	45	53
Average age of household head (years)	47.6	46.3	45.1	44.7	46.3	39.7	41.6	45.1
Average education of HH head (years)	4.9	3.7	3.9	4.6	3.9	4.8	5.4	5.1
Average number of years experience in farming (years) (farm operators only)	22.4	17.5	18.9	21.12	21.50	14.2	17.1	19.3
Average number of household members:								
Male (over 10 yrs. old)	2.4	2.0	2.7	2.3	2.2	2.0	2.2	2.2
Female (over 10 yrs.old)	2.1	2.2	2.0	1.9	2.1	1.6	1.9	2.1
Child (male or female below 10 yrs. old)	1.3	1.2	1.2	1.7	1.2	2.0	1.5	1.2
Total	5.9	5.4	5.9	5.9	5.5	5.6	5.6	5.5
Average number of permanent laborers per houshold:								
Male	0.1	–	–	0.2	0.3	0.3	0.1	0.1
Female	–	–	–	–	–	–	–	–
Total	0.1	–	–	0.2	0.3	0.3	0.1	0.1

Source: Farm Surveys, Wet Season 1979, as presented by Presentacion B. Moran and Edith C. Camacho in their report on the "Consequences of Farm Mechanization Project Site Description: Philippines." A paper presented at the Joint ADC/IRRI Workshop on the Consequences of Small Rice Farm Mechanization in Asia, The International Rice Research Institute, Los Baños, Laguna, Philippines, 14-18 September 1981.

Land and Farm Characteristics of Villages

The physical and farm characteristics of each village are presented in Table 6.6. Bunol was observed to have the largest farmland area among all the villages under consideration, amounting to approximately 422 hectares. Average farm size across villages ranges from 1.8 to 2.7 hectares while the average area planted to rice ranges from 1.7 to 2.3 hectares. It is may be observed that the variation in average size of landholding becomes more pronounced when the comparison across villages is made according to land tenure status of the farm operator. This may be observed in Table 6.7.

Land utilization for each village, in terms of type of crop planted is presented in Table 6.8. Note in this table that the major crop in each village is rice which takes up 93 to 100 percent of the total farm area in each village. Of the total rice area, 97 to 100 percent is planted to improved rice varieties. Only a small portion of the land is planted to corn and other crops such as sorghum, tomatoes, mungbeans, stringbeans and chillies. The average rice cropping intensity for the farm in each village ranges from 100 to 201 percent, with the villages of San Isidro, Lagare and Caalibangbangan exhibiting the highest cropping intensity. It is worthwhile to note that 98 to 99 percent of the total farm area of these three villages are gravity-irrigated (Table 6.9) which makes it ideal for rice farmers to grow a second crop during the production year. The impact of such accessible water supply may be reflected by the high average rice yields[113] attained by farms in these same gravity-irrigated villages, particularly during the dry season (Table 6.10). An exception to this is the village of Bunol which has a

Table 6.6. Farm characteristics of selected villages in Cabanatuan and Guimba, Nueva Ecija, Philippines, wet season 1979.

Item	Cabanatuan City				Guimba			
	San Isidro	Lagare	Kalikid Sur	Caalibangbangan	Galvan	Narvacan I	San Andres	Bunol
Number of farms	111	107	138	198	108	72	109	199
Total farm area	260.71	194.48	374.33	358.53	188.25	130.47	215.67	421.92
Average farm area	2.35	1.82	2.71	1.81	1.74	1.81	1.98	2.12
Total number of parcels operated	152	131	162	214	131	87	173	260
Number of parcels per farm	1.37	1.22	1.17	1.08	1.21	1.21	1.59	1.31
Total area planted to rice	254.31	194.48	293.38	348.93	183.25	129.45	209.21	394.24
Average area planted rice	2.29	1.82	2.13	1.76	1.70	1.80	1.94	1.98

Source: Household Census 1979, as presented by Presentacion B. Moran and Edith C. Camacho in their report on the "Concequences of Farm Mechanization Project Site Description: Philippines." A paper presented at the Joint ADC/IRRI Workshop on the Consequences of Small Rice Farm Mechanization in Asia, The International Rice Research Institute, Los Baños, Laguna, Philippines, 14-18 September 1981.

Table 6.7. Tenure status of cultivators by village, Nueva Ecija, Philippines, wet season 1979 and dry season 1980.

Type of tenure	Cabanatuan City				Guimba			
	San Isidro	Lagare	Kalikid Sur	Caalibangbangan	Galvan	Narvacan I	San Andres	Bunol
Wet Season								
Owner[a] (>75% owned)								
Total landholding (has.)	27.97	3.90	33.50	69.88	66.74	62.46	71.22	8.4
Average size of landholding (has.)	2.54	1.30	4.20	2.18	2.0	2.23	2.16	2.1
Number of farms reporting	11	3	8	32	33	28	33	4
Part owner[a] (25-75% owned)								
Total landholding (has.)	16.40	15.00	5.00	3.35	-	1.50	14.70	10.50
Average size of landholding (has.)	3.28	5.00	5.00	1.68	-	1.50	2.45	3.50
Number of farms reporting	5	3	1	2	-	1	6	3
Lessee								
Total landholding (has.)	55.65	70.91	23.42	37.70	-	-	-	53.88
Average size of landholding (has.)	2.32	2.15	2.60	1.40	-	-	-	1.86
Number of farms reporting	24	33	9	23	-	-	-	29
Share-cropper								
Total landholding (has.)	-	2.25	3.25	-	-	4.00	-	-
Average size of landholding (has.)	-	1.3	1.62	-	-	4.00	-	-
Number of farms reporting	-	2	2	-	-	1	-	-
Others								
Total landholding (has.)	6.00	-	9.25	1.25	0.75	10.00	3.85	17.75
Average size of landholding (has.)	6.00	-	3.08	0.63	0.75	1.25	1.28	2.54
Number of farms reporting	1	-	3	2	1	8	3	7
Dry Season								
Owner[a] (>75% owned)								
Total landholding (has.)	32.12	3.90	-[b]	80.27	6.10	27.95	23.19	12.20
Average size of landholding (has.)	2.14	1.30	-	2.11	1.52	2.15	2.11	1.74
Number of farms reporting	15	3	-	38	4	13	11	7
Part-owner[a] (25-75% owned)								
Total landholding (has.)	13.85	10.30	-	-	-	-	-	-
Average size of landholding (has.)	4.62	5.15	-	-	-	-	-	-
Number of farms reporting	3	2	-	-	-	-	-	-
Lessee								
Total landholding (has.)	41.25	73.46	-	21.84	2.00	-	-	28.18
Average size of landholding (has.)	2.58	2.16	-	1.56	1.00	-	-	1.48
Number of farms reporting	16	34	-	14	2	-	-	19
Share-cropper								
Total landholding (has.)	-	1.50	-	1.10	-	-	-	1.50
Average size of landholding (has.)	-	1.50	-	1.10	-	-	-	0.75
Number of farms reporting	-	1	-	1	-	-	-	2
Others								
Total landholding (has.)	13.40	2.50	-	6.25	0.50	2.00	3.60	7.30
Average size of landholding (has.)	2.23	2.50	-	1.56	0.50	1.00	0.90	1.46
Number of farms reporting	6	1	-	4	1	2	4	5

[a]Includes amortizing farm owners.
[b]No cultivators this season.

Source: Farm Surveys, Wet Season 1979 and Dry Season 1980, as presented by Presentacion B. Moran and Edith C. Camacho in their report of the "Consequences of Farm Mechanization Project Site Description: Philippines." A paper presented at the Joint ADC/IRRI Workshop on the Consequences of Small Rice Farm Mechanization in Asia, The International Rice Research Institute, Los Baños, Laguna, Philippines, 14-18 September 1981.

Table 6.8. Land use by village, Nueva Ecija, Philippines, wet and dry seasons, crop year 1979-1980.

Item	Cabanatuan City				Guimba			
	San Isidro	Lagare	Kalikid Sur	Caalibangbangan	Galvan	Narvacan I	San Andres	Bunol
Wet Season								
Number of households	49	47	24	76	35	39	45	53
Number of farms reporting a crop	41	41	23	59	35	37	42	43
Total landholding (has.)	146.02	92.06	75.42	112.18	67.11	77.96	89.77	90.53
Total cropped land area (has.)	105.02	89.81	45.72	108.32	60.24	70.66	84.16	77.95
Total area devoted to:								
Traditional rice varieties	-	-	1.40	-	0.50	-	0.25	2.25
Improved rice varieties	105.02	89.81	44.32	105.42	59.74	69.66	83.91	74.55
Other crops	-	-	-	2.90	-	1.00	-	1.55
Dry Season								
Number of households	49	47	24	76	35	39	45	53
Number of farms reporting a crop	40	41	0	59	7	15	15	34
Total landholding (has.)	100.62	91.66	-	109.46	8.60	29.95	26.79	49.18
Total cropped land area (has.)	98.67	90.66	-	107.67	2.95	12.55	9.56	24.41
Total area devoted to:								
Traditional rice varieties	-	-	-	0.50	-	-	-	0.50
Improved rice varieties	98.67	90.66	-	105.07	2.95	11.55	9.56	23.91
Other crops	-	-	-	2.10	-	1.00	-	-
Overall rice cropping intensity (%)	194.00	200.90	100.00	199.40	104.90	117.80	111.40	131.30

Source: Farm Surveys, Wet Season 1979 and Dry Season 1980, as presented by Presentacion B. Moran and Edith C. Camacho in their report of the "Consequences of Farm Mechanization Project Site Description: Philippines." A paper presented at the Joint ADC/IRRI Workshop on the Consequences of Small Rice Farm Mechanization in Asia, The International Rice Research Institute, Los Baños, Laguna, Philippines, 14-18 September 1981.

Table 6.9. Distribution of farm area by water source in selected villages, Cabanatuan and Guimba, Nueva Ecija, Philippines, crop year 1979-1980.

Village	Total Farm Area (has.)	Rainfed Area (has.)	Rainfed Area (%)	Irrigated Area (has.)	Irrigated Area (%)
Cabanatuan					
San Isidro	260.71	4.69	1.8	256.02	98.2
Lagare	194.48	1.94	1.0	192.54	99.0
Kalikid Sur	374.33	342.89	91.6	31.44	8.4
Caalibangbangan	358.53	2.15	0.6	356.38	99.4
Guimba					
Galvan	188.25	171.68	91.2	16.57	8.8
Narvacan I	130.47	41.10	31.5	89.37	68.5
San Andres	215.67	196.91	91.3	18.76	8.7
Bunol	421.92	229.10	54.3	192.82	45.7

Source: Household Census, 1979, as presented by Presentacion B. Moran and Edith C. Camacho in their paper on the "Consequences of Farm Mechanization Project Site Description: Philippines." A paper presented at the Joint ADC/IRRI Workshop on the Consequences of Small Rice Farm Mechanization in Asia, The International Rice Research Institute, Los Baños, Laguna, Philippines, 14-18 September 1981.

Table 6.10. Comparative rice area and yield by village, wet season 1979 and dry season 1980, Nueva Ecija, Philippines.

Area/Village/ Average Yield	No. Reporting[a]		Rice Crop			
			Traditional		Modern Varieties	
	WS[b]	DS[c]	WS	DS	WS	DS
Cabanatuan						
San Isidro	41	40	-	-	-	-
Yield (kgs/ha)	-	-	-	-	3,224	3,647
Area (has)	-	-	-	-	105.02	98.67
Lagare	41	41	-	-	-	-
Yield (kgs/ha)	-	-	-	-	4,545	4,694
Area (has)	-	-	-	-	89.81	93.66
Kalikid Sur	23	-	-	-	-	-
Yield (kgs/ha)	-	-	690	-	1,609	-
Area (has)	-	-	1.40	-	44.32	-
Caalibangbangan	59	59	-	-	-	-
Yield (kgs/ha)	-	-	-	4,000	3,717	4,332
Area (has)	-	-	-	0.50	105.42	105.07
Guimba						
Galvan	35	7	-	-	-	-
Yield (kgs/ha)	-	-	1,380	-	1,953	2,865
Area (has)	-	-	0.50	-	59.74	2.95
Narvacan I	37	15	-	-	-	-
Yield (kgs/ha)	-	-	-	-	2,278	2,649
Area (has)	-	-	-	-	69.66	10.55
San Andres	42	15	-	-	-	-
Yield (kgs/ha)	-	-	3,312	-	1,945	1,928
Area (has)	-	-	0.25	-	83.91	9.56
Bunol	43	34	-	-	-	-
Yield (kgs/ha)	-	-	1,446	5,520	2,332	3,877
Area (has)	-	-	1.75	0.50	74.55	23.91

[a]Number of households.
[b]Wet season.
[c]Dry season.

Source: Farm Surveys, Wet Season 1979 and Dry Season 1980, as presented by Presentacion B. Moran and Edith C. Camacho in their report on the "Consequences of Farm Mechanization Project Site Description: Philippines." A paper presented at the Joint ADC/IRRI Workshop on the Consequences of Small Rice Farm Mechanization in Asia, The International Rice Research Institute, Los Baños, Laguna, Philippines, 14-18 September 1981.

considerable number of water pumps compared to other villages which are generally rainfed (Table 6.11).

Clay loams predominate throughout the villages, except for the village of Kalikid Sur whose soil was predominantly sandly loam. In terms of topography, most of the land area in all villages were flat and sloping. Generally speaking, only a minimum portion of the total land area of the project site face restricting factors such as water logging/flooding, soil infertility and sandiness.

Degree of Mechanization and Labor Input Utilization of Villages

The distribution of the sources of power among the eight villages is shown in Table 6.11. It may be noticed that although two-wheel and four-wheel tractors are available in most of the villages, except for Kalikid Sur, the carabao is generally relied upon as a source of power. Across villages the carabao population ranges from 26 in San Isidro to 202 in Kalikid Sur. In terms of the total distribution of tractor, thresher, rice mill and irrigation pumps, the municipality of Cabanatuan City has a comparatively higher number of these type of farm equipment than Guimba.

In order to provide information with regard to the relationship between the total land area in each village and the number of each type of power source, a land-power source ratio is presented in Table 6.11. Based on this table, it may be observed that San Isidro has the highest farmland:carabao ratio at 10.02 while it has the lowest land:two-wheel tractor ratio at 5.67. In contrast, Kalikid Sur has the lowest land:carabao ratio at 1.85. These findings are consistent with the fact that San Isidro heavily relies on two-wheel tractors for

Table 6.11. Distribution of farm power sources and land:power source ratio in selected villages in Nueva Ecija, Philippines, as of March 1979.

Village	Number						Land:power ratio[a]					
	Carabao	Two-wheel	Four-wheel	Thresher	Rice Mill	Pump	Carabao	Two-wheel	Four-wheel	Thresher	Rice Mill	Pump
Cabanatuan												
San Isidro	26	46	1	4	2	3	10.02	5.67	260.71	65.18	130.36	86.90
Lagare	43	33	1	–	–	2	4.52	5.89	194.48	–	–	97.24
Kalikid Sur	202	–	–	–	–	9	1.85	–	–	–	–	41.59
Caalibangbangan	149	16	4	2	2	2	2.41	22.41	89.63	179.27	179.27	179.27
Guimba												
Galvan	49	1	–	–	–	4	3.84	188.25	–	–	–	47.06
Narvacan I	57	–	–	–	–	27	2.29	–	–	–	–	4.83
San Andres	78	4	–	–	–	20	2.76	53.92	–	–	–	10.78
Bunol	166	1	2	2	2	36	2.54	421.92	210.96	210.96	210.96	11.72

[a]Total farm area over the total number of carabaos or machines.

Source: Household Census, 1979, as presented by Presentacion B. Moran and Edith C. Camacho in their paper on the "Consequences of Farm Mechanization Project Site Description: Philippines." A paper presented at the Joint ADC/IRRI Workshop on the Consequences of Small Rice Farm Mechanization in Asia, The International Rice Research Institute, Los Baños, Laguna, Philippines, 14-18 September 1981.

primary tillage while Kalikid Sur mainly utilizes carabaos for this type of farm activity. This is supported by Table 6.12 which provides the percent distribution of farm area of all villages which have been plowed by a combination of carabao and mechanical power during the 1979 wet season. Based on this table, the villages of San Isidro, Lagare and Caalibangbangan utilized mechanical power (either solely or in combination with carabao power) for plowing activity on at least 94 percent of their farm area. Relative to the other villages, they may be considered as highly mechanized. The moderately mechanized villages are Bunol (62 percent) and San Andres (71 percent). The villages with the lowest level of mechanization are Kalikid Sur (26 percent), Galvan (29 percent) and Narvacan I (33 percent).

Labor input utilization by farms with different sources of land preparation power is shown in Table 6.13. The table indicates that within seasons, mechanized farms generally required less labor for land preparation in the sample villages. When comparing labor utilization between seasons, it may be observed that the total man-hours per hectare used by mechanized farms remained relatively the same in both wet and dry seasons. However, for non-mechanized farms, labor input requirements were higher in the dry season than the wet season. This may be attributed to (1) higher labor requirement for land preparation due to harder and drier soil during the dry months land preparation is to be undertaken, (2) higher labor requirement for care/cultivation, i.e., weeding, application of insecticides and fertilizer and water management and (3) higher labor requirement for post-production activities due to higher yields.

Table 6.12. Distribution of area by type of power used for primary tillage (plowing) in selected villages in Cabanatuan and Guimba, Nueva Ecija, Philippines, wet season 1979.

Village	Total Area (has.)	Per Cent Distribution of Area By Type of Power Used							Degree of Mechanization (%)
		Carabao	Two-wheel	Four-wheel	Carabao/ Two-wheel	Carabao/ Four-wheel	Two-wheel/ Four-wheel	Total	
Cabanatuan									
San Isidro	260.71	1.6	50.3	1.3	45.4	1.4	-	100.0	98.4
Lagare	194.48	6.4	51.3	5.4	26.6	8.5	1.8	100.0	93.6
Kalikid Sur	374.33	73.8	1.6	7.7	14.8	1.6	0.5	100.0	26.2
Caalibangbangan	258.53	6.1	18.4	14.6	33.3	13.7	13.9	100.0	93.9
Guimba									
Galvan	188.25	70.9	0.8	1.9	21.2	2.8	2.4	100.0	29.1
Narvacan I	130.47	67.0	5.2	15.0	2.7	5.7	4.4	100.0	33.0
San Andres	215.67	28.6	11.9	9.4	29.0	13.6	7.5	100.0	71.4
Bunol	421.92	38.2	2.2	16.7	9.0	6.9	27.0	100.0	61.8

Source: Household Census, 1979, as presented by Presentacion B. Moran and Edith C. Camacho in their report on the "Consequences of Farm Mechanization Project Site Description: Philippines." A paper presented at the Joint ADC/IRRI Workshop on the Consequences of Small Rice Farm Mechanization in Asia, The International Rice Research Institute, Los Baños, Laguna, Philippines, 14-18 September 1981.

Table 6.13. Comparative labor input by type of farm in selected villages in Cabanatuan and Guimba, Nueva Ecija, Philippines, wet and dry seasons, crop year 1979-1980.

Item	Cabanatuan City				Guimba			
	San Isidro	Lagare	Kalikid Sur	Caalibangbangan	Galvan	Narvacan I	San Andres	Bunol
	Man-hours per hectare							
Wet Season 1979								
Mechanized farms[a]								
Land preparation	33.6	44.8	***[c]	35.2	68.0	***	42.4	***
Total labor input	457.6	484.8	-	449.6	474.4	-	520.0	-
Non-mechanized farms[b]								
Land preparation	***	***	97.6	56.0	88.8	109.6	112.0	98.4
Total labor input	-	-	574.4	477.6	532.8	632.8	564.8	488.8
Dry Season 1980								
Mechanized farms								
Land preparation	36.8	37.6	-	32.8	-	***	***	-
Total labor input	471.2	422.4	-	435.2	-	-	-	-
Non-mechanized farms								
Land preparation	172.8	84.0	-	112.0	191.2	132.0	133.6	162.4
Total labor input	644.8	398.4	-	483.2	978.4	656.0	720.0	812.8

[a]These refer to farms which used two-wheel tractors, solely or in combination with a carabao, for land preparations operations.
[b]These refer to farms which used only carabaos for land preparation operations.
[c]Excluded due to very few observations (less than three farms).

Source: Farm Surveys, Wet Season 1979 and Dry Season 1980, as presented by Presentacion B. Moran and Edith C. Camacho in their report on the "Consequences of Farm Mechanization Project Site Description: Philippines." A paper presented at the Joint ADC/IRRI Workshop of the Consequences of Small Rice Farm Mechanization in Asia, The International Rice Research Institute, Los Baños, Laguna, Philippines, 14-18 September 1981.

Economic Characteristics of Villages

Information regarding sources of supplementary income is provided in Tables 6.14a and 6.14b. For the 1979 wet season, farm households in Bunol exhibited the highest average off-farm and non-farm incomes, i.e., 1,496 pesos and 4,436 pesos respectively. This is further reflected by the high average supplementary income (average total off- and non-farm income) earned by the average farm household of Bunol, i.e., 2,908 pesos relative to the other villages. In contrast, Narvacan I exhibited the lowest average supplementary income earned by farm households. In general, average income and employment from non-farm activities were comparatively higher than those from off-farm activities in all villages. This may be attributed to the seasonality of off-farm employment in contrast with the regularity of working hours and income of non-farm jobs.

For the dry season, it may be observed that the average supplementary income for the villages, except for San Isidro, San Andres and Bunol, was relatively higher than that of the wet season. This increase in additional income may be attributed to increased employment in non-farm jobs as well as to more household members being employed in mixed off- and non-farm activities. Similar to the wet season, average non-farm income was observed to be relatively higher than average off-farm income in all villages, except for San Isidro.

It is worthwhile to mention that more farm households during the dry season derived supplementary income from non-farm and mixed off- and non-farm activities. This may be attributed to the fact that farm households without irrigation facilities are unable to undertake land

Table 6.14a. Average employment and income from off- and non-farm sources by village, Nueva Ecija, Philippines, wet season 1979.

Source of household income	Cabanatuan City				Guimba			
	San Isidro	Lagare	Kalikid Sur	Caalibangbangan	Galvan	Narvacan I	San Andres	Bunol
Off-farm								
Number of households (HH)	8	10	1	16	6	6	7	13
Average number of household members	5.6	7	2	5	5	3	6	5
Average number of days employment per HH	122	97	20	93	66	43	92	162
Average income per HH in pesos	943	1,061	339	1,030	1,210	247	606	1,496
Non-farm								
Number of households (HH)	8	5	7	24	9	-	6	12
Average number of household members	7	6	6	7	6	-	6	6
Average number of days employment per HH	142	105	167	159	183	-	169	197
Average income per HH in pesos	2,654	1,255	1,631	2,279	1,913	-	3,292	4,436
Mixed off- and non- farm								
Number of hoseholds (HH)	1	-	-	1	1	-	-	-
Average number of household members	8	-	-	5	5	-	-	-
Average number of days employment per HH	201	-	-	108	208	-	-	-
Average income per HH in pesos	297	-	-	508	1,978	-	-	-
Total off- and non-farm								
Number of housholds (HH)	19	16	8	41	16	6	13	25
Average number of household members	7	7	5	6	5	5.5	6	6
Average number of days employment per HH	129	97	149	130	128	43	127	178
Average income per HH in pesos	2,212	1,171	1,470	1,739	1,530	247	1,846	2,908

Source: Farm Surveys, Wet Season 1979, as presented by Presentacion B. Moran and Edith C. Camacho in their report on the "Consequences of Farm Mechanization Project Site Description: Philippines." A paper presented at the Joint ADC/IRRI Workshop on the Consequences of Small Rice farm Mechanization in Asia, The International Rice Research Institute, Los Baños, Laguna, Philippines, 14-18 September 1981.

Table 6.14b. Average employment and income from off- and non-farm sources by village, Nueva Ecija, Philippines, dry season 1980.

Source of household income	Cabanatuan City				Guimba			
	San Isidro	Lagare	Kalikid Sur	Caalibangbangan	Galvan	Narvacan I	San Andres	Bunol
Off-farm								
Number of households (HH)	8	7	1	16	6	4	16	12
Average number of members per household	6.3	6.6	4	5.6	5.3	5.0	6.6	6.0
Average number of days employment per HH	134	150	17	79	73	23	40	137
Average income per HH in pesos	1,982	1,470	326	941	681	413	402	1,456
Non-farm								
Number of households (HH)	12	6	7	17	17	11	8	16
Average number of members per household	7.3	6.0	5.3	6.4	5.8	7.6	5.4	4.2
Average number of days employment per HH	148	109	128	115	133	86	103	123
Average income per HH in pesos	1,697	1,715	2,911	2,489	1,976	1,530	2,106	2,240
Mixed off- and non-farm								
Number of households (HH)	2	1	1	1	2	-	-	-
Average number of members per household	5.5	8.0	3.0	7.0	4.5	-	-	-
Average number of days employment per HH	219	274	25	126	124	-	-	-
Average income per HH in pesos	6,385	1,910	716	2,500	2,275	-	-	-
Total off- and non-farm								
Number of households (HH)	22	14	9	34	25	15	24	28
Average number of members per household	6.8	6.4	4.9	6.0	5.6	6.9	6.2	5.0
Average number of days employment per HH	149	141	104	98	118	69	61	129
Average income per HH in pesos	2,227	1,607	2,381	1,761	1,689	1,232	970	1,904

Source: Farm Surveys, Dry Season 1980, as presented by Presentacion B. Moran and Edith C. Camacho in their report on the "Consequences of Farm Mechanization Project Site Description: Philippines." A presented at the Joint ADC/IRRI Workshop on the Consequences of Small Rice Farm Mechanization in Asia, The International Rice Research Institute, Los Baños, Laguna, Philippines, 14-18 September 1981.

cultivation activities in the dry season, such as in the villages of Kalikid Sur and Galvan. Thus, residents of these villages seek for employment in activities outside their farms as alternative sources of income.

As of wet season 1979, average total farm assets per household ranged from 12,426 pesos in Bunol to 22,444 pesos in San Isidro (Table 6.15). In general, the major assets were agricultural land, farm machinery, draft animals and productive animals. Villages such as San Isidro and Lagare, which have a high concentration of two-wheel and four-wheel tractors, were observed to have the lowest present values of draft animals. The present value of draft animals in San Isidro was 684 pesos while for Lagare it was 804 pesos for the 1979 wet season. Furthermore, these same villages, had the highest present values for farm machinery and farm implements or tools. On the other hand, Kalikid Sur, a village which utilizes only carabao power for land cultivation exhibited the highest present value of draft animals, i.e., 2,521 pesos, while at the same time it showed the lowest present values for farm machinery and farm implements or tools.

Across villages, average total liabilities ranged from 1,564 pesos in Caalibangbangan to 4,383 pesos in San Isidro while total net worth ranged from 9,865 pesos in Narvacan I to 19,611 pesos in Bunol for wet season 1979.

The Farm Classifications

Based on the population described above, farm households with different modes of mechanization were selected and classified into the different categories of mechanized farms as defined in Chapter V. The

Table 6.15. Average peso value of assets, liabilities and net worth, by village, in Nueva Ecija, Philippines, wet season 1979.

Item	Cabanatuan City				Guimba			
	San Isidro	Lagare	Kalikid Sur	Caalibangbangan	Galvan	Narvacan I	San Andres	Bunol
Number of households	49	47	24	77	35	39	45	53
Assets								
Draft animals	684	804	2,521	1,370	1,037	1,758	1,824	1,294
Productive animals	688	570	933	337	533	608	521	772
Buildings	913	1,051	414	991	247	464	1,110	473
Farm implements/tools	1,055	1,046	503	724	398	505	422	435
Agricultural land	8,143	2,979	5,452	8,847	10,584	7,456	15,309	3,561
Non-agricultural land	4,365	2,518	5,417	2,763	758	38	431	4,416
Vehicles	1,455	859	76	1,565	–	100	958	114
Home consumer durables	2,308	1,161	234	1,375	642	586	314	583
Farm machinery	2,833	4,176	–	2,337	464	1,257	2,442	778
Total assets	22,444	15,164	15,550	20,309	14,663	12,772	23,331	12,426
Total liablities	4,383	4,196	1,820	1,564	2,198	2,779	3,720	2,561
Total networth	18,061	10,968	13,730	18,745	12,465	9,993	19,611	9,865

Source: Farm Surveys, Wet Season 1979 and Dry Season 1980, as presented by Presentacion B. Moran and Edith C. Camacho in their report on the "Consequences of Farm Mechanization Project Site Description: Philippines." A paper presented at the Joint ADC/IRRI Workshop on the Consequences of Small Rice Farm Mechanization in Asia, The International Rice Research Institute, Los Baños, Laguna, Philippines, 14-18 September 1981.

distribution of these farm classifications among the eight surveyed villages in Nueva Ecija is presented in Table 6.16.

In terms of the distribution of farms using mechanical power, it may be observed that most of the mechanized farms are located within the municipality of Cabanatuan City. Furthermore, the majority of the mechanized farms are found in the villages of San Isidro and Lagare. On the other hand, most of the farms with non-mechanized land preparations, i.e, carabao(C) and carabao/thresher(CT) farms, are located in Guimba.

Based on Tables 6.17a and 6.17b, which presents some selected characteristics of the different farm classification for both wet and dry seasons, it may be said that the sample farms in all farm classifications are relatively homogeneous with regard to demographic characteristics. However, their similarities do not extend beyond these features. For example, farms which mainly use carabao power were observed to have the smallest farm area while those which utllize mechanical power solely or in combination with carabao power exhibited larger farm areas in both cropping seasons. In addition, for farms which rely on two-wheel tractors for land preparation it may also be observed that a larger portion of the total farm-holding is devoted to rice cultivation relative to those which mainly use carabao power. This is indicated by the intensity of land use index. Although the variation of this index is not too pronounced among the different farm classifications during the wet season, it is quite obvious in the dry season. Intensity of land use during the dry season was generally above 90 percent for mechanized farms, with the exception of farms under the two-wheel tractor/carabao classification. In contrast, the

Table 6.16. Distribution of the different farm-types among the eight surveyed villages, crop year 1979-1980.

Farm Type	Cabanatuan City				Guimba				Total
	San Isidro	Lagare	Kalikid Sur	Caalibangbangan	Galvan	Narvacan I	San Andres	Bunol	
				Wet Season					
Carabao (C)	2	–	16	7	5	19	7	16	72
Carabao/thresher (CT)	–	1	2	–	19	14	10	12	58
Two-wheel (TW)	10	6	–	5	–	–	–	–	21
Two-wheel/thresher (TWT)	18	21	–	1	–	–	–	–	41
Two-wheel/carabao (TWC)	5	2	2	10	4	1	7	–	31
Two-wheel/carabao/thresher (TWCT)	2	3	–	6	3	–	11	2	27
				Dry Season					
Carabao (C)	2	1	–	2	5	5	10	1	26
Carabao/thresher (CT)	1	3	–	6	2	9	–	26	47
Two-wheel (TW)	5	2	–	3	–	–	1	–	11
Two-wheel/thresher (TWT)	21	22	–	11	–	–	–	–	54
Two-wheel/carabao (TWC)	–	1	–	2	–	1	2	–	6
Two-wheel/carabao/thresher (TWCT)	8	5	–	12	–	–	–	–	25

Table 6.17a. Selected characteristics of the different types of farm households in eight villages in Cabanatuan City and Guimba, Nueva Ecija, 1979, wet season.

Items	Type of Farm Household					
	Carabao (C)	Carabao/thresher (CT)	Two-wheel (TW)	Two-wheel/thresher (TWT)	Two-wheel/carabao (TWC)	Two-wheel/ carabao/ thresher (TWCT)
Number of households	72	58	21	41	31	27
Demographic characteristics						
Average age of household head (years)	41.77	42.58	44.41	47.63	43.14	43.69
Average education of household head (years)	4.32	4.58	4.03	4.14	5.14	4.79
Average experience in farming (years)	18.28	19.36	24.05	21.00	19.68	16.04
Average number of household members	5.50	5.45	5.52	5.88	5.74	5.00
Land characteristics						
Average size of farm holding (has.)	1.85	2.14	2.57	2.66	2.07	1.94
Average rice crop area (has.)	1.52	2.05	2.50	2.63	1.98	1.94
Intensity of land use (%)[a]	82.16	95.79	97.28	98.87	95.65	100.00
Irrigation index (%)[b]	81.62	93.46	97.28	84.59	88.89	94.85
Tenure status						
Owner (%)	48.60	63.80	28.60	17.10	61.30	50.00
Part-owners (%)	4.20	3.50	4.70	7.30	6.50	10.70
Lessees (%)	29.10	17.20	66.70	70.70	29.00	21.40
Share-croppers (%)	4.20	-	-	-	-	3.60
Others (%)	13.90	15.50	-	4.90	3.20	14.30
Average yield (kg./ha.)						
Rice-traditional	1,131	872	-	-	-	-
Rice-improved	2,185	2,043	4,099	3,854	2,721	2,848
% area planted to improve rice varieties	98	98	100	100	100	100
Average years mechanized	-	-	7.8	7.5	7.5	6.1

[a]Rice cropped area divided by size of farm holding multiplied by 100.
[b]Irrigated farm area divided by size of farm holding multiplied by 100.
[c]Average number of years each farm-type has been using two-wheel tractors for land preparation.

Table 6.17b. Selected characteristics of the different types of farm households in eight villages in Cabanatuan City and Guimba, Nueva Ecija, 1980, dry season.

Item	Type of Farm Household					
	Carabao (C)	Carabao/thresher (CT)	Two-wheel (TW)	Two-wheel/thresher (TWT)	Two-wheel/carabao (TWC)	Two-wheel/carabao/thresher (TWCT)
Number of Households	26	47	11	54	6	25
Demographic characteristics						
Average of age of household head (years)	40.81	40.09	36.55	47.24	42.00	44.32
Average education of household head (years)	4.12	4.91	4.00	3.81	6.67	4.96
Average experience of household head (years)	18.92	15.89	14.36	21.76	16.83	19.36
Average number of household members	5.69	5.83	5.27	5.76	6.83	5.44
Land chaaracteristics						
Average size of farm holding (has.)	1.40	1.71	1.58	2.38	2.68	1.88
Average rice crop area (has.)	0.82	0.91	1.46	2.32	1.49	1.96
Intensity of land use (%)[a]	58.57	53.22	92.41	97.48	55.60	99.00
Irrigation index (%)[b]	45.88	54.97	84.18	96.22	62.69	99.00
Tenure status						
Owner (%)	61.60	42.60	27.30	29.60	66.70	40.00
Part-owners (%)	–	–	–	3.70	–	4.00
Lessees (%)	11.50	46.80	54.50	59.30	33.30	40.00
Share-croppers (%)	7.70	4.20	–	–	–	–
Others	19.20	6.40	18.20	7.40	–	16.00
Average yield (kg./ha.)						
Rice-tradtional	–	–	–	–	–	–
Rice-improved	2,505	4,199	4,336	4,173	3,541	4,546
% area planted to improved rice varieties	100	100	100	100	100	100
Average years mechanized	–	–	7.7	7.6	7.4	6.2

[a]Rice cropped area divided by size of farm holding multiplied by 100.
[b]Irrigated farm area divided by farm holding multiplied by 100.
[c]Average number of years each farm-type has been using two-wheel tractors for land preparation.

same index for farms using carabao power for land preparation, i.e., carabao(C) and carabao/thresher(CT) farm classifications, remained within the 50 to 60 percent level. It is interesting to note that the intensity of land use index exhibits a relationship with the irrigation index across the different farm types. It may be observed that farm-types with a high irrigation index, i.e., above 80 percent, are able to utilize farm land more intensively compared to those which have limited water facilities as reflected by their low irrigation indeces. This implies that aside from mechanical power, the intensity of land use is largely dependent on water availability, particularly for the dry season.

In terms of land tenure status, most of the farm operators owned the land they were cultivating, particularly for farms under the carabao(C), carabao/thresher(CT), two-wheel tractor/carabao(TWC) and two-wheel tractor/carabao/thresher(TWCT) classifications. However, for the two-wheel tractor and two-wheel tractor/thresher classifications, most of the farms were lessees. This observation holds true for both seasons.

The crop mainly grown in all farm classifications is rice, with improved rice varieties taking up at least 98 percent of the total rice area. However, the data in Tables 6.17a and 6.17b do not indicate any meaningful yield pattern which may be useful for comparing rice yield across the different farm categories. For the wet season, rice yield ranged from 2.2 to 4.2 metric tons across the different farm-types, while for the dry season the range was 2.5 to 4.5 metric tons.

It is worthwhile to mention that most of the mechanized farms have been using two-wheel tractors for land preparation for approximately 6 to 7 years. The distribution of two-wheel tractor owners and users among mechanized farms for crop-year 1979-1980 is presented in Table 6.18. It may be noticed that farms which mainly use two-wheel tractors for primary tillage (or land preparation operations) generally own two-wheel tractors. For example, during the wet season, out of the total 21 farm households under the two-wheel tractor(TW) farm classification, 15 farms own two-wheel tractors. The remaining 6 farms are merely tractor users who either rent or borrow two-wheel tractors from friends. For the two-wheel tractor/thresher(TWT) farm category, 28 of 41 farms were two-wheel tractor owners. The opposite is true for those farms which supplement carabao power with mechanical power for land preparation operations. In these farm-types, i.e., two-wheel tractor/carabao(TWC) and two-wheel tractor/carabao/thresher(TWCT) farms, more farms were observed to rent or borrow farm machinery. This is exemplified by the fact that of the 31 two-wheel tractor/carabao(TWC) farms, 23 are users while only 8 are owners. For the two-wheel tractor/carabao/thresher(TWCT) farms, of the 27 farms only 3 are owners and 24 are users. The same pattern of tractor ownership and use may be observed for the dry season.

In the same table, it may be observed that although some farms have adopted mechanical power, a majority of these mechanized farms still own carabaos and use these animals at some stage in their farming operations.

In terms of supplementary sources of income, Tables 6.19a and 6.19b indicate that all farm-types derive additional income from

Table 6.18. Distribution of owners and users of primary tillage power sources among the different farm classifications, crop year 1979-1980.

	Farm Classification						Total
	Carabao (C)	Carabao/thresher (CT)	Two-wheel (TW)	Two-wheel/thresher (TWT)	Two-wheel/carabao (TWC)	Two-wheel/ carabao/ thresher (TWCT)	
			Wet Season				
Two-wheel tractor owners	-	-	15	28	8	3	54
Two-wheel tractor users	-	-	6	13	23	24	66
Carabao owners	47	38	4	6	20	19	134
Number of households	72	58	21	41	31	27	256
			Dry Season				
Two-wheel tractor owners	-	-	5	33	2	9	49
Two-wheel tractor users	-	-	6	21	4	16	47
Carabao owners	18	37	0	14	4	18	91
Number of households	26	47	11	54	6	25	169

Table 6.19a. Average employment and income from off - and non-farm sources by farm-type classification, Nueva Ecija, Philippines, wet season 1979.

Source of household income	Farm Classification					
	Carabao (C)	Carabao/thresher (CT)	Two-wheel (TW)	Two-wheel/thresher (TWT)	Two-wheel/carabao (TWC)	Two-wheel/ carabao/ thresher (TWCT)
1. Off-farm						
Number of household (HH)	7	6	-	3	-	3
Average number of members per household (HM)	6	5.2	-	9	-	5
Average employment per household (days)	90.3	31.5	-	72.3	-	7
Average income per household (pesos)	580	296	-	725	-	48
2. Non-farm						
Number of households (HH)	13	8	3	13	8	9
Average number of members per household (HM)	6.3	5.2	7.7	6.4	6.8	6.4
Average employment per household (days)	16.6	204	226	158.1	133.9	204.6
Average income per household (pesos)	2,459	3,587	1,664	2,650	1,514	4,102
3. All sources						
Number of households (HH)	20	14	3	16	8	12
Average number of members per household (HM)	6.2	5.2	7.7	7.1	6.8	6.1
Average employment per household (days)	42.4	130.1	226	134.7	133.9	155.2
Average income per household (pesos)	1,802	2,176	1,664	2,125	1,514	3,088

Table 6.19b. Average employment and income from off - and non-farm sources by farm-type classification, Nueva Ecija, Philippines, dry season 1980.

Source of household income	Farm Classification					
	Carabao (C)	Carabao/thresher (CT)	Two-wheel (TW)	Two-wheel/thresher (TWT)	Two-wheel/carabao (TWC)	Two-wheel/carabao/thresher (TWCT)
1. Off-farm						
Number of household (HH)	5	4	-	-	-	-
Average number of members per household (HM)	5.6	6.8	-	-	-	-
Average employment per household (days)	38.4	28.5	-	-	-	-
Average income per household (pesos)	382	294	-	-	-	-
2. Non-farm						
Number of household (HH)	6	10	3	13	1	10
Average number of members per household (HM)	6.5	5.5	4.7	7.3	5	6.3
Average employemnt per household (days)	156.8	95.8	84	147.5	110	121.3
Average income per household (pesos)	3,520	1,749	1,365	2,192	1,595	2,179
3. Mixed off - and non-farm						
Number of household (HH)	-	3	-	-	-	-
Average number of members per houseshold (HM)	-	5.7	-	-	-	-
Average employment per household (days)	-	113.7	-	-	-	-
Average income per household (pesos)	-	2,189	-	-	-	-
4. All sources						
Number of household (HH)	11	17	3	13	1	10
Average number of members per household (HM)	6.1	5.8	4.7	7.3	5	6.3
Average employment per household (days)	103	83	84	147.5	110	121.3
Average income per household (pesos)	2,094	1,484	1,365	2,192	1,595	2,179

non-farm jobs. Average total supplementary income from all sources for the wet season ranged from 1,514 pesos to 3,088 pesos, while for the dry season it ranged from 1,365 pesos to 2,179 pesos.

Some financial features of each farm classification are presented in Table 6.20 for both wet and dry seasons. The table shows that farms which use carabao power, solely or in combination with two-wheel tractors, have relatively higher average peso values for draft animals compared to those farms which only use two-wheel tractors for land preparation operations. On the other hand, two-wheel-tractor-using farms(TW) exhibited higher average peso values for both farm implements/tools and farm machinery. Furthermore, it may be generalized that land of mechanized farms are appraised at higher values than non-mechanized farms. In terms of average total liabilities, non-mechanized farms exhibited lower debt obligations than mechanized farms. Liabilities of non-mechanized farms were mainly due to loans intended to cover production expenses. As for mechanized farms, debt obligations arised from loans availed of for the purpose of purchasing farm equipment and mechinery, aside from loans intended to cover production expenses.

The above descriptive information regarding the study area and the different farm classifications under consideration establishes the background for the analysis of the survey data — the results of which are discussed in the succeeding chapter.

Table 6.20. Average Peso values of selected assets and liabilities of farm classification, wet season 1979 and dry season 1980, Nueva Ecija, Philippines.

Type of asset	Farm Classification					
	Carabao (C)	Carabao/thresher (CT)	Two-wheel (TW)	Two-wheel/thresher (TWT)	Two-wheel/carabao (TWC)	Two-wheel/ carabao/ thresher (TWCT)
	P[a]	P	P	P	P	P
			Wet Season			
Number of households	72	58	21	41	31	27
Draft animals	1,833	1,737	666	371	1,995	1,759
Farm implements and tools	436	490	1,094	1,226	745	539
Farm machinery	469	808	5,048	3,769	1,667	846
Agricultural land	5,442	9,447	8,089	8,236	10,931	11,082
Liabilities	2,087	2,562	3,348	5,057	2,753	3,112
			Dry Season			
Number of households	26	47	11	54	6	25
Draft animals	1,682	2,287	182	715	2,383	2,452
Farm implements and tools	452	615	1,283	948	1,554	864
Farm machinery	744	975	5,274	3,279	1,393	2,458
Agricultural land	6,781	6,881	7,835	9,340	18,263	26,100
Liabilities	2,794	2,800	2,336	3,621	3,308	3,112

[a]Pesos.

Footnotes

Chapter VI

[106] Presentacion Moran and Delia Unson, "Operations Handbook No. 1, Farm Survey and Recordkeeping Procedures for Consequences of Small Rice Farm Mechanization Project," Agricultural Engineering Department, International Rice Research Institute, Los Baños, Laguna, May, 1980, p. 2.

[107] A detailed description is presented in Appendix A which presents the sampling procedures and field research design developed at a workshop held at The International Rice Research Institute, Los Baños, Laguna, Philippines, in September 1978.

[108] As defined in the "Consequences of Small Rice Farm Mechanization" Workshop, a household is defined as a group of persons living in one dwelling and sharing common food preparation facilities. Thus, if two families live under one roof but share a common food preparation, they are considered a single household by this definition.

[109] A rice farm household is defined as a group of persons living in one dwelling and sharing common food preparation facilities whose main farming activity is rice production and whose main source of income is derived from this particular activity. The head of a rice farm household is called a rice farm operator. A rice farm operator is defined as a person who cultivates at least 1,000 square meters (or 0.1 hectare) of rice land. He must also contribute labor and make management decisions commonly made by persons in his category. A farmer who does not contribute labor but makes decisions can be considered a farm operator if he has contributed some labor at one time in the past.

[110] A landless field labor household is one whose household head does not operate his own farm and derives more than 50 percent of his income from working on farms owned by others. Specifically, his work must principally involve crop-related activities such as plowing, harrowing, planting, weeding, harvesting, threshing, etc.

[111] A non-farm household is one whose head does not operate a farm and derives the major part of his income from non-agricultural activities such as fishing, forestry, handicrafts, industry, service, etc. Thus, though a household may get a large share of its income from non-agricultural jobs held by members, if the household head operates a rice farm, the household is still classified as a rice farm

household rather than a non-farm household.

112As defined in the Workshop, a parcel is a contiguous piece of land not subdivided by physical features such as roads, large bunds, terraces, water channels or streams. Small bunds for irrigation purposes can be disregarded as long as the <u>same</u> crop is grown on each subdivision and if they have the same type of irrigation and tenure status. Irrigation canals that divide a parcel can also be ignored as long as the subdivisions are treated as one parcel.

A parcel is divided into different fields or subparcels if: (a) more than 500 square meters of the area is planted to different crop. (b) irrigation is given to one portion of the area but not to the other, or (c) tenure or management systems differ from one portion of the area to another. Subparcelling is ignored if: (a) a nursery is raised in one part of the parcel, or (b) different crops are grown on 100 square meters or less of the parcel. In the latter case, the parcel is treated as an intercropped or a mixed-cropped area. When a subparcel is further divided for reasons similar to those mentioned previously, the divisions are called sub-parcels.

113It must be noted that farms in these same villages have high fertilizer application rates also.

Chapter VII

Results and Discussion

In this chapter, an attempt to compare labor data between the different farm classifications is undertaken. For this purpose, the tabular method of comparison and covariance analysis are employed in order to provide information regarding labor differences between each farm classification. This preliminary analysis, in turn, will serve as the basis for further comparisons between the different farm-types using farm budget and production function analysis.

Comparison of Labor Utilization

The total labor hours per hectare utilized by each farm-type is presented in Table 7.1 for both wet and dry seasons of crop year 1979-1980.[114] In terms of the total labor hours devoted per operation among the different farm-types, obvious differences are observed in those farm operations in which mechanical power was used in combination with carabao and/or manual power. For example, for land preparation, farms such as TW, TWT, TWC and TWCT utilized considerably lower levels of manual labor than farms with non-mechanized land preparation operations, i.e., C and CT. With regard to post-production, in general, farms which availed of the services of mechanical threshers required less amount of labor hours to complete of such operation compared to farms which relied mainly on manual labor. These observations are true for both seasons.

Furthermore, it may be observed that mechanized land preparation

Table 7.1. Average labor hours used per hectare for various farm operations for each selected farm classification, Nueva Ecija, Philippines, crop year 1979-1980.

Farm Classification	Average Labor Hours Used For Various Farm Operations									
	Land Preparation		Planting		Care/ Cultivation		Post-Production		Total Hours	
	Hours	%	Hours	%	Hours	%	Hours	%	Hours	%
Wet Season										
Carabao	105	18	198	33	34	6	251	43	588	100
Carabao/thresher	112	19	211	35	32	5	242	41	597	100
Two-wheel	30	6	211	43	22	4	233	47	496	100
Two-wheel/thresher	37	8	199	45	26	6	182	41	444	100
Two-wheel/carabao	61	12	178	36	32	6	224	46	495	100
Two-wheel/carabao/thresher	54	11	208	42	24	5	206	42	492	100
Dry Season										
Carabao	143	23	222	35	26	4	235	38	626	100
Carabao/thresher	158	20	291	37	32	4	314	39	795	100
Two-wheel	34	7	166	36	22	5	242	52	464	100
Two-wheel/thresher	33	8	190	44	99	6	182	42	434	100
Two-wheel/carabao	58	11	228	43	29	5	216	41	531	100
Two-wheel/carabao/thresher	55	13	166	38	33	7	181	42	434	100

resulted in a decrease in the proportion of the total hours required to accomplish this operation to the total labor hours required to complete all the farm operations. Specifically, note that during the wet season, to accomplish land preparation operations, carabao(C) farms required 18 percent of the total labor hours while carabao/thresher(CT) farms needed 19 percent. However, for mechanized farms, i.e., TW, TWT, TWC and TWCT, the proportion spent for these operations was much lower. During the dry season, these same farm-types exhibited similar labor utilization patterns. With regard to post-production, it may be generalized that those farms which utilized mechanical threshers exhibited less labor requirements for this farm operation in both seasons. This also resulted in the decrease in the proportion of total labor hours devoted to this particular operation in relation to total labor hour requirements for all operations, especially during the wet season.

Table 7.2 gives an idea of how the total labor hours for each season are distributed among its components of hired and family labor. From this table, it may be observed that for land preparation, total hired and family labor hour requirements of carabao(C) and carabao/thresher(CT) farms were higher than those farms with mechanized land preparation. Furthermore, thresher-using farms employed less hired labor, as well as required less family labor hours, for post-production compared to non-thresher users. An exception to this is the dry season carabao/thresher(CT) farm classification which presented higher post-production labor usage than carabao(C) farms of the same season.

Of the four major farm operations, land preparation and

Table 7.2. Distribution of labor hours per hectare, hired and family labor, for various farm operations of selected farm classifications, Nueva Ecija, Philippines, crop year 1979–1980.

Farm Classification	Average Hired and Family Labor Used For Various Farm Operations									
	Land Preparation		Planting		Care/ Cultivation		Post-Production		Total Labor Hours	
	H[a]	F[b]	H	F	H	F	H	F	H	F
Wet Season										
Carabao	24	81	152	45	4	30	174	77	354	233
Carabao/thresher	30	82	176	35	–	32	160	82	366	231
Two-wheel	4	26	207	4	3	18	232	2	446	50
Two-wheel/thresher	6	31	180	18	2	23	161	16	355	8
Two-wheel/carabao	19	42	154	24	1	30	193	31	367	127
Two-wheel/carabao/thresher	19	35	195	13	1	22	160	47	375	117
Dry Season										
Carabao	18	125	183	39	1	25	130	105	332	294
Carabao/thresher	21	137	253	39	–[c]	32	270	43	544	251
Two-wheel	6	28	161	5	2	20	239	3	408	56
Two-wheel/thresher	7	27	177	13	5	24	179	3	368	67
Two-wheel/carabao	11	47	209	20	–	29	216	–	436	96
Two-wheel/carabao/thresher	13	42	153	2	5	27	180	1	351	82

[a]Hired labor.
[b]Family labor.
[c]Considerably less than one hour.

care/cultivation largely depended on family labor, as indicated by Table 7.2. This may also be observed in Table 7.3 which presents the percent hired and percent family labor per farm operation, for wet and dry seasons.

For example, for wet season carabao farms, 77 percent of the total land preparation labor was accomplished by family labor while 23 percent was done by hired labor. For the same farm classification, care/cultivation was completed by 87 percent family labor and 13 percent hired labor. It should be noted that due to the prevalent use of chemicals, care/cultivation operations have become less labor intensive. Weeding work, which used to be accomplished mainly by hired labor, has been considerably reduced through the proper application of herbicides/weedicides. Furthermore, it should be mentioned that the cultivation of early-maturing rice varieties has shortened the period within which all weeding activities must be accomplished.[115] In order to adjust to this situation, farmers in the study area have supplemented weeding labor with more intensive use of herbicides/weedicides. As a consequence, which may be observed from the survey data, hired and family labor input requirements of care/cultivation operations substantially decreased.

On the other hand, planting and post-production operations required more hired labor than family labor since these operations are labor intensive in nature.

It should be noted that differences in the labor hour utilization of the six different farm-types are not observable for those farm operations which were not mechanized at all, such as planting and care/cultivation. Furthermore, no distinct pattern of

Table 7.3. Per cent labor hours utilized per hectare, hired and family labor, for various farm operations of selected farm classifications, Nueva Ecija, Philippines, crop year 1979-1980.

Farm Classification	Land Preparation		Planting		Care/ Cultivation		Post-Production		Total Labor Hours	
	H[a]	F[b]	H	F	H	F	H	F	H	F
<u>Wet Season</u>										
Carabao	23	77	77	23	13	87	69	31	60	40
Carabao/thresher	27	73	83	17	–	100	66	34	61	39
Two-wheel	13	87	98	2	15	85	99	1	90	10
Two-wheel/thresher	15	85	91	9	9	91	92	8	80	20
Two-wheel/carabao	32	68	86	14	5	95	86	14	74	26
Two-wheel/carabao/thresher	35	65	94	6	6	94	77	23	76	24
<u>Dry Season</u>										
Carabao	12	88	82	18	5	95	55	45	53	47
Carabao/thresher	13	87	87	13	–[c]	100	86	14	68	32
Two-wheel	18	82	97	3	10	90	99	1	88	12
Two-wheel/thresher	19	81	93	7	17	83	98	2	85	15
Two-wheel/carabao	19	81	91	9	–	100	100	–	82	18
Two-wheel/carabao/thresher	24	76	92	8	16	84	100	–[c]	81	19

[a]Hired labor.
[b]Family labor.
[c]Considerably less than one hour.

hired labor employment and family labor use may be noticed for these same operations in all farm classifications.

However, it may be concluded that mechanized farms, specifically those with mechanized land preparation operations, used less labor (Table 7.4). This is reflected by the fact that these farms utilized less family labor hours, as well as employed less hired labor, to accomplish all farm operations. Furthermore, farms in the thresher-user category required less hired labor for post-production operations than non-thresher users. This resulted in the reduction of total labor hours utilized by thresher-using farms.

The basic conclusions are:

(1) Mechanized farms required less total labor hours to accomplish all farm operations than non-mechanized farms.

(2) Family labor hour requirements of mechanized rice farms are lower than those farms which are non-mechanized.

(3) Farms which utilized two-wheel tractors for land preparation and mechanical threshers for post-production operations reduced their employment of hired labor for these operations.

The basic weakness of the above method of analysis is that it is difficult to attribute the difference in labor utilization and employment, between the different farm-types, to mechanical power adoption. However, this may not necessarily be the case since the tabular analysis does not provide information regarding the causal relationship between mechanization and labor utilization. Furthermore, it is known that other factors, aside from mechanization, affect the degree of labor utilization and employment among farm groups. In

Table 7.4. Distribution of labor hours per hectare, hired and family labor, for various farm operations of non-mechanized and mechanized farms, Nueva Ecija, Philippines, crop year 1979-1980.

Farm Classification	Land Preparation		Planting		Care Cultivation		Post-production		Total Labor Hours		Total Labor Hours	Number of Household
	H[a]	F[b]	H	F	H	F	H	F	H	F		
Non-mechanized land preparation[c]	24	99	187	41	2	31	187	75	400	246	646	203
Mechanized land preparation[d]	10	35	177	17	3	25	186	19	376	96	472	216

[a]Hired labor
[b]Family labor
[c]Includes carabao (C) farms and carabao/thresher (CT) farms.
[d]Includes two-wheel tractor (TW), two-wheel tractor/thresher (TWT), two-wheel tractor/carabao (TWC) and two-wheel tractor/carabao/trhesher (TWCT) farms.

order to investigate which of these factors have significant impacts on labor input requirements, a covariance analysis is conducted. The results of this analytical method are discussed below.

Statistical Analysis

The tables presented above provide weak evidences regarding the in labor utilization and employment between different farm-types, especially in relation to land preparation. However, there is a need to test these differences in order to assess whether or not labor utilization and employment between these farm classifications are statistically significant.

To facilitate statistical analysis, it was assumed that the small rice farms considered in the study do not differ in the amount of labor utilized during the wet and dry seasons. This is supported by Table 7.5 which presents the results of the t-tests, verifying whether the mean labor utilized and mean labor employed for both seasons, for all farm classifications, were statistically different. It may be observed that, in general, the t-values were not significant with the exception of the hired labor and total labor means for the carabao/thresher(CT) farms. Based on these findings, subsequent comparative analyses of the different farm classifications will pertain to crop year 1979-1980.

Labor covariance analysis. Table 7.6 presents the results for hired, family and total labor. Based on these results, reductions in total family and total labor utilization were observed to occur in all farms using two-wheel tractors, either solely or in combination with carabao power, for land preparation as well as mechanical threshers

Table 7.5. Comparison of labor hours utilized by each farm-type during wet and dry seasons, crop year 1979-1980.

Farm Classification	Family Labor			Hired Labor			Total Labor		
	Wet Season	Dry Season	t value	Wet Season	Dry Season	t value	Wet Season	Dry Season	t value
Carabao (C)	233	294	-1.0334	354	332	0.3168	587	626	-0.4942
Carabao/thresher (CT)	231	251	-0.4613	366	544	-3.7178*	597	795	-3.3930*
Two-wheel (TW)	50	244	-1.5526	446	408	0.7499	496	652	-1.1385
Two-wheel/thresher (TWT)	88	66	1.3201	355	368	-0.3744	443	434	0.2617
Two-wheel/carabao (TWC)	128	96	0.9756	367	436	-0.9498	495	532	-0.4931
Two-wheel/carabao/thresher (TWCT)	117	82	1.2968	375	351	0.5055	492	433	1.1881

*Significant at P = 1%.

Table 7.6. Estimated difference in total labor use in rice production among farms with different modes of mechanization, crop year 1979-1980.

Independent Variables		Total Hired Labor	Total Family Labor	Total Labor
Constant		163.63***	482.69***	647.31***
		(2.63)[a]	(10.10)	(10.38)
Two-wheel	(M_1)	-29.96	-94.54**	-123.38**
		(-0.65)	(-2.38)	(-2.39)
Two-wheel/carabao	(M_2)	-17.86	-107.65***	-118.94***
		(-0.44)	(-3.10)	(-2.62)
Carabao/thresher	(M_3)	49.61*	-39.06	9.47
		(1.67)	(1.52)	(0.28)
Two-wheel/thresher	(M_4)	-87.99***	-143.31***	-234.34***
		(-2.58)	(-4.86)	(-6.08)
Two-wheel/carabao/ thresher	(M_5)	-76.75**	-124.75***	-194.10***
		(-2.04)	(-3.83)	(-4.57)
Seasonal Effect	(S)	-22.77	21.81	1.44
		(-1.00)	(1.11)	(0.06)
Irrigation	(I)	-16.87	-10.54	-34.54
		(-0.69)	(-0.50)	(-1.25)
Tenure	(T)	17.52	-23.97	-8.18
		(0.78)	(-1.24)	(-0.32)
Household members	(HM)	-3.97	-	-
		(-0.90)	-	-
Output	(Q)	0.07***	0.01***	0.09***
		(9.62)	(2.90)	(10.49)
Experience	(Ex)	1.53*	-2.25***	-0.99
		(1.69)	(-2.88)	(-0.97)
Education	(Ed)	6.51*	-6.67**	-1.44
		(1.70)	(-2.01)	(-0.33)
Wage-rice price ratio	(WRP)	14.91	-53.42***	-65.56***
		(0.76)	(-3.15)	(-2.96)
Cropping intensity	(CPI)	-0.25	-0.80***	-0.85***
		(-1.04)	(-3.83)	(-3.13)
Networth	(NW)	-0.0001	0.00004	-0.00004
		(-.31)	(0.14)	(-0.10)
R^2		0.24	0.23	0.34
F-value[b]		8.42***	8.80***	14.88***
Number of observations		419	419	419

[a]Values in parentheses are calculated t-values.
[b]F-statistic for testing the significance of the regression model.
***Significant at P=1%.
**Significant at P=5%.
*Significant at P=10%.

for post-production activities. This is implied by the mechanization dummy variables M_1, M_2, M_4 and M_5 which generally exhibited negative regression coefficients in the hired, family and total labor covariance models. However, due to the statistically insignificant coefficients of some of the mechanization dummy variables, it is difficult to conclude that reductions in hired labor employment occurred. However, it may be generalized that the results provide information with regard to the direction of labor change due to mechanization. Furthermore, the highly significant coefficients of M_1, M_2, M_4 and M_5 for the family labor covariance model indicate that mechanical power adoption have significantly reduced this labor component more than it has hired labor. This is consistent with the findings of previous studies conducted in the Philippines and Indonesia.

Consistent with the results of the t-test, total labor employment (and its two components of hired and family labor) for both wet and dry seasons was observed to be the same. This is implied by the insignificant regression coefficients of the season dummy, S.

Change in labor utilization due to irrigation (I) or water management based on the covariance models is inconclusive. Another observation is that, regardless of the tenure status (T), labor utilization and employment remained the same for farm owners and non-farm owners.

The variable representing the number of household members per farm unit (HM) exhibited a negative regression coefficient. This implies less employment of hired labor by farm households with a large reservoir of family labor. However, due to the statistically insignificant coefficients, such cannot be concluded from the covariance results.

A highly significant variable which positively influenced labor utilization and employment is the amount of output (Q) produced per hectare. For all regressions, this variable was found to be significant up to 1 percent.

Experience (Ex) and education (Ed) were observed to exhibit some effect on the utilization (or management) of total hired and family labor but it is difficult to derive any definite conclusion regarding their effect on total labor utilization.

As hypothesized, the wage:rice price ratio (WRP) exhibited a negative regression coefficient in both the total labor covariance models. This implies a decrease (or increase) in the demand for labor at times when average labor wage rate exhibits higher increases (or decreases) relative to that of the price of rough rice per kilogram. However, the negative sign of this same variable for the family labor covariance model implies that as labor wage increases relative to the price of rice, farmers would tend to work in other farms thus reducing family labor significantly in their own farms. This further implies that farmers have a higher valuation regarding the opportunity cost of their labor services relative to what they value the effort they exert in their own farm.

It should be noted that a labor covariance model pertaining to specific farm operations for which mechanical power may be substituted for animal power would be more appropriate to serve as a basis for analyzing labor differences between mechanized and non-mechanized farms. Due to the fact that total hired labor, total family labor and total labor include manual effort directed toward the accomplishment of other farm activities which generally cannot be done by farm machinery, i.e., planting and care/cultivation operations, a labor covariance model for land preparation as well as for post-production operations could provide more meaningful results as a basis for analysis. The estimated differences in labor utilization among farms for land preparation and post-production operations are presented in Table 7.7 and Table 7.9, respectively.

The covariance results presented in Table 7.7 indicate that the use of mechanical power in land preparation significantly decrease labor utilization for this farm operation. This is particularly true for all farms with different land preparation mechanization modes with regard to their utilization of total family labor and total labor. The lower family labor and total labor requirement of farms with mechanized land preparation operations, i.e., TW, TWC, TWT and TWCT, is statistically significant up to the 1 percent level. It should be noted that, although most of the regression coefficients of the mechanization dummies of the hired labor covariance model are not statistically significant, their negative signs imply a reduction in hired labor employment among the different mechanized farms.

Also, it may be observed that more labor per hectare of rice was required for land preparation during the dry season than in the wet season. This is verified by the positive regression coefficient of the season dummy (S) for both the family and total labor covariance models in Table 7.7. These coefficients are significant up to the 1 percent level.

Table 7.7. Estimated difference in total land preparation labor use in rice production among farms with different modes of mechanization, crop year 1979-1980.

Independent Variables		Total Hired Labor	Total Family Labor	Total Labor
Constant		41.87*** (4.05)a	116.16*** (7.14)	146.37*** (9.12)
Two-wheel	(M_1)	-6.60 (-0.86)	-64.76*** (-4.77)	-71.71*** (-5.35)
Two-wheel/carabao	(M_2)	-1.89 (-0.28)	-45.77*** (-3.80)	-49.03*** (-4.13)
Carabao/thresher	(M_3)	2.55 (0.51)	10.36 (1.17)	13.04 (1.50)
Two-wheel/thresher	(M_4)	-6.96 (-1.23)	-72.63*** (-7.24)	-80.16*** (-8.09)
Two-wheel/carabao/ thresher	(M_5)	-1.30 (-0.21)	-58.92*** (-5.29)	-60.49*** (-5.50)
Seasonal Effect	(S)	-1.80 (-0.49)	23.83*** (3.65)	21.28*** (3.30)
Tenure	(T)	12.43*** (3.37)	-26.49*** (-4.06)	-13.63*** (-2.12)
Household members	(HM)	-1.52** (-2.04)	- -	- -
Experience	(Ex)	-0.25 (-1.60)	-0.20 (-0.73)	-0.46* (-1.70)
Education	(Ed)	0.55 (0.84)	-1.70 (-1.47)	-0.94 (-0.83)
Wage-rice price ratio	(WRP)	-7.08** (-2.14)	5.74 (0.98)	0.89 (0.15)
Cropping intensity	(CPI)	-0.04 (-1.03)	-0.10 (-1.46)	-0.15** (-2.15)
Networth	(NW)	-0.00001 (-0.17)	0.00003 (0.26)	0.00001 (0.0009)
R^2		0.12	0.28	0.34
F-valueb		4.32***	13.27***	17.66***
Number of observations		419	419	419

aValues in parentheses are calculated t-values.
bF-statistic for testing the significance of the regression model.
***Significant at P=1%.
**Significant at P=5%.
*Significant at P=10%.

With regard to the effect of land tenure on land preparation hired labor employment, the highly significant and positive regression coefficient of T implies that farm owners employ more hired labor than non-farm owners. As a result, these same farmers utilize less family labor. These relationships are indicated by the hired and family labor covariance models, respectively. It is worthwhile to mention that such finding is verified by the significant inverse relationship of land preparation hired labor and the number of household members (HM). This is further supported by the data presented in Table 7.8 which indicates that farms owned by its operator utilize more hired labor and less family labor per hectare compared to those farms which are either rented, leased or borrowed by the farm operator.

For all covariance models, it may be observed that experience (Ex), education (Ed), cropping intensity (CPI) and networth (NW) do not significantly explain variations in labor use in all estimated models. As far as the wage:rice price ratio (WRP) is concerned, the signs of the regression coefficient of variable WRP verifies the hypothesis that, as far as land preparation is concerned, less hired labor will be employed as the average wage rate increases (refer to the total land preparation hired labor models) and that more family labor will be utilized as substitute for hired labor under such a situation (as indicated by the total land preparation family labor models).

With regard to the estimated difference in labor post-production use among farms with different modes of mechanization, Table 7.9 indicates that thresher-using fams, i.e., two-wheel/tractor/thresher farms (TWT) and two-wheel tractor/carabao/thresher farms (TWCT),

Table 7.8. Land preparation labor requirement per hectare of farms with different land tenure status, crop year 1979-1980.

Farm Classification		Total Land Preparation Labor Hours Per Hectare		
		Hired Labor	Family Labor	Total Labor
Carabao	(C)			
Rented		12	118	130
Owned		29	77	106
Carabao/thresher	(CT)			
Rented		10	143	153
Owned		37	83	120
Two-wheel	(TW)			
Rented		5	38	43
Owned		8	27	35
Two-wheel/thresher	(TWT)			
Rented		6	30	36
Owned		6	27	33
Two-wheel/carabao	(TWC)			
Rented		11	46	57
Owned		23	41	64
Two-wheel/carabao/ thresher	(TWCT)			
Rented		11	40	51
Owned		20	37	57

Table 7.9. Estimated difference in total post-production labor use in rice production among farms with different modes of mechanization, crop year 1979–1980.

Independent Variables		Total Hired Labor	Total Family Labor	Total Labor
Constant		23.98 (0.55)	220.90*** (8.32)	256.26*** (6.78)
Two-wheel	(M_1)	-16.41 (-0.51)	4.43 (0.20)	-10.96 (-0.35)
Two-wheel/carabao	(M_2)	1.96 (0.07)	-42.66** (-2.16)	-34.32 (-1.25)
Carabao/thresher	(M_3)	16.03 (0.77)	-24.44* (-1.71)	-9.25 (-0.46)
Two-wheel/thresher	(M_4)	-67.98*** (-2.84)	-30.47* (-1.86)	-99.77*** (-4.27)
Two-wheel/carabao/ thresher	(M_5)	-55.33** (-2.10)	-25.84 (-1.43)	-75.82*** (-2.95)
Seasonal Effect	(S)	-17.55 (-1.10)	7.53 (0.69)	-8.00 (-0.52)
Tenure	(T)	10.81 (0.70)	3.24 (0.31)	13.29 (0.88)
Household members	(HM)	-1.02 (-0.33)	- -	- -
Output	(Q)	0.05*** (9.32)	-0.007** (-2.14)	0.04*** (8.27)
Experience	(Ex)	1.19* (1.87)	-1.06** (-2.45)	-0.04 (-0.06)
Education	(Ed)	1.99 (0.74)	-1.86 (-1.01)	-0.85 (-0.32)
Wage-rice price ratio	(WRP)	5.64 (0.41)	-26.93*** (-2.87)	-40.38*** (-3.02)
Cropping intensity	(CPI)	-0.006 (-0.04)	-0.44** (-3.85)	-0.32** (-2.00)
Networth	(NW)	-0.0002 (-0.72)	-0.00001 (-0.01)	-0.0002 (-0.63)
R^2		0.21	0.17	0.21
F-value[b]		7.89***	6.45***	8.32***
Number of observations		419	419	419

[a]Values in parentheses are calculated t-values.
[b]F-statistic for testing the significance of the regression model.
***Significant at P=1%.
**Significant at P=5%.
*Significant at P=10%.

significantly utilized less post-production labor compared to non-thresher users. The tenure dummy variable has a positive effect on post-production labor in all estimated equations while the number of household members shows a negative relationship with hired labor. However, these results are not statistically significant.

Rice output (Q) is observed to positively affect total post-production labor utilization. The regression coefficient of this variable is highly significant up to the 1 percent level. However, the experience (Ex) and education (Ed) variables do not provide conclusive results with regard to their influence on labor utilization for post-production operations. It is also worthwhile to note that only the total post-production labor covariance models exhibited significant and economically meaningful regression coefficients with regard to the wage:rice price ratio (WRP) variable — that is, coefficients with the expected signs.

A note on the seasonal effects for the post-production labor model is appropriate. It may be noticed that in all estimates, the season dummy exhibited an insignificant regression coefficient. This phenomenon may be explained by the fact that although all farms in the different farm categories cultivated a smaller rice area during the dry season compared to the wet season and, hence, utilized less labor hours in post-production operations on a whole farm basis (refer to Table 7.10), the scale effect is eliminated when labor utilization is computed in terms of total labor hours per hectare.

From the covariance analyses, it was observed that the adoption of farm machinery by small rice farms affected mainly those operations in which mechanical power can be substituted for manual and/or animal

Table 7.10. Average labor hours used per farm for post-production operations and average rice farm area, crop year 1979-1980.

Farm Classification		Hired Labor	Family Labor	Total Labor	Average Rice Area[a]
		Wet Season			
Carabao	(C)	277	104	381	1.52
Carabao/thresher	(CT)	339	125	464	2.05
Two-wheel	(TW)	618	3	621	2.50
Two-wheel/thresher	(TWT)	418	54	472	2.63
Two-wheel/carabao	(TWC)	394	44	438	1.98
Two-wheel/carabao/ thresher	(TWCT)	335	64	399	1.94
		Dry Season			
Carabao	(C)	79	63	142	0.82
Carabao/thresher	(CT)	209	21	230	0.91
Two-wheel	(TW)	322	51	373	1.46
Two-wheel/thresher	(TWT)	418	6	424	2.32
Two-wheel/carabao	(TWC)	434	-	434	1.49
Two-wheel/carabao/ thresher	(TWCT)	350	1	351	1.96

[a]Hectares.

power, this supports the substitution view as cited by Binswanger (1978). Of the major operations of rice production, mechanization significantly reduced labor utilization and employment in land preparation and post-production, as verified by the statistical tests (Tables 7.7 and 7.9). The evidence shows that the use of two-wheel tractors, singly or in combination with carabao power, in land preparation has reduced family labor requirements as well as hired labor employment. In the case of farms using mechanical threshers, it may be concluded that these farms utilized less family and hired labor in post-production operations compared to those farms which did not use such machinery. Furthermore, labor utilization and employment effects differred among farms with different modes of mechanization. Aside from two-wheel tractor and mechanical thresher usage, other factors that were observed to affect labor utilization are amount of output produced (Q), season (S) and factors which may enhance the managerial capability of the farm operator such as experience (Ex) and education (Ed). It should be mentioned that the conclusions obtained from the covariance analyses are consistent with those obtained from the tabular analysis.

Budget Analysis

The foregoing analyses have shown that significant differences exist between mechanized and non-mechanized farms with regard to the amount of labor hours utilized by each farm classification. In order to put the overall analysis into proper perspective, another dimension that has to be given importance is the farm budgets. The farm budgets presented in this section were estimated on a per hectare basis in order to eliminate the scale effect on revenue and costs. Furthermore, each financial statement represents the average farm for each farm classification. This means that farms which have different modes of irrigation and tenure systems are represented in the farm budgets specific to a particular farm classification.

A breakdown of the important items included in the budgets are presented in Tables 7.11 to 7.18. A detailed description on how these statements were arrived at are presented in Appendix C.

Referring to Table 7.11, it may be observed that the mechanized farm categories, in general, have higher total gross benefits than non-mechanized farms. This may be attributed to higher yield per hectare, as reflected by the total value of output, realized by farms which are mechanized. However, one has to be cautious in attributing this yield difference solely to farm machinery adoption since mechanized farms generally are located on more fertile farmland. Furthermore, these same farms possess better irrigation facilities as well as apply more fertilizer and chemicals. This is reflected by Table 7.13 which shows that mechanized farms incurred more expenditures for irrigation, fertilizer and chemicals than non-mechanized farms. Since these three variable cost items make up at least 75 percent of the total production materials expense of each farm category, it follows that mechanized farms have greater total production materials expense, except for two-wheel tractor/ carabao(TWC) farms, than non-mechanized farms, i.e., carabao(C) and carabao/thresher(CT) farms.

Table 7.12 compares the hired labor expenses of the different rice farms with different modes of mechanization for the various farm

Table 7.11. Comparison of gross benefits of rice farms with different modes of mechanization, average per season, crop year 1979-1980.

I. Revenue	Farm Classification					
	Carabao (C)	Carabao/thresher (CT)	Two-wheel (TW)	Two-wheel/thresher (TWT)	Two-wheel/carabao (TWC)	Two-wheel/carabao/thresher (TWCT)
	P[a]	P	P	P	P	P
A. Total value of output	2,520	3,309	4,683	4,560	3,197	4,140
B. Value of output share	602	729	1,060	1,056	721	909
C. Total gross benefits (A - B)	1,918	2,580	3,623	3,504	2,476	3,231

[a]Pesos.

Table 7.12. Comparison of hired labor expense for different farm operations among rice farms with different modes of mechanization, average per season, crop year 1979–1980.

II. Paid-out Variable costs: Hired Labor Expense	Farm Classification											
	Carabao (C)		Carabao/thresher (CT)		Two-wheel (TW)		Two-wheel/thresher (TWT)		Two-wheel/carabao (TWC)		Two-wheel/ carabao/ thresher (TWCT)	
	P[a]	%	P	%	P	%	P	%	P	%	P	%
A. Land preparation	62	15	87	16	59	10	79	16	177	29	173	30
B. Planting	146	35	194	35	202	36	190	38	172	29	187	32
C. Care/cultivation	3	–	–	–	4	1	6	1	2	–	5	1
D. Post-production (harvesting)	210	50	268	49	300	53	223	45	252	42	217	37
E. Total hired labor expense	421	100	549	100	565	100	498	100	603	100	582	100

[a]Pesos.

Table 7.13. Comparison of production materials expense among rice farms with different modes of mechanization, average per season, crop year 1979-1980.

III. Paid-out Variable Costs: Production Materials Expense	Farm Classification											
	Carabao (C)		Carabao/thresher (CT)		Two-wheel (TW)		Two-wheel/thresher (TWT)		Two-wheel/carabao (TWC)		Two-wheel/ carabao/ thresher (TWCT)	
	P[a]	%	P	%	P	%	P	%	P	%	P	%
A. Seeds	104	17	106	14	132	13	86	9	107	15	90	10
B. Fertilizer	230	39	299	40	440	43	420	42	284	40	396	45
C. Chemicals	83	14	117	16	181	17	209	21	100	15	137	16
D. Irrigation	128	22	168	22	195	19	194	20	159	22	176	20
E. Sacks	46	8	60	8	84	8	81	8	57	8	73	9
F. Total production materials expense	591	100	750	100	1,032	100	990	100	707	100	872	100

[a]Pesos.

operations. In terms of land preparation hired labor expense, it may be observed that, in spite of the fact that mechanized farms required less hired labor hours (see Appendix Tables C.1b to C.6b) these farms incurred more expense for hired labor than non-mechanized farms. The main reason for this is the higher rate per hour paid to the two-wheel tractor and its operator compared to that paid to a carabao and its operator. The difference in the total paid-out cost for land preparation between the farm categories is magnified if the cost of tractor rent (which may be obtained in Table 7.14) is added on to the hired labor expense for this activity. By doing so, the total paid-out expense for land preparation for TW, TWT, TWC and TWCT farms becomes 349, 294, 292 and 268 pesos, respectively. This is approximately 300 to 500 percent of the total paid-out expense for land preparation for those farms, i.e., C and CT farms, which do not mechanized this aspect of rice production.

Expenditure on hired labor for planting operations do not considerably differ among the different farm groups. The insignificant amount of expense, approximately nil to 1 percent of the total hired labor expense, incurred for care/cultivation activities may be attributed to the decline in weeding labor requirements due to the intensive use of weedicides and herbicides in the study areas. This may be noticed in Table 7.13 which shows that chemical expense accounts for 14 to 21 percent of the total production materials expense across the various farm groups. The major paid-out expense for hired labor is accounted for by harvesting labor which is at least 37 to 53 percent of the total hired labor expense.

Table 7.14. Comparison of miscellaneous expenses among rice farms with different modes of mechanization, average per season, crop year 1979–1980.

IV. Paid-out Miscellaneous Expense	Farm Classification											
	Carabao (C)		Carabao/thresher (CT)		Two-wheel (TW)		Two-wheel/thresher (TWT)		Two-wheel/carabao (TWC)		Two-wheel/carabao/thresher (TWCT)	
	P[a]	%	P	%	P	%	P	%	P	%	P	%
Variable Costs:												
A. Tractor rent	–	–	–	–	290	46	215	39	115	30	95	26
B. Repairs and maintenance	11	6	44	17	13	2	27	5	21	6	3	1
C. Marketing expense	8	5	13	5	36	6	45	8	24	6	36	10
D. Interest expense	155	89	203	78	290	46	266	48	220	58	238	63
E. Total miscellaneous variable expenses	174	100	260	100	629	100	553	100	380	100	372	100

[a]Pesos.

Of the total miscellaneous variable expenses, Table 7.14, tractor rent is the major contributing factor for all mechanized farms -- making up at least 71 to 86 percent of this type of expense. This is further reflected by the fact that the total miscellaneous variable expenses of mechanized farms is considerably greater than non-mechanized farms.

The interest expense for each farm classification is also in Table 7.14. This expense, based on the sum of production materials expense, hired labor expense and miscellaneous variable expenses, is computed at 30 percent per annum or 15 percent per season. It is assumed that farmers avail of credit in order to cover these major farm operating expenses.

Table 7.15 presents a summary of the items that are included in the computation for the gross farm family income of each farm classification. In this table, it may be observed that the total variable costs for mechanized farms ranged from 1,470 to 1,936 pesos while for non-mechanized farms total variable costs ranged from 1,031 to 1,356 pesos. For all farm categories, total production materials expense and total hired labor expense account for 82 to 98 of all variable costs. It is worthwhile to mention that for all farms, at least 50 percent to 60 percent of the total variable costs may be attributed to total production materials expense while 30 to 40 percent to total hired labor expense. Gross farm family income is arrived at by deducting the total costs from total gross benefits for all farm classifications. This represents the return to farm resources, farm family labor and management.

Table 7.15. Comparison of gross family income of rice farms with different modes of mechanization, average per season, crop year 1979-1980.

V. Item	Farm Classification											
	Carabao (C)		Carabao/thresher (CT)		Two-wheel (TW)		Two-wheel/thresher (TWT)		Two-wheel/carabao (TWC)		Two-wheel/ carabao/ thresher (TWCT)	
	P[a]	%	P	%	P	%	P	%	P	%	P	%
A. Total gross benefits	1,918	-	2,580	-	3,623	-	3,504	-	2,476	-	3,231	-
B. Paid-out variable costs:												
1. Hired labor expense	421	35	549	35	565	25	498	24	603	36	582	32
2. Production materials expense	591	50	750	48	1,032	47	990	49	707	42	872	48
3. Tractor rent	-	-	-	-	290	13	215	11	115	7	95	5
4. Repairs and maintenance	11	1	44	3	13	1	27	1	21	1	3	-
5. Marketing costs	8	1	13	1	36	2	45	2	24	1	36	2
6. Interest expense	155	13	203	13	290	13	266	13	220	13	238	13
C. Total variable paid-out costs	1,186	100	1,559	100	2,226	100	2,041	100	1,690	100	1,826	100
D. Gross farm family income	732	-	1,021	-	1,397	-	1,463	-	786	-	1,405	-

[a]Pesos.

By deducting depreciation expense from the gross farm family income, the net farm family income of each farm classification is obtained. This represents the return to family labor and management. Table 7.16 shows that mechanized farms, except for two-wheel tractor/carabao(TWC) farms, realized greater net farm family income than those which were not mechanized.

Having computed the weighted average value of imputed family labor for each major farm operation for each individual farm, an average was then taken with respect to each of the farm classification considered in this study for comparative purposes. A detailed description of the computation for each farm category is presented in Appendix Tables D.1f to D.6f while a summary comparison of imputed value of family labor among farms with different modes of mechanization is presented in Table 7.17. By deducting these values from the net farm family incomes, the net farm income after imputed family labor, which represents the return to farm management, for each farm classification is obtained. The results are presented in Table 7.18. Except for two-wheel tractor/carabao(TWC) farms, all mechanized farms exhibited considerably higher net farm incomes after deducting their respective imputed value of family labor.

Based on the above farm budgets, an estimation of the costs and returns per kilogram of rough rice among rice farms under the specified farm classifications was undertaken. The results are shown in Table 7.19. It may be noticed that mechanized farms do not provide any evidence with regard to lower average variable and fixed costs relative to those incurred by non-mechanized farms. This implies that the mechanized farms considered in this paper are unable to spread

Table 7.16. Comparison of net farm family income among rice farms with different modes of mechanization, average per season, crop year 1979-1980.

VI. Item	Farm Classification					
	Carabao (C)	Carabao/thresher (CT)	Two-wheel (TW)	Two-wheel/thresher (TWT)	Two-wheel/carabao (TWC)	Two-wheel/ carabao/ thresher (TWCT)
	P[a]	P	P	P	P	P
A. Gross farm family income	732	1,021	1,397	1,463	786	1,405
B. Depreciation	149	194	302	309	286	354
C. Net farm family income	583	827	1,095	1,154	500	1,051

[a]Pesos.

Table 7.17. Comparison of imputed family labor values among rice farms with different modes of mechanization, average per season, crop year 1979-1980.

VII. Family Labor	Farm Classification: Carabao (C)		Carabao/thresher (CT)		Two-wheel (TW)		Two-wheel/thresher (TWT)		Two-wheel/carabao (TWC)		Two-wheel/carabao/thresher (TWCT)	
	P[a]	%	P	%	P	%	P	%	P	%	P	%
A. Total land preparation family labor	194	47	197	57	140	77.	144	62	133	49	140	52
B. Planting	43	10	37	10	5	3	19	8	48	18	15	6
C. Care/cultivation	38	9	33	10	32	18	38	17	45	16	37	14
D. Post-production	141	34	79	23	5	2	30	13	46	17	74	28
E. Marketing	–	–	–	–	–	–	–	–	–	–	–	–
F. Total imputed family labor value	416	100	346	100	182	100	231	100	272	100	266	100

[a]Pesos.

Table 7.18. Comparison of net farm income after imputed family labor of rice farms with different modes of mechanization, average per season, crop season 1979-1980.

VIII. Item	Farm Classification					
	Carabao (C)	Carabao/thresher (CT)	Two-wheel (TW)	Two-wheel/thresher (TWT)	Two-wheel/carabao (TWC)	Two-wheel/ carabao/ thresher (TWCT)
	P[a]	P	P	P	P	P
A. Net family income	583	827	1,095	1,154	500	1,051
B. Total imputed family labor value	416	346	182	231	272	266
C. Net farm income after imputed family labor (A - B)	167	481	913	923	228	785

[a]Pesos.

Table 7.19. Comparison of costs and returns per kilogram of rough rice among rice farms with different modes of mechanization, average per season, crop year 1979-1980.

Item	Farm Classification					
	Carabao (C)	Carabao/thresher (CT)	Two-wheel (TW)	Two-wheel/thresher (TWT)	Two-wheel/carabao (TWC)	Two-wheel/carabao/thresher (TWCT)
	P[a]	P	P	P	P	P
Average total cost per kilogram rough rice[b]	0.85	0.82	0.86	0.84	0.96	0.84
Average price per kilogram rough rice	1.11	1.10	1.12	1.13	1.12	1.13
Average return per kilogram rough rice[c]	0.26	0.28	0.26	0.29	0.16	0.29

[a]Pesos.

[b]Average total cost/kilogram rough rice = $\frac{\text{Total paid-out variable costs + value of output share + depreciation expense}}{\text{total output in kilograms}}$

[c]Average return/kilogram rough rice = Average price/kilogram rough rice - Average total cost/kilogram rough rice.

variable and fixed expenses over higher amounts of output which may result in lower average variable and fixed costs for these farms. In this regard, the question of economics of scale becomes an important issue to resolve. Furthermore, due to differences in the average farm-gate price of rough rice received by each farm classification, no conclusive evidence may be observed with regard to mechanized farms receiving higher average return per kilogram rough rice than non-mechanized farms.

The comparison of the output level which covers the variable costs of each farm classification is presented in Table 7.20. Given the average price per kilogram rough rice received by each farm classification, it may be observed that mechanized farms require higher output levels than non-mechanized farms to cover their respective paid-out variable costs. This may be attributed to the fact that mechanized farms incur more paid-out costs resulting from higher expenditure on fertilizer, chemicals, irrigation, hired labor and tractor rent.

The above analysis provides information with regard to the effect of mechanization and other factors, such as fertilizer, irrigation and chemicals, on the net income as well as on the average return per kilogram rough rice of each farm classification. However, in order to arrive at a meaningful conclusion with regard to the beneficial effects of farm mechanization on small rice farm incomes, the separation of each of these effects from one another must be undertaken. Such a task requires the estimation of a production function for each farm classification which includes these factors and estimating each of their average contribution to rice output. These

Table 7.20. Comparison of output levels covering variable costs among small rice farms with different modes of mechanization, average per season, crop year 1979–1980.

Item	Farm Classification					
	Carabao (C)	Carabao/thresher (CT)	Two-wheel (TW)	Two-wheel/thresher (TWT)	Two-wheel/carabao (TWC)	Two-wheel/ carabao/ thresher (TWCT)
Average price/kilogram rough rice (pesos)	1.11	1.10	1.12	1.13	1.12	1.13
Total paid-out cost (pesos)	1,186	1,559	2,226	2,041	1,690	1,826
Output level at which variable costs are covered (kgs.)	1,068	1,417	1,988	1,806	1,509	1,616

estimates may then be used to adjust the rice output of each farm classification from which the net effect of mechanical power adoption on farm income may be derived.

Production Function Analysis

The production function approach to the analysis of mechanization impact on rice output provides one with information regarding the distribution of output among inputs as well as the sensitivity of such distribution to changes in the levels of input applied with a given technology.[116] For analytical purposes, production functions of the Cobb-Douglas type are estimated to obtain such information.

The initial step in this approach requires the testing for differences in the technical efficiency parameters of small rice farms with different modes of mechanization. With the use of dummy variables, this allows one to determine whether these farm types differ in their production functions. It should be mentioned that, for now, the maintained hypothesis is that the production functions of the different farm classifications are identical up to a technical efficiency parameter. The production functions that are estimated are based on the following relationship:

(7.1) $$Q = A\, L^{al}\, F^{af}\, Ch^{ac}\, e^{b'}$$

where: $b' = b_i I + b_s S + b_1 M_1 + b_2 M_2 + b_3 M_3 + b_4 M_4 + b_5 M_5 + w$

Q, A, L, F, Ch, I, S, M_1, M_2, M_3, M_4 and M_5 are as discussed before.

w is the residual term.

It should be noted that a similar relationship was estimated for each of farm-type with the inclusion of independent variables such as, education (Ed) and experience (Ex), to represent farmer management ability, as well as other variables which may provide information regarding yield benefits derived from proper dessimination of rice production technology information and credit accessibility. These variables are represented by the quality of extension services (ES) and membership in farmers' organization (FO), respectively. The estimated results of these regressions are presented in Appendix Table D.1. However, due to the insignificant regression coefficients, these variables were dropped from the estimated production functions used in the succeeding analyses.

Expressing the above equation into logarithmic form, the following is obtained.

$$(7.2) \quad \ln Q = \ln A + a_1 \ln L + a_f \ln F + a_c \ln Ch + b_i I + b_s S + b_1 M_1 + b_2 M_2 + b_3 M_3 + b_4 M_4 + b_5 M_5 + w'$$

where: a's and the b's are the regression coefficients.

w' is the residual term.

The results of the regression estimates of the above production function model are presented in Table 7.21. It may be observed that most of the independent variables were found to be statistically significant up to the 1 percent level. The highly significant regression coefficients of the mechanization dummy variables, MD_1, MD_2, MD_3, MD_4 and MD_5, indicate that farms with different modes of

Table 7.21. Estimated Cobb-Douglas production functions using the dummy variable approach to test for differences in the technical efficiency parameters of small rice farms with different modes of mechanization, Nueva Ecija, Philippines, crop year 1979-1980.

Independent Variable	Statistical Values
Constant	2.98*** (6.66)[a]
Labor (L)	0.56*** (7.45)
Fertilizer (F)	0.07*** (2.58)
Chemicals (Ch)	0.12*** (4.38)
Irrigation (I)	0.28*** (3.85)
Season (S)	0.16** (2.25)
Two-wheel (M_1)	0.58*** (4.24)
Two-wheel/Carabao (M_2)	0.33*** (2.60)
Carabao/thresher (M_3)	0.20** (2.19)
Two-wheel/thresher (M_4)	0.62*** (5.85)
Two-wheel/carabao/thresher (M_5)	0.56*** (4.83)
R^2	0.43
F - value	30.38***
Number of observations	419
Degrees of freedom	408

[a]Values in parantheses are t-values.
***Significant at P = 1%.
**Significant at P = 5%.

mechanization for land preparation operations differ in their technical efficiency parameters. They further imply that farms using two-wheel tractors for land preparation and mechanical threshers for threshing operations have higher technical efficiency parameters than farms using only carabao power (the reference group).

Since the above results indicate that the different farm groups operate on different production functions, further estimates were conducted for each farm classification with identical functional specification. The production function in its general form is presented below:

$$(7.3) \qquad \ln Q = \ln A_j + a_{lj} \ln L_j + a_{fj} \ln F_j + a_{cj} \ln Ch_j + b_{ij} I_j + b_{sj} S_j + v$$

where: j refers to the specific farm group for which the production function is estimated. These specific farm groups are: C, CT, TW, TWT, TWC and TWCT.

The estimated production function for each farm classification indicated above are presented in Table 7.22. Notice that for these estimated functions, all independent variables exhibited positive effects on rice output. Furthermore, most of them exhibited highly significant regression coefficients. These results are consistent with conventional production economic theory as far as input-output relationship is concerned.

The results in Table 7.22 show that farms using mechanical power, whether solely or in combination with animal power, exhibited higher

Table 7.22. Estimated Cobb-Douglas production functions of small rice farms[a] with different modes of mechanization, Nueva Ecija, Philippines, crop year 1979-1980.

Independent Variable		Carabao (C)	Carabao/ thresher (CT)	Two-wheel tractor (TW)	Two-wheel tractor/ thresher (TWT)	Two-wheel tractor/ carabao (TWC)	Two-wheel tractor/ carabao/ thresher (TWCT)	Pooled Regression[c]
Constant		0.59 (0.42)[b]	4.00*** (6.88)	7.26*** (7.64)	5.68*** (10.24)	1.69* (1.81)	4.86*** (6.25)	3.98*** (9.07)
Labor	(L)	0.97*** (4.03)	0.76*** (4.70)	0.18 (0.91)	0.16* (1.79)	0.69*** (3.56)	0.23* (1.82)	0.42*** (5.71)
Fertilizer	(F)	0.02 (0.26)	0.11*** (3.12)	0.08 (1.42)	0.04* (1.86)	0.03 (0.51)	0.31*** (2.69)	0.04* (1.61)
Chemicals	(Ch)	0.15** (2.01)	0.01 (0.44)	0.07 (1.08)	0.22*** (6.00)	0.35*** (2.97)	0.04 (0.80)	0.18*** (6.78)
Irrigation	(I)	0.05 (0.21)	0.24** (2.44)	0.35* (1.80)	0.25** (2.89)	0.31* (1.80)	0.44*** (3.63)	0.36*** (4.95)
Season	(S)	0.20 (0.74)	0.25** (2.33)	0.02 (0.13)	0.13* (1.93)	0.08 (0.44)	0.31** (2.33)	0.21*** (2.90)
R^2		0.27	0.57	0.28	0.42	0.81	0.64	0.36
F-value		6.67***	25.90***	1.98	13.03***	26.62***	16.69***	45.46***
Number of observations		98	105	32	95	37	52	419
Degrees of freedom		92	99	26	89	31	46	413

[a]Estimated on a per hectare basis.
[b]Values in parentheses are t-values.
[c]A production function with the same independent variables was estimated by pooling all the data obtained from the six farm classifications into one estimating regression equation.
***Significant at P = 1%.
**Significant at P = 5%.
*Significant at P = 10%.

efficiency parameters than those which are purely non-mechanized, i.e., carabao(C) farms. This is indicated by the significant large values of the regression constant of carabao/thresher(CT),two-wheel tractor(TW), two-wheel tractor/thresher(TWT), two-wheel tractor/carabao(TWC) and two-wheel/carabao/thresher(TWCT) farms. In addition, it may be observed that the labor variable was found to be significant in most of the estimated production functions, except for the two-wheel tractor(TW) farm classification. Furthermore, the labor coefficient is highest for farms with purely non-mechanized land preparation operations, i.e., carabao(C) and carabao/thresher(CT) farms, while those farms using two-wheel tractors for these same operations, i.e., two-wheel tractor(TW) and two-wheel tractor/thresher(TWT) farms, exhibited the lowest labor coefficients. Such behavior of the labor coefficient implies that increases in the degree of mechanization results in labor redundancy, particularly in land preparation operations.

The influence of fertilizer on rice output was found to be significant in those farms, i.e., CT, TWT and TWCT arms, which incurred high expenditures on this input. It should be noted that the two-wheel tractor(TW) farms also applied high levels of fertilizer but did not exhibit significant regression coefficients for this variable. As far as the effect of chemicals on rice output is concerned, only C, TWT and TWC farms exhibited significant regression coefficients.

Since most of the mechanized farms, whether partially or fully mechanized, are located in areas with irrigation facilities only these farm-types showed significant influence of irrigation on rice output. The regression coefficient of the irrigation variable in the production function of carabao(C) farms was insignificant which is not surprising since these farms are generally non-irrigated or are inefficiently irrigated. The season dummy variable for all farm classifications was found to be positive—implying that higher rice output is produced during the dry season by all farm-types. It should be noted that the low R^2 of each estimated farm-specific production function implies considerable weakness in the explanatory power of the independent variables included in the regression equations. However, since the main concern of the covariance analysis is to determine whether the impact of mechanical power adoption significantly reduced farm labor utilization in mechanized farms, the low R^2 of each labor covariance model does not invalidate the analysis.

In order to investigate whether the estimated regression coefficients of the production functions pertaining to the different farm classifications significantly differ from one another, the Chow test was utilized for such a task. The results of the test are shown in Table 7.23 which indicate that the estimated parameters of each of the estimated farm-specific Cobb-Douglas production significantly differ up to the 1% level.

Based on the above estimated production functions, it may be said that all farms with different degrees of mechanization, i.e., CT, TW, TWT, TWC and TWCT farms, attain greater technical efficiency compared to those which are non-mechanized, i.e., C farms. This is implied by the significantly larger regression constant for all these said farm-types. However, the question of whether or not each farm-type utilizes labor at a level in which the profit-maximizing condition is attained needs to be considered. Given their respective level of

Table 7.23. A test for structural differences in the production functions of farms with different modes of mechanization, Nueva Ecija, Philippines, crop year 1979-1980.

Farm Classification		Sum of Squared Residuals (E_j^2)	Number of Observations (n_j)	Number of Regression Coefficients (k_j)	Degrees of Freedom
Carabao	(C)	112.66	98	6	92
Carabao/thresher	(CT)	16.75	105	6	99
Two-wheel	(TW)	2.82	32	6	26
Two-wheel/thresher	(TWT)	8.36	95	6	89
Two-wheel/carabao	(TWC)	4.53	37	6	31
Two-wheel/carabao/ thresher	(TWCT)	5.81	52	6	46
Total		150.93	419	36	383
Pooled Regression	(P)	189.56	419	6	413
Difference		38.63			
F-value[a]		16.51***			

$$^{a}F^{*} = \frac{[E_p^2 - (E_c^2 + E_{ct}^2 + E_{tw}^2 + E_{twt}^2 + E_{twc}^2 + E_{twct}^2)]/k_p}{(E_c^2 + E_{ct}^2 + E_{tw}^2 + E_{twt}^2 + E_{twc}^2 + E_{twct}^2)/(N - K)} = \frac{38.63/6}{150.93/383}.$$

where: $K = k_c + k_{ct} + k_{tw} + k_{twt} + k_{twc} + k_{twct}$
$N = n_c + n_{ct} + n_{tw} + n_{twt} + n_{twc} + n_{twct}$

***Significant up to the 1% level.

technology, as well as factor and product prices, each farm-type's profit-maximizing condition is represented by:

(7.4) $$VMP_{Lj}=P_{Lj}$$

where: j refers to a specific farm-type, i.e., C, CT, TW, TWT, TWC and TWCT farms.

VMP_{Lj} is the value marginal product of labor, in pesos.

P_{Lj} is the average labor wage rate per hour, in pesos.

(7.5) $$(P_{qj})(MPP_{Lj})=P_{Lj}$$

where: P_{qj} is the average price per kilogram of rough rice.

MPP_{Lj} is the marginal physical product of labor.

The expression presented by equation (7.5) may be further expressed as:

(7.6) $$(P_{qj})[(a_{1j})(\bar{Q}_j/\bar{L}_j)]=P_{Lj}$$

where: a_{1j} is the output-labor elasticity as obtained from the production function estimates of each farm-type.

$\bar{Q}_j$ is the average amount of rough rice produced by each farm classification per hectare, in kilograms.

$\bar{L}_j$ is the average amount of labor-hour input utilized by each farm classification for all farm operations per hectare.

The above relationships imply that profit-maximizing farms utilize labor at a level where their respective value marginal products are equal to the farm-specific labor price.

Having calculated the farm-specific average labor wage rate ($P_{L_{ij}}$) as speicified in Chapter V, the average wage rate for each farm classification, P_{L_j}, is obtained by the following expression:

$$(7.7) \qquad \frac{P_{L_{1j}} + P_{L_{2j}} + \ldots + P_{L_{nj}}}{n} = P_{L_j}$$

where: n is the number of households in the jth farm classification.

Based on the relationship expressed by (7.6), the results presented in Table 7.24 were obtained. This table presents the values of the marginal physical product of labor, MPP_L, value marginal product of labor, VMP_L, and the average labor wage rate, P_L, of each farm classification.

Recall at this point that statistical tests showed that each farm classification possess its own unique production function relationship, given the covariance analysis which provided the information on what important input variables were to be included in the model. Specifically, the tests indicated that mechanized farms exhibited greater technical efficiency parameters and showed different output-input response relationships compared to non-mechanized farms. This is specifically with regard to the output-labor response relationship.

The difference in technical efficiency parameters between a

Table 7.24. Information regarding the value marginal product and average labor wage rate per hour of farms with different modes of mechanization, Nueva Ecija, Philippines, crop year 1979-1980.

		Carabao (C)	Carabao/ thresher (CT)	Two-wheel tractor (TW)	Two-wheel tractor/ thresher (TWT)	Two-wheel tractor/ carabao (TWC)	Two-wheel tractor/ carabao/ thresher (TWCT)
Average rice price	(P_q)	1.11[a]	1.10	1.12	1.13	1.12	1.13
Output elasticity of labor	(a_1)	0.97[b]	0.76	0.18	0.16	0.69	0.23
Rice yield per hectare	($\bar{Q}$)	2,270[c]	3,008	4,181	4,035	2,854	3,664
Labor hours per hectare	($\bar{L}$)	597	686	550	438	501	464
Marginal physical product of labor	(MPP_L)	3.69[d]	3.33	1.37	1.37	3.93	1.82
Value marginal product of labor	(VMP_L)	4.10[e]	3.66	1.52	1.66	4.40	2.06
Average labor wage rate	(P_L)	1.70[f]	1.54	2.22	2.12	1.88	2.22

[a]Peso per kilogram.
[b]Regression coefficient of the labor variable.
[c]In kilograms.
[d]$MPP_L = (a_1)[(\bar{Q}/\bar{L})]$.
[e]$VMP_L = (P_q)(MPP_L)$.
[f]Peso per man-hour.

mechanized and non-mechanized farm implies that at a specific level of input, such as labor, a mechanized farm is able to produce more output relative to that which is not mechanized. In Figure 4.1b, at L_2 level of labor input, a mechanized farm will be able to produce q_3^* output while a non-mechanized farm will be producing q_2 output.

It may be observed in Table 7.24 that farms with large output elasticity values with respect to labor (i.e., C and CT farms) exhibited high MPP_L values. This implies that for each additional unit of rice output, a large portion of this additional unit may be attributed to labor. However, for farms which are highly mechanized, such as TW and TWT farm, their marginal physical product of labor exhibited lower absolute values—implying that the contribution of labor, relative to other inputs, to each additional unit of output is lower in farms with highly mechanized operations. Multiplying the MPP_L values of each farm classification by the farm-specific average rice price, P_q, the VMP_L are obtained for each of these farm-types. The VMP_L and P_L values indicate that farms with non-mechanized land preparation operations (i.e., (C) and (CT) farms) are unable to optimize labor utilization due to very low labor wage rate. For these farm classifications, $VMP_L > P_L$ which implies that to maximize profit they must expand their labor utilization beyond their current levels, in spite of the fact that these farms already use considerably more labor input hours than the other farm-types which have mechanized land preparation operations. It should be noted that such results do not differ from the graphical illustration presented in Chapter IV which discussed the theoretical framework of the study. In the case of the farms using only carabao power for land preparation, the very low labor wage rate faced by these farms does not provide any incentive for their operators to use mechanical power. As a result, given their respective farm budgets and the relatively high price of man-machine services, these farms will tend to rely mainly on labor-animal power. In Figure 4.1d, this is indicated by point F which is the point of tangency of isocost curve IC_1 and isoquant q_2.

However, in the case of the mechanized farms, except for the two-wheel tractor/carabao farms(TWC), the difference between the VMP_L and P_L values is not too pronounced due to (1) the lower share of the labor input for each additional unit of rice and (2) the higher average labor wage rate in these farms. The higher labor wage rate in the mechanized farms may be due to the higher level of "specialized" labor required to accomplish certain farm operations, i.e., land preparation and threshing with mechanical power, in these farm-types. As a result of the lower output share of labor and the higher average wage rate, mechanized farms are able to utilize this factor closer to the profit-maximizing labor input level than those which are not mechanized. From the above discussion, one may expect that as long as the contribution of labor remains at a low level and the labor wage rate continues to be high, mechanized farms will tend to employ less labor compared to non-mechanized farms.

This implies that under a mechanized scheme (Figure 4.1e), a mechanized farm with isocost curve $I'C_2'$ and producing the same amount of output as a non-mechanized farm, i.e., q_2 output, will utilize labor at that level where it is able to maximize profit. In this case, at L_1 amount of labor which is less than what a non-mechanized farm requires to produce q_2, as shown in Figure 4.1d.

It should be noted that in order to calculate the amount of rice output that is attributable to labor, and subsequently to some extent to mechanization, it is necessary to isolate the labor effect on output from that of the other inputs. The adjusted yield per hectare for each farm classification is obtained by using the following relationship:

(7.9) $$Q_j^* = A_j \, L_{ij}^{a_{1j}} \, F_j^{a_{fj}} \, Ch_j^{a_{cj}} \, e^{b_i I_{ij} + b_s S}$$

where: j refers to a particular farm classification, i.e., C, CT, TW, TWT, TWC and TWCT.

Q_j^* refers to the adjusted yield per hectare of a particular farm classification.

A_j is the estimated technical efficiency parameter of the jth farm.

a_{1j} is the estimated regression coefficient of L_{ij} as obtained from the farm-specific Cobb-Douglas production function.

L_{ij} is the average labor hours per hectare utilized inrice production by the ith farm in the jth farm classification.

a_{fj} is the estimated regression coefficient of F_j as obtained from the farm-specific Cobb-Douglas production function.

F_j is the average amount of fertilizer, in kilograms, that the carabao farm classification applied during a rice production season.

a_{cj} is the estimated regression coefficient of Ch_j as obtained from the farm-specific Cobb-Douglas production function.

Ch_j is the average expenditure of the carabao farm classification on chemicals during a rice production season, in pesos.

b_i is the estimated regression coefficient of the irrigation dummy I which has been discussed before.

b_s is the estimated regression coefficient of the season dummy S which has been discussed before.

Having calculated the adjusted yields per hectare of each farm classification, the t-test was used to investigate whether significant yield differences exist among small rice farms with different modes of mechanization. However, before a comparative analysis of the adjusted yields of each farm-type was undertaken, a test was conducted to verify whether actual yields of these farms differ from one another. The results of this test are presented in Table 7.25.

Table 7.25 presents a matrix of the level of statistical significance of the difference of actual yields of compared farms. For example, the box in the first row, third column indicate that farms using carabao power for land preparation (C) have significantly lower actual yields than farms using two-wheel tractor for the same operations (TW). Furthermore, the actual yield difference is statistically different up to the 1 percent level. It may be observed

Table 7.25. Test[a] of average yield per hectare of small rice farms with different modes of mechanization without adjustments for fertilizer, chemicals, irrigation and seasonal effects, crop year 1979-1980.

		C[b]	CT	TW	TWT	TWC	TWCT
		2,270[c]	3,008	4,181	4,035	2,854	3,664
C[b]	2,270[c]	-	***	***	***	**	***
CT	3,008	-	-	***	***	n.s.	**
TW	4,181	-	-	-	n.s	***	n.s
TWT	4,035	-	-	-	-	***	n.s.
TWC	2,854	-	-	-	-	-	**
TWCT	3,664	-	-	-	-	-	-

[a]t-test.
[b]Farm classification.
[c]Average yield per hectare in kilograms.
*** Yield difference is significant up to P = 1%.
** Yield difference is significant up to P = 5%.
n.s. Yield difference is not significant.

in Table 7.25 that the actual yields of C and CT, when compared to all other farms, exhibited significantly lower levels of output. This may be observed in the first and second rows which present the level of statistical significance of actual yield-differences of C and CT farms, respectively, and other farm-types with different degrees of mechanization.

However, after having adjusted for the effects of fertilizer, chemicals, irrigation and season the average yield of farms using mainly carabao for land preparation operations (C and CT farms) were found to be significantly higher than those which used two-wheel tractors for land preparation, i.e., TW and TWT farms. This is seen in the first row of Table 7.26. Furthermore, the adjusted yield of C and CT farms were found to be significantly higher than the adjusted yields of TWC and TWCT farms. Columns five and six of the first and second rows of Table 7.26 indicate this phenomenon.

Based on the above comparative analysis of adjusted yields of the different farm classifications, it may be concluded that rice farms with mechanized land preparation, as compared to those which are non-mechanized, do not attain higher levels of farm output. Furthermore, the higher output levels realized by these mechanized farms may be generally attributed to higher levels of fertilizer and chemical application (as indicated in Table 7.27) and better irrigation facilities (as indicated in Table 6.17b by the irrigation index).

Table 7.26. Test[a] of average yield per hectare of small rice farms with different modes of mechanization with adjustments for fertilizer, chemicals, irrigation and seasonal effects, crop year 1979-1980.

		C[b]	CT	TW	TWT	TWC	TWCT
		676[c]	1,373	62	64	809	172
C[b]	676[c]	-	***	***	***	**	***
CT	1,373	-	-	***	***	***	***
TW	62	-	-	-	n.s.	***	***
TWT	64	-	-	-	-	***	***
TWC	809	-	-	-	-	-	***
TWCT	172	-	-	-	-	-	-

[a]t-test.
[b]Farm classification.
[c]Adjusted average yield per hectare, in kilograms.
*** Yield difference is significant up to P = 1%.
** Yield difference is significant up to P = 5%.
n.s. Yield difference is not significant.

Table 7.27. Comparison of chemical and fertilizer expenditures between non-mechanized and mechanized farms, crop year 1979-1980.

Farm Classification	Chemical expenditure/ hectare	Fertilizer expenditure/ hectare	Amount of fertilizer applied/hectare	No. of Obser- vations
	(pesos)	(pesos)	(kgs.)	
Non-mechanized	101	347	203	203
Mechanized	168	400	239	216
t-value	-6.9962**	-2.0916*	-2.4505**	

**Significant at P = 1%.

*Significant at P = 5%.

Footnotes

Chapter VII

[114]A detailed breakdown of the different farm operations is presented in Appendix B.

[115]It should be noted that most of the weeding activities are done during the vegetative stage, that is, the period from transplanting to panicle initiation. This is approximately 35 days for IR50 to 65 days for IR8 varieties. In this connection, at least 280-520 man-hours are required to complete the magnitude of weeding work in such a short time so that proper timing of fertilizer application may be accomplished. This is, specifically, at panicle initiation. The importance of such scheduling prevents the weeds from competing with the rice plants for the fertilizer nutrients necessary for the rice reproductive stage. In order to accomplish these tasks at the proper time, family labor must be supplemented with large amount of hired labor.

[116]C. G. Ranade and R. W. Herdt, "Shares of Farm Earnings From Rice Production," Economic Consequences of the New Rice Technology, The International Rice Research Institute, Los Baños, Laguna, Philippines, 1978, pp. 87-104.

Chapter VIII

Summary and Conclusions

Rice, the major staple crop in the Philippines, is grown predominantly by small farms with different levels of mechanization. In spite of the fact that the sugar industry in the country has been mechanized since the late 1960's, mechanization of certain rice farm operations only occurred in the 1970's as a result of the CB-IBRD credit project geared toward the development of agriculture and the implementation of financing schemes to encourage farm machinery adoption.

The issue of farm mechanization in small rice farms has been the center of controversy with regard to its effects on farm labor employment, output and income. One school of thought argues that the adoption of farm machinery has resulted in the replacement and displacement of labor which is undesirable in countries where manual power is abundant and farming operations are labor intensive. On the other hand, the other school of thought argues that farm mechanization allows for more efficient farm operations which contribute to increases in yields as well as greater intensity of land use. As a result, increases in the labor requirements of certain farm activities, such as harvesting, have an offsetting effect on the amount of labor displaced from other farm operations, land preparation for example. It should be noted that such an argument implies an upward shift in the total product curve of a mechanized farm which in turn shifts the cost curve of such farm downward. Given the prices of rice and production inputs for that particular farm, an increase in its income results.

In a survey of two municipalities in Nueva Ecija, a province in the rice growing region of Central Luzon, Philippines, relevant information were gathered in order to investigate which of the phenomena, as presented above, may be observed in small rice farms in the Philippines. The farms included in the survey were classified into different farm categories depending on their level of mechanization. As defined before, these farms were classified as: (1) carabao farms (C), (2) carabao/thresher farms (CT), (3) two-wheel tractor farms (TW), (4) two-wheel tractor/thresher farms (TWT), (5) two-wheel tractor/carabao farms (TWC) and (6) two-wheel tractor/carabao/thresher farms (TWCT).

Statistical analyses showed that the major effect of mechanical power adoption is the significant reduction in the labor input requirements of farms using two-wheel tractors for land preparation and mechanical threshers for post-production operations. This is reflected by the fact that the use of two-wheel tractors, singly or in combination with carabao power in land preparation reduced family labor requirements and hired labor employment as well. In addition, mechanical threshers were found to have the potential of replacing and displacing post-production labor. Aside from the adoption of farm machinery, other factors that were observed to affect labor utilization were the amount of output produced, cropping season and managerial capability of the farmer operator.

Although the statistical and farm budget analyses indicated that mechanized farms realized higher levels of rice output as well as higher farm incomes than non-mechanized farms, these results cannot be considered conclusive as far as attributing the difference solely to mechanization. The reason for this is that mechanized farms apply higher levels of fertilizer and chemicals which may account for the higher yields attained by these farms. Furthermore, these same farms have better irrigation facilities than non-mechanized farms.

By using the estimated parameters derived from the production function estimates of each farm classification, the actual average yields of these farms were adjusted for the effects of other factors of production. A comparative statistical analysis, using the t-test, indicated that farms using mechanical power for land preparation significantly attained lower average yield per hectare compared to non-mechanized farms after adjusting for the contributory effects of fertilizer, chemicals, irrigation and season.

Based on these findings it may be concluded that the substitution of farm machinery for manual power in certain operations such as land preparation and post-production have resulted in the reduction of labor requirements for such tasks. In addition, contrary to the "net contributory" argument — that mechanized land preparation operations result in higher yields — it may be concluded that yield-differences between mechanized and non-mechanized farms are attributable to other factors such as the intensity of fertilizer and chemical usage and proper water management. Furthermore, although mechanized farms realized higher yield levels per hectare, no evidence was observed to support the net contributory argument that greater output results in increased harvesting labor requirements which, in turn, offsets the amount of labor displaced in land preparation due to mechanization.

It should be noted that if such an offsetting effect was observed, it may only be attributed to yield-influencing factors other than mechanization.

However, considering all the factors of production utilized by each farm, mechanized farms are more likely to realize higher farm output (subsequently, higher net farm income) as well as achieve economic efficiency (with respect to labor) than non-mechanized farms.

Policy Implications

Increasing farm output through the adoption of farm machinery, as a policy objective, involves many issues which require considerable attention so as to provide the proper direction for supplementary policy programs toward the attainment of this goal. Studies conducted to investigate the impact of mechanization on farm output, labor employment and income could provide valuable information with regard to these issues. Although the foregoing results provide weak evidence regarding the effects of mechanization on output, labor and income, several policy implications may be derived from them. If one is to identify these policy implications, it is necessary to take into account the social, economic and technical dimensions of such mechanization impacts. In otherwords, if the Philippine government's agricultural policy-makers were to develop agricultural programs related to mechanization of small rice farms, they must be able to establish an objective (or objectives) as well as a coherent and consistent body of policies which in aggregate constitute an agricultural mechanization policy relevant to the current issues besetting the country's agricultural sector. Although it is difficult to delineate policies geared toward a specific issue from the others, there are several considerations which must be taken into account relating to each of the above-mentioned dimensions.

Socio-economic considerations. The major social issue to be considered is the matter of labor displacement by the adoption of farm machinery in small rice farms. Although it has been shown that mechanization of certain farm operations, such as land preparation and post-production operations, resulted in the utilization of lower levels of labor imputs in these operations, it is important to ask pertinent questions relevant to this labor displacement issue. The main question related to the employment issue is: Since farm machinery has the potential of replacing and displacing manual labor in certain farm operations, is it possible to maintain a certain level of unemployment where farm output and income is maximized for a greater portion of the farm population? However, prior to answering this question, supplementary questions must be considered.

These questions are: What type of labor is being replaced? Is it family or hired labor? If hired labor, is the main source of hired labor landless laborers whose main source of income is farm employment? Or is the source from farm-owners who seek farm employment as an extra source of income? Who owns the farm machinery landless laborers or well-to-do farm owners?

The results of the study show that significantly lower levels in family labor use were observed in those farms using farm machinery compared to those which do not. Although decreases in hired labor use were also observed, the findings are inconclusive. This particular component of total farm labor requires closer scrutiny since the effects of mechanization on displaced hired labor differs depending on the source of this type of farm labor. Generally, hired labor services are provided by (1) landless laborers whose main source of income is derived from farm employment and (2) farm households with surplus family labor which provide additional supply in the labor market in order to supplement their farm income. These hired labor services are generally required during the peak periods of planting and harvesting operations — operations which family labor alone is unable to handle. Although land preparation operations also require hired labor services, the farm operator and his family usually are able to accomplish such tasks by themselves.

Based on these information, it would seem that any policy in favor of farm machinery adoption (particularly those machines geared for land preparation operations) will have differential impacts on the two major components of farm labor, i.e., hired and family labor. Such a policy will not substantially displace hired labor employment but will drastically decrease family labor utilization among mechanized farms. Labor displacement in farm operations such as post-production operations due to the use of mechanical threshers was also observed to occur but considerable effects in the reduction of hired and family labor are not yet evident. This may be due to the fact that most of the farms still rely on the pre-World War II reconditionad heavy mechanical threshers which are difficult to maneuver into the muddy rice paddies. As a consequence, only farms along the road where these large threshers are able to pass avail of their services. However, it is worthwhile to note that in spite of the existence of such large mechanical threshers, threshing is still generally done manually. It seems apparent that as the smaller and higher portable mechanical thresher gains more popularity among the farmers in the Central Luzon region, significant employment effects may be observed in the future with regard to post-production operations. If the adoption of machinery in certain farm operations releases family labor and landless labor from these farm tasks, policies promoting mechanization must include programs which may facilitate the redirection of this surplus farm labor toward other income-earning endeavors.

Limitations of the Study

In spite of the consistency in the results of the analytical approaches undertaken in the study, several limitations must be taken into consideration. Among these are the following:

1. Model mispecification. The common problem encountered in statistical model building is the omission of important variables which may play major roles in explaining the behavior of a particular dependent variable. Usually the omission results from the (a) lack of knowledge of the whole model that one is trying to establish, (b) inability to measure certain variables that are known to exert considerable influences on the dependent variable being studied, (c) desire to build a simple model that is easy to manage and (d) limiting nature of the data available to the researcher. These factors hold true in the case of the specified production models developed for this study in which other independent variables such as soil quality and management were

left-out. Thus, the estimated production function estimated for each farm classification may have been mispecified.

2. Aggregation bias. It should be noted that the "average farm", as presented for each farm classification, represents farms which are owned and rented by the farm operator, irrigated and non-irrigated, plant different types of modern rice varieties, apply different levels and types of fertilzer and chemicals as well as differ in the managerial skills of the farmer operator. Furthermore, each farm within each farm group have varying combinations of hired and family labor. This being the case, the regression coefficients of the production function estimates may have been affected considerably. Unfortunately, the direction of the bias is not known. In the case of the farm budgets, the aggregation problem may be generally reflected by the prices used in estimating revenue and costs. Since farmers do not follow the same farm operation timetables, variations in input-buying and output-selling schedules exist among farms within a specific farm classification as well as between farms with different modes of mechanization. Therefore, each and every farm is faced with different input and output prices at that time the farmer operator makes a decision to buy a particular input or sell a product. By expressing input and output prices in terms of their averages, the actual price that farmers paid for a particular input and the actual price they received for their output produced may either be over- or underestimated.

3. Farmer recall errors. Due to the fact that the farmer-interviewees are subjected to questions which required them

to recall certain information, it is inevitable that measurement errors exist in the data obtained from the farm surveys.

4. Four-wheel tractors not considered. Another limitation of the study is that farms using other types of farm machinery for land preparation operations were not considered, such as four-wheel, heavy-duty tractors. However, due to the existence of numerous modes of farm mechanization in the study area, it was deemed practical to concentrate on the farm classifications considered in the study.

5. Technical limitations. Due to the lack of information on farm machinery horsepower, this was not incorporated in the analyses. Since tractors with different horsepower capacities vary in their degree of efficiency, the inclusion of such data in the covariance and production function analyses could have provided more economically meaningful results with regard to labor and output effects of farm mechanization.

6. Farm level analysis. The fact that the main concern of the study is the immediate effects of mechanization on labor utilization, output and income at the farm level, the results only provide information on just one part of the whole picture. For future research, it is worthwhile to look into mechanization effects on the income of landless laborers as well as on the income distribution among farms with varying (a) degrees of farm machinery usage, (b) farm sizes, (c) tenure status and (d) irrigation systems. Furthermore, it may be fruitful for policy considerations to consider the secondary effects of farm mechanization on off-farm (i.e., industry and service sectors)

labor employment and income distribution in order to acquire a more balanced perspective regarding the mechanization issues.

7. Others. Since the budget analysis did not take into consideration other sources of income, it is recommended that future research on the analysis of farm income include an accounting as to how much farm machinery and draft animal owners earn from customwork as well as how much income is derived by each farm household from other sources aside from rice farming. This will also require a detailed accounting of all farm expenses. In other words, a whole farm budget analysis may prove useful for future policy considerations with regard to the overall farm effects of mechanization.

The issue of timeliness in operations such as those in land preparation has been associated with positive effects of mechanization on rice yield. However, due to the various dimensions of this issue, as well as to the time constraint, no attempt was made to incorporate any analysis regarding this matter. Since timeliness is conditioned by the physical environment (i.e., topography, degree of water control, soil type and weather conditions) within which a rice crop is grown, as well as by the inherent characteristics of the rice varieties, future research could provide valuable information on how the interaction of such factors affect limeliness, and subsequently, rice yields.

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APPENDIX A

Sampling Procedures

APPENDIX A

Sampling Procedures[1/]

A. General

Considerable discussion took place during the workshop on the topic of what sampling procedure to use. The participants generally agreed that probability sampling should be used, so that general conclusions can be drawn, at least about the villages in which the studies are carried out.

It was also agreed that the sample should be stratified, because a simple random sample of all farms in a village would likely result in drawing too few farms with some of the levels of mechanization which are of high interest in the study. Furthermore, the analytical basis of the study consists of "with" and "without" types of comparisons, hence the analyst must have sufficient numbers in each category to be compared. The sampling problem is somewhat akin to sampling a population for the presence of a particular attribute.

The next two questions addressed by the workshop thus became "how many is a sufficient number in a stratum" and "what should be the stratification procedure."

A great deal of discussion also reviewed the subject of accuracy of data collected from enumerator surveys particularly because of recall problems on the part of respondents. There was also concern over respondent fatigue or unwillingness of respondents to spend the amount of time necessary to be interviewed on the details of all inputs and outputs for each and every parcel farmed. The group therefore decided to collect detailed data on only one parcel per farmer, following the concept of the "Intensive Data Parcel" used in the IRRI Constraints Project.2/ Details are given in Section D.

B. Stratification and the Number of Observations

It was initially proposed to the workshop that 19 strata be used. The stratification variables were three mechanization (hand, animal, mechanical), two size (large, small), and three irrigation (rainfed, irrigated one crop/year, irrigated two crops/year). To these 18 (3 x 2 x 3) was added an additional landless laborer stratum. Fifteen samples were proposed for each of the 18 farm stratum, for a total of 270 farm observations, and 50 landless laborer samples were suggested for an overall total of 320 sample points.

The farm size variable seemed to be difficult to handle across countries. A large farm in Indonesia might be smaller than a small farm in Thailand. The evidence from the Binswanger study was not strong on this point.3/ There was general agreement therefore to drop size as a stratification variable. Researchers should examine their data, expecially by stratum, and if size appears ex post to have an important effect on variables of interest, then post-survey stratification of the data can be employed. Size may also be used as an independent variable in multivariate analysis.

There was also considerable discussion on how to stratify on the mechanization variable. There was criticism of the tendency to use the terms "mechanization" and "mechanized land preparation" interchangeably. Participants were reminded that mechanization means replacing a man or an animal by a machine to carry out a certain operation, and that while tillage is an important operation, so are other operations, such as weeding, threshing, etc.4/ The group therefore agreed to the following five strata:

1. Hand (human power)
2. Animal
3. Mechanized land preparation
4. Mechanized threshing
5. Mechanization of both land preparation and threshing

It was recognized that while farms with human beings as sole source of power will likely constitute an important stratum in Indonesia, it will likely be an emplty category in Thailand and perhaps in the Philippines. Strata 4 and 5 might also be an empty category in Thailand at one of the two sites already selected. However threshers are spreading rapidly in Thailand, and by the time of the survey, it may be possible to fill a thresher stratum, or at least every effort should be made to do so.

The three irrigation strata (rainfed, irrigated one crop/year and irrigated two crops/year) were acceptable to all. We thus have 15 farm strata (5 x 3) plus one non farm labor strata. With respect to the latter, Thailand will substitute farm labor from outside the village (still likely to be farmers from neighboring villages but probably without irrigation).

The question of number of observations per cell was debated at length. The variance is of course the key determinant of numbers of observations needed. The initial proposal of 15 per cell was based on advice from statisticians that 15 was about the minimum number needed for most kinds of analysis. Participants felt, and the Binswanger study strongly supports that small numbers of observations restrict the analysis, or at least reduce considerably the strength of the conclusions. It was therefore decided to stay with the farm sample size of about 270 as initially proposed, which would allow 18 per cell if all 15 cells existed.

An analytical weakness in following this method was pointed out, however, namely the reduced ability to test non-mechanized versus mechanized categories. For example, suppose a sample of 75 farms was allocated evenly over 5 stratum, of which one was animal power and 4 were mechanical power, giving 15 sample farms per stratum. If one were to use ANOVA to test for certain differences among stratum, then the equal number of observations in each cell is quite useful. If however, one wishes to test for differences between non-mechanized (15 samples) and mechanized (60 samples) then the small number of non-mechanized samples unduly restricts the analysis.

Where all 15 cells are present and can be filled, then it was agreed that the survey should probably proceed with 18 or 20 per cell, unless the budget permits slightly larger numbers for the human and animal power cells. If some cells are empty, however, then the surplus observations should probably be allocated over the strata to strengthen the analysis. For example, suppose that at the first Thai site no "human labor only" strata exist, but the other 12 strata are present. Then the 54 observations saved (18 per stratum x 3 irrigation strata) should probably be allocated to the animal power strata. Then when a non-mechanized versus mechanized comparison is made within an irrigation stratum, one has 36 samples for non-mechanized and 54 for mechanized (3 mechanization strata x 18 samples/stratum). Overall, one would have 108 non-mechanized and 162 mechanized observations.

In general, although we do not know <u>ex ante</u> how large the variance of the key variables will be, we suspect it is large. Therefore, the number of observations must stay fairly large and if budget constraints are encountered, it would be better to reduce the number of strata rather than reduce the number of observations per stratum.

Because the sample is stratified and because we are seeking roughly equal numbers of observations per cell, the probability of selection for each element in the population will be different, depending upon which substratum the particular element falls into. It is still a random sample, because even though all observations do not have an equal probability of selection, the probabilities are known. This method is close to that of optimum allocation, but with subjective estimates of the variance, and an assumption of equal cost of sampling.

The consequences for analysis of data using unequal probabilities are:

1. Estimates of average or overall characteristics must take unequal probabilities into account by weighting each observation.
2. Multivariate analysis will not describe the sampled population, but instead will be biased. The results will describe only the particular sample. The coefficients

that emerge from the analysis may not be valid for more general analyses.

The problem in 2 above might be alleviated if a basic sample is drawn (perhaps 75 percent of the total observations desired) according to stratified sampling with proportional allocation of samples. Then in order to assure a minimum number of observations per cell, say 20 or 25, additional samples elements can be drawn to add to those in the basic cell. Univariate (descriptive) statistics can use all observations, properly weighted, and multivariate statistics can use only the self weighting observations from the first sample with proportional allocation.

C. <u>Selecting Households</u>

The first step in a sample survey is the construction of the sampling frame. A sample frame is defined as a device that permits equal access to all elements in the population of interest. Frames can be either list or area frames. A list frame will be used in the mechanization consequences study. The task therefore, is to define the population and then prepare a list which permits equal access to each element in that population.

The population of interest was defined as those rice farming households which farmed (produced) a minimum of 1000 square meters (0.1 ha.) of rice during the wet season. A more specific definition than "farmed" is probably needed, such as follows. "A rice farming household is a household which operates at least 1000 square meters of land planted to rice in the wet season, on which that household makes all of those management decisions commonly made by households in that tenure category, and the household also contributes at least some labor to the production of that rice."

It is important to keep the definition at the household level, because we are interested in total household income from farm, off-farm, and non-farm sources, and the impact of mechanization on the total amount and on the sources of that income. It is also important to keep the "labor contribution" part of the definition in order to keep absentee owners, functionally retired persons, etc., out of the sample. While one might successfully argue for inclusions of these persons on conceptual grounds, these categories of people are very difficult to interview.

Having defined the population of interest, the next task is to prepare the list frame. Within the village structure of the countries of interest, constructing the list frame means conducting a census of all households in the villages selected for inclusion in the survey. In rare cases, the village headman may possess a list that is completely accurate. Even then this list is unlikely to include all information needed. Also, relying only on the memory of the headman or a few elders, while useful for some kinds of information, can be quite misleading for other categories of data. If the number of households is very large or too large to conduct a census within budget limits, then the researcher should consider drawing a census sample a part of the village on an area basis and then carrying out a census of households within the sample areas selected.

The household census schedule is shown in a later section of this report. The important point is that it should contain sufficient information to permit assigning each household to a specific sample stratum. In the present context, that means identifying: (1) if the household grows at least 1000 square meters of rice; (2) whether the household makes the customary production decisions about that rice; and (3) whether the household contributed some labor to producing that rice. If the answer to any of these questions is no, then, that household is not to be included in the population of sample farm households. One further question needs to be asked in such cases, namely, whether more than one-half of total household income comes from farm related activities. If yes, then that household is included in the farm population; but whether or not it is a landless labor household requires further investigation.

If the household is a farm household qualifying for the population of interest, then further information needs to be sought for each parcel farmed by that household. A parcel is defined as a contiguous piece of land, farmed by the same household, all planted to the same crop or mixture of crops, produced under the same technology, and subject to the same general degree of water control (irrigated, rainfed, etc.). Also, the respondent must be able to state the amount of inputs and output for each parcel. If the respondent provides this information only for the whole farm, then the whole farm is one parcel. The number of parcels per farm will vary among countries. For mechanization, the method of land preparation (hand, animal power, power tiller, small tractor, large tractor) as well as, in the case of tiller/tractor preparation, the ownership of the machine (own or hired), will need to be determined. Also, the method of threshing (by power thresher, or by other means) should be obtained.

The second set of information describes the irrigation situation for each parcel. Although the quality of water control may vary from one part of a parcel to another part of the same parcel, the parcel must be placed in one of the three discrete categories specified above. Another difficulty that may be encountered is if a household farms several separate (not contiguous) pieces of land, each with a different irrigation classification from the others, and the respondent cannot provide input the output information on each piece, i.e., can provide it only on a whole farm basis. The latter condition, i.e., being able to provide input-output data (especially output) on only a whole farm basis, is expected to be quite common in Thailand, where the harvested crop from all parcels and plots is usually brought to a central place, such as the farmsted, for threshing. This contrasts with the Philippines, where threshing usually takes place on the parcel on which the grain was produced. If all pieces of land are in the same water control stratum, then treating the whole farm as one parcel is satisfactory when data can be provided only for whole farm. But how to deal with the case where the pieces of land are under different water control regimes was not resolved and will be examined again after more information from the household census in each village is available.

After the household census has been completed, each element in the population of interest is to be placed in the proper cell by constructing new lists for each substratum (cell). At this point the project leaders, perhaps in conjunction with the IRRI coordinator, will need to examine the lists and determine sampling fractions and the final number of observations per substratum.

The preferred method will be to use stratified random sampling with proportional allocation followed by optimal allocation, which means that a constant sampling fraction will be used for all strata, for up to 75 percent of the total observations desired, as discussed in section B above. Households thus, selected will be marked and, since they are self weighting, will be used for multivariate analysis. Random sampling will then be continued within each susbstratum until the desired number of observations (optimal allocation) per substratum have been drawn. In this second drawing, there is likely to be a different probability of selection for elements within each substratum. Observations selected in the optimal allocation (second drawing) also need to be marked so that they can be subsequently weighted for univariate analysis.

Termination of the first drawing will depend on the distribution of the population among strata. If a high proportion of the population are in one stratum, then that part of the desired total sample size that will be selected in the first draw (proportional allocation) will be less than if the population was more evenly distributed among stratum. It is stressed again that the sample design and execution is so important that the project leaders and senior researchers should be intimately involved, including a consulting statistician, i.e., it should not be left solely to junior enumerators.

D. Selecting Parcels

Considerable reservation was expressed regarding the length of the questionnaire. It was felt that to obtain all the input-output information listed for each parcel from multiparcel households would be difficult, and might have a negative effect on the quality of the data. One solution suggested, and generally accepted, was to collect certain income and employment data on the whole farm, certain input-output and cropping practice data on each parcel and collect the detailed input-output data only on one parcel per household. This would resemble the "Intensive Data Parcel" (IDP) concept that was quite workable and successful in the IRRI constraints project.

It was also agreed to define a new population following the household census consisting of all parcels farmed by all farm households, to stratify the new population of parcels and to sample the stratified parcels following the same procedure used for sampling households. Sampling will initially be by proportional allocation among strata until a minimum number of observations have been drawn and subsequently switching to a form of optimal allocation, with roughly equal numbers of observations per stratum. The consequences of this procedure are that more than one parcel may be drawn for some farms, and no parcels selected for other farms. The exact procedure needs further work on and also needs to be reviewed by statisticians.

Concern was expressed by the engineers that since certain aspects of mechanization are whole-farm in their impact, using a sample of parcels would miss some very important data, especially on the interactions among various components of a typical farming system. It was pointed out however, that (1) data will be collected on a whole farm basis for each sample farm, and (2) if good parcel data are obtained, then it will be possible to reconstitute the total whole farm situation, based on the brief parcel information obtained in the cropping pattern history and the operational holdings schedules. Both of these schedules are to be completed for all parcels on the farm during each round of the survey.

There are obviously important compromises embodied in the above sampling design and a final determination of the exact procedures to be used will be conditioned by local conditions, availability of information and budgetary constraints.

Conduct of the Survey

Little time was spent during the workshop discussing the actual conduct of the survey. The general plan is to collect information for up to three seasons, consisting of two main seasons and the one off season in between them. Three or more major survey rounds will be used to collect these data, one at the beginning and end of each season. How soon before and after the season the survey should take place will depend on local conditions. It should be soon close enough to the major operation that the farmer has little difficulty recalling the timing and level of inputs and output associated with the operation.

Subject to budget constraints, follow-up visits may be made after each major round, to reconcile conflicting data and to determine yields on farms or parcels where threshing had not taken place during the main round visit. The skill, judgement, and experience of the survey leader and the survey staff will also determine somewhat the number and timing of visits.

The enumerators were urged to carry notebook/diaries and tape measures, and to record all interesting details observed, even if that specific information was not called for in the data schedule. Tape measures are used in determining sizes of machines, width of passes, row spacings, plant population, etc. Teaching enumerators to be observant was stressed as a key ingredient in their training.

Footnotes

APPENDIX A

1/The International Rice Research Institute, "The Consequences of Small Rice Farm Mechanization on Production, Incomes, and Rural Employment in Selected Countries of Asia — A Workshop Report," The International Rice Research Institute, Los Banos, Laguna, Philippines, September 11-13, 1978, pp. 11-18.

2/De Datta, S. K., K. A. Gomez, R. W. Herdt and R. Barker. 1978. A Handbook on the Methodology for an Integrated Experiment-survey on Rice Yield Constraints. The International Rice Research Institute, Los Banos, Laguna, Philippines.

3/Binswanger, H. P. 1978. The Economics of Tractors in South Asia: An Analytical Review. Agricultural Development Council, New York and International Crop Research Institute for Semi-Arid Tropics, Hyderabad, India.

4/For detailed discussion of this issue see Moss, C. J. 1977. Engineering Research, Development Design at IRRI. Presented at an FAO meeting, Rome. December 13-14, 1977.

APPENDIX B

Detailed Distribution of Labor Hours Per Farm Operation Among the Different Farm Classifications

Appendix Table B.1a. Average total labor hours used per hectare for land preparation operations, wet season, 1979.

Farm Classification		Average Labor Hours Used For Land Preparation Operations									
		Seedbed Preparation		Plowing		Harrowing		Levelling		Average Total Hours	
		Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao	(C)	10	10	50	48	34	32	11	10	105	100
Carabao/ thresher	(CT)	7	7	54	48	39	35	12	11	112	100
Two-wheel	(TW)	4	12	12	40	10	33	5	16	31	100
Two-wheel/ thresher	(TWT)	2	6	15	42	14	37	6	15	37	100
Two-wheel/ carabao	(TWC)	5	9	30	48	21	34	6	9	62	100
Two-wheel/ carabao/ thresher	(TWCT)	5	9	26	48	17	30	7	12	55	100

Appendix Table B.1b. Average total labor hours used per hectare for planting operations, wet season, 1979.

Farm Classification		Average Labor Hours Used For Planting Operations									
		Seed Preparation		Seeding of Seedbed		Pulling of Seedlings		Trans- planting		Average Total Hours	
		Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao	(C)	1	1	2	1	29	14	166	84	198	100
Carabao/ thresher	(CT)	1	1	2	1	26	12	182	86	211	100
Two-wheel	(TW)	1	1	3	1	18	8	190	90	212	100
Two-wheel/ thresher	(TWT)	1	1	4	2	12	6	181	91	198	100
Two-wheel/ carabao	(TWC)	1	1	5	2	19	11	154	86	179	100
Two-wheel/ carabao/ thresher	(TWCT)	1	1	3	1	30	14	175	84	209	100

Appendix Table B.1c. Average total labor hours used per hectare for care/cultivation operations, wet season, 1979.

Farm Classification	Average Labor Hours Used For Care/cultivation Operations									
	Weeding		Application Fertilizer		Herbicide/ Weedicide/ Application		Insecticide Application		Average Total Hours	
	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao (C)	21	61	5	16	1	3	7	20	34	100
Carabao/ thresher (CT)	17	53	6	19	1	2	8	26	32	100
Two-wheel (TW)	1	3	8	39	2	9	10	49	21	100
Two-wheel/ thresher (TWT)	3	12	8	31	3	11	12	46	26	100
Two-wheel/ carabao (TWC)	9	29	10	33	2	7	10	32	31	100
Two-wheel/ carabao/ thresher (TWCT)	6	24	8	34	2	10	7	32	23	100

Appendix Table B.1d. Average total labor hours used per hectare for post-production operations, wet season, 1979.

Farm Classification	Average Labor Hours Used For Post-Production Operations									
	Harvesting		Threshing		Harvesting/ Threshing/ Winnowing		Harvesting/ Threshing		Average Total Hours	
	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao (C)	20	8	7	3	193	77	30	12	250	100
Carabao/ thresher (CT)	166	69	6	2	67	27	4	2	242	100
Two-wheel (TW)	4	2	-	-	74	32	156	67	234	100
Two-wheel/ thresher (TWT)	153	84	7	4	8	5	13	7	182	100
Two-wheel/ carabao (TWC)	11	5	-	-	116	52	96	43	223	100
Two-wheel/ carabao/ thresher (TWCT)	151	73	4	2	37	19	12	6	206	100

Appendix Table B.2a. Average total labor hours used per hectare for land preparation operations, dry season, 1980.

Farm Classification		Average Labor Hours Used For Land Preparation Operations									
		Seedbed Preparation		Plowing		Harrowing		Levelling		Average Total Hours	
		Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao	(C)	16	11	66	46	42	30	19	13	143	100
Carabao/ thresher	(CT)	14	9	76	48	51	32	17	11	158	100
Two-wheel	(TW)	7	12	21	35	17	29	14	24	59	100
Two-wheel/ thresher	(TWT)	3	10	12	36	11	32	7	22	33	100
Two-wheel/ carabao	(TWC)	15	24	25	44	12	21	6	11	58	100
Two-wheel/ carabao/ thresher	(TWCT)	7	14	25	45	14	25	9	16	55	100

Appendix Table B.2b. Average total labor hours used per hectare for planting operations, dry season, 1980.

Farm Classification		Average Labor Hours Used For Planting Operations									
		Seed Preparation		Seeding of Seedbed		Pulling of Seedlings		Trans-planting		Average Total Hours	
		Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao	(C)	1	1	3	1	35	16	183	82	222	100
Carabao/ thresher	(CT)	1	1	3	1	47	16	240	81	291	100
Two-wheel	(TW)	1	1	4	2	16	8	196	89	217	100
Two-wheel/ thresher	(TWT)	1	1	12	6	9	5	168	88	190	100
Two-wheel/ carabao	(TWC)	1	1	5	2	25	10	198	87	229	100
Two-wheel/ carabao/ thresher	(TWCT)	1	1	4	2	13	8	148	89	166	100

Appendix Table B.2c. Average total labor hours used per hectare for care/cultivation operations, dry season, 1980.

Farm Classification	Average Labor Hours Used For Care/cultivation Operations									
	Weeding		Application Fertilizer		Herbicide/ Weedicide/ Application		Insecticide Application		Average Total Hours	
	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao (C)	6	24	9	35	1	3	10	38	26	100
Carabao/ thresher (CT)	2	7	11	33	4	12	16	48	33	100
Two-wheel (TW)	-	-	17	49	3	8	15	43	35	100
Two-wheel/ thresher (TWT)	1	3	12	40	5	17	12	40	30	100
Two-wheel/ carabao (TWC)	-	-	10	34	5	17	14	49	29	100
Two-wheel/ carabao/ thresher (TWCT)	2	6	11	36	4	13	14	45	31	100

Appendix Table B.2d. Average total labor hours used per hectare for post-production operations, dry season, 1980.

Farm Classification	Average Labor Hours Used For Post-Production Operations									
	Harvesting		Threshing		Harvesting/ Threshing/ Winnowing		Harvesting/ Threshing		Average Total Hours	
	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao (C)	22	9	10	4	194	83	9	4	235	100
Carabao/ thresher (CT)	303	96	3	1	8	3	-	-	314	100
Two-wheel (TW)	127	37	-	-	112	33	101	30	340	100
Two-wheel/ thresher (TWT)	171	94	3	2	8	4	-	-	182	100
Two-wheel/ carabao (TWC)	-	-	-	-	172	79	44	21	216	100
Two-wheel/ carabao/ thresher (TWCT)	140	77	4	2	7	4	30	17	181	100

Appendix Table B.3a. Average hired labor hours used per hectrare for land preparation operations, wet season, 1979.

Farm Classification		Average Labor Hours Used For Land Preparation Operations									
		Seedbed Preparation		Plowing		Harrowing		Levelling		Average Total Hours	
		Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao	(C)	0.4	2	13	54	8	33	3	11	24	100
Carabao/ thresher	(CT)	0.1	–	13	42	11	38	6	20	30	100
Two-wheel	(TW)	–	–	2	39	2	40	1	21	5	100
Two-wheel/ thresher	(TWT)	0.2	4	2	42	2	31	1	23	5	100
Two-wheel/ carabao	(TWC)	0.1	–	9	48	8	41	2	11	19	100
Two-wheel/ carabao/ thresher	(TWCT)	–	–	8	40	8	41	4	19	20	100

Appendix Table B.3b. Average hired labor hours used per hectare for planting operations, wet season, 1979.

Farm Classification		Average Labor Hours Used For Planting Operations									
		Seed Preparation		Seeding of Seedbed		Pulling of Seedlings		Trans-planting		Average Total Hours	
		Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao	(C)	-	-	0.2	-	17	11	135	89	152	100
Carabao/ thresher	(CT)	-	-	-	-	18	10	158	90	176	100
Two-wheel	(TW)	-	-	0.3	-	16	8	190	92	206	100
Two-wheel/ thresher	(TWT)	-	-	0.3	-	11	6	169	94	180	100
Two-wheel/ carabao	(TWC)	-	-	0.8	1	12	8	140	91	153	100
Two-wheel/ carabao/ thresher	(TWCT)	-	-	-	-	23	12	172	88	195	100

Appendix Table B.3c. Average hired labor hours used per hectare for care/cultivation operations, wet season, 1979.

Farm Classification	Average Labor Hours Used For Care/cultivation Operations									
	Weeding		Application Fertilizer		Herbicide/ Weedicide/ Application		Insecticide Application		Average Total Hours	
	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao (C)	4.0	93	0.1	2	-	-	0.2	5	4.3	100
Carabao/ thresher (CT)	-	-	-	-	-	-	-	-	-	-
Two-wheel (TW)	-	-	0.7	21	0.6	18	2.0	61	3.3	100
Two-wheel/ thresher (TWT)	-	-	1.0	45	0.2	9	1.0	46	2.2	100
Two-wheel/ carabao (TWC)	-	-	0.4	27	0.3	20	0.8	53	1.5	100
Two-wheel/ carabao/ thresher (TWCT)	0.2	17	0.6	50	0.2	17	0.2	16	1.2	100

Appendix Table B.3d. Average hired labor hours used per hectare for post-production operations, wet season, 1979.

Farm Classification	Average Labor Hours Used For Post-Production Operations									
	Harvesting		Threshing		Harvesting/ Threshing/ Winnowing		Harvesting/ Threshing		Average Total Hours	
	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao (C)	2	1	-	-	156	90	15	9	173	100
Carabao/ thresher (CT)	100	63	-	-	55	35	4	2	159	100
Two-wheel (TW)	4	2	-	-	73	31	156	67	232	100
Two-wheel/ thresher (TWT)	141	85	7	4	5	3	13	8	166	100
Two-wheel/ carabao (TWC)	1	1	-	-	95	49	96	50	192	100
Two-wheel/ carabao/ thresher (TWCT)	114	72	4	3	27	17	14	9	159	100

Appendix Table B.4a. Average family labor hours used per hectare for land preparation operations, wet season, 1979.

Farm Classification		Average Labor Hours Used For Land Preparation Operations									
		Seedbed Preparation		Plowing		Harrowing		Levelling		Average Total Hours	
		Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao	(C)	10	12	37	46	26	32	8	10	81	100
Carabao/ thresher	(CT)	7	9	41	50	28	34	6	7	82	100
Two-wheel	(TW)	4	15	11	41	8	30	4	14	27	100
Two-wheel/ thresher	(TWT)	2	6	13	42	12	39	4	13	31	100
Two-wheel/ carabao	(TWC)	5	12	20	49	13	31	4	8	42	100
Two-wheel/ carabao/ thresher	(TWCT)	5	14	19	53	9	25	3	8	36	100

Appendix Table B.4b. Average family labor hours used per hectare for planting operations, wet season, 1979.

Farm Classification		Average Labor Hours Used For Planting Operations									
		Seed Preparation		Seeding of Seedbed		Pulling of Seedlings		Trans-planting		Average Total Hours	
		Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao	(C)	1.0	2	2	5	11	25	31	68	45	100
Carabao/ thresher	(CT)	1.0	2	2	6	9	24	24	68	36	100
Two-wheel	(TW)	0.5	12	2	44	2	44	-	-	4.5	100
Two-wheel/ thresher	(TWT)	1.0	4	4	21	1	6	13	69	19	100
Two-wheel/ carabao	(TWC)	1.0	3	4	15	6	26	14	56	25	100
Two-wheel/ carabao/ thresher	(TWCT)	1.0	4	3	22	6	48	3	26	13	100

Appendix Table B.4c. Average family labor hours used per hectare for care/cultivation operations, wet season, 1979.

Farm Classification	Average Labor Hours Used For Care/cultivation Operations									
	Weeding		Application Fertilizer		Herbicide/ Weedicide/ Application		Insecticide Application		Average Total Hours	
	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao (C)	17	56	5	18	1	4	7	22	30	100
Carabao/ thresher (CT)	17	53	6	19	1	2	8	26	32	100
Two-wheel (TW)	1	3	8	42	1	8	8	47	18	100
Two-wheel/ thresher (TWT)	3	13	7	30	3	12	11	45	24	100
Two-wheel/ carabao (TWC)	9	30	10	34	2	6	9	30	30	100
Two-wheel/ carabao/ thresher (TWCT)	5	24	7	33	2	10	7	33	21	100

Appendix Table B.4d. Average family labor hours used per hectare for post-production operations, wet season, 1979.

Farm Classification	Average Labor Hours Used For Post-Production Operations: Harvesting		Threshing		Harvesting/ Threshing/ Winnowing		Harvesting/ Threshing		Average Total Hours	
	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao (C)	18	24	7	9	37	48	15	20	77	100
Carabao/ thresher (CT)	66	80	5	6	12	14	-	-	83	100
Two-wheel (TW)	-	-	-	-	1	100	-	-	1	100
Two-wheel/ thresher (TWT)	13	81	-	-	3	19	-	-	16	100
Two-wheel/ carabao (TWC)	10	32	-	-	21	68	-	-	31	100
Two-wheel/ carabao/ thresher (TWCT)	36	78	-	-	10	22	-	-	46	100

Appendix Table B.5a. Average hired labor hours used per hectare for land preparation operations, dry season, 1980.

Farm Classification	Average Labor Hours Used For Land Preparation Operations									
	Seedbed Preparation		Plowing		Harrowing		Levelling		Average Total Hours	
	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao (C)	–	–	8	44	8	44	2	12	18	100
Carabao/ thresher (CT)	–	–	12	57	6	29	3	14	21	100
Two-wheel (TW)	–	–	–	–	–	–	–	–	–	–
Two-wheel/ thresher (TWT)	–	–	2	33	2	33	2	34	6	100
Two-wheel/ carabao (TWC)	–	–	4	36	5	46	2	18	11	100
Two-wheel/ carabao/ thresher (TWCT)	0.3	–	5	38	5	38	3	23	13	100

Appendix Table B.5b. Average hired labor hours used per hectare for planting operations, dry season, 1980.

Farm Classification	Average Labor Hours Used For Planting Operations									
	Seed Preparation		Seeding of Seedbed		Pulling of Seedlings		Trans- planting		Average Total Hours	
	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao (C)	–	–	–	–	23	13	159	87	182	100
Carabao/ thresher (CT)	–	–	–	–	36	14	216	86	252	100
Two-wheel (TW)	–	–	–	–	12	8	149	92	161	100
Two-wheel/ thresher (TWT)	–	–	10	6	9	5	159	89	178	100
Two-wheel/ carabao (TWC)	–	–	–	–	11	5	198	95	209	100
Two-wheel/ carabao/ thresher (TWCT)	–	–	–	–	12	8	141	92	153	100

Appendix Table B.5c. Average hired labor hours used per hectare for care/cultivation operations, dry season, 1980.

Farm Classification	Average Labor Hours Used For Care/cultivation Operations									
	Weeding		Application Fertilizer		Herbicide/ Weedicide/ Application		Insecticide Application		Average Total Hours	
	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao (C)	-	-	0.6	43	-	-	0.8	57	1.4	100
Carabao/ thresher (CT)	-	-	-	-	-	-	-	-	-	-
Two-wheel (TW)	-	-	2.0	100	-	-	-	-	2.0	100
Two-wheel/ thresher (TWT)	-	-	1.0	20	1.0	20	3	60	5.0	100
Two-wheel/ carabao (TWC)	-	-	-	-	-	-	-	-	-	-
Two-wheel/ carabao/ thresher (TWCT)	2	38	1	19	0.2	4	2	39	5.2	100

Appendix Table B.5d. Average hired labor hours used per hectare for post-production operations, dry season, 1980.

Farm Classification	Average Labor Hours Used For Post-Production Operations									
	Harvesting		Threshing		Harvesting/ Threshing/ Winnowing		Harvesting/ Threshing		Average Total Hours	
	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao (C)	4	3	1	1	116	89	9	7	130	100
Carabao/ thresher (CT)	262	97	3	1	5	2	-	-	270	100
Two-wheel (TW)	105	44	-	-	33	13	101	43	239	100
Two-wheel/ thresher (TWT)	169	94	3	2	7	4	-	-	179	100
Two-wheel/ carabao (TWC)	-	-	-	-	172	80	44	20	216	100
Two-wheel/ carabao/ thresher (TWCT)	139	77	4	2	7	4	30	17	180	100

Appendix Table B.6a. Average family labor hours used per hectare for land preparation operations, dry season, 1980.

Farm Classification	Average Labor Hours Used For Land Preparation Operations									
	Seedbed Preparation		Plowing		Harrowing		Levelling		Average Total Hours	
	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao (C)	16	13	58	46	34	27	17	14	125	100
Carabao/ thresher (CT)	14	10	63	46	45	33	14	11	136	100
Two-wheel (TW)	4	14	10	36	8	29	6	21	28	100
Two-wheel/ thresher (TWT)	3	11	10	37	9	33	5	19	27	100
Two-wheel/ carabao (TWC)	15	31	22	46	7	15	4	8	48	100
Two-wheel/ carabao/ thresher (TWCT)	7	17	20	49	9	22	5	12	41	100

Appendix Table B.6b. Average family labor hours used per hectare for planting operations, dry season, 1980.

Farm Classification		Average Labor Hours Used For Planting Operations									
		Seed Preparation		Seeding of Seedbed		Pulling of Seedlings		Trans-planting		Average Total Hours	
		Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao	(C)	1	3	3	8	11	28	24	61	39	100
Carabao/ thresher	(CT)	1	3	3	8	11	28	24	61	39	100
Two-wheel	(TW)	1	20	4	80	-	-	-	-	5	100
Two-wheel/ thresher	(TWT)	1	8	2	15	1	8	9	68	13	100
Two-wheel/ carabao	(TWC)	1	5	5	25	14	70	-	-	20	100
Two-wheel/ carabao/ thresher	(TWCT)	1	8	4	31	1	8	7	53	13	100

Appendix Table B.6c. Average family labor hours used per hectare for care/cultivation operations, dry season, 1980.

Farm Classification	Average Labor Hours Used For Care/cultivation Operations									
	Weeding		Application Fertilizer		Herbicide/ Weedicide/ Application		Insecticide Application		Average Total Hours	
	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao (C)	6	24	9	36	1	4	9	36	25	100
Carabao/ thresher (CT)	2	6	11	34	3	9	16	51	32	100
Two-wheel (TW)	-	-	9	45	2	10	9	45	20	100
Two-wheel/ thresher (TWT)	1	4	10	42	4	17	9	37	24	100
Two-wheel/ carabao (TWC)	-	-	10	34	5	17	14	49	29	100
Two-wheel/ carabao/ thresher (TWCT)	-	-	10	38	4	15	12	47	26	100

Appendix Table B.6d. Average family labor hours used per hectare for post-production operations, dry season, 1980.

Farm Classification	Average Labor Hours Used For Post-Production Operations									
	Harvesting		Threshing		Harvesting/ Threshing/ Winnowing		Harvesting/ Threshing		Average Total Hours	
	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%	Hrs.	%
Carabao (C)	18	17	9	9	78	74	-	-	105	100
Carabao/ thresher (CT)	41	95	-	-	2	5	-	-	43	100
Two-wheel (TW)	-	-	-	-	3	100	-	-	3	100
Two-wheel/ thresher (TWT)	2	67	1	33	-	-	-	-	3	100
Two-wheel/ carabao (TWC)	-	-	-	-	-	-	-	-	-	-
Two-wheel/ carabao/ thresher (TWCT)	1	100	-	-	-	-	-	-	1	100

Appendix Table B.7a. Percent distribution of hired and family labor hours perhectare for land preparation operations, wet season, 1979.

Farm Classification		Percent Distribution of Labor Hours								Total Percent
		Seedbed Preparation		Plowing		Harrowing		Levelling		
		H[a]	F[b]	H	F	H	F	H	F	
Carabao	(C)	–	9	12	35	8	25	3	8	100
Carabao/ thresher	(CT)	–	7	11	37	10	25	5	5	100
Two-wheel	(TW)	–	12	6	35	6	26	3	12	100
Two-wheel/ thresher	(TWT)	–	6	6	36	6	33	3	10	100
Two-wheel/ carabao	(TWC)	–	8	15	33	13	21	3	7	100
Two-wheel/ carabao/ thresher	(TWCT)	–	9	14	34	14	16	7	6	100

[a]Family Labor.
[b]Hired Labor.

Appendix Table B.7b. Percent distribution of hired and family labor hours per hectare for planting operations, wet season, 1979.

Farm Classification		Percent Distribution of Labor Hours								Total Percent
		Seed Preparation		Seeding of Seedbed		Pulling of Seedlings		Trans-planting		
		H[a]	F[b]	H	F	H	F	H	F	
Carabao	(C)	–	–	–	1	9	6	69	15	100
Carabao/ thresher	(CT)	–	–	–	1	8	4	75	12	100
Two-wheel	(TW)	–	–	–	1	8	1	90	–	100
Two-wheel/ thresher	(TWT)	–	–	–	2	6	–	85	7	100
Two-wheel/ carabao	(TWC)	–	–	–	2	7	3	79	9	100
Two-wheel/ carabao/ thresher	(TWCT)	–	–	–	1	11	3	83	2	100

[a]Hired Labor.
[b]Family Labor.

Appendix Table B.7c. Percent distribution of hired and family labor hours per hectare for care/cultivation operations, wet season, 1979.

Farm Classification	Percent Distribution of Labor Hours								Total Percent
	Weeding		Application Fertilizer		Herbicide/ Weedicide/ Application		Insecticide Application		
	H[a]	F[b]	H	F	H	F	H	F	
Carabao (C)	12	50	-	15	-	3	-	20	100
Carabao/ thresher (CT)	-	53	-	19	-	2	-	26	100
Two-wheel (TW)	-	5	3	38	3	5	9	37	100
Two-wheel/ thresher (TWT)	-	11	4	27	1	11	4	42	100
Two-wheel/ carabao (TWC)	-	29	1	32	1	6	3	28	100
Two-wheel/ carabao/ thresher (TWCT)	1	23	3	31	1	9	1	31	100

[a]Hired Labor.
[b]Family Labor.

Appendix Table B.7d. Percent distribution of hired and family labor hours per hectare for post-production operations, wet season, 1979.

Farm Classification	Percent Distribution of Labor Hours								Total Percent
	Harvesting		Threshing		Harvesting/ Threshing/ Winnowing		Harvesting/ Threshing		
	H[a]	F[b]	H	F	H	F	H	F	
Carabao (C)	1	7	–	3	62	15	6	6	100
Carabao/ thresher (CT)	41	27	–	2	23	4	2	–	100
Two-wheel (TW)	2	–	–	–	31	–	67	–	100
Two-wheel/ thresher (TWT)	77	7	4	–	3	2	7	–	100
Two-wheel/ carabao (TWC)	–	5	–	–	43	9	43	–	100
Two-wheel/ carabao/ thresher (TWCT)	55	18	2	–	13	5	7	–	100

[a]Hired Labor.
[b]Family Labor.

Appendix Table B.8a. Percent distribution of hired and family labor hours per hectare for land preparation operations, dry season, 1980.

Farm Classification		Percent Distribution of Labor Hours								Total Percent
		Seedbed Preparation		Plowing		Harrowing		Levelling		
		H[a]	F[b]	H	F	H	F	H	F	
Carabao	(C)	–	11	6	41	6	24	1	11	100
Carabao/ thresher	(CT)	–	9	8	40	4	29	2	8	100
Two-wheel	(TW)	–	14	–	36	–	29	–	21	100
Two-wheel/ thresher	(TWT)	–	9	6	30	6	27	6	16	100
Two-wheel/ carabao	(TWC)	–	25	7	37	8	12	3	8	100
Two-wheel/ carabao/ thresher	(TWCT)	1	13	9	37	9	17	6	8	100

[a]Family Labor.
[b]Hired Labor.

Appendix Table B.8b. Percent distribution of hired and family labor hours per hectare for planting operations, dry season, 1980.

Farm Classification	Percent Distribution of Labor Hours								Total Percent
	Seed Preparation		Seeding of Seedbed		Pulling of Seedlings		Trans-planting		
	H[a]	F[b]	H	F	H	F	H	F	
Carabao (C)	–	–	–	1	11	5	72	11	100
Carabao/ thresher (CT)	–	–	–	1	11	4	74	10	100
Two-wheel (TW)	1	2	–	–	7	–	90	–	100
Two-wheel/ thresher (TWT)	–	–	5	1	5	–	83	6	100
Two-wheel/ carabao (TWC)	–	–	–	2	5	6	87	–	100
Two-wheel/ carabao/ thresher (TWCT)	–	–	–	2	7	1	85	5	100

[a]Hired Labor.
[b]Family Labor.

Appendix Table B.8c. Percent distribution of hired and family labor hours per hectare for care/cultivation operations, dry season, 1980.

Farm Classification	Percent Distribution of Labor Hours								Total Percent
	Weeding		Application Fertilizer		Herbicide/ Weedicide/ Application		Insecticide Application		
	H[a]	F[b]	H	F	H	F	H	F	
Carabao (C)	–	23	2	34	–	4	3	34	100
Carabao/ thresher (CT)	–	6	–	34	–	9	–	51	100
Two-wheel (TW)	–	–	9	41	–	9	–	41	100
Two-wheel/ thresher (TWT)	–	3	3	34	3	14	10	33	100
Two-wheel/ carabao (TWC)	–	–	–	34	–	17	–	49	100
Two-wheel/ carabao/ thresher (TWCT)	6	–	3	32	1	13	6	39	100

[a]Hired Labor.
[b]Family Labor.

Appendix Table B.8d. Percent distribution of hired and family labor hours per hectare for post-production operations, dry season, 1980.

Farm Classification	Percent Distribution of Labor Hours								Total Percent
	Harvesting		Threshing		Harvesting/ Threshing/ Winnowing		Harvesting/ Threshing		
	H[a]	F[b]	H	F	H	F	H	F	
Carabao (C)	2	8	–	4	49	33	4	–	100
Carabao/ thresher (CT)	83	13	1	–	2	1	–	–	100
Two-wheel (TW)	43	–	–	–	14	1	42	–	100
Two-wheel/ thresher (TWT)	93	1	2	–	4	–	–	–	100
Two-wheel/ carabao (TWC)	–	–	–	–	80	–	20	–	100
Two-wheel/ carabao/ thresher (TWCT)	77	–	2	–	4	–	17	–	100

[a]Hired Labor.
[b]Family Labor.

Appendix Table B.9a. Percent hired and percent family labor hours, per hectare for specific land preparation operations, wet season, 1979.

Farm Classification		Percent Labor Hours							
		Seedbed Preparation		Plowing		Harrowing		Levelling	
		H[a]	F[b]	H	F	H	F	H	F
Carabao	(C)	4	96	26	74	24	76	24	76
Carabao/ thresher	(CT)	1	99	24	76	28	72	50	50
Two-wheel	(TW)	-	100	15	85	20	80	20	80
Two-wheel/ thresher	(TWT)	9	91	13	87	14	86	20	80
Two-wheel/ carabao	(TWC)	2	98	31	69	38	62	33	67
Two-wheel/ carabao/ thresher	(TWCT)	-	100	30	70	47	53	57	43

[a]Family Labor.
[b]Hired Labor.

Appendix Table B.9b. Percent hired and percent family labor hours per hectare for specific planting operations, wet season 1979.

Farm Classification		Percent Labor Hours							
		Seed Preparation		Seeding of Seedbed		Pulling of Seedlings		Trans-planting	
		H[a]	F[b]	H	F	H	F	H	F
Carabao	(C)	–	100	9	91	61	39	81	19
Carabao/ thresher	(CT)	–	100	–	100	67	33	87	13
Two-wheel	(TW)	–	100	13	87	89	11	100	–
Two-wheel/ thresher	(TWT)	–	100	7	93	92	8	93	7
Two-wheel/ carabao	(TWC)	–	100	17	83	67	33	91	9
Two-wheel/ carabao/ thresher	(TWCT)	–	100	–	100	79	21	98	2

[a]Hired Labor.
[b]Family Labor.

Appendix Table B.9c. Percent hired and percent family labor hours per hectare for specific care/cultivation operations, wet season, 1979.

Farm Classification	Percent Labor Hours							
	Weeding		Application Fertilizer		Herbicide/ Weedicide/ Application		Insecticide Application	
	H[a]	F[b]	H	F	H	F	H	F
Carabao (C)	19	81	2	98	–	100	3	97
Carabao/ thresher (CT)	–	100	–	100	–	100	–	100
Two-wheel (TW)	–	100	8	92	38	62	20	80
Two-wheel/ thresher (TWT)	–	100	12	88	6	94	8	92
Two-wheel/ carabao (TWC)	–	100	4	96	13	87	8	92
Two-wheel/ carabao/ thresher (TWCT)	4	96	8	92	9	91	3	97

[a]Hired Labor.
[b]Family Labor.

Appendix Table B.9d. Percent hired and percent family labor hours per hectare for specific post-production operations, wet season, 1979.

Farm Classification	Percent Labor Hours							
	Harvesting		Threshing		Harvesting/ Threshing/ Winnowing		Harvesting/ Threshing	
	H[a]	F[b]	H	F	H	F	H	F
Carabao (C)	10	90	-	100	81	19	50	50
Carabao/ thresher (CT)	60	40	-	100	82	18	100	-
Two-wheel (TW)	100	-	-	-	99	1	100	-
Two-wheel/ thresher (TWT)	92	8	100	-	62	38	100	-
Two-wheel/ carabao (TWC)	9	91	-	-	82	18	100	-
Two-wheel/ carabao/ thresher (TWCT)	76	24	100	-	73	27	100	-

[a]Hired Labor.
[b]Family Labor.

Appendix Table B.10a. Percent hired and percent family labor hours per hectare for specific land preparation operations, dry season, 1980.

Farm Classification		Percent Labor Hours							
		Seedbed Preparation		Plowing		Harrowing		Levelling	
		H[a]	F[b]	H	F	H	F	H	F
Carabao	(C)	-	100	12	88	19	81	11	89
Carabao/ thresher	(CT)	-	100	16	84	12	88	18	82
Two-wheel	(TW)	-	100	-	100	-	100	-	100
Two-wheel/ thresher	(TWT)	-	100	17	83	18	82	29	71
Two-wheel/ carabao	(TWC)	-	100	15	85	42	58	33	67
Two-wheel/ carabao/ thresher	(TWCT)	4	96	20	80	36	64	38	62

[a]Family Labor.
[b]Hired Labor.

Appendix Table B.10b. Percent hired and percent family labor hours per hectare for specific planting operations, dry season, 1980.

Farm Classification		Percent Labor Hours							
		Seed Preparation		Seeding of Seedbed		Pulling of Seedlings		Trans-planting	
		H[a]	F[b]	H	F	H	F	H	F
Carabao	(C)	–	100	–	100	67	33	87	13
Carabao/ thresher	(CT)	–	100	–	100	77	23	90	10
Two-wheel	(TW)	–	100	–	100	100	–	100	–
Two-wheel/ thresher	(TWT)	–	100	83	17	90	10	95	5
Two-wheel/ carabao	(TWC)	–	100	–	100	44	56	100	–
Two-wheel/ carabao/ thresher	(TWCT)	–	100	–	100	92	8	95	5

[a]Hired Labor.
[b]Family Labor.

Appendix Table B.10c. Percent hired and percent family labor hours per hectare for specific care/cultivation operartions, dry season, 1980.

Farm Classification	Percent Labor Hours							
	Weeding		Application Fertilizer		Herbicide/ Weedicide/ Application		Insecticide Application	
	H[a]	F[b]	H	F	H	F	H	F
Carabao (C)	–	100	6	94	–	100	8	92
Carabao/ thresher (CT)	–	100	–	100	–	100	–	100
Two-wheel (TW)	–	–	18	82	–	100	–	100
Two-wheel/ thresher (TWT)	–	100	9	91	20	80	25	75
Two-wheel/ carabao (TWC)	–	–	–	100	–	100	–	100
Two-wheel/ carabao/ thresher (TWCT)	100	–	9	91	5	95	14	86

[a]Hired Labor.
[b]Family Labor.

Appendix Table B.10d. Percent hired and percent family labor hours per hectare for specific post-production operations, dry season, 1980.

Farm Classification	Percent Labor Hours							
	Harvesting		Threshing		Harvesting/ Threshing/ Winnowing		Harvesting/ Threshing	
	H[a]	F[b]	H	F	H	F	H	F
Carabao (C)	18	82	10	90	60	40	100	-
Carabao/ thresher (CT)	86	14	100	-	29	71	-	-
Two-wheel (TW)	100	-	-	-	92	8	100	-
Two-wheel/ thresher (TWT)	99	1	75	25	100	-	-	-
Two-wheel/ carabao (TWC)	-	-	-	-	100	-	100	-
Two-wheel/ carabao/ thresher (TWCT)	99	1	100	-	100	-	100	-

[a]Hired Labor.
[b]Family Labor.

APPENDIX C

Detailed Farm Budgets of Each Farm Classification

Appendix Table C.1a. Total gross benefits of carabao farms, average per season, crop year 1979-1980.

I. Revenue	Quantity	Unit	Peso/ Unit	Peso Value
A. Total value of output	2,270	kg.	1.11[a]	2,520
B. Total value of output share				
a) Threshers' share -manual[b]	227	kg.	1.11	252
b) Landlord's share[c]	315	kg.	1.11	350
Value of output share	544	kg.	1.11	602
C. Total gross benefits (A - B)	1,826	kg.	1.11	1,918

[a]Actual average price of rice per kilogram received by farmers under this farm classification.

[b]Share of manual threshers is 10% of total output manually threshed. It is assumed that 50% of total rice output is threshed manually for these farms using mechanical theshers.

[c]Approximately 14% of total rice output net of threshers' share.

Appendix Table C.1b. Land preparation hired labor and customwork expense of carabao farms, average per season, crop year 1979-1980.

II. Paid-out Variable Costs: Hired Labor Expense	Quantity	Unit	Peso/ Unit	Peso Value
A. Land preparation hired labor:				
a) Seed preparation -with carabao	0.3	man-animal hr.	2.58[a]	-
b) Plowing -with carabao	11.9	man-animal hr.	2.58[a]	31
c) Harrowing -with carabao	10.1	man-animal hr.	2.58[a]	26
d) Levelling -with carabao	1.9	man-animal hr.	2.58[a]	5
Total land preparation hired labor expense	24.2			62
B. Planting	161.1	man-hr.	0.91[b]	146
C. Care/cultivation	4.3	man-hr.	0.75[b]	3
D. Harvesting	163.9	man-hr.	1.28[b]	210
E. Total hired labor expense	353.5			421

[a]Actual average wage rate per hour (man-animal hour) for this farm classification. Does not include meals.
[b]Actual average wage rate per hour for this activity for this farm classification.

Appendix Table C.1c. Other paid-out costs of carabao farms, average per season, crop year 1979-1980.

III. Other Paid-out Costs	Quantity	Unit	Peso/ Unit	Peso Value	
Additional variable costs:					
A. Production materials					
a) Seeds	50[a]	kg.	2.07[b]	104	
b) Fertilizer	136[c]	kg.	1.69	230[d]	
c) Chemicals				83[e]	
d) Irrigation				128[f]	
e) Sacks	46[g]		1.00	46	
Total production materials expense					591
B. Repairs and maintenance					11[h]
C. Marketing costs					8[h]
D. Interest expense[i]					155
Total additional variable costs					765

[a]Assumed that seeding rate per hectare is 50 kilograms since limited information was available with regard to the amount of rice seeds utilized by each farm household.
[b]Actual average rice seed price per kilogram for this farm classification.
[c]Actual average amount of fertilizer, in kilograms, applied per hectare by this farm classification.
[d]Actual average value of fertilizer for this farm classification.
[e]Actual average peso value of chemical expenditure for this farm classification.
[f]Actual average peso value of expenditure on irrigation for this farm classification. Includes oil, fuel and lubricants.
[g]Number of sacks is computed by dividing the average output of this farm classification by 50 kilograms since each sack of paddy rice weighs this much.
[h]Actual average value for this farm classification.
[i]At 30% of total loan per annum or 15% per season.

Appendix Table C.1d. Gross farm family income of carabao farms, average per season, crop year 1979-1980.

IV. Item		Peso Value
A. Total gross benefits		1,918
B. Total paid-out costs:		
Variable		
a) Hired labor expense	421	
b) Production materials expense	591	
c) Repairs and maintenance	11	
d) Marketing costs	8	
e) Interest expense	155	
C. Total costs		1,186
D. Gross farm family income		732

Appendix Table C.1e. Net farm family income of carabao farms, average per season, crop year 1979-1980.

V.	Item	Peso Value
A.	Gross farm family income	732
B.	Depreciation[a]	149
C.	Net farm family income (A - B)	583

[a]Computation is based on a ten-year straight line method which includes assets such as farm draft animals, farm tools and implements and farm machinery.

Appendix Table C.1f. Imputed family labor values of carabao farms, average per season, crop year 1979-1980.

VI. Family Labor	Quantity	Unit	Peso/ Unit	Peso Value
A. Land preparation:				
a) Seedbed preparation -with carabao	12.2	man-hr.	2.00	24
b) Plowing -with carabao	45.1	man-hr.	2.00	90
c) Harrowing -with carabao	29.3	man-hr.	2.00	59
d) Levelling -with carabao	10.3	man-hr.	2.00	21
Total imputed family labor value for land preparation	97.3			194
B. Planting	44.5	man-hr.	0.96	43
C. Care/cultivation	29.1	man-hr.	1.29	38
D. Post-production	86.5	man-hr.	1.63	141
E. Marketing	-	man-hr.	-	-
F. Total imputed family labor value	257.4			416

Appendix Table C.1g. Net farm income after imputed family labor of carabao farms, average per season, crop year 1979-1980.

VII.	Item	Peso Value
A.	Net farm family income	583
B.	Total imputed family labor value	416
C.	Net farm income after imputed family labor (A - B)	167

Appendix Table C.2a. Total gross benefits of carabao/thresher farms, average per season, crop year 1979-1980.

I. Revenue	Quantity	Unit	Peso/ Unit	Peso Value
A. Total value of output	3,008	kg.	1.10[a]	3,309
B. Total value of output share				
a) Threshers' share				
-manual[b]	150	kg.	1.10[a]	165
-mechanical[c]	90	kg.	1.10[a]	99
b) Landlord's share[d]	423	kg.	1.10[a]	465
Value of output share	534	kg.	1.10[a]	729
C. Total gross benefits (A - B)	2,474	kg.	1.10[a]	2,580

[a]Actual average price of rice per kilogram received by farmers under this farm classification.

[b]Share of manual threshers is 10% of total output manually threshed. It is assumed that 50% of total rice output is threshed manually for those farms using mechanical theshers.

[c]The common practice in the project area is to allocate 6% of the total rice output actually threshed by machines to the thresher operators/owner. It is assumed that 50% of the total rice output is threshed mechanically for those farms using these machines.

[d]Approximately 14% of total rice output net of threshers' share.

Appendix Table C.2b. Land preparation hired labor and customwork expense of carabao/thresher farms, average per season, crop year 1979-1980.

II. Paid-out Variable Costs: Hired Labor Expense	Quantity	Unit	Peso/ Unit	Peso Value
A. Land preparation hired labor:				
a) Seed preparation -with carabao	0.1	man-animal hr.	2.26[a]	-
b) Plowing -with carabao	13.5	man-animal hr.	2.26[a]	31
c) Harrowing -with carabao	8.3	man-animal hr.	2.26[a]	19
d) Levelling -with carabao	4.4	man-animal hr.	2.26[a]	37
Total land preparation hired labor expense	26.3			87
B. Planting	210.1	man-hr.	0.92[b]	194
C. Care/cultivation	-	man-hr.	-	-
D. Harvesting	209.2	man-hr.	1.28[b]	268
E. Total hired labor expense	445.6			549

[a]Actual average wage rate per hour (man-animal hour) for this farm classification. Does not include meals.
[b]Actual average wage rate per hour for this activity for this farm classification.

Appendix Table C.2c. Other paid-out costs of carabao/thresher farms, average per season, crop year 1979-1980.

III. Other Paid-out Costs	Quantity	Unit	Peso/ Unit	Peso Value	
Additional variable costs:					
A. Production materials					
a) Seeds	50[a]	kg.	2.11[b]	106	
b) Fertilizer	174[c]	kg.	1.72	299[d]	
c) Chemicals				117[e]	
d) Irrigation				168[f]	
e) Sacks	60[g]			60	
Total production materials expense				750	
B. Repairs and maintenance					44[h]
C. Marketing costs					13[h]
D. Interest expense[i]					203
Total additional variable costs					1,010

[a]Assumed that seeding rate per hectare is 50 kilograms since limited information was available with regard to the amount of rice seeds utilized by each farm household.
[b]Actual average rice seed price per kilogram for this farm classification.
[c]Actual average amount of fertilizer, in kilograms, applied per hectare by this farm classification.
[d]Actual average value of fertilizer for this farm classification.
[e]Actual average peso value of chemical expenditure for this farm classification.
[f]Actual average peso value of expenditure on irrigation for this farm classification. Includes oil, fuel and lubricants.
[g]Number of sacks is computed by dividing the average output of this farm classification by 50 kilograms since each sack of paddy rice weighs this much.
[h]Actual average value for this farm classification.
[i]At 30% of total loan per annum or 15% per season.

Appendix Table C.2d. Gross farm family income of carabao/thresher farms, average per season, crop year 1979-1980.

IV. Item	Peso	Value
A. Total gross benefits		2,580
B. Total paid-out costs:		
Variable		
a) Hired labor expense	549	
b) Production materials expense	750	
c) Repairs and maintenance	44	
d) Marketing costs	13	
e) Interest expense	203	
C. Total costs		1,559
D. Gross farm family income		1,021

Appendix Table C.2e. Net farm family income of carabao/thresher farms, average per season, crop year 1979-1980.

V.	Item	Peso Value
A.	Gross farm family income	1,021
B.	Depreciation[a]	194
C.	Net farm family income (A - B)	827

[a]Computation is based on a ten-year straight line method which includes assets such as farm draft animals, farm tools and implements and farm machinery.

Appendix Table C.2f. Imputed family labor values of carabao/thresher farms, average per season, crop year 1979-1980.

VI. Family Labor	Quantity	Unit	Peso/ Unit	Peso Value
A. Land preparation:				
a) Seedbed preparation -with carabao	10.9	man-hr.	1.85	20
b) Plowing -with carabao	50.4	man-hr.	1.85	93
c) Harrowing -with carabao	35.8	man-hr.	1.85	66
d) Levelling -with carabao	9.6	man-hr.	1.85	18
Total imputed family labor value for land preparation	106.7			197
B. Planting	37.0	man-hr.	0.99	37
C. Care/cultivation	32.1	man-hr.	1.04	33
D. Post-production	64.9	man-hr.	1.22	79
E. Marketing	-	man-hr.	-	-
F. Total imputed family labor value	240.7			346

Appendix Table C.2g. Net farm income after imputed family labor of carabao/thresher farms, average per season, crop year 1979-1980.

VII.	Item	Peso Value
A.	Net farm family income	827
B.	Total imputed family labor value	346
C.	Net farm income after imputed family labor (A - B)	481

Appendix Table C.3a. Total gross benefits of two-wheel tractor farms, average per season, crop year 1979-1980.

I. Revenue	Quantity	Unit	Peso/ Unit	Peso Value
A. Total value of output	4,181	kg.	1.12[a]	4,683
B. Total value of output share				
a) Threshers' share -manual[b]	418	kg.	1.12[a]	468
b) Landlord's share[c]	529	kg.	1.12[a]	592
Value of output share	860	kg.	1.12[a]	1,060
C. Total gross benefits (A - B)	3,321	kg.	1.12[a]	3,623

[a]Actual average price of rice per kilogram received by farmers under this farm classification.
[b]Share of manual threshers is 10% of total output manually threshed. It is assumed that 50% of total rice output is threshed manually for those farms using mechanical theshers.
[c]Approximately 14% of total rice output net of threshers' share.

Appendix Table C.3b. Land preparation hired labor and customwork expense of two-wheel tractor farms, average per season, crop year 1979-1980.

II. Paid-out Variable Costs: Hired Labor Expense	Quantity	Unit	Peso/ Unit	Peso Value
A. Land preparation hired labor:				
a) Seed preparation -with two-wheel tractor	0.1	man-machine hr.	12.87[a]	1
b) Plowing -with two-wheel tractor	1.6	man-machine hr.	12.87[a]	21
c) Harrowing -with two-wheel tractor	1.5	man-machine hr.	12.87[a]	19
d) Levelling -with two-wheel tractor	1.4	man-machine hr.	12.87[a]	18
Total land preparation hired labor expense	4.6			59
B. Planting	191.3	man-hr.	1.06[b]	202
C. Care/cultivation	2.8	man-hr.	1.30[b]	4
D. Harvesting	234.4	man-hr.	1.28[b]	300
E. Total hired labor expense	433.1			565

[a]Actual average wage rate per hour (man-machine hour) for this farm classification. Includes fuel and oil.
[b]Actual average wage rate per hour for this activity for this farm classification.

Appendix Table C.3c. Other paid-out costs of two-wheel tractor farms, average per season, crop year 1979-1980.

III. Other Paid-out Costs	Quantity	Unit	Peso/ Unit	Peso Value	
Additional variable costs:					
A. Production materials					
a) Seeds	50[a]	kg.	2.17[b]	132	
b) Fertilizer	262[c]	kg.	1.68	440[d]	
c) Chemicals				181[e]	
d) Irrigation				195[f]	
e) Sacks	84[g]		1.00	84	
Total production materials expense					1,032
B. Tractor rent	37.5	hr.	7.72[h]		290
C. Repairs and maintenance					13[i]
D. Marketing costs					36[i]
E. Interest expense[j]					290
Total additional variable costs					1,661

[a]Assumed that seeding rate per hectare is 50 kilograms since limited information was available with regard to the amount of rice seeds utilized by each farm household.

[b]Actual average rice seed price per kilogram for this farm classification.

[c]Actual average amount of fertilizer, in kilograms, applied per hectare by this farm classification.

[d]Actual average value of fertilizer for this farm classification.

[e]Actual average peso value of chemical expenditure for this farm classification.

[f]Actual average peso value of expenditure on irrigation for this farm classification. Includes oil, fuel and lubricants.

[g]Number of sacks is computed by dividing the average output of this farm classification by 50 kilograms since each sack of paddy rice weighs this much.

Appendix Table C.3c. footnotes continued...

[h]In a paper presented by Juarez and Duff at the Joint Workshop of Agro-economic Survey and International Rice Research Institute, 25-27 August 1980 on the Village Economy and Institutions, entitled "The Economic and Instituitonal Impact of Mechanical Threshing in Iloilo and Laguna", the authors indicated that for mechanical threshing operations, 60% of the total payment for such operations goes to the owner of the mechanical thresher (portable axial flow type) and 40% goes to the operators and helpers. For estimating tractor rent for this farm classification, it is assumed that 60% of the wage rate for man-machine use per hour may apply for its computation, i.e., 60% of 12.87 pesos.

[i]Actual average value for this farm classification.

[j]At 30% of total loan per annum or 15% per season.

Appendix Table C.3d. Gross farm family income of two-wheel tractor farms, average per season, crop year 1979-1980.

IV.	Item	Peso	Value
A.	Total gross benefits		3,623
B.	Total paid-out costs:		
	Variable		
	a) Hired labor expense	565	
	b) Production materials expense	1,032	
	c) Tractor rent	290	
	d) Repairs and maintenance	13	
	e) Marketing costs	36	
	f) Interest expense	290	
C.	Total costs		2,226
D.	Gross farm family income		1,397

Appendix Table C.3e. Net farm family income of two-wheel tractor farms, average per season, crop year 1979-1980.

V.	Item	Peso Value
A.	Gross farm family income	1,397
B.	Depreciation[a]	302
C.	Net farm family income (A - B)	1,095

[a]Computation is based on a ten-year straight line method which includes assets such as farm draft animals, farm tools and implements and farm machinery.

Appendix Table C.3f. Imputed family labor values of two-wheel tractor farms, average per season, crop year 1979-1980.

VI.	Family Labor	Quantity	Unit	Peso/ Unit	Peso Value
A.	Land preparation:				
	a) Seedbed preparation -with two-wheel tractor	2.9	man-hr.	5.15[a]	15
	b) Plowing -with two-wheel tractor	11.1	man-hr.	5.15[a]	57
	c) Harrowing -with two-wheel tractor	8.9	man-hr.	5.15[a]	46
	d) Levelling -with two-wheel tractor	4.2	man-hr.	5.15[a]	22
	Total imputed family labor value for land preparation	27.1			140
B.	Planting	4.6	man-hr.	1.18	5
C.	Care/cultivation	18.8	man-hr.	1.71	32
D.	Post-production	1.9	man-hr.	2.86	5
E.	Marketing	-	man-hr.	-	-
F.	Total imputed family labor value	52.4			182

[a]Imputed value of family labor per hour for land preparation with two-wheel tractor is 40% of 12.87 pesos.

Appendix Table C.3g. Net farm income after imputed family labor of two-wheel tractor farms, average per season, crop year 1979-1980.

VII. Item	Peso Value
A. Net farm family income	1,095
B. Total imputed family labor value	182
C. Net farm income after imputed family labor (A - B)	913

Appendix Table C.4a. Total gross benefits of two-wheel tractor/thresher farms, average per season, crop year 1979-1980.

I. Revenue	Quantity	Unit	Peso/ Unit	Peso Value
A. Total value of output	4,035	kg.	1.13[a]	4,560
B. Total value of output share				
a) Threshers' share				
-manual[b]	202	kg.	1.13[a]	228
-mechanical[c]	137	kg.	1.13[a]	155
b) Landlord's share[d]	596	kg.	1.13[a]	673
Value of output share	775	kg.	1.13[a]	1,056
C. Total gross benefits (A - B)	3,260	kg.	1.13[a]	3,504

[a]Actual average price of rice per kilogram received by farmers under this farm classification.

[b]Share of manual threshers is 10% of total output manually threshed. It is assumed that 50% of total rice output is threshed manually for those farms using mechanical theshers.

[c]The common practice in the project area is to allocate 6% of the total rice output actually threshed by machines to the thresher operators/owner. It is assumed that 50% of the total rice output is threshed mechanically for those farms using these machines.

[d]Approximately 14% of total rice output net of threshers' share.

Appendix Table C.4b. Land preparation hired labor and customwork expense of two-wheel tractor/thresher farms, average per season, crop year 1979-1980.

II.	Paid-out Variable Costs: Hired Labor Expense	Quantity	Unit	Peso/ Unit	Peso Value
A.	Land preparation hired labor:				
	a) Seed preparation -with two-wheel tractor	0.1	man-machine hr.	12.47[a]	1
	b) Plowing -with two-wheel tractor	2.5	man-machine hr.	12.47[a]	31
	c) Harrowing -with two-wheel tractor	1.9	man-machine hr.	12.47[a]	24
	d) Levelling -with two-wheel tractor	1.8	man-machine hr.	12.47[a]	23
	Total land preparation hired labor expense	6.3			79
B.	Planting	178.7	man-hr.	1.06[b]	190
C.	Care/cultivation	3.9	man-hr.	1.59[b]	6
D.	Harvesting	173.9	man-hr.	1.28[b]	223
E.	Total hired labor expense	362.8			498

[a]Actual average wage rate per hour (man-machine hour) for this farm classification. Includes fuel and oil.
[b]Actual average wage rate per hour for this activity for this farm classification.

Appendix Table C.4c. Other paid-out costs of two-wheel tractor/thresher farms, average per season, crop year 1979-1980.

III. Other Paid-out Costs	Quantity	Unit	Peso/ Unit	Peso Value	
Additional variable costs:					
A. Production materials					
a) Seeds	50[a]	kg.	1.72[b]	86	
b) Fertilizer	250[c]	kg.	1.68	420[d]	
c) Chemicals				209[e]	
d) Irrigation				194[f]	
e) Sacks	81[g]		1.00	81	
Total production materials expense					990
B. Tractor rent	28.7	hr.	7.48[h]		215
C. Repairs and maintenance					27[i]
D. Marketing costs					45[i]
E. Interest expense[j]					266
Total additional variable costs					1,543

[a]Assumed that seeding rate per hectare is 50 kilograms since limited information was available with regard to the amount of rice seeds utilized by each farm household.
[b]Actual average rice seed price per kilogram for this farm classification.
[c]Actual average amount of fertilizer, in kilograms, applied per hectare by this farm classification.
[d]Actual average value of fertilizer for this farm classification.
[e]Actual average peso value of chemical expenditure for this farm classification.
[f]Actual average peso value of expenditure on irrigation for this farm classification. Includes oil, fuel and lubricants.
[g]Number of sacks is computed by dividing the average output of this farm classification by 50 kilograms since each sack of paddy rice weighs this much.

Appendix Table C.4c. footnotes continued...

[h]In a paper presented by Juarez and Duff at the Joint Workshop of Agro-economic Survey and International Rice Research Institute, 25-27 August 1980 on the Village Economy and Institutions, entitled "The Economic and Instituitonal Impact of Mechanical Threshing in Iloilo and Laguna", the authors indicated that for mechanical threshing operations, 60% of the total payment for such operations goes to the owner of the mechanical thresher (portable axial flow type) and 40% goes to the operators and helpers. For estimating tractor rent for this farm classification, it is assumed that 60% of the wage rate for man-machine use per hour may apply for its computation, i.e., 60% of 12.47 pesos.

[i]Actual average value for this farm classification.

[j]At 30% of total loan per annum or 15% per season.

Appendix Table C.4d. Gross farm family income of two-wheel tractor/ thresher farms, average per season, crop year 1979–1980.

IV.	Item	Peso	Value
A.	Total gross benefits		3,504
B.	Total paid-out costs:		
	Variable		
	a) Hired labor expense	498	
	b) Production materials expense	990	
	c) Tractor rent	215	
	d) Repairs and maintenance	27	
	e) Marketing costs	45	
	f) Interest expense	266	
C.	Total costs		2,041
D.	Gross farm family income		1,463

Appendix Table C.4e. Net farm family income of two-wheel tractor/thresher farms, average per season, crop year 1979-1980.

V.	Item	Peso Value
A.	Gross farm family income	1,463
B.	Depreciation[a]	309
C.	Net farm family income (A - B)	1,154

[a]Computation is based on a ten-year straight line method which includes assets such as farm draft animals, farm tools and implements and farm machinery.

Appendix Table C.4f. Imputed family labor values of two-wheel tractor/tractor farms, average per season, crop year 1979-1980.

VI. Family Labor	Quantity	Unit	Peso/ Unit	Peso Value
A. Land preparation:				
a) Seedbed preparation -with two-wheel tractor	2.5	man-hr.	5.00[a]	12
b) Plowing -with two-wheel tractor	10.7	man-hr.	5.00[a]	54
c) Harrowing -with two-wheel tractor	10.3	man-hr.	5.00[a]	52
d) Levelling -with two-wheel tractor	5.2	man-hr.	5.00[a]	26
Total imputed family labor value for land preparation	28.7			144
B. Planting	15.1	man-hr.	1.29	19
C. Care/cultivation	23.8	man-hr.	1.59	38
D. Post-production	8.2	man-hr.	3.65	30
E. Marketing	-	man-hr.	-	-
F. Total imputed family labor value	75.8			231

[a]Imputed value of family labor per hour for land preparation with two-wheel tractor is 40% of 12.47 pesos.

Appendix Table C.4g. Net farm income after imputed family labor of two-wheel tractor/thresher farms, average per season, crop year 1979-1980.

VII.	Item	Peso Value
A.	Net farm family income	1,154
B.	Total imputed family labor value	231
C.	Net farm income after imputed family labor (A - B)	923

Appendix Table C.5a. Total gross benefits of two-wheel tractor/carabao farms, average per season, crop year 1979-1980.

I. Revenue	Quantity	Unit	Peso/ Unit	Peso Value
A. Total value of output	2,854	kg.	1.12[a]	3,197
B. Total value of output share				
a) Threshers' share -manual[b]	285	kg.	1.12[a]	319
b) Landlord's share[c]	359	kg.	1.12[a]	402
Value of output share	557	kg.	1.12[a]	721
C. Total gross benefits (A - B)	2,297	kg.	1.12[a]	2,476

[a]Actual average price of rice per kilogram received by farmers under this farm classification.

[b]Share of manual threshers is 10% of total output manually threshed. It is assumed that 50% of total rice output is threshed manually for those farms using mechanical theshers.

[c]Approximately 13% of total rice output net of threshers' share.

Appendix Table C.5b. Land preparation hired labor and customwork expense of two-wheel tractor/ carabao farms, average per season, crop year 1979-1980.

II. Paid-out Variable Costs: Hired Labor Expense	Quantity	Unit	Peso/ Unit	Peso Value
A. Land preparation hired labor:				
a) Seed preparation				
-with carabao	-	man-animal hr.	4.03[a]	-
-with two-wheel tractor	0.2	man-machine hr.	11.58[b]	2
b) Plowing				
-with carabao	2.4	man-animal hr.	4.03[a]	10
-with two-wheel tractor	6.7	man-machine hr.	11.58[b]	78
c) Harrowing				
-with carabao	1.6	man-animal hr.	4.03[a]	6
-with two-wheel tractor	4.3	man-machine hr.	11.58[b]	50
d) Levelling				
-with carabao	0.5	man-animal hr.	4.03[a]	2
-with two-wheel tractor	2.5	man-machine hr.	11.58[b]	29
Total land preparation hired labor expense	18.2			177
B. Planting	162.4	man-hr.	1.06[c]	172
C. Care/cultivation	1.2	man-hr.	1.69[c]	2
D. Harvesting	196.6	man-hr.	1.28[c]	252
E. Total hired labor expense	378.4			603

[a]Actual average wage rate per hour (man-animal hour) for this farm classification. Does not include meals.

[b]Actual average wage rate per hour (man-machine hour) for this farm classification. Includes fuel and oil.

[c]Actual average wage rate per hour for this activity for this farm classification.

Appendix Table C.5c. Other paid-out costs of two-wheel tractor/carabao farms average per season, crop year 1979-1980.

III. Other Paid-out Costs	Quantity	Unit	Peso/ Unit	Peso Value	
Additional variable costs:					
A. Production materials					
a) Seeds	50[a]	kg.	2.13[b]	107	
b) Fertilizer	171[c]	kg.	1.66	284[d]	
c) Chemicals				100[e]	
d) Irrigation				159[f]	
e) Sacks	57[g]		1.00	57	
Total production materials expense					707
B. Tractor rent	16.5	hr.	6.75		115
C. Repairs and maintenance					12[i]
D. Marketing costs					24[i]
E. Interest expense[j]					220
Total additional variable costs					1,087

[a]Assumed that seeding rate per hectare is 50 kilograms since limited information was available with regard to the amount of rice seeds utilized by each farm household.
[b]Actual average rice seed price per kilogram for this farm classification.
[c]Actual average amount of fertilizer, in kilograms, applied per hectare by this farm classification.
[d]Actual average value of fertilizer for this farm classification.
[e]Actual average peso value of chemical expenditure for this farm classification.
[f]Actual average peso value of expenditure on irrigation for this farm classification. Includes oil, fuel and lubricants.
[g]Number of sacks is computed by dividing the average output of this farm classification by 50 kilograms since each sack of paddy rice weighs this much.

Appendix Table C.5c. footnotes continued...

[h]In a paper presented by Juarez and Duff at the Joint Workshop of Agro-economic Survey and International Rice Research Institute, 25-27 August 1980 on the Village Economy and Institutions, entitled "The Economic and Instituitonal Impact of Mechanical Threshing in Iloilo and Laguna", the authors indicated that for mechanical threshing operations, 60% of the total payment for such operations goes to the owner of the mechanical thresher (portable axial flow type) and 40% goes to the operators and helpers. For estimating tractor rent for this farm classification, it is assumed that 60% of the wage rate for man-machine use per hour may apply for its computation, i.e., 60% of 11.58 pesos.

[i]Actual average value for this farm classification.

[j]At 30% of total loan per annum or 15% per season.

Appendix Table C.5d. Gross farm family income of two-wheel tractor/carabao farms, average per season, crop year 1979-1980.

IV.	Item	Peso	Value
A.	Total gross benefits		2,476
B.	Total paid-out costs:		
	Variable		
	a) Hired labor expense	603	
	b) Production materials expense	707	
	c) Tractor rent	115	
	d) Repairs and maintenance	21	
	e) Marketing costs	24	
	f) Interest expense	220	
C.	Total costs		1,690
D.	Gross farm family income		786

Appendix Table C.5e. Net farm family income of two-wheel tractor/ carabao farms, average per season, crop year 1979-1980.

V.	Item	Peso Value
A.	Gross farm family income	786
B.	Depreciation[a]	286
C.	Net farm family income (A - B)	500

[a]Computation is based on a ten-year straight line method which includes assets such as farm draft animals, farm tools and implements and farm machinery.

Appendix Table C.5f. Imputed family labor values of two-wheel tractor/carabao farms, average per season, crop year 1979-1980.

VI. Family Labor	Quantity	Unit	Peso/Unit	Peso Value
A. Land preparation:				
a) Seedbed preparation				
-with carabao	-	man-hr.	-	-
-with two-wheel tractor	-	man-hr.	-	-
b) Plowing				
-with carabao	15.0	man-hr.	2.12	32
-with two-wheel tractor	10.8	man-hr.	4.63[a]	50
c) Harrowing				
-with carabao	7.7	man-hr.	1.12	16
-with two-wheel tractor	4.9	man-hr.	4.63[a]	23
d) Levelling				
-with carabao	3.7	man-hr.	2.12	8
-with two-wheel tractor	0.8	man-hr.	4.63[a]	4
Total imputed family labor value for land preparation	42.9			133
B. Planting	23.6	man-hr.	1.11	48
C. Care/cultivation	29.8	man-hr.	1.50	45
D. Post-production	26.1	man-hr.	1.75	46
E. Marketing	-	man-hr.	-	-
F. Total imputed family labor value	122.4			272

[a]Imputed value of family labor per hour for land preparation with two-wheel tractor is 40% of 11.58 pesos.

Appendix Table C.5g. Net farm income after imputed family labor of two-wheel tractor/carabao farms, average per season, crop year 1979-1980.

VII. Item	Peso Value
A. Net farm family income	500
B. Total imputed family labor value	272
C. Net farm income after imputed family labor (A - B)	228

Appendix Table C.6a. Total gross benefits of two-wheel tractor/carabao/ thresher farms, average per season, crop year 1979-1980.

I. Revenue	Quantity	Unit	Peso/ Unit	Peso Value
A. Total value of output	3,664	kg.	1.13[a]	4,140
B. Total value of output share				
a) Threshers' share				
-manual[b]	183	kg.	1.13[a]	210
-mechanical[c]	110	kg.	1.13[a]	124
b) Landlord's share[d]	509	kg.	1.13[a]	575
Value of output share	663	kg.	1.13[a]	909
C. Total gross benefits (A - B)	3,001	kg.	1.13[a]	3,231

[a]Actual average price of rice per kilogram received by farmers under this farm classification.

[b]Share of manual threshers is 10% of total output manually threshed. It is assumed that 50% of total rice output is threshed manually for those farms using mechanical theshers.

[c]The common practice in the project area is to allocate 6% of the total rice output actually threshed by machines to the thresher operators/ owner. It is assumed that 50% of the total rice output is threshed mechanically for those farms using these machines.

[d]Approximately 14% of total rice output net of threshers' share.

Appendix Table C.6b. Land preparation hired labor and customwork expense of two-wheel tractor/carabao/thresher farms, average per season, crop year 1979-1980.

II. Paid-out Variable Costs: Hired Labor Expense	Quantity	Unit	Peso/ Unit	Peso Value
A. Land preparation hired labor:				
a) Seed preparation				
-with carabao	0.2	man-animal hr.	3.57[a]	-
-with two-wheel tractor	0.1	man-machine hr.	12.80[b]	1
b) Plowing				
-with carabao	1.3	man-animal hr.	3.57[a]	5
-with two-wheel tractor	5.2	man-machine hr.	12.80[b]	67
c) Harrowing				
-with carabao	1.7	man-animal hr.	3.57[a]	6
-with two-wheel tractor	4.8	man-machine hr.	12.80[b]	62
d) Levelling				
-with carabao	1.4	man-animal hr.	3.57[a]	5
-with two-wheel tractor	2.1	man-machine hr.	12.80[b]	27
Total land preparation hired labor expense	16.8			173
B. Planting	174.8	man-hr.	1.07[c]	187
C. Care/cultivation	3.1	man-hr.	1.61[c]	5
D. Harvesting	169.4	man-hr.	1.28[c]	217
E. Total hired labor expense	364.1			582

[a]Actual average wage rate per hour (man-animal hour) for this farm classification. Does not include meals.
[b]Actual average wage rate per hour (man-machine hour) for this farm classification. Includes fuel and oil.
[c]Actual average wage rate per hour for this activity for this farm classification.

Appendix Table C.6c. Other paid-out costs of two-wheel tractor/carabao/thresher farms, average per season, crop year 1979-1980.

III. Other Paid-out Costs	Quantity	Unit	Peso/ Unit	Peso Value	
Additional variable costs:					
A. Production materials					
a) Seeds	50[a]	kg.	1.79[b]	90	
b) Fertilizer	233[c]	kg.	1.70	396[d]	
c) Chemicals				137[e]	
d) Irrigation				176[f]	
e) Sacks	73[g]		1.00	73	
Total production materials expense					872
B. Tractor rent	12.4	hr.	7.68[h]		95
C. Repairs and maintenance					3[i]
D. Marketing costs					36[i]
E. Interset expense[j]					238
Total additional variable costs					1,244

[a]Assumed that seeding rate per hectare is 50 kilograms since limited information was available with regard to the amount of rice seeds utilized by each farm household.
[b]Actual average rice seed price per kilogram for this farm classification.
[c]Actual average amount of fertilizer, in kilograms, applied per hectare by this farm classification.
[d]Actual average value of fertilizer for this farm classification.
[e]Actual average peso value of chemical expenditure for this farm classification.
[f]Actual average peso value of expenditure on irrigation for this farm classification. Includes oil, fuel and lubricants.
[g]Number of sacks is computed by dividing the average output of this farm classification by 50 kilograms since each sack of paddy rice weighs this much.

Appendix Table C.6c. footnotes continued...

[h]In a paper presented by Juarez and Duff at the Joint Workshop of Agro-economic Survey and International Rice Research Institute, 25-27 August 1980 on the Village Economy and Institutions, entitled "The Economic and Instituitonal Impact of Mechanical Threshing in Iloilo and Laguna", the authors indicated that for mechanical threshing operations, 60% of the total payment for such operations goes to the owner of the mechanical thresher (portable axial flow type) and 40% goes to the operators and helpers. For estimating tractor rent for this farm classification, it is assumed that 60% of the wage rate for man-machine use per hour may apply for its computation, i.e., 60% of 12.80 pesos.

[i]Actual average value for this farm classification.

[j]At 30% of total loan per annum or 15% per season.

Appendix Table C.6d. Gross farm family income of two-wheel tractor/carabao/thresher farms, average per season, crop year 1979-1980.

IV.	Item	Peso	Value
A.	Total gross benefits		3,231
B.	Total paid-out costs:		
	Variable		
	a) Hired labor expense	582	
	b) Production materials expense	872	
	c) Tractor rent	95	
	d) Repairs and maintenance	3	
	e) Marketing costs	36	
	f) Interest expense	238	
C.	Total costs		1,826
D.	Gross farm family income		1,405

Appendix Table C.6e. Net farm family income of two-wheel tractor/carabao/thresher farms, average per season, crop year 1979-1980.

V.	Item	Peso Value
A.	Gross farm family income	1,405
B.	Depreciation[a]	354
C.	Net farm family income (A - B)	1,051

[a]Computation is based on a ten-year straight line method which includes assets such as farm draft animals, farm tools and implements and farm machinery.

Appendix Table C.6f. Imputed family labor values of two-wheel tractor/carabao/thresher farms, average per season, crop year 1979-1980.

VI. Family Labor	Quantity	Unit	Peso/ Unit	Peso Value
A. Land preparation:				
a) Seedbed preparation				
-with carabao	-	man-hr.	-	-
-with two-wheel tractor	-	man-hr.	-	-
b) Plowing				
-with carabao	18.7	man-hr.	2.77	52
-with two-wheel tractor	4.8	man-hr.	5.12	25
c) Harrowing				
-with carabao	5.5	man-hr.	2.77	15
-with two-wheel tractor	5.2	man-hr.	5.12	27
d) Levelling				
-with carabao	3.3	man-hr.	2.77	9
-with two-wheel tractor	2.4	man-hr.	5.12	12
Total imputed family labor value for land preparation	39.9			140
B. Planting	13.0	man-hr.	1.19	15
C. Care/cultivation	24.2	man-hr.	1.52	37
D. Post-production	24.6	man-hr.	3.01	74
E. Marketing	-	man-hr.	-	-
F. Total imputed family labor value	101.7			266

[a]Imputed value of family labor per hour for land preparation with two-wheel tractor is 40% of 12.80 pesos.

Appendix Table C.6g. Net farm income after imputed family labor of two-wheel tractor/carabao/thresher farms, average per season, crop year 1979-1980.

VII. Item	Peso Value
A. Net farm family income	1,051
B. Total imputed family labor value	266
C. Net farm income after imputed family labor (A - B)	785

APPENDIX D

Preliminary Estimation of Cobb-Douglas Production Function

Appendix Table D.1. Estimated Cobb-Douglas production functions using the dummy variable approach to test for differences in the technical efficiency parameters of small rice farms with different modes of mechanization, Nueva Ecija, Philippines, crop year 1979-1980.

Independent Variable	Statistical Values
Constant	2.88*** (6.29)[a]
Labor (L)	0.55*** (7.39)
Fertilizer (F)	0.07*** (2.69)
Chemicals (Ch)	0.12*** (4.39)
Irrigation (I)	0.28*** (3.84)
Season (S)	0.16** (2.26)
Two-wheel (M_1)	0.57*** (4.17)
Two-wheel/carabao (M_2)	0.32*** (2.51)
Carabao/thresher (M_3)	0.20** (2.15)
Two-wheel/thrsher (M_4)	0.60*** (5.67)
Two-wheel/thrsher/carabao (M5)	0.54*** (4.70)
Education (Ed)	-0.01 (-0.73)
Experience (Ex)	0.003 (0.94)
Extension Service (ES)	-0.07 (-0.83)
Member Farmers Organization (GP)	0.14 (1.59)
R^2	0.44
F-value	22.36
Number of observations	419
Degrees of freedom	404

[a]Values in parentheses are t-values.
***Significant at P = 1%.
**Significant at P = 5%.
*Significant at P = 10%.