THE EFFECT OF TRACTOR USE ON THE STRUCTURE OF INCOME AND INCOME DISTRIBUTION ON SMALL RICE FARMS: A CASE STUDY OF SUPHANBURI PROVINCE, THAILAND

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THESIS

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ผลของการใช้รถไถนาที่มีต่อโครงสร้างของรายได้ และการกระจายรายได้ของเกษตรกรที่ทำฟาร์มขนาดเล็ก จังหวัดสุพรรณบุรี ประเทศไทย

by

Miss SOMPORN SAITAN

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สาขา เศรษฐศาสตร์เกษตร

เรื่อง ผลของการใช้รถไถนาที่มีต่อโครงสร้างของรายได้ และการกระจายรายได้ของเกษตรกรที่ทำฟาร์มขนาดเล็ก จังหวัดสุพรรณบุรี ประเทศไทย

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เครื่องจักรกลการเกษตรได้มีบทบาทที่สำคัญในการเพิ่มความสามารถในการผลิตโดยการลดการใช้แรงงาน และสามารถนำแรงงานนั้นไปทำงานชนิดอื่นได้ ที่สำคัญคือเกษตรกรมีรายได้จากการให้เช่าเครื่องจักรกลการเกษตรซึ่งเป็นการเพิ่มพูนต่อรายได้ฟาร์ม

การศึกษาโครงสร้างของรายได้และผลกระทบของการใช้เครื่องจักรกลการเกษตรต่อรายได้นั้น จากการใช้สมการการผลิตรีเกรสชั่นพบว่าการใช้เครื่องจักรกลการเกษตรมีผลกระทบต่อรายได้นอกฟาร์มและนอกการเกษตรอย่างมีนัยสำคัญ ผลต่อรายได้ฟาร์มนั้นโดยวิธีการศึกษาส่วนแบ่งปัจจัยการผลิต พบว่าส่วนแบ่งแรงงานมีค่าต่ำเมื่อเปรียบเทียบกับส่วนแบ่ง ที่ดินและเครื่องจักรกลการเกษตร ผลของการใช้เครื่องจักรกลการเกษตรที่เห็นได้ชัดคือการทำให้มีการใช้แรงงานครัวเรือนและการจ้างงานมากขึ้น

ในส่วนของการกระจายรายได้นั้น เส้นลอเร็นส์และสัมประสิทธิ์จินี แสดงให้เห็นว่าไม่มีความแตกต่างในรายได้ระหว่างกลุ่มผู้เช่าและผู้เป็นเจ้าของเครื่องจักรกลการเกษตร ทั้งนี้เป็นเพราะรายได้นอกฟาร์มและนอกการเกษตรมีส่วนที่จะก่อให้เกิดความเสมอภาคในการกระจายรายได้ระหว่างกลุ่มเกษตรกรผู้เช่าและผู้เป็นเจ้าของเครื่องจักรกลการเกษตร

AN ABSTRACT OF THE THESIS

Miss Somporn Saitan

Master of Science

(Agricultural Economics)

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Farm mechanization plays an important role in increasing farm productivity by reducing the labor requirements for important farm operations and thus allowing the farmers to engage in supplementary employment. This, and any income earned through custom renting of machines, adds to the farm income from crop and livestock activities.

The structure of income is therefore affected by mechanization and in this study it is shown, using regression analysis, that the use of tractors significantly affects farm employment enabling farmers to spend more time on off- and non-farm work.

Since mechanization affects the allocation of inputs in crop production, it is believed that this leads to a redistribution of income away from wage earners. Factor share analysis showed that labor's share is lower on tractor hiring farms when compared to tractor-owning farms but that the shares to land and capital were higher on the tractor hiring farms. In the current environment, it appears that mechanization only affects family labor and that the hired labor share remains unchanged.

The final issue examined is the distribution of incomes. This limited analysis was carried out using Lorenz curves and Gini ratios and non significant inequalities were found within classes. Income from off-farm and non-farm sources enabled low income earners to achieve a reasonably equitable share of total income.

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CHAPTER I

INTRODUCTION

Statement of the Problem

The agricultural sector plays an important role in the economy of Thailand, a role which will continue for many years. The majority of the Thai population live in farm households and 78% of the labor force participates in agriculture (20 p. 9). Futhermore, about 32% of the gross domestic product (GDP) is derived from the agricultural sector. Compared with the wholesale and retail trade sectors, which contribute the next largest share (18 percent), agriculture is the major source of income and employment for the Thai people.

The standard of living of farmers affects the whole economy and political stability of Thailand. Among the problems faced by farmers are low incomes, unemployment and/or underemployment, and an inequitable distribution of income between urban and rural areas and between regions. A recent review of current income conditions indicated that income per capita in the non-agricultural labor force was nine times higher than per capita income for agricultural workers (13 p. 19). The average annual income for a family living in Bangkok was 32,000 baht compared to 3,500 baht for Thailand's average farm family (4 p. 23). Disequity in income between farms within regions is as important an issue as the distribution between region. Another

recent study of income distribution in Thailand suggested that, over time, the income distribution among rural families had become more unequal while among urban families the distribution of income had become more equal (13 p. 21). In the same study a tendency towards a higher degree of inequality between rural and urban incomes was also observed.

A major policy goal of the Thai government is to raise the level and improve the distribution of income among both the farm and non-farm population. In the fifth National Economic and Social Development Plan (1982-1986), a stated objective of the government is to " .... improve the structure of agricultural production and productivity ...." (18 p. 7). To achieve this goal, there must be an increase in farm output and an increase in national income through agricultural development.

At present, both poverty and income distribution problems are of great concern to the government. The government has introduced various economic policies to resolve these basic issues by increasing farm incomes through improved crop output. Multiple cropping is one solution, but requires innovative cropping patterns and new - biological, chemical and mechanical-technologies. Biological and chemical technologies usually increase output per unit of land while mechanical technology increases the efficiency of farm labor, but also reduces the amount of labor required.

Mechanization plays a crucial role in this development strategy. Mechanization is thought to have enabled double cropping or increased intensity of land use and is therefore expected to contribute to an increase in net incomes. In Thailand, mechanization plays a highly complementary role with other new technologies in crop production and together these technological changes clearly have an impact on farm incomes.

Mechanization reduces seasonal labor requirements in crop production (27 p. 74). At a given output price, net farm income from crop production will increase by any reduction in costs resulting from the introduction of mechanization. Also, the farmer may either utilize the time saved in land preparation and threshing in alternative employment which will increase farm income or the saved time may enable the farmer to increase his consumption of leisure and thereby his welfare. Furthermore, farmers who own a machine can earn additional income by rendering custom services to farmers who do not own machines or who have insufficient machine capacity to meet their own requirement.

In contrast, others allege that mechanization by its capital intensive nature has been divisive in its impact. Although incomes have increased in general, the larger farmers and owners of mechanical power have been the prime beneficiaries. This, together with inequality in rates of adoption, has tended to produce greater inequality in the distribution of income.

Since the introduction of mechanization induces the reallocation of the other inputs in crop production, there is hypothesized to be a redistribution effect which will increase the income of machine owning farmers at the expense of other farmers. In addition to the redistribution problem, mechanization is hypothesized to discriminate in favor of large farmers to the detriment of small farmers. Inequality of income between farmers who employ different levels of farm mechanization needs further analysis.

Objectives

The objectives of this study are:

1. To trace out the impact of farm mechanization on the structure of income among groups of farmers employing different types and different levels of mechanization.

2. To determine the impact of tractor use on income distribution among the factors of production by different types of tractor users.

3. To investigate the impact of tractor use on income distribution among earners by different types of tractor users.

4. To examine the impact of tractor use on income inequality within groups of farms employing different types and levels of mechanization.

Scope of the Study

The data used in this thesis was gathered in the 1981/82 wet and dry seasons from selected villages of the Central Plains of Thailand. This study is confined to farmers using two-wheel and small four-wheel tractors for land preparation in selected irrigated rice farming villages of Amphoe U-Thong and Don-Chedi in Suphanburi Province.

Procedures

Data Source

Data from the Consequences of Small Rice Farm Mechanization Project was used for this study. The countries involved in this project were the Philippines, Indonesia and Thailand. In Thailand, the project was a joint research effort of the International Rice Research Institute (IRRI) and Kasetsart University. Field research was conducted in Suphanburi province, the most specialized rice producing area in Thailand and one in which irrigation and the use of modern agricultural technology is well developed. Small tractors play an important role in this area because of their versatility in a range of operations such as land preparation, water pumping and threshing. Tractors therefore are likely to have an important impact both on farm employment and on the farmer's income.

The data gathering component of the project consisted of a series of cross-sectional surveys covering a total of 223 farm households from 5 villages. These were classified into two-main groups: 1) farmers who employed small four-wheel tractors and 2) farmers who employed two-wheel tractors. In each group a sub-group based on the type of ownership (owners versus hirers) was distinguished, enabling further analysis of the income and wealth effects.

The five villages under study were: Village nos. 1,5,6 Tambol Rai Rod, and village no. 6 Tambol Donchedi, Amphoe Don-Chedi and village no. 7 Tambol Pla-plachai Amphoe U-Thong, Suphanburi Province.

Secondary information was assembled from the Office of the Agricultural Economics (OAE), Ministry of Agriculture and Cooperatives.

Theoretical Framework

Theoretical framework used in this study is based on the concept of factor share analysis, using an accounting procedure, an income function and the size distribution of income in order to evaluate the impact of farm mechanization on the structure of income and income distribution.

Hypotheses

The major issue to be resolved is whether different types or levels of mechanization bring about significant changes in income and income distribution. This suggests the following hypotheses to be tested:

1. Household incomes of four-wheel tractor farms are higher than on two-wheel tractor farms.

2. There are differences in relative factor shares resulting from the differences in payments to capital and labor.

3. No differences exist in income inequality indicators within various categories of mechanization farms.

Definitions

To measure the importance of mechanization as a source of income variation, cross-sectional results from the Consequences of Small Rice Farm Mechanization survey (CSRFM) are used. The definitions used in this study came from "Operations Handbook No. 1 Farm Survey and Recordkeeping Procedures" for that project (17 p 17-67).

Farm household

The farm 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 do not share common food preparation facilities than they are considered as separate households by this definition.

Size of farm

In the survey only rice farms which cultivated at least 0.1 ha but less than 62.5 ha of land in either wet or dry seasons, were considered.

Farm income

This refers to the income derived from activities on one's own farm. It is calculated by subtracting the cost of crop related activities (e.g., plowing, harvesting, threshing, etc.) and general farm activities (e.g., fencing, repairing, etc.) from the value of total output.

Off-farm income

Off-farm income is income derived from agricultural work on other farms.

Non-farm income

Non-farm income is income derived from non-agricultural work such as services, commerce and industry or the practice of a profession.

Tractors

Farm tractors were classified into two size groups according to the method of operation:

1) Small four-wheel tractors are locally produced with engines ranging from 8-14 horsepower and generally used both on wet and dry paddy land.

2) Power tillers, or walking tractors which are small two-wheel tractors with engines ranging from 6 to 12 horsepower locally produced, again used mainly in both wet and dry paddy land.

Output

Output is determined just after the paddy is threshed, i.e. net of harvest and threshing losses.

The output price

The output price is the farm gate price of paddy after threshing.

Costs

Costs referred to in the following section include those from land preparation up to hauling threshed paddy from the fields to the farm gate.

Labor inputs

Labor inputs are classified into the following groups: family labor, exchange labor and contract labor. Family labor is defined as any member of the household who is not paid either in cash or kind for any field work done. Exchange labor is not paid for any field work done on the mutual and implied condition that the operator returns the service in the future. Lastly, contract labor is any person hired on a piecework or job basis. Labor was also grouped into male (male 10 years old or over), female (female 10 years old or over) or child (male or female under 10 years old). The amount of labor use was recorded in man-hours (i.e., number of laborers multiplied by the number of hours worked per laborer) and 1 manday defined as 8 man hours.

Land

Land is generally defined as physical inputs which can be used only for rice production.

The estimation of land costs were derived from land values, land taxes and land rents. Land value is the estimated market value at 5 baht rai^{-1} per annum and was split into 3 baht rai^{-1} and 2 baht rai^{-1} in the wet and dry seasons respectively. Land rent refers to the rent paid on land by the farmer only if he is not the owner of the land.

Capital input

Capital inputs include the services of fixed capital which are usable over a number of production periods or seasons such as tractors, water pumps and threshers as well as capital funds applied in the production process.

Current inputs

Current inputs are those whose total value is transferred to output and exhausted during the production period. They include seeds,

fertilizer, pesticide, gasoline for tractors and other machines. Some current inputs were self-supplied and evaluated by their opportunity costs.

Review of Literature

1. Hayami, Y. and R. W. Herdt (11) have pointed out that if a new rice variety results in increased output, the higher output will tend to decrease prices and the benefits will be shared widely by rice consumers, whether they are landless laborers, workers, farmers or urban people. The absolute benefit to various individuals is positively related to the proportion of their income spent on rice consumption. In the absence of increased output, however, adoption of machinery may cause a shift in the proportion of earnings going to the owners of the different factors of production. A machine that replaces labor can be expected to receive the wage formerly paid to the laborers. In such an event the owner of the machine will receive the earnings. This simply means that there has been a redistribution of income in favor of machine owners. Where this occurs, decisions to promote mechanization will also support a transfer of income from labor to machine owners.

2. Lockwood, B. (15) concluded that tractorization in Pakistan had led to an expansion in the farm area operated by tractor farmers at the expense of tenants and others who had previously farmed the areas involved. This expulsion of tenant families directly reduced

the amount of labor applied to the area previously rented out, since it was now farmed using more machinery.

3. Jabbar, N. A. et. al. (12) indicated that the large scale introduction of power tillers into land preparation was likely to benefit large and, already rich, farmers at the expense of small and marginal farmers. Tiller use significantly increased the size of the cultivated holding, where part of this new accumulation in farm size was from land previously rented out and part from newly acquired land. The cost of tiller cultivation was cheaper because an overvalued currency resulted in the underpricing of the tiller, subsidized fuel prices and cheap credit which was usually readily available to larger farmers.

4. Sinaga, R. S., et. al. (24) reported that the profitability of tractor ownership in West Java was affected by government policies which impinged on import duties, the foreign exchange rate and the rate of interest and that this was the main reason for the adoption of mechanical practices. There was no indication of a labor shortage for lowland rice field preparation prior to the introduction of tractors in West Java. In fact, there was evidence of a general decline in real agricultural wages. This situation is thus quite different from that experienced in Taiwan and South Korea, where agriculture mechanization was stimulated by a sharp increase in real agricultural wages.

5. Anuwat (27) attempted to investigate the impact of farm mechanization on rice production and labor requirements in Thailand and found that there were many comfounding issues to be considered. The analyses indicated that mechanization of land preparation did increase output and that the adoption of other types of new technology --- increased fertilizer use and modern varieties --- were also found to increase output. The introduction of transplanting was another factor that was found to contribute to an increase in output. The results of the estimated labor requirement function indicated that the practice of transplanting had lead to increased labor utiliation but that tractors had a direct labor displacement effect. However, in this study, the impact of fertilizer and HYVs on labor requirement was inconclusive.

6. Paris, T. B. (21) using the functional income distribution (factor share) analysis, showed that farm operators received not only the returns to management but also a significant proportion of the return to land, labor and other capital. Therefore hired laborers and landlords do not have exclusive claims to the factor shares of labor and land respectively. Hence, income distribution among factors may have little coincidence with income distribution among earners. An increased labor share does not necessarily imply that hired and landless workers are the only ones benefited because owner-operators sometimes hire out their own labor.

7. Saefudin, Y. (23) examined value added shares for farms in West Java and found that on mechanized farms in the wet season labor's share decreased by 8% while capital shares increased by 4%. The earner share analysis showed that the shares of farmer and hired labor were 5% and 2% lower on non-mechanized farms, indicating that land preparation mechanization did not significantly affect income distribution since it was only family labor that was replaced by the tractor. For the dry season, there were minor differences between mechanized and non-mechanized farms in terms of value added and income shares. This was due to minimum tillage practices which required less labor for land preparation, and are widely practiced by non-mechanized farmers in the dry season.

8. Jarin (25) measured the increased income in the Thai agricultural sector as a result of new technology and machinery by using the concepts of factor shares and Cobb-Douglas production functions. This study showed using a simple two factor Cobb-Douglas production function with constant returns to scale, that the output elasticity of labor is roughly twice as high as that of capital (0.31 compared to 0.69). He therefore concluded that after mechanization the factor share of labor would be greater than that of capital.

The effect of mechanization on income and income distribution is therefore not a clearcut issue since the linkages between factor shares and farm income are complex. Also, since mechanization is also

associated with changes in other cultural practices, it is difficult to isolate the exact effects of mechanization.

Although a number of studies have shown the effect of mechanization on income and income distribution, this has not been studied using the size distribution of income approach. Some authors have used the size distribution of income concept to measure the distributional impact of land tenure (Watchara, 1979), prices, resource development policies (Supote, 1978) and off-farm employment (Thanwa, 1982). Others, have used this concept to measure the distribution of income and wealth in Thailand (Udom, 1975).

CHAPTER 2

THEORETICAL CONCEPTS AND THE METHODOLOGY OF THE STUDY

Data

Primary data was obtained from the Consequences of Small Rice Farm Mechanization Project in Suphanburi Province, Central Plain Thailand. The primary objective of this project was to measure the effect of small farm mechanization on rice production, income and rural employment.

The data was collected from seven villages in Suphanburi Province which were purposely selected in order to represent small farms in predominantly irrigated rice producing areas, and containing a range of levels of mechanized land preparation. A complete census of all households was undertaken in the selected villages. This provided the background information required to draw a stratified random sample from the household list on the basis of type of mechanization and water control. The census information included the main and subsidiary occupations of adults, land holding size, type of irrigation, education as well as information on ownership and machine use. Households were stratified into nine strata based on the type of irrigation and the source of power used for primary tillage.

1. Rainfed and Animal
2. Rainfed and Animal + Machine
3. Rainfed and 2-wheel Tractor
4. Rainfed and small 4-wheel Tractor
5. Irrigated and Animal
6. Irrigated and Animal + Machine
7. Irrigated and 2-wheel Tractor
8. Irrigated and small 4-wheel Tractor
9. Field labor (landless labor)

The data collected in the survey was based on FAO's Farm Mechanization Data Collection and Analysis System (FMDCAS) (6 p. 46) and included a record of initial resources as well as details of inputs, outputs used for production activities throughout the seasons. The data was collected in two rounds: the first just after land preparation, and the second after harvesting.

Classification of Farms

For the purpose of the present study, the following classification scheme was used:

4T(O) = Owner small 4-wheel tractor
the number of sample size was 51 in the wet season and 46 in the dry season;

2T(O) = Owner 2-wheel tractor
sample size was 94 in the wet season and 92 in the dry season;

4T(H) = Hired small 4-wheel tractor
the sample size was 27 in both the wet and dry seasons;

2T(H) = Hired 2-wheel tractor,
the sample size was 51 in both the wet and dry seasons.

In this study, only mechanized households with irrigation were considered (stratum 7 and 8). The distribution of households between the 2-wheel and small 4-wheel class has been further sub-classified by type of ownership (Table 1). The data for both the wet and dry seasons of the 1981-82 cropping year was used.

Table 1. Distribution of household sample of the data set used in the study.

Level of mechanization	Type of operator					
	Owned		Hired		Total	
	Wet	Dry	Wet	Dry	Wet	Dry
4 wheel tractor	51	46	27	27	78	73
2 wheel tractor	94	92	51	51	145	143
Total	145	138	78	78	223	216

Analytical Procedures

The analysis is divided into three parts. First, to determine the impact of tractor use in land preparation on off-farm and non-farm income, a income function approach is employed. Second, a modification of the factor-share approach is utilized to examine the effect of tractor use in land preparation on farm income. With this methodology, the proportion of total output going to various classes of individuals involved in production is calculated using an accounting procedure. This is a valid approach reflecting the implications of personal income distribution among households. Lastly, the size distribution of income concept is used as a model to study the impact of tractor use on income equality.

Tractorization affects farm household income through the increased efficiency of the machine when compared to animal power. Also tractor power enables faster land preparation than does animal power and hence, increases the productivity of the farmer, thus providing opportunities for farm labor to develop supplemental employment opportunities. Before discussing the effects of mechanization on income it is first necessary to define the income concept used in the model.

Farm household income (YH) consists of on-farm income (YF), off farm agricultural income (YO) and non-farm income (YN). At given levels of farm tractorization, the four-wheel tractor farms are expected to receive higher on-farm, off farm and non-farm income than the two-wheel tractor farms. Analysis of the composition of income for each level of tractorization is required to test this hypothesis. Income can be summarized as follows (3 p. 28-40):

$$YH_i = YF_i + YO_i + YN_i \qquad (1)$$

where: YH_i = farm household income;

YF_i = on-farm income including all income from crop and livestock production;

YO_i = off-farm income from work in the agricultural sector but excluding crop and livestock production activities on the owner's farm;

YN_i = non-farm income from non-agricultural work such as services, commerce and industry;

i = level of tractorization

Net farm income includes all income from crop and livestock production activities after deducting input costs. The farm income of the rice farm can be expressed as follows:

$$YF_i = YFR_i + YFO_i \qquad (2)$$

where: YFR_i = net farm income from rice for a farm employing tractorization level i;

YFO_i = net farm income from other crops and livestock for a farm employing tractorization level i;

Also, net farm rice income can be formulated as follows:

$$YFR_i = PR.QR_i - CR_i(QR_i) \qquad (3)$$

where: PR = farm gate price of paddy in baht/kilogram;

QR_i = output of paddy in kilogram;

CR_i = average production costs for rice (baht/kilogram of paddy), consisting of fixed cost of current inputs such as fertilizers, seeds, insecticides, pesticides, herbicides, fuel for water pumps and for tractors, rental of machines and wages paid to hired labor.

Net farm income from non-rice sources is defined follows:

$$YFO_i = \overline{YFO_i} \qquad (4)$$

where: $\overline{YFO_i}$ = an unknown amount for non-rice farm production

If the above accounting concept of cost is used, the returns to the farm employing tractorization level i consist of:

The imputed wage for family labor (IW_i);
The imputed rent for owned land (IR_i);
The depreciation on capital (DK_i);
and a residual (X_i) representing the return to management.
This can be expressed mathematically as follows;

$$YFR_i = IW_i + IR_i + DK_i + X_i \qquad (5)$$

Alternatively, the factor share approach can be used. In this case, the total value of rice produced by a farm employing tractorization level i is divided among the various factors of production: land, labor, capital, current input and operational profit. Hence, this can be expressed as an identity:

$$PR.QR_i = R_i + W_i + K_i + C_i + O_i \qquad (6)$$

where: R_i = payment to land = payment to landlord
+ imputed rent for own land;

W_i = payment to labor = payment to hired labor
+ imputed cost of exchange labor
+ imputed cost of family labor;

K_i = payment to capital = payment to machine rental
+ imputed value for own machine;

C_i = payment to current inputs = payment for seeds
fertilizer
pesticide
oil and fuel
etc;

O_i = operator's profit = residual of value of
production minus costs;

i.e. $$O_i = (PR.QR_i) - R_i - W_i - K_i - C_i$$

Hence, we can calculate the shares of each of the factors of production:

$$\text{The share of land} = \frac{R_i}{(PR.QR_i)} \qquad (7a)$$

$$\text{The share of labor} = \frac{W_i}{(PR.QR_i)} \qquad (7b)$$

$$\text{The share of capital} = \frac{K_i}{(PR.QR_i)} \qquad (7c)$$

$$\text{The share of current input} = \frac{C_i}{(PR.QR_i)} \qquad (7d)$$

$$\text{The share of residual} = \frac{O_i}{(PR.QR_i)} \qquad (7e)$$

The share of land, labor and capital derived from the factor share approach can be compared with those derived from a production function, under the usual neo-classical assumption of perfect competition. If the Cobb-Douglas form of the production function is used, then the value of the estimated production elasticities gives the associated factor shares directly. The form of the income function used in this study corresponds closely to the Cobb-Douglas production function, and so we can compare the factor shares derived from the two methods.

Income Function Analysis

Income is derived from a number of sources. It is earned as a result of work both on and off farm together with any earning from the hiring out of capital or the renting out of land. Underlying the relationship between income and family resources, is the production function. The properties of the underlying production function will first be examined before estimating the income relationship.

Intuitively, the production function describes the transformation of a set of inputs into output. More specifically for any output level it represents the minimum quantity of input, in combination that is required to produce a given output. For a group of

homogenous economic production units, the production function can be specified as follows:

$$Q = Q(X_1 \ldots X_h)$$

where: Q is the observed output of each economic unit

and X_h ($h = 1,2 \ldots n$) represents the inputs into the production process

An important factor in the use of production functions is the choice of a specific algebraic form to describe the function. There are numerous alternative forms reported in the literature, and the choice is usually based on 'a priori' notions about the physical and economic 'laws' of production as well as the ease of interpretation and estimation.

One of the most commonly employed forms of production function is the Cobb-Douglas formulation whose popularity is largely attributed to its basic consistency with the established body of neo-classical economic theory.

Cobb Douglas Production Function

The Cobb Douglas production function takes the form:

$$Q = A.X_1^{\alpha_1}.X_2^{\alpha_2} \ldots X_h^{\alpha_h}$$

where: Q is the output of each unit,

A is an additive constant term,

X_h (h = 1, ... n), represents input levels,

and β_h (h = 1, ... n), represents coefficient of each input

In order to estimate this nonlinear function, it is transformed into natural logarithm and can be easily estimated in its log-linear form:

$$\log Q = \log A + \Sigma_{\beta} \log X_i$$

where: β_i (i = 1,... n) are the input elasticities with respect to the output Q

Functional Form for Income Function Analysis

Assuming that a similar relationship underlies the relationship between income and its sources the following non-linear function was estimated separately for off-farm and non-farm income.

$$Y_i = A_i X_{1i}^{\alpha_1} . X_{2i}^{\alpha_2} e^{\beta_1 D_1 + \beta_2 D_2} \qquad (8)$$

where: Yi = off-farm income by farm employing tractorization level i;

where: i = 1 = 2 wheel tractor users,

and i = 2 = 4 wheel tractor users,

X_{1j} = ratio of family labor to total labor used on the farm,

X_{2i} = man hours spent on off-farm activities,

D_i = a dummy, equal to 1, if the farmer hires out a machine,

and D_2 = a dummy, equal to 1, if the farmer rents out land.

$A, \alpha_1, \alpha_2, \beta_1, \beta_2$ are constant coefficents to be determined.

A similar function was used for non-farm income, with two variable inputs --- man-hours spent on non-farm activities and the ratio of man-hours of family labor to total labor;

$$Y_i = AP_i^{\alpha} Q_i^{\beta} \qquad (9)$$

where Y_i = non-farm income by farm employment tractorization level i;

where: i = 1 = 2-wheel tractor user,

i = 2 = 4-wheel tractor user,

P_i = ratio of man-hours of family labor to total labor,

and Q_i = man-hours spent on non-farm activities,

A, α, β are constant coefficients to be determined.

These log-linear income functions will be used in the study to investigate the relationship between off and non-farm income and

off- and non-farm labor, on farm family labor observation and the income potential from land and rent.

Because of data limitations it is not possible to calculate rental and hiring incomes and so a dummy variable was used in order to test whether the variables were significant factors or not.

The functions for off- and non-farm income were be estimated separately for different tractorization levels, i.e. 2 wheel tractor users and 4 wheel tractor users.

Factor Share Analysis

The concept of factor shares is fundamental to economics and is used in economic research to examine the structure of production, cost and returns, income distribution and the choice of technologies.

A factor share is defined as the ratio of costs of the factor inputs used in a production process to the total value of output, i.e., total revenue.

Consider a simple production process in which a firm utilizes four inputs, current inputs (C), capital (K), labor (W) and land (A), in order to produce a single output, (Q). Assuming the firm purchases inputs and sells the output in markets with constant unit prices, p, i, w, r and P respectively, the share of each factor of production, for the firm, is defined as follows: (7 p. 5).

$$\text{Factor share of current inputs} = \frac{pC}{PQ}$$

$$\text{Factor share of capital} = \frac{iK}{PQ}$$

$$\text{Factor share of labor} = \frac{wW}{PQ}$$

$$\text{Factor share of land} = \frac{rA}{PQ}$$

where C, K, L and A are the physical quantities of each of the factors used in the production process, and Q is the physical quantity of the output produced by using this combination of inputs. The numerators of the right hand side are the firm's factor costs and the common denominator is the total revenue (output price x output quantity). Factor costs are payments for inputs purchased in the market, sometimes called "factor payments".

Although the concept of factor shares often constitutes a starting point for this type of economic analysis, the definition of costs and returns used in the analysis are not standardized.

Leftwich (1966), indicated that the cost of production includes money outlays which the farm employs to purchase resources for use in production of its product.

Yang (1965), worked out the cost of production for a crop enterprise. He suggested the inclusion of the following items in the estimation of the total cost of production:

1. land, and land improvements,
2. human labor including hired, exchange andunpaid family labor,
3. animal labor, whether hired or owned,
4. machinery, equipment and tools, and
5. material such as seed, fertilizer, insecticide, etc.

Flinn, et. al. (1981) used the following cost concept with regard to enterprise budgeting of crops:

1. variable costs including non-labor inputs, household labor, hired labor and interest on cash costs.
2. fixed costs including depreciation of buildings, cost of maintaining canals, ditches and land taxes.

Paris (1982) indicated that in the factor share concept, the total output can be distributed among the following factors:

1. land,
2. fixed capital,
3. management,
4. labor, and
5. current inputs

Herdt (1978) divided the total value of output into payments made to each factor of production: labor, land, capital, current inputs and/or residual.

The proportion of total output when divided into the shares received by the various individuals involved in the production process, such as hired labor, landlord, current inputs and operator is called earners share. If in the long run perfect competition does not prevail, then there may be a residual which goes to the operator in an earner's share analysis.

In this study, the total income from rice production was equated to the sum of output going to each of the following production factors:

1. land,
2. labor,
3. capital,
4. current inputs and,
5. a residual.

It was also equated to the sum of payments to the earners in the production process such as:

1. current inputs,
2. hired labor,
3. landlord,
4. hired capital and,
5. farmer.

Income Distribution by Factors of Production

Figure 1 is a conceptualization of the distribution of income between two factors of production, say, labor (L) and capital (K). Assuming that competition ensures that factors are paid their marginal value product, the price ratio between factors will correspond to the slope of the isoquant at Ko and No labor (24 p. 79).

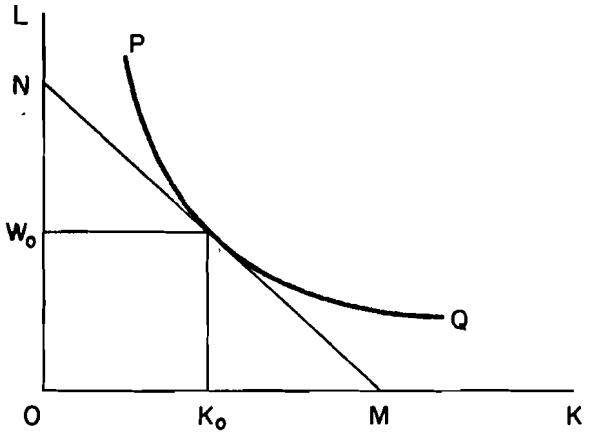

Figure 1. A Model of income distribution by factor share.

The existence of a price relationship between factors enables the measurement of total output (or income) in terms of the total quantity of either factor that output could buy, that is, total output could be represented by its value in terms of one of the factors. In Figure 1, OK_o is the value of capital's share in terms of capital and OM_o is total output in terms of capital. Similarly, OW_o is the

value of labor's share in terms of labor and ON is total output in terms of labor. The ratio of capital income to that of labor income is

$$\frac{OK_o}{MK_o} \text{ or } \frac{OW_o}{NW_o}.$$

When more than two factors are involved, the share of each factor can be computed as follows:

$$S_1 = \frac{r_i X_i}{\sum_{i=1}^{n} r_i X_i} \qquad (10)$$

where: r_i = price of factor i = 1,2, ... n

X_i = amount or level of factor;

An alternative measure for calculating factor shares is to compute the payments to the following:

a. land = the payment to the landlord plus an imputed cost for using the land

b. labor = the payment to hired labor plus an imputed value for family and exchange labor,

c. capital = the payment for machine rental plus an imputed value for owned tractor services

d. current inputs = the sum of expenses on fertilizers, insecticides, pesticides, seeds, oil and fuel for machine, and

e. a residual = value of output minus the sum of the payments to current inputs, land, labor and capital.

The share of any factor relative to the total can now be measured as:

$$S_k = \frac{k}{\text{total income}} \qquad (11)$$

Income Distribution by Earners Shares

Income distribution among earners is directly related to the distribution of ownership of the various factor of production. Typically each family earns income from the provision of labor services as well as the ownership of property of one kind or another. The relative importance of the different income sources may vary over the life cycle of the household. It follows therefore that income distribution among factors may bear little relationship to income distribution among earners. Constancy in the factor share distribution does not necessarily imply constancy in the earner share distribution.

It is possible that labor's factor share will not belong entirely to hired laborers since the operator may supply a part of the labor input himself and the land factor share may not go entirely to the landlord because some farmers own their land. For these reasons it is necessary to develop a separate measure of income by earner shares. The procedure employed involves determining the earner shares going to the following:

a. landlord = value of output given as rent on land minus production cost shouldered by landlord

b. hired labor = the sum of all hired labor payments for farm operations (excluding meals)

c. current inputs = the sum of expenses for fertilizers, insecticides, pesticides, herbicides, as well as oil and fuel

d. operator = total output less (a + b + c).

The total of the shares earned by the landlord, hired labor, current inputs and the operator exhausts the total income and is therefore one method of allocating income to different earner groups. Dividing each of the earner shares by the total income gives the relative share of each earner;

$$S_k = \frac{k}{\text{total income}} \qquad (12)$$

where: k = a,b,c, or d

Measures of income inequality

The literature on distribution theory focuses on three aspects:

a) the functional distribution of income;

b) factor shares or the share of total national income that each factor of production receives and,

c) the size distribution of income.

The first two issues relate to the distribution of income among factors of production. Most economic literature on income distribution has focused on these two topics. The present study, however, concerns the distribution of income among individuals, households, and other units. A brief review of alternative theories of the size distribution of income is presented in this section.

A widely used measure in the analysis of the size distribution of income is the Gini concentration ratio which determines the degree of income inequality by measuring the accumulated change of income relative to the farm household distribution. This coefficient can be discussed geometrically using the Lorenz Curve or can be handled numerically.

A Lorenz curve is defined as the relationship between the cumulative proportion of income units and the cumulative proportion of income received by these units. The curve has been used principally as a graphical device to represent the size distribution of income as illustrated below: (2 p. 46).

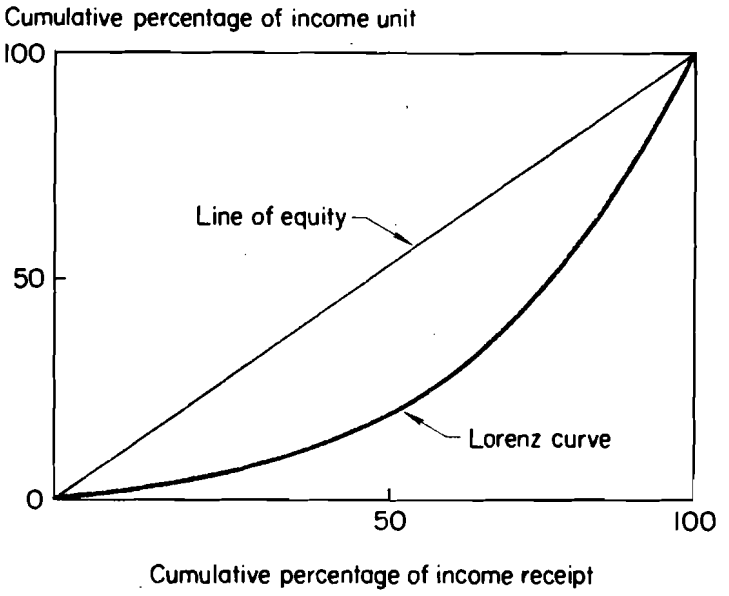

Figure 2. The Lorenz curve.

In Figure 2 the line of equality is the diagonal through the original of a unit square. If all income was equally distributed so that each 10 percent of the population received 10 percent of the total income then the Lorenz curve lies along the diagonal "line of income equality", this is the special case of 'perfect equality' of income distribution.

If the botton 10% receive less than 10% of total income then the Lorenz curve lies off and below the diagonal. Hence the closeness of the Lorenz curve to the diagonal, provides a method of assessing the extent of concentration in income. (In the extreme case where all the income is received by one person, the Lorenz curve follows the horizontal axis until it reaches the last person and then rises steeply, so that it has an $\_\rfloor$ shape).

The Lorenz curve enables us to define the Gini concentration ratio as:

$$\text{Gini ratio} = \frac{\text{Area between Lorenz curve and diagonal}}{\text{Total area under diagonal}}$$

This can be expressed algebraically in terms of a recursive relationship from which it is easy to compute the Gini coefficient, as follows (3 p. 24).

$$G = 1 - \sum_{i=1}^{k} (F_{i+1} - F_i)(Y_i + Y_{i+1}) \qquad (13)$$

where: G = Gini concentration ratio

F_i = cumulative percentage of household numbers for the income class i;

F_{i+1} = cumulative percentage of household numbers for the income class i + 1;

Y_i = cumulative percentage of household income for the income class i;

Y_{i+1} = cumulative percentage of household income for the income class i + 1;

i = income class;

and k = total number of income classes

In this study, the Gini coefficient calculated from the sample villages will be compared with that of the region and with other comparable coefficients to determine whether tractor use has any effect on income distribution.

CHAPTER 3

DESCRIPTION OF THE STUDY AREA

Characteristics of the Study Area

Size and Location

Suphanburi province is located in the central plains of Thailand. The province covers about 5,350,000 square kilometers and is situated about 165 kilometers from Bangkok. The general topography in the west of the province consists of numerous mountain ranges while in the south and east there are lowland areas which are suitable for rice cropping. The north is largely non-arable or mountainous.

Government and Population

Suphanburi province is divided into 8 Amphoes (cities), 92 Tambols (towns), 650 villages and 98,300 households. The population is about 663,400, consisting of 333,400 men and 330,100 women (Figure 3).

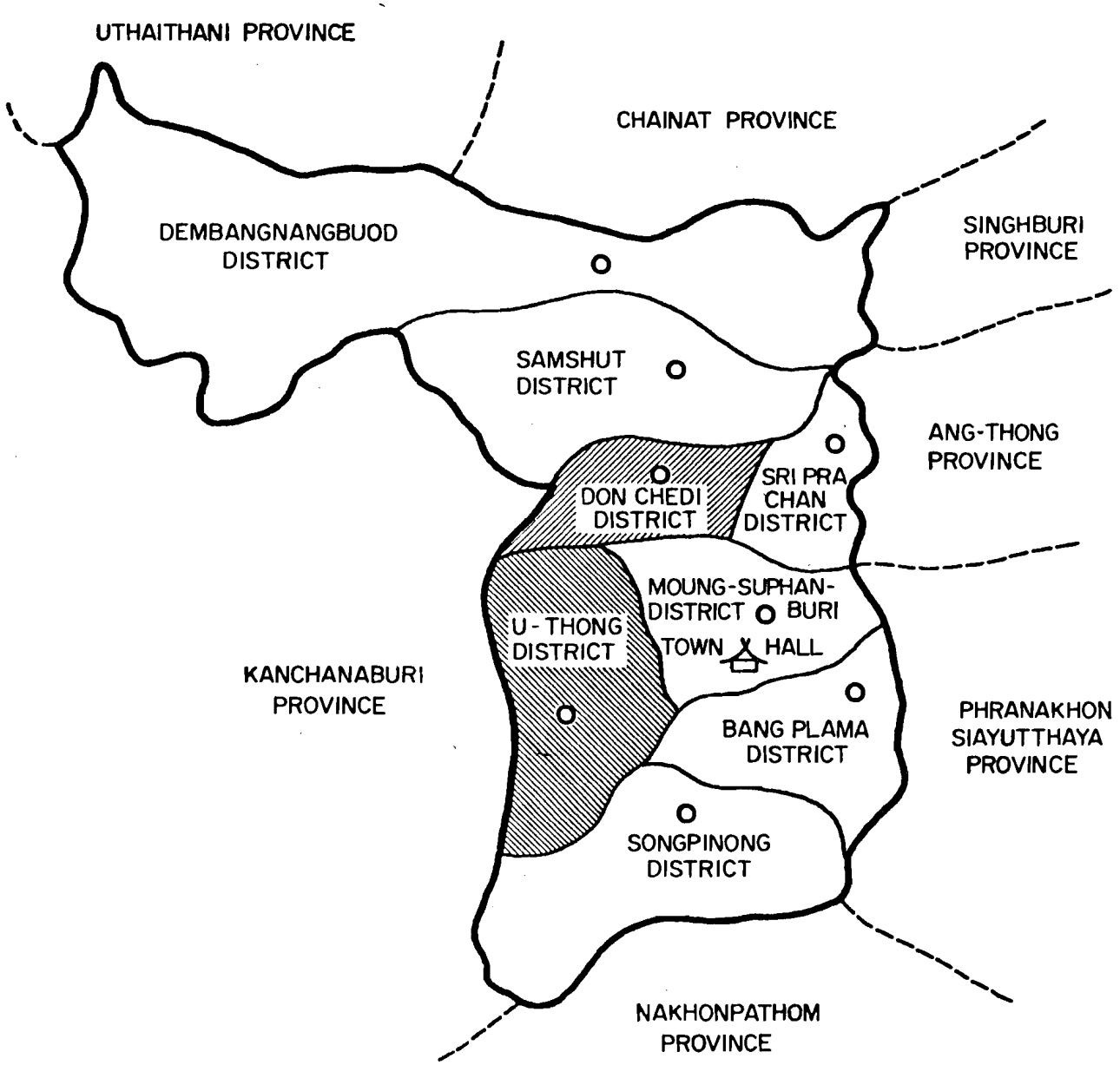

Figure 3. Map of Suphanburi Province, Thailand.

Natural Resources and Occupations

The major resources of this province are lumber such as Teak, Yang, Teng-rung. The major crop is rice although plantation crops are also grown of which maize, sorghum, mungbean, soy beans and corn are the most important. Farm income is mainly from rice, maize, sorghum and soybeans.

Climate

Suphanburi Province has a hot climate with 3 seasons. The summer season runs from March to May, the rainy season from June to October and the winter season from November to February. The temperature during the last 5 years (1977-1982) ranged between 24 °C and 30 °C while rainfall over last 5 years was 850, 298, 503, 285 and 616 millimeters respectively (Table 2). Average rainfall is about 550 millimeters with a monthly maximum of about 135 millimeters in September and monthly minimum of 3 millimeters in March.

The Distribution of Representative Farms

The background of individual farmers provided numerous insights into the decision-making processes in production and also the acceptance of modern technology.

Table 2. Average rainfall and temperature at weather station, 1977-1982, Suphanburi, Thailand.

Month	1978		1979		1980		1981		1982		Average	
	T (°C)	R (MM)	T (°C)	R (MM)	T (°C)	R (MM)	T (°C)	R (MM)	T (°C)	R (MM)	T (°C)	R (MM)
01	26.60	19.43	27.60	-	25.60	-	24.30	-	24.41	-	25.72	19.43
02	27.40	40.73	28.80	1.20	17.80	1.92	27.15	5.26	28.30	-	27.89	9.82
03	30.40	0.01	30.60	-	30.30	0.18	29.96	10.61	219.76	8.50	30.20	3.86
04	30.40	76.32	30.90	5.60	31.70	7.02	30.72	15.37	29.76	92.23	30.70	39.31
05	29.60	154.24	31.20	33.58	31.50	31.98	29.88	36.32	30.46	68.75	30.33	14.97
06	29.10	56.55	29.70	59.58	29.20	99.47	28.70	11.02	29.18	77.23	29.18	60.77
07	28.90	151.68	29.80	29.68	29.20	35.29	28.94	49.04	28.90	65.93	29.15	66.32
08	28.60	33.08	29.10	33.42	29.30	55.92	28.26	23.34	28.32	59.03	28.72	40.96
09	29.20	202.32	28.80	122.82	28.60	92.40	28.80	62.10	28.24	143.13	28.73	134.55
10	27.70	69.25	27.70	12.06	27.30	143.12	28.26	27.79	28.76	60.73	22.80	63.39
11	24.90	-	24.60	-	25.30	-	23.10	-	23.50	29.20	24.78	29.10
12	24.90	-	24.60	-	25.30	-	23.10	-	23.50	29.20	24.78	29.10
Total	339.20	855.76	319.33	297.94	310.80	502.60	333.85	285.79	337.08	616.28	339.36	550.38

Source: Suphanburi Weather Station.

Note: T = Temperature
R = Rainfall

Age and Educational Levels of Farmer

The proportion of the population in each labor age group is important in any country. The ratio of the number of people who are of laboring age divided by the number of children and older people is called the dependency ratio.

In general, the population can be divided into 3 age levels:

children - age between 0 - 14 years

workers - age between 15 - 59 years

old people - age above 60 years

Table 3 shows that 66% of the population of Suphanburi are farmers who are of working age, while 29% and 5% are respectively children and old people. The average number of people who are of working age per household is about 5.3 giving a low dependency ratio of 2.0. This means that farmers will need to hire laborers from other farms for production activities such as transplanting and threshing.

Age of Household Head

The household head makes or influences all the major decisions concerning farm operation. In the sample, most of the household heads were between 35 and 44 years old. A few, 14%, were younger than 35 and less than 2% were younger than 24 years old. On the other hand, only

Table 3. Distribution of age of household members by tractor ownership, 1981/82, Suphanburi, Thailand.

Age	Type of Tractor Ownership																					
	4T (O)					2T (O)					4T (O)					2T (O)					TOTAL	
	Child	Woman	Man	Total	%	Child	Woman	Man	Total	%	Child	Woman	Man	Total	%	Child	Woman	Man	Total	%	Grand	%
0-14	56	7	14	77	26.92	116	15	23	134	29.00	27	4	7	38	31.67	45	11	13	69	28.87	338	18.74
15-39	-	83	105	188	65.73	-	169	179	348	65.34	-	32	42	74	61.66	-	90	79	169	70.71	779	66.24
Over 60	-	18	3	21	7.34	-	20	9	29	3.46	-	8	-	8	6.67	-	1	-	1	0.42	59	3.01
TOTAL	56	108	122	286	100.00	116	204	211	531	100.00	27	44	49	120	100.00	45	102	92	239	100.00	1176	100.00
Ave. no. of family				5.6					5.6					4.4					4.7		5.3	
Labor force per household				3.7					3.7					2.7					3.3		3.5	
Dependency ratio				1.9					1.9					1.6					2.4		2.0	

Source: Consequences of Small Rice Farm Mechanization (CSRFM) Data.

11% were older than 65 years and less than 2% older than 75 years (Table 4).

Level of education

Table 5 shows that 63% of the farmers had finished their studies at the Prathom 4 level, while 16% had no formal schooling and only 3% had studied past Prathom 4 level. Nevertheless, most of the farmers have had long experience in rice production. Also, there are frequent field experiments carried out by the Suphanburi government, extending new technologies to promote yield increasing practices. Farmers are interested in learning more and quickly accept new technologies and ideas.

Financial and Asset Position

Financial position

Some farmers borrowed money from other farmers for rice production in Suphanburi province. Cash for expenses is usually only available after the sale of paddy following the harvesting. Hence, farmers receive their income from rice production only once or twice each year. Loans can be divided into two groups -- in cash and in kind. From the 223 farm households it was found that 2 wheel

Table 4. Age profile of household heads by type of tractor ownership, 1981/82, Suphanburi, Thailand.

Age groups (years)	Percent of household heads in such age group by type of tractor ownership				
	4T (O)	2T (O)	4T (O)	2T (H)	Total
Less than 24	-	-	3.7	-	0.4
25 - 34	11.8	12.8	18.5	17.6	14.3
35 - 44	29.4	28.7	25.9	27.4	28.3
45 - 54	29.4	29.8	11.1	25.5	26.5
55 - 64	19.6	19.1	18.5	17.7	18.8
65 - 74	9.8	8.5	22.2	11.8	11.2
Over 75	-	1.1	-	-	0.4
Number of respondents	51	94	27	51	22

Source: CSRFM data.

Table 5. Educational background of household heads by type of tractor ownership, 1981/82, Suphanburi, Thailand.

Educational background	Type of tractor ownership				Total (%)
	4T (O) (%)	2T (O) (%)	4T (H) (%)	2T (H) (%)	
No schooling	13.37	13.83	22.22	19.61	16.14
Can read or write	5.88	5.32	-	1.96	4.00
1st grade (Prathom 1)	1.96	1.06	-	3.92	1.79
2nd grade (Prathom 2)	-	2.13	-	9.80	3.14
3rd grade (Prathom 3)	13.73	4.26	11.11	9.80	4.04
4th grade (Prathom 4)	60.71	72.34	62.96	45.10	63.23
More than 4th grade	-	1.06	3.70	9.80	3.14
Total number	31	94	27	51	223

Source: CSRFM data.

tractor hiring farms had less debt (76%) outstanding than the other farm groups. Minor debtors were 2T(O), 4T(H) and 4T(O) for 78% by each other of debt farm. The data show that the tractor-owning farms mostly borrowed cash but the tractor-hiring farm mostly borrowed in kind (Table 6).

The purpose of borrowing

The major reason for borrowing cash for all groups was for production needs with each group differing only in the amount of money required for the production process. Farmers also borrowed for seasonal farm expenses (59%), for family expenses (21%), for long-term investments (9%), for consumption (7%), for machine purchase (1%), and for investment in other industries (1%) (Table 7). For all farm types, a personal note was mainly used as loan security (in 79% of cases), but also land (18%), other assets (2%), crops (1%) and buildings (0.5%) were given as collateral (Table 8).

Sources of credit were divided into 3 main types

(1) non-institutional sources such as landlords, friends/relatives, middlement and input dealers;

(2) institutional sources such as cooperatives, private banks, farmer banks and government schemes operating through banks and

(3) other sources.

Table 6. Farmer indebtedness and the form of debt by type of tractor ownership, 1981/82, Suphanburi, Thailand.

Type pf tractor ownership	No. of farmers	Percent [b]	Form of debt				Percent
			Cash	in kind	in cash and in kind	Total	
4T(0)	51	23.72	6 (15.00)	23 (57.5)	11 (27.5)	40 (100)	73.43
2T(0)	94	42.19	10 (13.69)	33 (47.93)	28 (38.36)	73 (100)	77.66
4T(H)	27	12.14	12 (57.14)	3 (14.29)	6 (28.57)	21 (100)	77.78
2T(H)	51	22.54	22 (56.41)	12 (30.77)	5 (12.82)	39 (100)	76.47

Remarks: Number in parentheses are percent of households by type of debt.

[a] Indebt farm as percent of non-debt farm.

[b] Percent of indebt farm by group of farmer employed.

Source: CSRFM data.

Table 7. Use of credit and loanable funds by survey farmers, 1981/82, wet season, Suphanburi, Thailand.

Type of tractor ownership	Long term investment in agriculture	Investment in other industries	Seasonal farm expense	Consumption	Family expense	Machine purchase	Other	Total	Percent
4T(O)	9.86	2.82	59.15	5.63	19.72	2.82	-	100	-
2T(O)	6.98	-	67.24	6.98	20.93	2.33	1.55	100	-
4T(H)	12.82	-	46.15	15.38	25.64	-	-	100	-
2T(H)	7.27	-	63.64	3.64	18.18	-	3.64	100	-
Percent (average)	8.5	1.36	59.18	7.14	20.75	1.7	1.4	10	-

Source: CSRFM data.

Table 8. Type of collateral used to guarantee loans by type of tractor ownership, 1981/82 Suphanburi, Thailand.

Type of tractor ownership	Type of security						
	Personal note	Land	Crops	Building	Other	Total	Percent[a]
4T(0)	76.47 (39)	23.53 (12)	- (-)	- (-)	- (-)	100 51	23.72
2T(0)	76.09 (70)	21.74 (20)	- (-)	1.09 (1)	1.09 (1)	100 (92)	42.79
4T(H)	81.48 (22)	7.41 (2)	3.70 (1)	- (-)	7.41 (2)	100 (27)	12.56
2T(H)	84.44 (38)	8.89 (4)	4.44 (2)	- (-)	2.22 (1)	100 (45)	20.93
Total	78.60 (169)	17.67 (38)	1.40 (3)	0.47 (1)	1.86 (4)	100 (215)	100

Remarks: Numbers in parenthesis represent numbers in each class by collateral grouping of farmers employed.

[a] Percent of total employed farmers in each group to total in all groups.

Source: CSRFM data.

Table 9 shows that the main types of other sources used by the farmers are from the farmer bank (44%), the cooperative (18%), the middleman (14%) and friends/relatives (12%).

Wealth position

Total assets consisted of farm and non-farm assets. Farm assets are composed of fixed capital such as land, productive and draft animals, buildings, farm implements, farm tractors and other machines which are used for production. Non-farm assets included within the farm household's operation, such as buildings and lands were not used in the production process. However, these are not included in the liquid assets of the farm.

Table 10 shows that average total assets per farm were about 924,000 baht. This amount minus the average debt per farm of (29,500 baht) gives a remaining net worth of around 894,500 baht per farm. Assets classified by source into farm and non-farm assets are presented in Tables 11-12 by type of tractor ownership. Land is the main asset for most farms. Tables 11-12 show that total assets as well as both farm and non-farm net assets are closely related to tractor ownership. The value of assets was much higher on the tractor-owning farms. The value of net assets was 380,000 and 285,000 baht for 4-wheel and 2-wheel tractor owners while for 4-wheel and 2-wheel tractor hirers net assets were only 135,000 and 96,000 baht respectively (Table 10).

Table 9. Source of credit, by type of tractor ownership, 1981/82, Suphanburi, Thailand

Source	Type of tractor ownership						Average interest (%)
	4T(O)	2T(O)	4T(H)	2T(H)	Total	Percent	
Non-Institutional							
Landlord	14.69	28.57	42.86	14.29	100	3.24	25.33
	(1)	(2)	(3)	(1)	(7)		
Friend/relative	26.09	56.62	8.70	21.74	100	12.34	26.52
	(6)	(13)	(2)	(5)	(23)		
Middlemen	16.67	23.33	23.33	36.67	100	13.89	25.60
	(3)	(7)	(7)	(11)	(30)		
Input dealer	10.00	40.00	30.00	20.00	100	4.63	23.14
	(4)	(4)	(3)	(2)	(10)		
Institutional							
Cooperative	12.82	46.15	10.26	30.77	100	18.06	15.67
	(5)	(18)	(4)	(12)	(39)		
Private bank	-	100.00	-	-	100	2.31	15.88
		(5)			(5)		
Farmers bank	34.04	44.68	7.45	13.38	100	43.52	13.55
	(32)	(42)	(7)	(13)	(94)		
Government scheme	100	-	-	-	100	10.46	16.80
through banks	(1)	(2)	(1)	(1)	(4)		
Other	-	50.00	25.00	23.00	100	1.85	24.39
	-	(2)	(1)	(1)	(4)		
Total	23.61	20.83	12.49	20.83	100		
	(51)	(93)	(27)	(45)	(100)		

Remarks: The numbers in brackets represent the type of debt classified by group of farmers employed.

[a] The interest rate is the percentage of source of credit.

Source: CSRFM data.

Table 10. Average farm assets classified by type of tractor ownership, 1981/82, Suphanburi, Thailand.

Type of tractor ownership	Asset			Debt [a]	Net Asset
	Farm	Non-farm	Total		
4T(O)	318,071	72,527	390,598	11,527	379,071
2T(O)	226,849	62,932	289,782	5,289	284,492
4T(H)	101,197	40,330	141,448	6,481	134,966
2T(H)	65,651	36,493	102,144	6,174	95,970
Total	711,689	212,284	923,976	29,474	894,500

[a] Level of debt.

Source: CSRFM data.

Table 11. Average farm assets by type of tractor ownership, 1981/82, Suphanburi, Thailand.

	Type of tractor ownership				Total average
	4T(O)	2T(O)	4T(H)	2T(H)	
Land	272,931	194,549	94,518	56,797	168,605
Productive animal	2,347	2,142	2,949	1,048	2,032
Draft animal	1,549	3,842	120	3,752	2,829
Building	4,892	3,603	1,621	818	3,017
Farm implement	5,492	4,962	766	1,141	3,696
Farm tractor	24,682	15,327	-	-	18,617
Other machine	6,176	2,422	1,140	2,097	3,041
Total	318,071	266,849	101,197	65,651	195,328

Source: CSRFM data.

Table 12. Average non-farm assets by type of tractor ownership, by type of tractor ownership, 1981/82, Suphanburi, Thailand.

Type of non-farm assets	Type of tractor ownership				Total average
	4T(O)	2T(O)	4T(H)	2T(H)	
Building	19,427	24,809	15,061	14,272	19,923
Land	25,814	21,636	10,982	13,968	19,485
Vehicles	19,932	10,487	4,634	4,680	10,590
Consumer durable	7,354	6,006	9,654	3,524	6,784
Total	72,527	62,938	40,339	36,444	56,782

Source: CSRFM data.

Farm Resources

Before discussing resource availability, the principal features of the prevalent farming system are described.

There are two major types of paddy land found in the study area. Since most of this area of the Central Plain has clay soils, rice is a major crop. Usually for the wet season, rice is planted in May or June and harvested in November to January while for the dry season planting is in January or February and harvesting from May to June.

Land preparation is usually accomplished with small tractors. Some farmers own their own tractors while others custom hire in machines. Planting and seeding are mostly done by human labor, using hoes. Harvesting is done entirely by human labor while threshing is usually done with a mechanical thresher.

Paddy land consists of rainfed and irrigated lowlands. Irrigated land is defined as land which receives supplementary water during the planting season, either by direct application from an irrigation canal system or by using a water pump to lift the water from the river or canal. A large proportion of the rice area in this region is grown in this manner.

Both broadcasting and transplanting methods are used for crop establishment. New and old varieties are grown but farmers prefer new

varieties and RD7 and RD11 were especially popular at the time of the survey. Chemical fertilizer use is common in the area. Previously, land preparation and threshing were done by draft animals and human labor. Today, the use of tractors for land preparation is normal and widespread.

The most limiting farm resource is capital. The availability of labor is usually not a major restriction. However, there are certain periods during the crop production cycle when family labor may not be sufficient to complete necessary work on time. During these perods, farmers may hire in labor either from their neighbors or from other areas.

Land

Tables 13 - 15 show farm land and cropped areas for each of the farm types. The number of farms, average land holdings, paddy areas and farm sizes are shown in Table 13. There are major differences between the number of farms, land holdings and farm sizes in both the wet and dry seasons. In general, the paddy area in the wet season was higher than in the dry season but it appears that the owned tractor farms had a larger paddy area during the wet season but less, during the dry season, than hired tractor farms. The percentage of paddy area to farm holdings showed that 2-wheel hired tractor users had more land in rice than the other groups (97% compared with 89%, 86% and

Table 13. Number of farms, land holding, paddy area and farm size per household by type of tractor ownership, 1981/82, Suphanburi, Thailand.

Type of tractor ownership	Number of farms		Land holding (has)		Paddy area (has)		Farm size (has)		Ratio of paddy area total farm holdings	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
4T(0)	51 (22.87)	46 (21.30)	238.16 (32.77)	249.29 (31.05)	233.28 (32.18)	197.04 (29.79)	5.06	5.42	0.86	0.79
2T(0)	94 (42.15)	92 (42.59)	378.52 (41.05)	383.14 (47.72)	335.08 (48.29)	316.64 (47.87)	4.03	4.16	0.89	0.83
4T(H)	27 (12.11)	27 (12.30)	66.04 (8.38)	74.19 (9.24)	53.00 (7.64)	58.20 (8.80)	2.45	2.75	0.80	0.78
2T(H)	51 (22.87)	51 (23.61)	85.07 (10.79)	96.26 (11.99)	82.59 (11.90)	89.01 (13.55)	1.67	1.89	0.97	0.93
Total	223	216	787.79	802.88	693.95	661.49	13.21	14.22	0.88	0.82

Note: Figures in parentheses represent percent of total sample.

Source: CSRFM data.

Table 14. The distribution of households by farm size, 1981/82, Suphanburi, Thailand.

Farm size (ha)	Wet season		Dry season	
	Number of farm	Percent	Number of farm	Percent
0.00 - 0.99	23	10	24	11
1.00 - 1.99	42	19	48	22
2.00 - 2.99	33	15	38	18
3.00 - 3.99	45	21	43	20
4.00 - 4.99	33	15	35	16
5.00 - 5.99	20	9	14	6
6.00 - 6.99	10	4	7	3
7.00 - 7.99	5	2	1	1
8.00 - 8.99	5	2	5	2
9.00 - 9.99	4	2	1	1
10.00 - 10.10	3	1	-	-
Total	233	100	216	100

Source: CSRFM data.

80% for 2-wheel tractor owners, 4-wheel tractor owners and 4-wheel tractor hirers.

The distribution of land is shown in Table 14. Most farms occupy between 3.0 and 4.0 hectares in the wet season and between 1.0 and 2.0 hectares in the dry season. There were no extreme differences between the mean farm sizes.

Land tenure categories comprised owners, share tenants and leaseholders (Table 15). Share-tenants are defined as those with land which is owned and rented. The 2-wheel tractor-owning farms had the largest land area in both the wet and dry seasons. Large differences exist between share tenants and leaseholders in both seasons. Tractor owning farms also had larger holdings than hired tractor farms (Table 15). When comparing paddy area per farm, tractor owning farms also had significantly larger areas planted to rice than tractor-hired farms. Farm size also influences the level of input use. The quantity of output per hectare was highest on the tractor-owning farms. Tractor-owning farms had larger farm sizes when compared with tractor hiring farms. The data shows that even though the wet season is the major cropping season, the quantity of output in the dry season was higher. The price of paddy in the wet season was however higher than in the dry season and so cash farm incomes were greater in the wet season.

Table 15. Land tenure classification by type of tractor ownership, 1981/82, Suphanburi, Thailand.

Type of tractor ownership	Land tenure classification						Total	
	Owner operator		Share tenant		Leaseholder		Wet	Dry
	Wet	Dry	Wet	Dry	Wet	Dry		
4T(0)	28.2	26.7	23.8	25.0	6.5	7.6	22.9	21.3
2T(0)	39.3	43.2	59.5	55.8	34.8	28.3	42.2	42.6
4T(H)	9.7	9.0	7.1	9.6	23.9	22.6	12.1	12.5
2T(H)	23.0	21.6	9.5	9.6	34.3	41.5	22.1	23.6
Total number	135	111	42	52	46	53	223	216

Source: CSRFM data.

Table 16. Paddy area, output, value of output and farm price by type of tractor ownership, 1981/82, Suphanburi, Thailand.

Type of tractor ownership	Paddy area (ha/farm)		Quantity of output (kgs)				Farm price (baht/kgs)	
			Wet season		Dry season		Wet	Dry
	Wet	Dry	per farm	per ha.	per farm	per ha		
4T(O)	4.38	4.28	15,422	3,522	16,769	3,914	3.30	2.51
2T(O)	3.56	3.44	13,443	3,771	12,203	3,545	3.26	2.47
4T(H)	1.96	2.76	6,737	3,432	9,926	3,605	3.31	2.31
2T(H)	1.62	1.76	5,111	3,156	5,941	3,381	3.24	2.48

Source: CSRFM data.

Labor

Labor resources are divided into three categories:

1) family labor,

2) exchange labor, and

3) hired labor.

The number of full-time equivalent farm workers for each farm is estimated from the average number of persons of 14 to 65 years of age, who actually work on the farm and excluded persons who either cannot work or only do household chores. The estimates of workers per farm for each farm group are given in Figures 4 to 7. Man-days are calculated by dividing total man-hours by the number of working hours in a day which weas assumed to be 8 hours. Labor use for farm activities was divided into three types:

1) labor employed with a tractor and used for land preparation (LWTL),
2) labor employed with other machines irrespective of activity (LWMA), and
3) labor employed without a machine irrespective of activity (LTMA).

Farm activities included land preparation/planting, care/cultivating, irrigating, harvesting/processing, transplanting, milling and marketing.

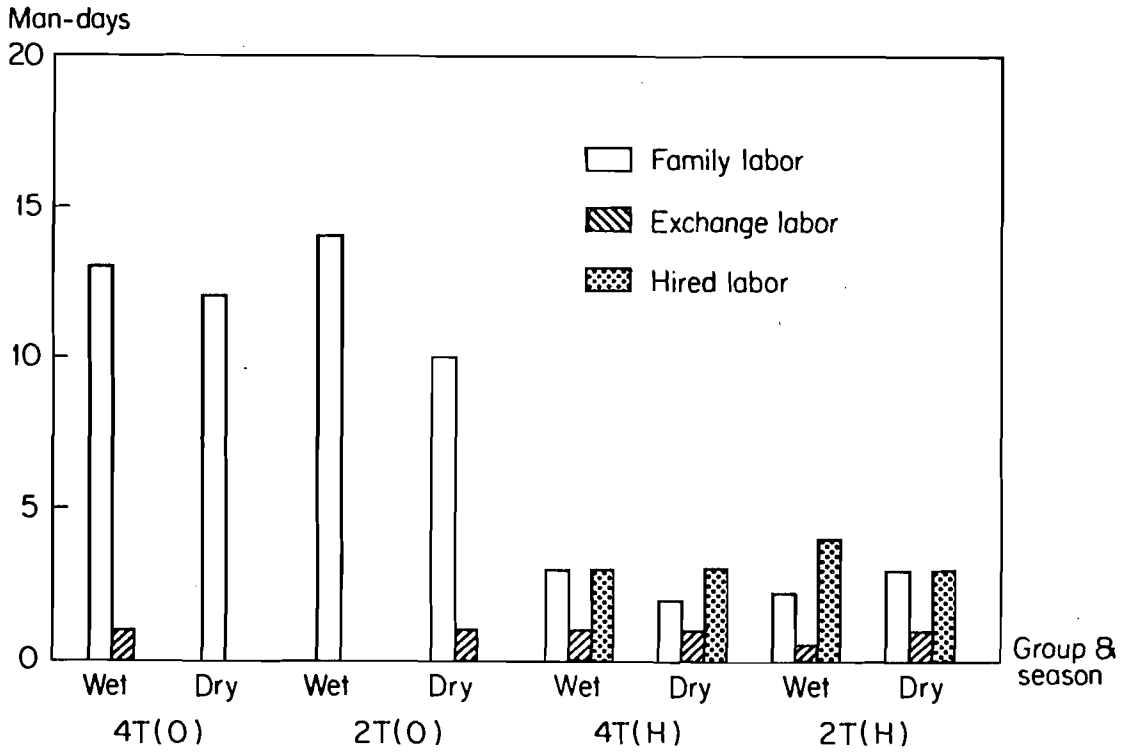

Figure 4. Labor use with tractor use for land preparation, 1981/82, Suphanburi, Thailand.

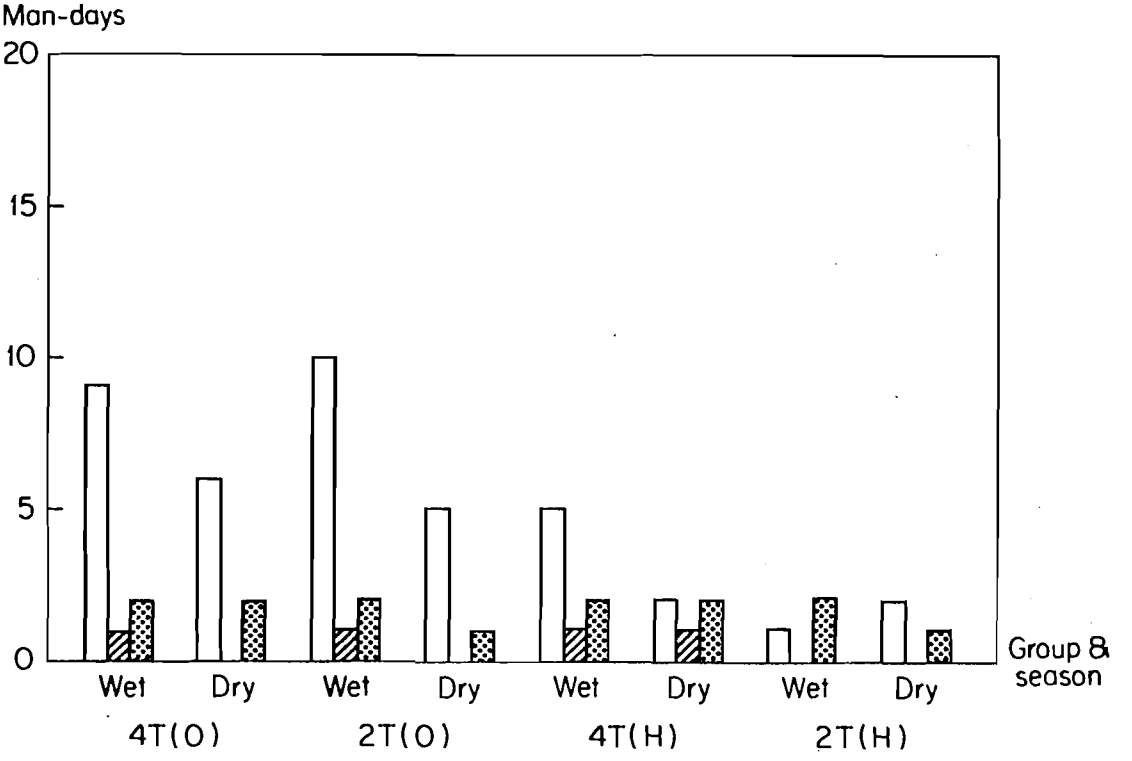

Figure 5. Labor use with machine for all field operations, 1981/82, Suphanburi, Thailand.

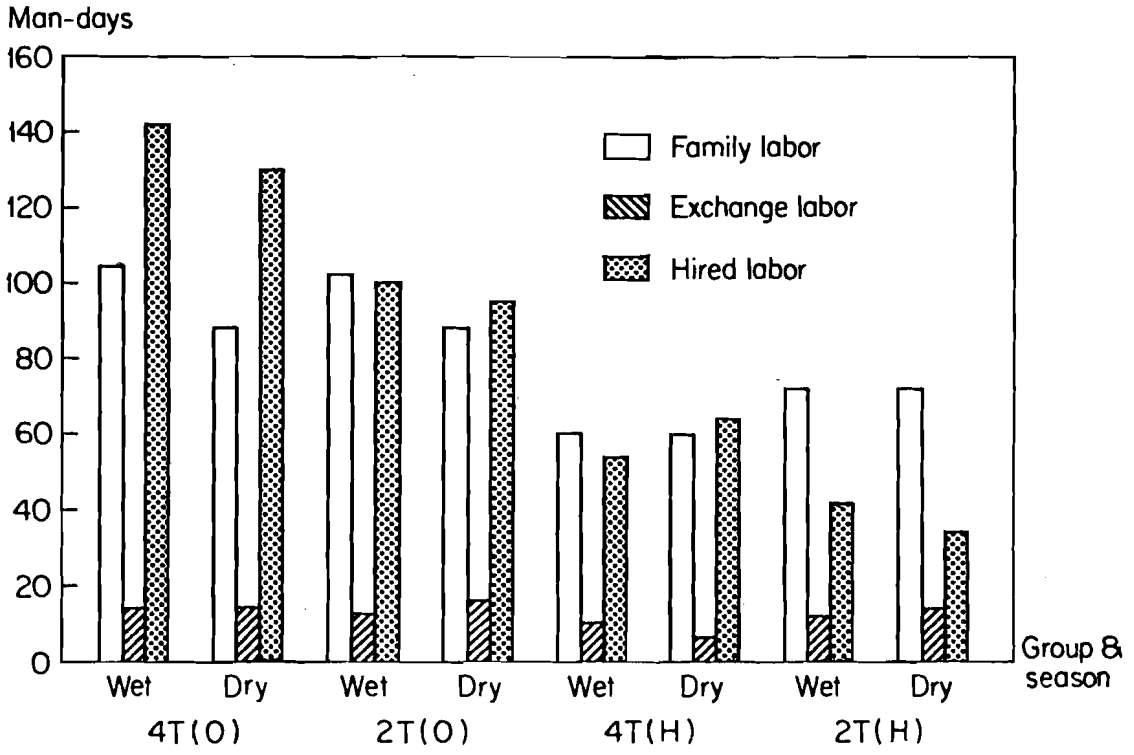

Figure 6. Labor use for non-machine field operation, 1981/82, Suphanburi, Thailand.

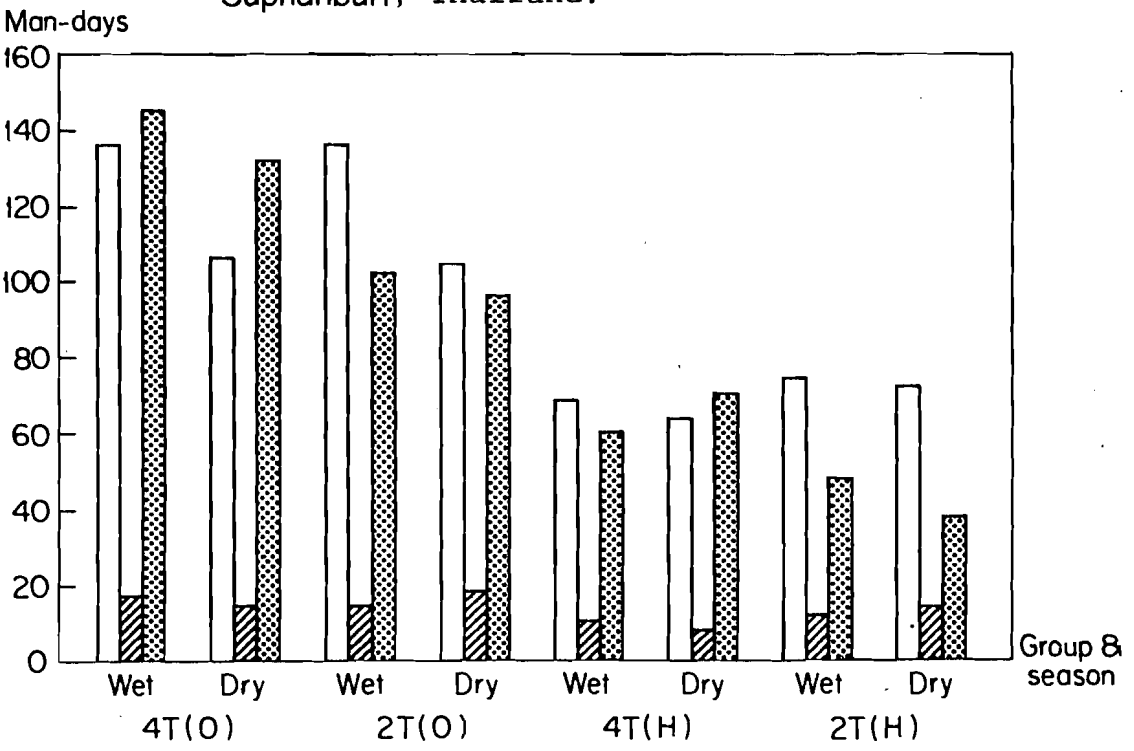

Figure 7. Average labor use for all farms, 1981/82, Suphanburi, Thailand.

The survey results indicated that overall farms used more family labor than hired labor.

In addition to the family supply of labor, farmers hire in labor for certain activities. The limits on hiring generally increase with farm size, although the association is not perfect. It appears that tractor owning farms both in the 4-wheel and 2-wheel tractor classes have a larger demand for hired labor than tractor-hiring farms both in the wet and dry seasons.

Comparing seasons, it was found that farms use more labor in the wet season than in the dry season but that there was no difference between farm groups with respect to the type of labor employed.

The survey indicated that besides working on their farms, farmers and their families engaged in off-farm employment. This employment was limited to seasonal jobs, and most of the jobs were on other farms. The survey showed that small farms usually supply more labor for off-farm employment than the larger farms. This corresponds to the hirer level of hired labor employment on the larger farms.

Mechanization

Suphanburi Province is a highly concentrated area of rice production, being well irrigated and extensive in the adoption of modern agricultural technology. Machinery was brought into this area

about 15 years ago (16 p. 37). Small tractors played an important role in agriculture because of their versatility and were used for land preparation, water pumping and, less commonly, for threshing. Other types of machines are also common in this area. Most of them are manufactured by indigenous, small-scale firms.

A wide range of machines are available to farmers: 1)two-wheel tractors; 2) small four-wheel tractors; 3) mechanical sprayers; 4) rice threshers; 5) water pumps; 6) small trucks; and 7) other farm machines (Table 17). Of these products, water pumps, two-wheel tractors, small four-wheel tractors and mechanical sprayers are the most popular.

The main reasons given by farmers for the adoption of farm machinery were as follows: time saving, timely planting and reduced drudgery (Table 18). On farms hiring tractors for land preparation the reasons given varied with the type of tractor. In the case of 4-wheel tractor hiring farms, the main reason given was timely planting, but for two-wheel tractor hiring farms the main reason was reduced work. Four-wheel tractor hiring farms are larger than two-wheel hiring tractor farms and are therefore more concerned about timely crop establishment.

The survey shows that family members were the dominant influence in the decision making process for all groups (Table 19). Although the family members contributed to the decision making, the final decision rested in the hands of the household head.

Table 17. Number of machines owned by farmers by tractor ownership, 1981/82, Suphanburi, Thailand.

Type of machine	Type of tractor ownership				
	4T(O)	2T(O)	4T(H)	2T(H)	Total
Two-wheel tractor	-	95	-	-	95
Small four-wheel tractor	51	-	-	-	51
Engine	-	-	-	2	2
Mechanical sprayer	21	27	2	4	34
Rice thresher	7	3	-	1	11
Water pump	29	46	11	12	98
Small truck	-	1	-	1	2
Other farm machines	2	3	-	-	5
Total	110	175	13	20	318
Total observations	51	94	27	51	223

Source: CSRFM data.

Table 18. Farmers reasons for machine use by type of tractor ownership, 1981/82, Suphanburi, Thailand.

Reason	Type of tractor ownership				
	4T(0)	2T(0)	4T(H)	2T(H)	Total
Lower cost	less than 1	2	14	2	2
Plant crop on time	17	25	29	15	21
Labor and animals unavailable	2	6	5	4	4
Better ploughing	10	16	-	-	12
Reduce drudgery, easy to operate	2	16	19	26	18
Can be used for transportation	4	1	5	6	3
Saves time	29	22	10	15	24
Hire out	1	2	-	13	3
Help expand cultivated area	-	1	5	6	1
Reduces weeds	4	4	5	11	4
Increase output	7	4	10	2	6
Permits reclaiming land	4	-	-	-	1

Source: CSRFM data.

Table 19. Source of suggestion to acquire a farm machine, by type of tractor ownership, 1981/82, Suphanburi, Thailand.

Group of people	Type of tractor ownership				Total
	4T(O)	2T(O)	4T(H)	2T(H)	
Family member	48	45	73	70	48
Extension officer	1	-	-	-	-
Machine seller	2	1	-	-	1
Farmer's group	-	1	-	-	1
Village headman	1	1	-	5	1
Neighbor	14	7	-	5	9
Friend (farmer)	34	45	24	20	40
Total	100	100	100	100	100

Source: CSRFM data.

The data in Table 20 shows that tractor use was not only limited to land preparation but extended to other activities in rice cultivation although it appears that most farm machine utilization is for on-farm work. Less than 10 percent of machine running time was for custom services.

The major application of tractors in the study area was for land preparation for wetland rice cultivation. Table 21 shows the average working time for all machines on a per farm (83 hours) and per hectare basis (27 hours). Common work rates for tractor owning farms were higher than for tractor-hiring farms in both the wet and dry seasons. There was little difference in terms of tractor hours utilized per hectare between the groups. Tractor owning farms spent more time in land preparation than did tractor hiring farms.

Comparing seasons, tractor use per farm and per hectare was higher in the wet season than in the dry season. This is because land preparation is more difficult at this time of year, following the dry season. When not engaged in tillage, tractors are engaged in the transportation of the crop from inaccessible areas as well as other miscellaneous purposes such as paddy threshing, water pumping.

Table 20. Pattern of machine utilization by type of tractor ownership, 1981/82, Suphanburi, Thailand.

Use	Type of tractor ownership				
	4T(0)	2T(0)	4T(H)	2T(H)	Total
Custom service	11	9	-	5	9
On farm work	89	91	100	95	91
Total	100	100	100	100	100

Source: CSRFM data.

Table 21. Tractor hours spent in land preparation, by type of tractor ownership, 1981/82, Suphanburi, Thailand.

Type of tractor ownership	Farm size		Tractor hours spent in land preparation				Total	
	Wet season	Dry season	Wet season		Dry season		per farm	per ha
			per farm	per ha	per farm	per ha		
4T(0)	4.38	4.28	110	23	95	22	103	23
2T(0)	3.06	3.44	197	55	85	25	142	40
4T(H)	1.96	2.16	37	26	43	20	44	20
2T(H)	1.62	1.76	37	26	48	27	43	27
Total average	3.11	3.06	98	32	68	23	83	27

Source: CSRFM data.

CHAPTER 4

INCOME AND INCOME DISTRIBUTION

This chapter examines the structure of existing farm income, and impact of mechanization on the structure of farm income, the absolute size of income shares among factors and earners, and the degree of income equality.

The structure of income is examined first. The focus is to investigate the determinants of each component of farm household income with particular attention to how tractor use in land preparation affects each of these components.

Secondly, the effects of tractor use on off-farm and non-farm income are evaluated using the income function approach. The factor share concept is then used to examine the effect of tractor use on farm income and income distribution among factors of production and among earners. The last step is to measure the degree of inequality which exists among farm classes.

The Structure of Income

Farm household income is classified by source into own farm, off-farm and non-farm categories. Net farm income is taken to be net cash farm income and is defined as the return to the family farm

operation after deduction of all production costs. Off-farm income is defined as earnings from work on other people's farms or from agricultural jobs outside one's own farm. This includes all types of field and general farm activities. Non-farm income is the value of work undertaken in non-agricultural sectors, e.g. handicrafts, commerce, etc.

The average annual farm household incomes of 4T(O), 2T(O), 4T(H) and 2T(H) farms were 26,740, 19,140, 14,860 and 12,600 baht in the wet season and 14,680, 13,300, 10,650 and 8,790 baht in the dry season, respectively (Tables 22 and 23). Both users and owners of four-wheel tractors have higher incomes than two-wheel tractor users or owners. However, the structure of income exhibits some differences between the two types of ownership. Figure 10 shows that the owners, 4T(O) and 2T(O), had higher incomes than the hirers, 4T(H) and 2T(H), respectively.

The structure of total farm household income of the whole sample shows that the greatest proportion of a farm household income is derived from farming, 73% in the wet season and 72% in the dry season, whereas earnings derived from off-farm and non-farm sources were respectively 18% and 9% in the wet season and 15% and 13% in the dry season.

However, the structure of income among the four-types of farms was similar in that the main income source for all groups was still farm income. There was only a realtively small difference in off and

Table 22. Average farm household income, by source of income and type of tractor ownership, 1981/82 wet season, Suphanburi, Thailand.

	Type of tractor ownership									
	4T(O)		2T(O)		4T(H)		2T(H)		Average	
	Baht	%	Baht	%	Baht	%	Baht	%	Baht	%
Total household income - per household	26,748	100	19,530	100	14,940	100	12,682	100	18,493	100
Total farm income - per household	21,509	80	14,378	74	10,365	69	7,124	56	13,344	72
Total off-farm income - per household	3,898	14	3,780	16	2,869	19	2,877	22	2,701	15
1. Income from off-laboring	1,929	7	3,780	16	2,869	19	2,827	22	2,701	15
2. Income from hiring out farm machine	1,953	7	237	1	-	-	642	5	708	4
3. Income from land rent	16	-	45	-	-	-	-	-	15	-
Total non-farm income - per household	1,341	6	1,674	9	1,629	11	2,000	16	1,662	9
1. Income from handicraft	382	1	213	1	380	3	189	1	291	2
2. Income from service	421	2	860	4	341	2	209	2	458	2
3. Income from commerce	71	-	369	2	159	1	1,158	9	440	2
4. Income from other non-farm activities	467	2	232	1	749	5	444	4	473	3
Income from other source	-	-	16	-	78	1	94	1	63	-

Table 23. Average total farm household income, by source of income and type of tractor ownership, 1982 dry seasons, Suphanburi, Thailand.

	Type of tractor ownership									
	4T(O)		2T(O)		4T(H)		2TH		Average	
	Baht	%	Baht	%	Baht	%	Baht	%	Baht	%
Total household income - per household	14,709	100	13,298	100	10,615	100	8,976	100	11,872	100
Total farm income - per household	13,030	89	10,231	77	5,285	49	4,164	47	8,177	69
Total off-farm income	629	4	1,852	13	1,301	12	3,256	37	1,760	15
1. Income from off-farm laboring	324	2	1,633	12	1,301	12	3,256	37	1,629	14
2. Income from hiring out farm machine	305	2	188	1	-	-	-	-	123	1
3. Income from land rent	-	-	31	0.3	-	-	-	-	8	-
Total non-farm income	1,049	7	1,215	9	4,064	38	1,376	16	1,926	16
1. Income from handicraft	167	1	235	1	675	6	670	8	437	3
2. Income from service	673	5	254	2	1,026	10	315	3	567	5
3. Income from commerce	209	1	258	2	725	7	177	2	342	3
4. Income from other activities	-	-	468	4	1,638	15	214	3	580	5
Income from other source	-	-	-	-	35	0.3	-	-	9	-

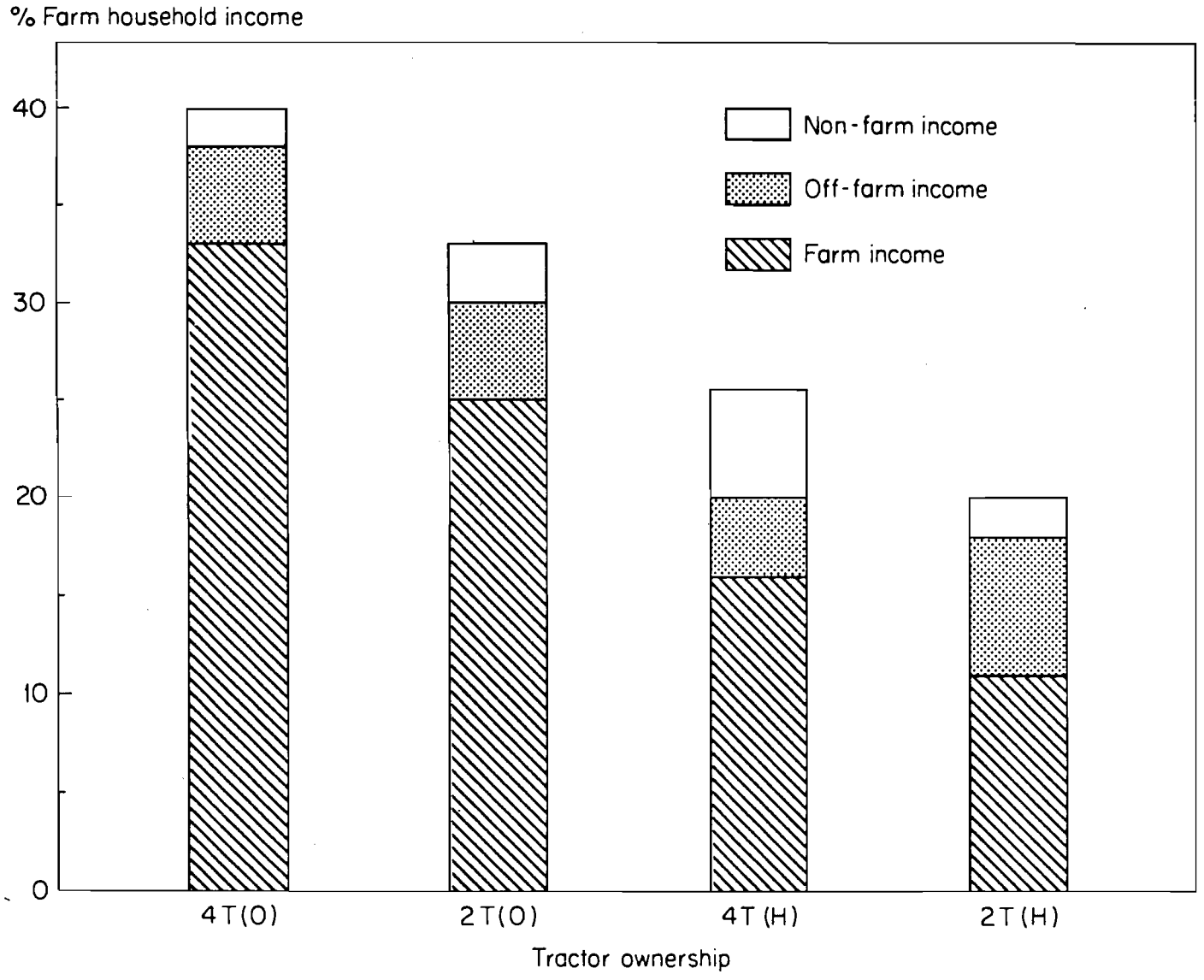

Fig. 8. Household income from all sources by tractor ownership, 1981/82 Suphanburi, Thailand.

non-farm income by tractor ownership group. The data in Tables 23 and 24 show that both off-farm and non-farm income are higher in the hired tractor group in both the wet and dry seasons.

Comparing wet and dry seasons, there were minor differences in farm and off-farm income. For all groups, non-farm income contributed only 8% in the wet season while in the dry season the contribution was slightly higher at 12%.

If total farm income is regrouped into net farm and net off-farm income, by lumping non-farm and off-farm income together remains the main income source of the farm household. The contribution of net farm income is 73% whereas off-farm income is only 27% in the wet season and 74% compared to 26% in the dry season.

Income Function Analysis

The impact of tractor use on off-farm and non-farm income for each of the four groups of tractor user, 4T(O), 4T(H), 2T(O), 2T(H), was analyzed using multiple regression (Tables 24 and 25). The analysis was carried out separately for both the wet and dry seasons.

Off-farm income:

Off-farm income was expressed as a function of man hours worked off-farm, (Table 24) the proportion of family to total labor, together with dummies (intercept shiftness) for household hiring out machine and land.

The overall explanatory power of the models as measured by the coefficient of multiple regression was high, with R^2 ranging from 60% to 90%. Sample size was reasonable although the 4T(H) class sample was slightly smaller than the other.

For the 4T(O) class, all the explanatory variables were signifantly different from zero at the 99% level of confidence except the proportion of family to total labor. This was true for both the wet and dry seasons. These results are as expected, and show that off-farm income is significantly affected by:

(1) The number of hours spent working off-farm.

(2) The hiring out of the machine.

(3) The renting out of land

The coefficient for the dummies are approximately 25% and 50% of the intercept suggesting that the renting of land and the hiring out of machines are major contributors to off farm incomes in this class.

The parameter for off-farm man hours measures the elasticity of off-farm work with respect to off-farm income. This has a value of about 0.58; 1% increase in off-farm work would only increase off-farm income by about 60%. This rises to over 70% in the dry season. However, it should be noted that the dummy for renting out of land is not significant in the dry season and the coefficient of the dummy for hiring out of machine almost doubles. The total effect in the sum of intercept and dummy coefficients is, however, the same in both season.

For the 2T(0) class a similar pattern emerges, with the dummies for renting out land and hiring in labor significant in both seasons. The combined effect in the wet season of the intercept and the dummy for hiring out the machine is nearly the same for both 2T(0) and 4T(0) suggesting that off-farm income difference are not due to machinery contracting. However, this is not true for the land dummy, where the 4T(0) has considerably higher intercepts in both wet and dry seasons.

The effect of hiring out of machines is, however, much reduced in the dry season for 2T(0) where there are technical reason in favor of the 4T(0).

The number of hours worked rises in the dry season for all tractor owner but especially for 2T(0). This is probably due to the reduced opportunities for dry season renting out of machine.

The importance of renting out land is also lower on 2T(O) farms. This is expected since these farms are smaller but may also be due to the extra speed that 4 wheel tractors have over 2 wheel tractors.

For hirers, both 4 wheel and 2 wheel, the main source of off-farm income is labor with an elasticity of approximately 1 in the wet season and close to 1 in the dry season. In the wet season, some income is contributed in the 4T(H) class from the renting out of land.

The proportions of family to total labor are not significant in any season for any of the farm groups. It is assumed that each household uses family labor first and then only is extra labor required for over and above production. The ratio of family labor to total labor is therefore a crude index approximating the excess requirements of the family farm over the family labor supply.

For none of the tractor using groups was this variable found to have a significant impact on off-farm income. This suggests that the relationship of working household size to farm size for all levels of tractorization is unimportant i.e. that there is no push or displacement effect or if there was such an effect, adjustments have been made and equilibrium reestablished. From this evidence it seems unlikely that tractors are displacing family labor from the farm.

Table 24. Multiple regression results for the impact of tractor use on off-farm income, 1981-82 crop year, Suphanburi.

Variable	4T(O)		2T(O)		4T(H)		2T(H)	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Constant (A)	3.9065**	2.8808**	4.5330**	2.2475**	0.9135ns	2.9739**	2.8463**	2.7730**
	(6.93)	(4.02)	(8.12)	(3.87)	(0.89)	(6.29)	(3.07)	(4.44)
X_1 (α_1)	-0.1077)ns	-0.2801ns	0.3808ns	-0.0599ns	-0.1631ns	-0.0334ns	-0.04953ns	-0.2481
	(-0.39)	(-0.69)	(1.09)	(-0.16)	(-0.55)	(0.18)	(-1.24)	(-0.77)
X_2 (α_2)	0.5817**	0.7335**	0.5443**	0.8899**	1.0977**	0.8008**	0.7875	0.8432**
	(6.34)	(6.01)	(6.80)	(10.44)	(6.64)	(10.45)**	(5.59)	(8.79)
D_1 (β_1)	1.3572**	2.7610**	0.8307*	0.9922*	-	-	-	-
	(4.46)	(2.54)	(3.24)	(2.65)				
D_2 (β_2)	2.1275**	-0.1459ns	0.9659**	1.9186**	1.020*	-	-0.1939ns	-
	(6.00)	(-0.14)	(2.80)	(3.67)	(2.47)	-	(-1.50)	
R^2	0.6571	0.7698	0.6036	0.7412	0.8354	0.9107	0.6021	0.7008
F-value	18.20	13.37	18.66	32.22	20.28	56.08	12.61	39.82
No. of samples	43	21	54	50	16	14	29	37

Notes: 1. The off-farm income functions were specified as follows:

$$\ln Y_i = A + \alpha_1 \ln X_1 + \alpha_2 \ln X_2 + \beta_1 D_2 + \beta_2 D_2$$

where:
Y_i = off farm income (Baht)
X_1 = proportion of family labor to total labor.
X_2 = man-hours spent on off-farm activities
D_1 = Dummy for machine hired out
D_1 = 1 if machine is hired, 0 otherwise
D_2 = Dummy for land in hectare rented out
D_2 = 1 if land is rented out, 0 otherwise
i = level of tractorization.

2. * = significant at 99 percent of tractorization
3. ** = significant at 90 percent level of confidence
4. ns = non-significant
5. values in parentheses are "t" statistics.

Non-farm income

A similar relationship to that for off-farm income was estimated for non-farm income (Table 25) with non-farm income being expressed as a function of non-farm mandays and, the proportion of family to total labor.

Again, the overall explanatory power of these models was high. Above 60% of the variation in non-farm income was explained by the independent variables, except in case of the 4-wheel tractor hiring class where the sample size was very small.

Excluding the 4-wheel tractor hiring class from the analysis, the number of manhours spent on non-farm income was always highly significant with elasticities close to or slightly below 1. This was expected since the correlation between non-farm income and non-farm earnings is very high.

However, the parameter associated with the proportion of family labor to total labor, although negative, was not significant. An increase in the contribution of family labor to farm activities resulting in a withdrawal of non-farm labor, is not likely to reduce non-farm labor significantly. This may reflect the fact that non-farm income as opposed to off-farm income is not limited to the agricultural cycle.

The intercept terms are only weakly significant showing that there was a considerable variation in the non-farm work pattern of

Table 25. Multiple regression results for the impact of tractor use on nonfarm income, 1981/82, Suphanburi.

Variable	4T(0)		2T(0)		4T(H)		2T(H)	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Constant (A)	2.6743* (3.23)	1.9951* (3.16)	3.3609** (4.85)	1.8933* (2.64)	8.0606* (4.21)	0.7614^{ns} (0.38)	1.5775^{ns} (1.25)	2.949* (2.32)
X_1 (α_1)	-0.1285^{ns} ( )	-0.343^{ns} ( )	0.2578^{ns} ( )	-0.4821^{ns} ( )	-0.1104^{ns} ( )	-0.1721^{ns} ( )	-0.7395* ( )	-0.6057^{n} (
X_2 (β_1)	0.8727** (6.91)	0.9549** (6.94)	0.7411** (6.49)	0.9136** (7.77)	0.0653^{ns} (0.23)	1.1241* (3.90)	1.0039** (3.07)	0.8674* (3.72)
R^2	0.8726**	0.9007	0.7124**	0.8309**	0.0336	0.7579**	0.7128**	0.6397**
F-value	27.39	3.604	21.06	36.86	0.05	7.83	16.13	9.77
No. of samples	11	11	26	18	6	8	17	14

Notes: 1. The non-farm income functions were specified as follows:

$$\ln Y_i = A + \alpha \ln X_1 + \beta \ln X_2$$

where Y^i = non-farm income (Baht)
X_1 = proportion of family labor to total labor
X_2 = man-hours spent on non-farm activities
i = level of tractorization

2. * = significant at 99 percent level of confidence.
3. ** = significant at 90 percent level of confidence.
4. ns = nonsignificant
5. value in parentheses are "t" statistics.

households. For the tractor-owning classes the intercept terms were lower in the dry season when compared to the wet season, suggesting that fewer jobs were accepted by family labor in the dry season. For the 2-wheel tractor hirers, the reverse was true, with the dry season intercept significantly larger than the wet season intercept. Perhaps this group, with smaller overall income, is more dependent on non-farm income in order to satisfiy their minimum income requirements.

Most of the variability in off-farm and non-farm income can be explained by the number of hours worked in these activities. The proportion of family to total labor used on the farm, although often negative was rarely significant. This suggests that there was a rough equilibrium between farm operation requirements and family labor. The dummies for renting out land and custom renting of machine showed that ownership of land and capital were also important sources of income.

Analysis of the Impact of Mechanization on Income Distribution

In this section, the distribution of real income to various factors of production is analyzed. The total mean output for each tractorization level in kilograms of paddy is equated to the sum of average payments to: (1) land, (2) labor, (3) current inputs, (4) capital, and (5) a management residual, which is assumed to be a proxy for operator's profit.

The distribution of real income among the different earners group, landlords, hired laborers, dealers in current inputs, and operators is also examined and an analysis of the determinants of the factor shares is presented.

The estimated total costs for each tractorization level, including the imputed cost of unpaid family labor, owned land and capital are shown in Tables 26 and 27. The cost of family labor was imputed by multiplying the manhours of family labor by the average wage paid per hour to hired labor for the same activity. In order to impute a cost to owned land, the area of owned land was multiplied by the average market rental rate for the area. Similarly, for capital, an imputed value was found by multiplying owned capital, mostly machinery, by the market rate for tractor hiring.

There was a similar distribution of total cost for both the owned tractor and hired tractor farms for all mechanization groups in both the wet and dry seasons. Total value of output is defined as the yield per hectare priced at the market rate. Value added is the net output after all factor have received their return. Gross family factor income is the net income after paid-out cost and current input costs have been subtracted.

In the wet season, land and current inputs represented the largest portion of total cost on tractor owning farms. The largest component of imputed costs was the 'user-cost' of owned land.

Table 26. Rice production costs and returns per hectare, 1981/82 Wet season, Suphanburi, Thailand

Item	Tractor owning farms			Tractor hiring farms			Total average
	4T(O)	2T(O)	Average	4T(H)	2T(H)	Average	
A Production Costs:							
1. Current inputs	2598.05	2917.83	1784.58	2625.29	2366.32	2468.68	2722.32
2. Labor	2527.07	2570.44	2552.37	2538.85	3005.11	2820.81	2605.28
a. Family	1041.01	1233.26	1153.15	1169.10	1543.78	1395.68	1200.95
b. Hired	1486.06	1337.78	1399.22	1369.75	1461.33	1404.33	
3. Land	2688.27	2837.37	2775.24	2823.74	2732.79	2768.74	2773.96
a. Owned	2274.81	1855.26	2030.08	1626.99	1861.08	1768.55	1978.54
b. Rented	413.46	928.11	745.15	1196.83	871.71	1000.22	795.42
4. Capital	1525.54	1836.91	1707.16	1380.88	1252.68	1303.35	1627.58
a. Own	1351.01	1354.08	1469.46	418.66	260.54	323.04	1243.52
b. Hired	174.53	282.83	962.22	992.14	980.31	384.06	
5. Total cost	9338.93	10162.55	9368.75	9356.90	9361.58	9729.14	
6. Total input paid out	2074.05	2602.12	2382.08	3528.80	3325.18	3405.66	2583.81
B. Total value of output	10732.32	10953.55	10861.37	11874.60	10470.85	11025.69	10893.75
C. Gross value added	8134.28	8035.71	8076.78	9249.31	8104.53	8557.02	8171.43
D. Gross family factor income (/gffI)	6060.22	5433.60	5694.71	5720.51	4779.35	5151.36	5587.62
E. Residual	1393.39	790.99	1042.01	2505.84	1113.96	1664.12	1164.62

[a] Financial analyses.

Source: Appendix 9 to 16.

Table 27. Rice Production cost and returns per hectare, 1982 dry season, Suphanburi, Thailand (baht/ha).[a]

Item	Tractor owning farm			Tractor hiring farm			Total average
	4T(O)	2T(O)	Average	4T(H)	2T(H)	Average	
A. Production costs:							
1. Current inputs	2657.67	2556.60	2595.40	2262.73	2372.83	2329.48	2535.96
2. Labor	2641.74	2421.42	2506.05	2695.71	2710.62	2704.75	2550.45
a. Family	1110.61	1106.45	1108.04	1067.66	1531.87	1349.09	1161.91
b. Hired	1531.46	1314.97	1398.01	1628.04	1178.75	1355.66	1388.55
3. Land	2083.60	1816.01	1981.65	1531.72	2029.17	1833.30	1899.58
a. Owned	1909.25	1387.61	1587.70	630.69	1452.51	1128.92	1485.19
b. Rented	174.35	428.39	330.95	901.03	576.67	704.38	414.39
4. Capital	1441.68	1446.18	1444.45	1325.10	1441.29	1395.54	1433.52
a. Owned	1221.09	1213.89	1216.66	295.58	274.28	282.67	1007.96
b. Hired	220.58	232.28	227.80	1029.52	1167.01	1112.87	425.57
5. Total cost	8825.01	8240.21	8464.53	7815.26	8553.91	8263.07	8419.51
6. Total input paid out	1926.39	1975.65	1956.75	3558.59	2922.43	3172.92	2228.51
B. Total value of output	889.86	8686.78	8768.51	8393.71	8043.11	8181.16	8637.27
C. Gross value added	6242.19	6730.17	6173.14	6130.98	5670.28	5831.68	6701.31
D. Gross family factor income (GFFI)	4315.80	4154.53	4216.39	1572.39	2747.85	2678.76	3872.81
E. Residual	74.85	446.57	303.98	578.45	-510.80	-81.91	217.76

[a] Financial analysis.

Source: Appendix 9 to 16.

Land was also the largest cost item for tractor hiring farms but current input costs were lower for this class than for tractor hiring farms. Tractor hiring farms had higher costs than tractor-owning farms despite the fact that tractor hiring farms had lower imputed land costs. (This was because the tractor hiring farms owned a larger share of their cultivated land).

In the dry season, the largest cost component changed for land to current costs for the tractor-owning farms and from land labor for the tractor hiring farms. Both land use and land user costs were lower in the dry season (Table 13). Conversely, hired labor costs on all farms were greater in the dry season.

There were large differences in both total costs (paid-out and imputed) and total paid-out costs between tractor owning and tractor hiring farms. In the wet season, capital costs were greater on tractor owning farms but this was compensated for by the lower current costs to this group. Land was the largest single cost for the tractor hiring farms also. Imputed family and hired labor costs were much higher on tractor hiring farms, which together with the costs of rented land, (which was higher on tractor hiring farms), resulted in total paid out costs on tractor hiring farms being higher than on tractor owning farms.

There were also a difference in total cost and total paid out cost during the dry season on both farm groups. Even though the proportion of total capital cost is the same on tractor owning and

tractor hiring farms and, together with current input costs, the total paid out cost on tractor hiring farms was still higher than on tractor owning farms.

The total value of output, value added, gross family factor income and the residual (profit) were all higher in the wet compared to the dry seasons for all groups. This was mainly due to the higher wet season yields.

The relative shares of factors and earners, with respect to both value added and family income were also estimated (Tables 28 to 31). The relative shares of labor, land and capital in both output and value added are higher during the wet than the dry season. The residual and operator shares were also highest in the wet season. This was primarily due to lower yields in the dry season. The wet season is also the main cropping period and farmers have the greatest incentive for intensive cultivation of their crops.

Between groups, the share of labor was lowest on tractor-owning farms in both the wet and dry seasons. However, the share of hired labor was almost the same on tractor owning and tractor hiring farms in the wet season. In the dry season, the share of hired labor was slightly higher on tractor hiring farms. This results from the higher proportion of family labor used on tractor hiring farms and this was much higher during the dry season. Also, the tillage practices used by tractor hiring farms in the dry season required more

Table 28. Factor and earner shares for rice production using four alternative methods of land preparation, 1981/82, Wet season, Suphanburi, Thailand.

	Tractor owning farm			Tractor hiring farm			
	4T(O)	2T(O)	Average	4T(H)	2T(H)	Average	Total average
Factor shares							
1. Current inputs	24.21	26.64	25.64	22.11	22.59	22.39	24.98
2. Labor	23.55	23.47	23.50	21.38	28.69	25.58	23.92
3. Land	25.05	25.90	25.55	23.78	26.70	25.12	25.46
4. Capital	14.21	16.77	15.72	11.63	11.96	11.82	15.35
5. Residual	12.98	7.22	9.59	21.10	10.64	15.09	10.29
Total	100	100	100	100	100	100	100
Earner Shares							
1. Current inputs	24.21	26.64	25.64	22.11	22.59	22.39	24.98
2. Hired labor	13.85	12.21	12.88	11.54	13.96	12.93	12.89
3. Landlord	3.80	8.96	6.86	10.08	8.33	9.07	7.30
4. Hired capital	7.63	2.58	2.19	8.10	9.48	8.29	3.53
5. Operator	50.51	49.61	52.43	48.17	45.64	46.78	51.30
Total	100	100	100	100	100	100	100

Source: CSRFM data.

Table 29. Factor and earner shares for rice production using four alternative methods methods of land preparation, 1982 Dry season, Suphanburi, Thailand.

ITEM	Tractor owning farm			Tractor hiring farm			Total Average
	4T(O)	2T(O)	Average	4T(H)	2T(H)	Average	
Factor shares							
1. Current input	29.86	29.43	29.62	26.96	29.50	28.47	29.36
2. Labor	29.67	27.87	28.58	32.12	33.70	33.06	29.53
3. Land	23.41	20.91	21.88	18.25	25.23	22.41	21.99
4. Capital	16.20	16.65	16.47	15.78	17.92	11.67	16.60
5. Residual	0.86	5.18	3.45	6.89	-6.35	4.39	2.52
Total	100	100	100	100	100	100	100
Earner shares							
1. Current input	29.86	29.43	29.60	26.96	29.50	28.47	29.36
2. Hired labor	17.21	15.14	15.94	14.66	16.57	16.08	
3. Landlord	1.96	4.93	3.77	10.73	7.47	8.61	4.79
4. Hired capital	2.48	2.67	2.00	12.27	14.51	13.60	4.93
5. Operator	48.49	47.83	48.69	35.38	31.95	32.74	44.84
Total	100	100	100	100	100	100	100

Source: CSRFM data.

labor during land preparation. However, in general, there were only minor differences, in the factor share between tractor owning and tractor hiring farms in both wet and dry seasons.

The relative share of capital in both output and value added seems to be due primarily to the differences in the type of ownership. Needless to say, the proportion of owned capital on tractor owning farms was much higher than on tractor hiring farms with the result that the share of hired capital was higher on tractor-hiring farms. The relative size of the operational surplus expressed as a value added share was lower on the tractor hiring farms.

The Measurement of Income Inequality

Mechanization is often associated with changes in the distribution of income since an increased share of paid out cost goes to the owners of capital for the use of their machines rather than to wage labor. Further structural adjustments within the rural economy, such as changes in farm size and tenancy, may also lead to increased polarization of income.

However, it is not easy to qualify these effects. In particular, if labor has been displaced it is likely to migrate out of the area. It is therefore only possible to look at income distribution for the household remaining in the survey area.

Table 30. Income shares per hectare from rice production, 1981/82 Wet season, Suphanburi, Thailand.

Item	Tractor owner farm			Tractor hiring farm			Total average
	4T(O)	2T(O)	Average	4T(H)	2T(H)	Average	
Value added	100	100	100	100	100	100	100
Farmer							
Family labor	12.79	15.34	14.28	12.63	19.05	16.31	14.70
Owned land	27.96	23.08	25.13	17.59	22.96	20.07	24.21
Owned capital	16.61	19.36	18.19	4.52	3.21	3.78	15.22
Operator's surplus	17.13	9.84	12.90	17.09	13.74	19.45	14.25
	74.50	67.65	70.51	61.83	58.97	60.21	68.38
Hired labor	18.26	16.64	17.32	14.80	18.03	16.65	17.19
Landlord	5.08	12.20	9.23	12.93	10.76	11.68	9.73
Hired capital	2.16	3.51	2.94	10.44	12.24	11.46	4.70

Source: CSRFM data.

Table 31. Income share per hectare from rice production, 1982 Dry season, Suphanburi, province, Thailand.

ITEM	Tractor owner farm			Tractor hiring farm			Total average
	4T(O)	2T(O)	Average	2T(H)	4T(H)	Average	
Value added	100	100	100	100	100	100	100
Farmer							
Family labor	17.79	18.05	17.95	17.41	17.02	17.99	19.04
Owned land	30.59	22.64	23.72	25.62	19.29	24.34	24.40
Owned capital	19.57	19.80	19.71	4.82	4.84	4.83	16.52
Operator's surplus	1.20	7.28	4.92	9.43	1.68	-1.39	3..52
	69.15	67.77	68.30	41.95	39.47	45.77	63.48
Hired labor	24.53	21.45	22.65	26.55	20.78	23.17	22.76
Landlord	2.79	6.99	5.37	14.71	19.17	12.04	6.79
Hired capital	3.53	3.79	3.68	16.79	20.58	19.02	6.97

Source: CSRFM data.

Also, there are methodological problems. The usual methods of analyzing income distribution is by means of Lorenz curves and Gini concentration ratios. However, these measures have limitations.

The Lorenz curve shows the cumulative percentage distribution against cumulative percentage of total income. If income was shared perfectly equally than the Lorenz curve would lie alone the diagonal. The further away any particular distribution lies from the diagonal the more unequal the distribution, provided the distributions do not intersect. This is only subject to the condition that distributions are being ranked independently of the average levels of income (Atkinson, 1970).

Where the distributions intersect, as for this analysis, then it is possible the results obtained will not be unique and therefore misleading.

Apart from visual comparison of Lorenz curves, a common measure of the degree of income inequality which is often used is the Gini concentration ratios. This measures the area between the distribution and the diagonal and, provided equal weight is given to all types of income inequality, can be used as an indicator of income concentration.

In this study, a comparison is made for the different tractor classes and by type of ownership. Lorenz curves and the distribution of net farm earnings are presented in figures 9 to 12 while the

associated Gini ratios and average net farm earnings are shown in Tables 32 to 33.

The Lorenz curves for two-wheel and four-wheel use are shown in Figures 9 to 10. In the wet season, the share of the bottom 30 percent of income is higher for four wheel tractors. In the dry season, the reverse is true. However, the share of the bottom 60 percent is lower for four-wheel trctor users in both wet and dry seasons. The share of the top 10 percent is higher on two-wheel tractor farms in both wet and dry seasons when compared to the concentration within the four-wheel class.

The Gini coefficients for these distribution show, however, that overall there is a more equal distribution of income among two wheel users when compared to four wheel users in both wet and dry seasons (Figures 9 and 10). The Gini ratios for two-wheel vs. four-wheel users in the wet season are only very slightly lower (0.39 vs. 0.40) but this is more so in the dry season (0.40 vs. 0.47).

There is less inequality in the distribution of income within tractor owning and tractor hiring households during both the wet and dry seasons (Figures 11, 12). The concentration ratios are lower for owners both in the wet season (0.34 vs. 0.41) andin the dry season (0.37 vs. 0.51). This suggest that there may be a redistribution of income from the top income brackets to other classes.

Table 32. Percentile measures of farm income share by type of tractor ownership and use, 1981/82 Wet Season, Suphanburi, Thailand.

Group	Percentage share			
	Tractor ownership		Type of tractor use	
	Owner	Hirer	4T	2T
No. of farms	145	79	78	145
Bottom 30 percent	6.30	9.00	8.94	3.24
Bottom 60 percent	19.75	9.00	20.68	33.58
Top 30 percent	57.40	60.29	63.87	66.42
Top 20 percent	47.56	60.29	50.93	39.90
Top 10 percent	29.69	28.55	29.15	29.79
Concentration ratio	0.34	0.40	0.40	0.39
Average net farm earnings	35,887	17,489	31,874	21,502

Table 33. Percentile measures of farm income share by type of tractor ownership and tractor use, 1982 Dry Season, Suphanburi, Thailand.

Group	Percent share			
	Tractor ownership		Type of tractor use	
	Owner	Hirer	4T	2T
No. of farmer	138	78	73	143
Bottom 30 percent	3.34	17.13	5.80	6.19
Bottom 60 percent	19.13	17.13	20.57	28.58
Top 30 percent	66.34	82.84	70.23	71.40
Top 20 percent	39.56	48.14	48.54	52.00
Top 10 percent	37.48	28.48	26.70	25.32
Concentration ratio	0.37	0.51	0.47	0.40
Average net farm earnings	23,263	9,450	18,315	14,295

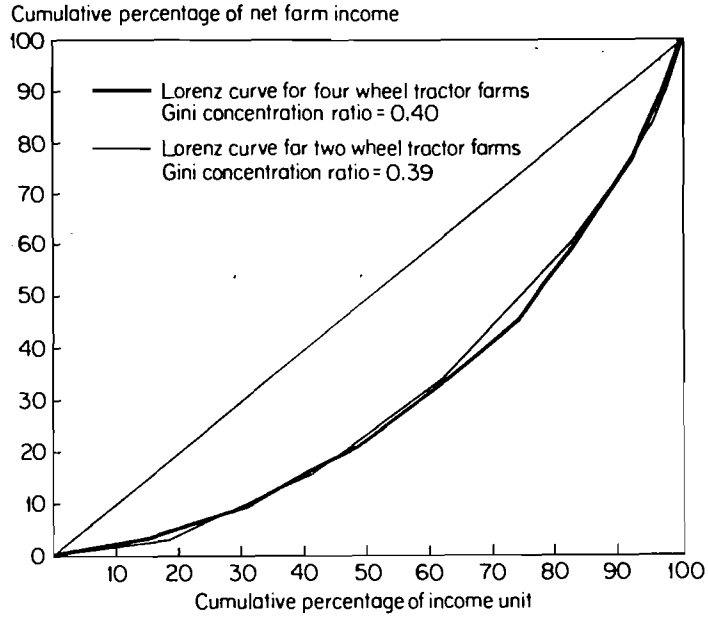

Figure 9. Lorenz curve showing the distribution of net farm income between two wheel and four wheel tractor farms. Wet season 1981/82, Suphanburi, Thailand.

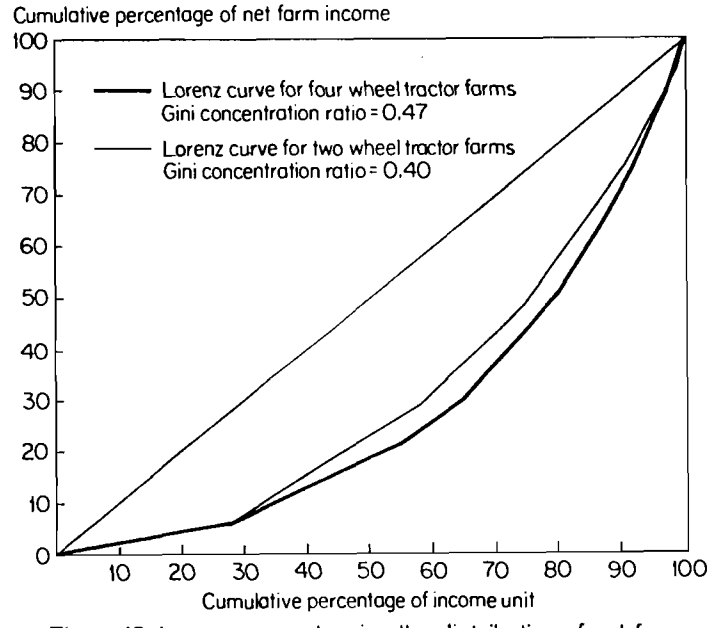

Figure 10. Lorenz curve showing the distribution of net farm income between two wheel and four wheel tractor farms. Dry season 1982, Suphanburi, Thailand.

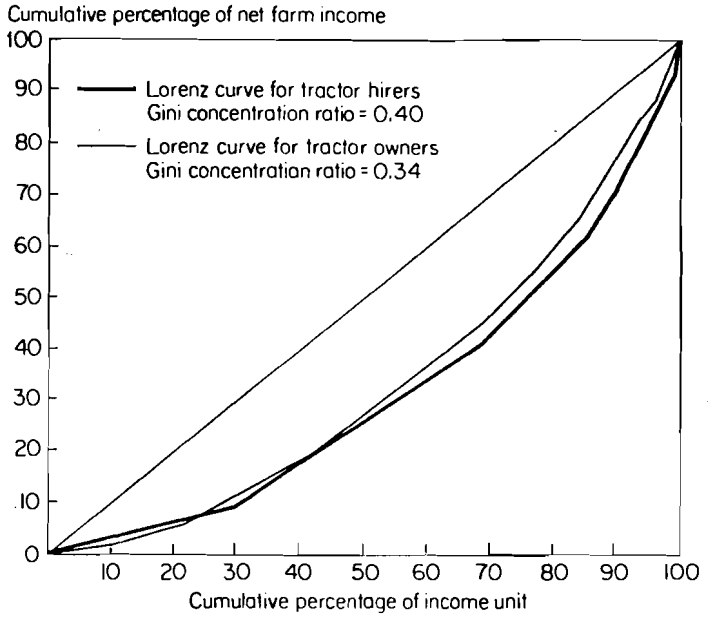

Figure 11. Lorenz curve showing the distribution of net farm income between tractor owners and hirers. Wet season 1981/82, Suphanburi, Thailand.

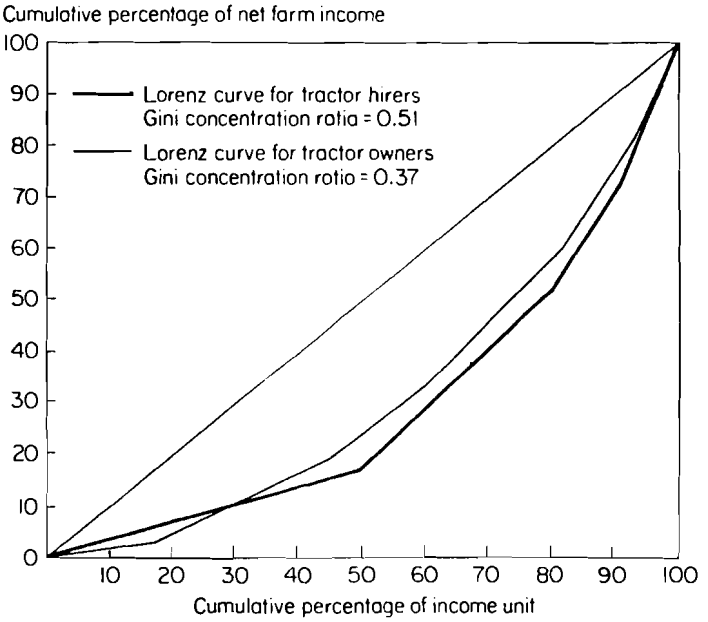

Figure 12. Lorenz curve showing the distribution of net farm income between tractor owners and hirers. Dry season 1982, Suphanburi, Thailand.

The income share of the bottom 30 percent is higher for hirers in both the wet and dry season. Likewise the share of the bottom 30 percent is higher for hirers in both seasons. However, the share of top 10 percent is higher for owners, again in both seasons.

For the farm household income comparisons, it was difficult to analyze any of the groups in the study location, because the Lorenz curves for all four distributions intersect at many points in both the wet and dry seasons.

CHAPTER 5

SUMMARY, CONCLUSIONS AND IMPLICATIONS

Summary and Conclusions

The general focus of this study was on the income redistribution impact resulting form the mechanization of land preparation. More specifically, the goals were: (1) to determine the impact of the mechanization of land preparation on the structure of income; (2) to ascertain the impact of the mechanization of land preparation on the distribution of income among the factors of production and among different earner groups; and (3) if possible, to examine directly the effects of mechanized land preparation on income inequalities.

To attain these objectives, data from the IRRI Consequences of Mechanization Project conducted in Suphanburi Province was used. Farm-level primary data was collected in Donchedi and U-Thong districts and secondary data obtained from the Department of Agricultural Economics of Thailand (DAE). The analysis is based on the data collected for wet season 1981-82 and dry season 1982. Two hundred and thirty-three farmers were involved in the wet season survey and almost as many in the dry season (216).

The socio-economic profile of farmers showed only minor differences in social characteristics. The profile suggested that many

lack technical knowledge since 80 percent of farm laborers had only been educated up to prathom 4 level. Also, a lack of capital as a result of low levels of saving was found to be a production constraint. It was notable that both farmers who own four wheel tractors or who owned and hired four wheel tractors had higher debts than those owning two-wheel tractors.

There were differences in land use both by season and by ownership of groups within each tractor class. Land use intensity in the wet season was higher than in the dry season,as expected. There was little variability in the type of land tenure found throughout the study area. Most of the farms were owner-occupied.

For both seasons, two- and four-wheel tractor owners owned larger farms than those hiring in tractors. This showed that human labor use in the wet season averaged 275 mandays per hectare on tractor owning farms and this was about 35 percent higher than on the tractor hiring farms. Most of the differences in labor demand can be explained by differences in the labor requirement associated with land preparation for each farm type.

During the dry season, total labor use per hectare was significantly lower than in the wet season. Tractor-owning farms used about 235 mandays/ha, roughly 28 percent more than the labor employed on tractor hiring farms.

Farmers are increasingly aware of the benefits of modern rice technology which is increasingly becoming a feature of farming in this area. The most widely used input was chemical fertilizers, followed by insecticides, herbicides and the new seed varieties. Almost 100 percent of all the survey farms employed machines and 40 percent used tractors. However, the level of mechanization varied considerably. Thirty-five percent of the farmers owned four-wheel tractors, 55 percent owned two-wheel tractors while 4 percent hired four-wheel tractors and 6 percent hired two-wheel tractors.

Input use differs by farm size and type of tractor ownership. There were only small yield differences observed between groups. On average, tractor-owning farms obtained 20% higher yields than tractor hiring farms. Yield differences were mainly due to tractors used in land preparation which permitted tractor owners to be able to do a more thorough and timely job of plowing, harrowing, and loosening the soil than those relying on hired in tractor services. For tractor owning farmers who are able to till and plant in a more complete and timely manner there are no, or few, constraints on the operation or timing of the land preparation operation.

Comparing the wet and dry seasons, yields per hectare were higher during the dry season even though the wet season was the main crop. The higher yield per hectare in the dry season seems closely associated with higher levels of fertilizer and pesticide use, greater weed control, variety selection, including the and use of short

duration rice varieties and irrigation. Also, day length and sunshine hours are higher in the dry season. However, the differences in yield were minor. The dry season paddy price, however, was lower than the wet season price and the net effect was that farm income was higher in the wet season.

The major source of income for the farmers surveyed was rice farming. Farm income represented 73 percent of total income in the wet season and 72 percent in the dry season. Off-farm income contributed 18 percent in the wet season and 15 percent in the dry season of total income while non-farm income added another 9 percent and 13 percent in the wet and dry season respectively. Nearly all farmers worked off-farm as well as on their own farms and many were involved in non-farm employment. Transplanting and harvesting were the primary off-farm work activities available to wage earners. Off-farm income depends on the off-farm employment available in each season.

The study showed that there were many factors affecting the level of income. Asset or wealth position, farm size, level of prices, pattern of labor use and production efficiency all had an impact on incomes. There were important differences between factors influencing income in the two seasons. Tractor ownership and use in land preparation also appeared to affect income levels significantly.

Examining production costs and returns in the wet season showed that the highest costs for tractor-owning farms were labor and current inputs while for tractor-hiring farms the greatest costs were

expended on labor and land. In the dry season, the level of expenditure for both tractor-owners and tractor-hirers was nearly equal. During both seasons, both tractor owners and hirers spent only a small proportion of their total outlay on tractor services. There were, however, major differences in total production costs between the two wheel and four-wheel tractor farms.

The heavy reliance on input use and the high cost of labor relative to the costs of tractors were important findings. Tractors played a major role in land preparation but only to a lesser degree in water pumping and transport. However these costs were relatively small compared to the cost of labor for transplanting, fertilizing, insectide application, weed control and harvesting. Farmers indicated that the major advantages of the tractor were that it saves time, plows deeper, and produces a better quality seedbed than animal or human methods as well as easing the physical burdens associated with land preparation. Perhaps the most important index of tractor acceptance as a primary tool for land preparation is that it was cheaper than the alternative which in Suphanburi, was animal power.

The hiring out of tractors generated nearly 20 percent of the household income of farmers who were engaged in this activity.

The net effect of tractor use for land preparation is to increase income. Combined with other types of new technology -- fertilizer, HYVs, etc. --- the net result may be an increase in output, although the separate contribution of mechanization is difficult to

isolate. If the rice price does not change, this means an increase in income.

Factor share analysis demonstrated that the share of labor and management were respectively 5 percent and 6 percent lower on tractor-owning farms when compared to tractor-hiring farms. Conversely, the share of land and capital was respectively 2 percent and 6 percent higher on tractor-owning farms. The share of capital was also relatively smaller than the labor share of income. One implication of this is that although investments in mechanization may well be justified for their positive effects on productivity, mechanization is more advantageous to the owners of capital than to the owners of labor. Essentially mechanization redistributes some of the income share of labor to capital. Also, the management or profit residual is also redistributed towards capital although this will have less effect on earners shares.

Among tractor classes, there were minor differences in the earner shares going to hired labor. Labor's share was only 1 percent lower on the tractor-owning farms.

The results of the income function analyses indicated that mechanized land preparation had no effect on overall income. Family labor was used in both off-farm and non-farm income generating activities and this may have compensated farms with small crop incomes.

Although exact figures on the impact of mechanization on income distribution can only be suggestive it is difficult to conclude that income inequality exists among tractor ownership groups. Even though tractor - owning farms spent more time using tractors than tractor - hiring farms, there were only minor differences in the use of other inputs. The Gini coefficient for all tractor groups showed differences in income inequality in both the wet and dry seasons. When off-farm and non-farm income are added to farm crop income, however, there does not appear to be any income inequity between 2-wheel and small 4-wheel tractor users. Work outside the household, supplemented and stabilized the income of the individual farmer. It was evident from this study that the pattern of income distribution among various farmer groups became more equal when total off-farm and non-farm income were considered. The results support the hypothesis that there are no major differences in the total income shares of the respondent classes in the survey. However, it should be remembered that all the farms in the survey are relatively homogenous in terms of farm size, tenure and access to water. Also, the technical differences between 2-wheel and 4-wheel tractors in terms of power (ranging from 7 to 20 HP) and performance are minimal.

The role of non-farm and off-farm income in mitigating income inequality is crucial. This of course depends on the existence of these jobs, whether found locally, in Bangkok or abroad. Also, it should be noted that mechanization is a gradual but dynamic process and that since Suphanburi has been a highly mechanized area for sometime, many adjustments will have already taken place. This study was limited

to a comparison of different types of mechanization, the area already being too mechanized to allow a comparison of animal and mechanized farms.

Implications

The following policy implications emerged from the study.

1. Farmers in the study area have relatively low levels of capital stock which indirectly result in production inefficiencies and lower levels of farm income. Government should provide incentives and opportunities to farmers to encourage capital investment in farm machinery and implements in order to fully utilize new technologies. This would bring about higher yields, increased income and indirectly stimulate savings.

2. Due to low levels of profit, farmers are forced to borrow money to carry them through the next production season. Funds from 'loan sharks' are readily available at very high interest rates and because of the lack of alternative sources, farmers have difficulty repaying these debts. Government loans should be made available to farmers at reasonable rates. This would facilitate modernization of the agricultural sector.

3. Machinery and other modern technologies are often employed in rice production. Two-wheel and small 4-wheel tractors, however,

were only utilized during the first phase of the production process and are largely idle for the rest of the year. The renting out of machines is only possible after the machine owners' own farm has been completed. Thus there is a need to find ways and applications whereby machines can generate income during the off season.

4. Mechanized land preparation had a positive impact on the income of all earners. The general increase in the share of operators, however, was relatively larger than the increase in the share of the landlord and the hired laborers, indicating that farm operators who provided management and used their own labor were the largest recipients of the benefits derived from tractor use in land preparation. To increase the welfare of small farmers, investments in tractors for land preparation are justified.

5. However, although no data is presented in this thesis, non-earners (sometimes laborers or farmers displaced in the mechanization process) may be negatively affected. Provided off- and non-farm jobs exist there is some evidence that these non-farm income sources compensate for a fall in crop income. Maximization of social welfare implies that policies to maintain or create sufficient non-farm employment opportunities should run parallelly, or ideally in advance, of mechanization promotion policies.

6. Inequality in income distribution among farmer operators was difficult to quantify. There appeared to be less income inequality within the tractor owning class than among the tractor hirers, although

the differences were relatively minor. Overall, it seems that adjustment to the two types of mechanization (2-wheel and small 4-wheel tractors) has followed a reasonably similar pattern and that mechanization has not produced a grossly unequalitarian distribution of income, at least among the remaining farmers in a relatively prosperous area with close proximity to non farm employment.

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Appendix Table 1. Derivation of factor and earner's shares

Variable	Variable Code
A. Production Cost	
1. Total current input	C_1
2. Total labor	C_2
- family	I_2
- hired	P_2
3. Total land rent	C_3
- owned land	I_3
- rented land	P_3
4. Capital interest and rental paid	C_4
- owned capital	I_4
- hired capital	P_4
5. Total cost	C
6. Total paid-out cost	P
B. Total output	O
C. Gross value added	$V = O - C_1$
D. Gross family factor income	$Y = V - (P_2 + P_3 + P_4)$
E. Residual	$R = O - C$

Appendix Table 2. Devivation of output and income shares.

Variable	Output	Value added share	Family Income share
Factor shares:			
1. Current input	$C_1/0$	-	-
2. Labor	$C_2/0$	C_2/V	I_2/Y
3. Land	$C_3/0$	C_3/V	I_3/Y
4. Capital	$C_4/0$	C_4/V	I_4/Y
5. Residual	R/0	R/0	R/Y
Total	100	100	100
Earner Shares:			
1. Current input	$C_1/0$	-	
2. Hired labor	$P_2/0$	P_2/V	
3. Landlord	$P_3/0$	P_3/V	
4. Hired capital	$P_1/0$	P_4/V	
5. Operator	Y/0	Y/V	
Total	100	100	

Appendix Table 3. Distribution of net farm income by income and tractor ownership class and type of tractor used, 1981-82, Wet season, Suphanburi, Thailand.

Net farm Income Classes	Type of tractor				Tractor ownership class			
	Four-wheel tractor		Two-wheel tractor		Owned-tractor		Hired tractor	
	No. of farm	Income	No. of farm	Income	No. of farm	Income	No. of farm	Income
Under 5000	15.28	2.74	18.80	3.24	11.19	1.49	29.58	9.01
5000 - 9999	30.56	8.96	42.11	16.36	22.38	6.32	67.61	39.70
10000 - 14999	48.62	20.71	67.66	33.58	42.53	19.78	84.51	60.91
15000 - 19999	65.29	36.13	81.96	60.10	68.65	44.90	90.14	71.45
20000 - 24999	73.62	45.72	87.98	70.21	76.86	54.75	44.37	81.04
25000 - 29999	76.40	49.07	94.75	84.78	83.58	64.97	97.19	89.05
30000 - 34999	81.96	57.90	97.01	89.56	88.06	83.01	100	100
35000 - 39999	88.90	70.82	98.51	93.78	93.28	83.01	100	100
40000 - 44999	91.68	76.68	-	-	94.03	84.64	-	-
45000 - 49999	94.46	83.39	-	-	95.52	8.43	-	-
50000 - 54999	97.24	91.02	99.26	96.60	97.76	94.79	-	-
Over 55000	100	100	100	100	100	100	-	-

Appendix Table 4. Distribution of net farm income by income and tractor ownershup class and tractor use, Dry season, 1982, Suphanburi, Thailand.

Net farm Income class	Type of tractor				Tractor ownership			
	Four-wheel tractor		Two-wheel tractor farm		Owned tractor		Hired tractor	
	No. of farm	Income	No. of farm	Income	No. of farm	Income	No. of farm	Income
Under 5000	29.23	5.81	27.56	6/.79	16.67	3.35	50.00	17.14
5000 - 9999	55.38	20.58	57.73	28.58	43.24	19.15	80.30	51.85
10000 - 14999	64.61	29.26	74.27	47.98	61.11	33.65	90.01	71.52
15000 - 14999	79.99	51.45	90.02	74.67	81.74	60.43	96.97	88.10
20000 - 24999	86.14	63.17	93.17	81.74	86.50	68.52	100	100
25000 - 29999	90.76	73.90	97.89	94.54	93.64	83.45	-	-
30000 - 34999	96.91	90.29	98.68	96.88	97.61	93.01	-	-
35000 - 39999	98.45	94.88	-	-	98.40	95.18	-	-
Over 40000	100	100	100	100	100	100	-	-

Appendix Table 5. Distribution of net farm income by income and tractor ownership class, Wet season, 1981-82, Suphanburi, Thailand.

Net farm Income class (NNFI)	Tractor ownership							
	4T(O)		2T(O)		4T(H)		2T(H)	
	No.of farm	Income	No. of farm	Income	No. of farm	Income	No. of farm	Income
Under 5000	6.25	0.73	13.95	2.03	33.33	10.66	27.66	7.76
5000 - 9999	18.75	3.22	24.42	6.92	54.16	23.68	74.47	51.75
10000 - 14999	37.50	15.50	45.35	22.34	70.83	41.18	91.49	72.75
15000 - 19999	58.33	31.59	74.42	53.56	79.16	53.93	95.75	84.62
20000 - 24999	64.58	37.18	83.72	66.37	91.6	76.77	-	-
25000 - 29999	66.6	39.84	93.02	82.13	95.83	97.88	91.86	
30000 - 34999	74.99	50.92	93.35	86.78	-	-	100	100
35000 - 34999	83.41	67.16	97.68	92.12	-	-	-	-
40000 - 44999	87.49	70.78	-	-	100	100	-	-
45000 - 49999	91.66	79.20	-	-		-	-	-
50000 - 54999	93.83	88.77	98.84	95.69	-	-	-	-
Over 55000	100	100	100	100	-		-	-

Appendix Table 6. Distribution of net farm income by income and tractor ownership class, 1982 Dry season, Suphanburi, Thailand.

Net farm Income class (NNFI)	Tractor ownership							
	4T(0)		2T(0)		4T(H)		2T(H)	
	No. of farm	Income	No. of farm	Income	No. of farm	Income	No. of farm	Income
Under 5000	96.67	2.43	16.67	3.91	48.80	52.17	19.39	
5000 - 9999	42.86	14.44	46.43	22.02	81.40	55.99	78.25	45.28
10000 - 14999	50.00	19.95	66.67	42.00	90.70	72.96	91.29	69.22
15000 - 19999	73.81	47.03	85.72	68.61	100	100	-	-
20000 - 24999	78.57	54.01	90.48	77.38	-	-	100	100
25000 - 29999	85.71	67.40	97.62	93.25	-	-	-	-
30000 - 34999	95.23	87.88	98.81	96.16	-	-	-	-
35000 - 39999	96.67	93.60	-	-	-	-	-	-
Over 40000	100	100	100	100	-	--	-	-

Appendix Table 7. Distribution of farm household income by income and tractoer ownership class 1981-82 Wet season, Suphanburi, Thailand.

Farm household Income (NNI)	Tractor ownership							
	4T(0)		2T(0)		4T(H)		2T(H)	
	No. of farm	Income	No. of farm	Income	No. of farm	Income	No. of farm	Income
Under 5000	4.17	0.42	5.81	0.72	8.3	2.09	12.77	3.17
5000 - 9999	10.42	2.06	10.46	2.34	25.00	9.70	42.56	19.92
10000 - 14999	27.09	9.01	34.88	16.66	34.17	33.09	69.96	42.20
15000 - 19999	47.92	21.76	56.97	34.41	75.00	55.33	87.74	69.43
20000 - 24999	58.34	30.15	73.25	50.80	83.33	65.74	89.37	72.82
25000 - 2999	62.51	34.17	82.55	62.04	91.66	80.04	93.63	81.43
30000 - 34999	66.69	38.72	88.36	71.05	-	-	-	-
35000 - 39999	72.93	46.63	94.17	81.23	89.03	97.89	93.32	
40000 - 44999	79.18	55.80	96.50	85.69	100	100	100	100
45000 - 49999	83.35	62.40	-	-	-	-	-	-
50000 - 54999	87.52	69.91	97.66	88.43	-	-	-	-
55000 - 59999	91.69	78.72	-	-	-	-	-	-
60000 - 64999	95.86	87.25	-	-	-	-	-	-
65000 - 69999	97.94	92.28	98.82	92.00	-	-	-	-
Over 70000	100	100	100	100	-	-	-	-

Appendix Table 8. Distribution of household income by income and tractor ownership class, 1982, Suphanburi, Thailand.

Farm Household Income (NNI)	Tractor ownership							
	4T(0)		2T(0)		4T(H)		2T(H)	
	No. of farm	Income	No. of farm	Income	No. of farm	Income	No. of farm	Income
Under 5000	9.52	1.38	9.52	1.93	27.90	8.37	26.09	6.51
5000 - 9999	35.71	12.43	32.14	13.41	53.48	24.66	52.18	20.84
10000 - 14999	50.00	22.12	55.45	32.35	67.43	40.71	69.57	36.31
15000 - 19999	66.67	39.42	76.19	54.87	93.34	86.40	78.26	48.20
20000 - 24999	73.81	48.67	83.33	65.06	-	-	86.95	63.63
25000 - 29999	83.33	64.36	90.47	72.98	97.67	92.05	91.30	73.46
30000 - 34999	92.15	82.81	94.04	83.10	-	-	95.65	83.78
35000 - 39999	97.61	93.02	97.61	93.69	100	100	-	-
40000 - 44999	-	-	100	100	-	-	-	-
Over 45000	100	100	-	-	-	-	100	100

Appendix Table 9. Land cost by tractor ownership, 1981-82 wet season, Suphanburi, Thailand.

	Tractor ownership			
	4T(O)	2T(O)	4T(H)	2T(H)
Land holding (ha)	249.27	383.14	74.19	96.26
Cultivated land (ha)	197.04	316.64	58.20	89.61
Land cost (baht/ha)				
Rent in land	413	928	1197	872
- cash	135	234	162	219
- paddy	278	694	1034	653
Imputed owned land	2274	1855	1627	1861
Total land cost	2688	2837	2824	2732

Appendix Table 10. Land cost by tractor ownership, 1982 dry seson, Suphanburi, Thailand.

	Tractor ownership			
	4T(O)	2T(O)	4T(H)	2T(H)
Land holding (ha)	258.16	378.52	66.04	85.07
Cultivated land (ha)	223.28	335.08	53.00	82.59
Land cost (baht/ha)				
Rent in land	174	428	901	576
- cash	38	117	211	131
- paddy	136	311	689	445
Imputed owned land	1909	1387	630	1452
Total land cost	2083	1816	1531	2029

Appendix Table 11. Labor cost per hectare, by tractor ownership, 1981/82 wet season, Suphanburi, Thailand.

	Tractor ownership			
	4T(O)	2T(O)	4T(H)	2T(H)
	baht/ha			
Labor used with tractors land preparation				
- family	151	175	110	59
- hired	-	-	70	130
Labor used with machines for all activities				
- family	27	24	80	46
- hired	29	15	26	32
Labor used without machines				
- family	863	1035	1178	1437
- hired	1457	1309	1277	1381
Total imputed cost	1041	1233	1169	1543
Total paid out cost	1486	1337	1369	1461

Appendix Table 12. Labor cost per hectare, by tractor ownership, 1982 dry season, Suphanburi, Thailand.

	Tractor ownership			
	4T(O)	2T(O)	4T(H)	2T(H)
	baht/ha			
Labor using tractor for land preparation				
- family	262	164	27	91
- hired	-	-	28	82
Labor using machine for all activities[a]				
- family	92	57	61	38
- hired	21	22	62	22
Labor without machines				
- family	756	885	978	1401
- hired	1510	1291	1537	1073
Total imputed cost	1110	1106	1067	1531
Total paid out cost	1531	1315	1628	1178

[a] Including planting, cultivating, irrigating, transporting, milling and marketing.

Appendix Table 13. Capital cost by tractor ownership, 1981-82 wet season, Suphanburi, Thailand.

	Tractor ownership			
	4T(O)	2T(O)	4T(H)	2T(H)
Tractor				
Tractor work (hrs/ha)	25	54	20	26
Imputed owned tractor cost (baht/ha)	818	999	-	-
Paid out hired tractor (baht/ha)	-	-	817	843
Market rent (baht/ha)	1250	1250	-	-
Machine				
Imputed machine cost (baht/ha)	532	555	418	260
Paid out machine (baht/ha)	174	282	145	397
Market rent (baht/hr)	60	60	60	60
Total				
Paid out (baht/ha)	532	555	962	992
Imputed cost (baht/ha)	1351	1554	418	260

Appendix Table 14. Capital cost by tractor ownership, 1982 dry season, Suphanburi, Thailand.

	Tractor ownership			
	4T(O)	2T(O)	4T(H)	2T(H)
Tractor				
Tractor hours worked (hrs/ha)	22	24	20	27
Imputed cost for tractor (baht/ha)	750	851	-	-
Paid out cost for hired tractor (baht/ha)	-	-	869.98	960
Market rent (baht/ha)	1250	1250	-	-
Other machines				
Paid out	220	232	159	206
Imputed owned	470	362	295	274
Market rent (baht/hrs)	60	60	60	60
Total				
Paid out cost (baht/ha)	220	232	1029	1167
Imputed cost (baht/ha)	1221	1213	295	274

Appendix Table 15. Material input and yield per hectare by tractor ownership class, 1981-82 wet season, Suphanburi, Thailand.

	Tractor ownership			
	4T(O)	2T(O)	4T(H)	2T(H)
Seed (kg/ha)	77.13	85.23	79.53	64.50
(baht/ha)	252.82	296.64	257.54	169.57
Fertilizer (kg/ha)	307.36	354.83	327.31	304.28
(baht/ha)	1587.21	1809.65	1768.16	1734.39
Pesticide (kg/ha)	23.21	30.39	24.33	22.99
(baht/ha)	274.80	349.48	236.29	259.27
Oil and Fuel (baht/ha)	483.234	462.06	302.83	203.09
Total material input (baht/ha)	2598.05	2917.84	2625.29	2366.32
Yield (kg/ha)	3522.72	3771.76	3432.47	3156.65
(baht/ha)	10755.28	10950.07	1193.57	10476.08

Appendix Table 16. Material input and yield per hectare by tractor ownership class, 1982 dry season, Suphanburi, Thailand.

	Tractor ownership			
	4T(O)	2T(O)	4T(H)	2T(H)
Seed (kg/ha)	99.83	81.45	78.90	83.36
(baht/ha)	191.45	242.67	201.15	204.26
Fertilizer (kg/ha)	356.71	328.90	300.34	303.95
(baht/ha)	1573.99	1600.88	1598.33	1599.88
Pesticide (kg/ha)	22.82	21.81	13.92	20.82
(baht/ha)	221.89	330.10	260.76	305.78
Oil and Fuel (lit/ha)(a)	54.71	47.74	22.06	26.05
(baht/ha)	447.64	382.38	202.49	262.89
Total material input (baht/ha)	2657.67	2556.60	2262.73	2372.83
Yield (kg/ha)	3914.89	3545.67	4605.15	3381.49
Value (baht/ha)	8852.36	8884.45	8415.40	8029.67