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The Consequences of Small Rice Farm Mechanization in Thailand

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The National Economic and Social Development Board
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FOREWORD

The history of farm mechanization in Thailand extends back to the early nineteenth century. It was not, however, until the last 25 years that the development and introduction of appropriate engineering designs and the emergence of a strong local farm machinery industry stimulated growth and utilization of farm machinery. On the demand side, expansion in the area under cultivation, extension and improvement in irrigation systems and adoption of multiple cropping increased the demand for tractors, threshers and water pumps and transport equipment.

Widespread adoption of farm machinery has raised many controversial issues. Of particular interest is the potential impact of machines on rural employment and income distribution. Until recently, the land frontier in Thailand has been open and population pressure low. Engineering technologies which complement land and enhance labor productivity have been indispensable to sustained growth in the production of rice and other crops such as maize, cassava and sugar. Many studies have been conducted to investigate the profitability and impact of farm machinery on output, income and employment. Different studies, however, reach different conclusions and policy recommendations. In general, the desirability of expanding the use of engineering technologies depends on the range of equipment designs available, the socio-economics, climate and the profitability of agricultural production.

A workshop on the Consequences of Small Rice Farm Mechanization in Thailand was held in Bangkok, November 10-11, 1983. The genearal objectives were to discuss: 1) the role of engineering technologies in accelerating and sustaining agricultural growth, 2) evaluate prevailing policies, 3) assess the nature of constraints facing the small farm equipment industry, and 4) develop some guidelines for the future. To accommodate these objectives, the workshop was divided into five sessions:

1. The role of agricultural engineering technologies in agriculture. This session reviewed the historical background of farm machines in Thai agriculture, including an assessment of past policies and programs.

2. The impact of mechanization on output, employment, and income. The empirical evidence relating to the production, employment and income impacts of mechanization was presented and discussed in this session.

3. The economics of mechanization. The costs and return from use of tractors and threshers were discussed in this session.

4. National policies, manufacturing and supporting infrastructure for mechanization. This session included an evaluation of policies effecting the farm machinery industry and agriculture.

5. Summary and development of recommendations. A set of policies and strategies were drawn from small group discussions.

The papers in this volume were presented at the workshop. Although of a preliminary nature, they provide evidence on the consequences of using small machines on Thai agriculture on a broad perspective on policy relating to agricultural development. The papers and discussion which composed the workshop also were useful in highlighting additional research and development which is needed to fill gaps in the existing range of engineering technologies used in Thai agriculture.

ACKNOWLEDGEMENT

The workshop was planned and carried through the collaborative agreement between the Kasetsart University Research and Development Institute and the International Rice Research Institute. General sponsorship was provided by the National Economic and Development Board and the Agricultural Engineering Division of the Department of Agriculture. Participants consisted of economists, engineers, agriculturalists, businessmen, government planners and researchers from universities, International Institutions and private companies. Workshop papers were contributed by resource speakers from the Department of Agriculture, Kasetsart University, Khon Kaen University, Sukhothaithamathirach, Thammasat University, Asian Institute of Technology, and the International Rice Research Institute.

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SEMINAR-WORKSHOP ON
THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION IN THAILAND

November 10-11, 1983
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EXECUTIVE SUMMARY

Like many other developing nations in the Asian region, Thailand agriculture moves towards increased farm mechanization. Despite extensive adoption and massive gains, there remain questions regarding the production, employment, income and income distribution effects of farm mechanization. A workshop on "The Consequences of Small Rice Farm Mechanization in Thailand" co-sponsored by the National Economic and Social Development Board (NESDB), Department of Agriculture (DA), Kasetsart University Research and Development Institute (KURDI) and The International Rice Research Institute (IRRI) was held in Bangkok to examine these issues. The workshop was attended by forty-six participants from government agencies, universities, the private sector and international organizations. The meeting focuses on the development of farm mechanization in Thailand, the impact of farm mechanization on interested economic variables, the evaluation of government policies on farm mechanization, and the policy formulation and recommendations.

The summary of major findings is as follows:

(1) The development of farm mechanization in Thailand

Thailand relied on imports of farm machinery until the domestic farm machinery industry emerged in the mid 1960s. The success of this industry is primarily based on the laissez-faire. The government contributes only to training, research and development (R & D). The large firms are generally located in the Central Plain and sell their products through wholesalers or retailers who also provide credit, parts and repair services to customers. Small manufacturers, on the other hand, are scattered throughout the country and sell their products directly to customers. They also provide credit, parts, repair services and training. Despite their substantial share of the market, domestic producers face several problems. Increased importation of used tractors led to tariff protection for local manufacturers in 1982. The protection led to higher domestic prices and lower demand for these machines. Additionally, most domestic manufacturers are small and therefore lack the funds to support R & D units. The shortage of funds makes it extremely difficult to expand and improve existing facilities. They also face high credit risks. Payments are hard to collect, and many times they are forced to reposses the machines.

Even though utilization of farm machinery has expanded rapidly over the last twenty years, hand-tools dominate Thai agriculture. The most commonly used farm machnes are threshers, water pumps and two- and four-wheel tractors. Tractors, the most popular among the farm machines, are primarily used for land preparation. Farmers have access to farm machines through ownership and contracting systems. The contract rates vary with the type of crop and with soil conditions.

Thailand consists of nineteen agro-economic zones in four different geographic regions: Northern, Northeastern, Southern and Central regions, each of which has different machine densities and degrees of mechanization. In general, zones in the Central region have the highest density and degree of farm mechanization, followed by the Northern, Southern and Northeastern regions in that order. Different levels of farm mechanization are due to differences in degrees of farm commercialization, adoption of new technology, the availability of agricultural infrastructure, farmers' incomes, contract rates, and other socio-economic factors.

(2) The impact of farm machinery

The discussion was conducted on both the macro and micro levels. The micro level results were based on survey data on tractors and threshers in Suhanburi province. The macro analysis employed the IRRI Rice Policy Model to simulate ten-year trends and to determine impacts of farm mechanization, irrigation and fertilizer policies on output, employment, policy cost, income and income distribution. Findings drawn from the workshop are as follows:

(a) Output effects

The use of tractors increases total output through the increase in cultivated land and cropping intensity, particularly in well-irrigated areas, since farmers spends less time to prepare more land. This implies that tractorization improves the productivity of both land and labor. In wet season, yields of farms employing two-wheel tractors were higher than those of farms employing four-wheel tractors while the reverse was true in the dry season. In contrast, use of threshers increased total output and yield, since their utilization leads to a reduction in grain loss.

(b) Employment effects

While the use of farm machinery replaces labor in individual farm operations, it does not necessarily reduce total rural employment. Tractorization enables farmers to prepare more land faster which leads to an increase in cultivated land. The expansion can create additional farm employment which in turn absorb all displaced labor. If this is the case, use of farm machnery leads to increased on farm and off-farm employment. Farm mechanization also generates employment in non farm activities. Previous studies show that appropriate farm mechanization techniques increase total rural employment.

(c) Income effects

Empirical evidence shows that the gross income of mechanized farms is higher than that of non-mechanized farms. Tractorization significantly affected both off-farm and non-farm incomes. Farm mechanization causes a slight unequalization in income distribution.

(d) Policy cost

The policy on irrigation investment has the largest effects and is the most costly policy.

(3) The evaluation of government policies

There are no specific policies relating to farm mechanization in Thailand. Several economic policies, however, directly and indirectly affect the manufacture and use of farm machinery.

(a) Trade policies

Frior to 1982, the import tariff structure was biased against the domestic manufacturers of farm machinery, since import tariff rates on parts and engines were higher than tariffs on imported machinery. High importation of cheap second hand tractors persuaded the government to grant higher tariff protection to the industry in 1982. High levels of protection lead to many controversial issues. The most lively debates revolved around the criticism that domestic producers were protected at the expense of poor farmers.

In addition, export taxes on rice have adverse influences on the agricultural sector, since this policy lowers the paddy price to farmers. The high elasticity of foreign demand for Thai rice reduces farmers' incomes and consequently lowers the demand for farm machinery.

(b) Credit policies

The Bank for Agriculture and Agricultural Cooperatives (BAAC) has extended credit in kind to its clients for purchases of farm machines since 1980. Once the registered machine brand is approved by the BAAC, farmers can obtain machines from manufacturers or dealers. This farm mechanization credit has been quite successful since farmers can get good quality machines at relatively low prices. This credit policy, however, benefits primarily large farmers. Credit distribution has been very unequal among different groups of farmers and across regions.

Domestic manufacturers also face financial problem. Besides commercial banks, domestic farm equipment manufacturers can obtain loans from the Small Industrial Finance Office (SIFO) and the Industrial Finance Corporation of Thailand (IFCT), but the amount of these loans are limited and mostly beneficial to large producers.

(c) Industrial development policies

In addition to credit policies, the government launches many policies to promote industrialization such as tax exemption. The promotion is presently emphasized on small-scale industries including that of farm machnery in the outer provinces. Development of farm

machnery is an integral part of rural industrialization. The development is not as successful as it should be because of insufficient infrastructure and market information.

(d) Agricultural development policies

Presently, the Thai government has launched many agricultural development policies such as the use of HYV and fertilizer, improved cropping intensity and irrigation systems. Extensive adoption of new technology increases demand for farm machinery. However, the agricultural development is not successful because of high production and marketing risks. The low education of farmers is another obstacle to the development.

(4) Policy recommendations

Many government agencies are presently involved in farm mechanization activities, but the shortage of manpower makes many of them ineffective. There have been no supporting agencies established to formally coordinate government efforts. Furthermore, most extension workers at field levels have very little or no agricultural engineering knowledge. There is no agency which formally disseminates research information to and obtains feed-back from farmers. The workshop therefore called for an increase in government involvement in farm mechanization.

(a) The government, via The National Agricultural Mechanization Committee, needs to formulate specific policies on farm mechanization as well as clearly assign responsibilities to the concerned agencies.

(b) The government should conduct research on and development of programs on farm mechanization while emphasizing the needs of the poorer agricultural areas. The program should be multi-discipline oriented to increase the capacity of the existing agencies as well as systematically collect data on farm machinery and equipment.

(c) Farm machinery testing units should be set up to evaluate the quality and standard of both domestic and imported machines to ensure machine quality.

(d) Extension officials at the field level should be trained in agricultural engineering to enable them to more effectively advise farmers.

(e) Technical assistance should be provided for domestic producers in the outer provinces.

(f) Advice on the choice of appropriate machines and the production location should be provided to the rural credit institutions.

(g) An increase in irrigated areas and an improvement in the irrigation system is needed.

(h) Whenever feasible, the government should encourage farm machinery and equipment utilization in the rainfed areas.

(i) The government has to assess the impact of taxation, quotas, and credit policies on farmers and domestic producers, specially on the development of forward and backward linkages.

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SECTION I

THE ROLE OF AGRICULTURAL ENGINEERING TECHNOLOGIES IN AGRICULTURE

THE GROWTH AND IMPACT OF SMALL FARM MECHANIZATION IN ASIA*

Kamphol Adulavidhaya and Bart Duff**

ABSTRACT

Mechanization has been adopted rapidly and widely in many countries of Asia during the past two decades. Land preparation and threshing are usually the first tasks to be mechanized, although where water is readily available water lifting equipment may precede these two tasks. There is clear evidence of government intervention in the pricing of farm equipment in most countries, usually through distorted exchange rates, credit subsidies or tariff bariers. Local manufacturing has become more important in all countries, with the exception of Malaysia and helps to foster backward linkages with other segments of the economy.

*Paper presented at the Workshop on the Consequences of Small Rice Farm Mechanization in Thailand held in Bangkok, Thailand, in November 10-11, 1983.

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THE GROWTH AND IMPACT OF SMALL FARM MECHANIZATION IN ASIA

Kamphol Adulavidhaya and Bart Duff

INTRODUCTION

The contents of this paper focus on use of mechanical technologies in agriculture production. The objective is to assemble evidence illustrating the impact of these innovations on growth in production and incomes and to assess the lessons to be derived for expanded use of mechanization in the contemporary developing countries of Asia. Before moving to a discussion of machines, however, it is well to review and summarize the current state of agriculture in the region.

During the past two decades rapid population growth combined with modest increases in per capita income have pushed consumption requirements for rice, the primary source of calories and protein upward at a rate exceeding 2% per year in Asia. With the exception of Japan, there has been increasing per capita demand for rice in all countries of the region.

In the past 10 years, we have also witnessed an unprecedented rise in the cost of energy which has added to inflationary pressures in most economies, particularly those such as Thailand, Bangladesh and the Philippines which have few well developed petroleum resources of their own. The rising prices of both rice and inputs such as fertilizer, water, chemicals and power have impacted most markedly on the lower income groups within these countries. These groups spend a higher proportion of their incomes on rice and suffer most when rice prices increase as a result of higher production costs.

Greatly accelerated investments in irrigation and infrastructure coupled with expanded research to develop and extend packages of modern rice varieties and complementary inputs has kept supply in equilibrium with demand for most years. During the past five years, however, it has become increasingly apparent that the spread of the new rice technology is slowing down. It has been estimated that three-fourths of the rice producers in Asia have been left untouched by the modern technology, particularly those dependent on rainfall or affected by problem soils and lack of control over water supplies.

In this paper, we are concerned with the growth and impact of agricultural machinery on rice production. The report is composed of seven sections. The first briefly reviews the current status of economic growth in the region and the associated changes in the level and composition of the rural labor force. The second and third sections present estimates of the current level and costs of mechanization. The

fourth section deals with the relationships between use of agricultural engineering technologies and other improved inputs. The employment issue is touched on in the fifth section. Patterns of local manufacture of farm equipment are examined in the sixth section. The final section presents a listing of generalizations describing the observed sequence of introduction and the composition of machinery used in the Asian region.

Economic Development and the Expanding Labor Force

There has been measurable growth in most Asian economies, although the figures shown in Table 1 mask the recent impact which inflation has had on increases in Gross National Product and per capita incomes. Agricultural productivity has keep pace with overall growth and increases in population for all but a few countries. It is projected that rice production will have to increase at an annual average rate of 3.6% in Asia if supply is to keep pace with demand (Herdt, 1981a). If supply falls behind increases in demand, the poorest segments of the population will suffer most. These people spent the highest proportion of their incomes on rice and will be able to purchase even less if excess demand increases the rice price. With an estimated 600 million persons already subsisting at inadequate consumption levels in the 1970s, the failure of rice production to meet anticipated increases in demand at constant prices will push an additional 100 million into this category by 1990. A 1% annual increase in the rice price will add 50 million more to this figure (Herdt, 1981a).

Japan, Korea and the Republic of China exhibit rapidly declining labor force participation in the agricultural sector (Table 2). This is evidence of extensive growth in the nonagricultural sectors which has increased the nonfarm demand for labor. In these instances, the substitution of mechanical for human and animal power is a clear solution to the problem of maintaining agricultural production with less labor. It has also been highly complementary to the sustained growth of agricultural output. All other countries have much larger proportions of their labor in agriculture and must anticipate an absolute increase in the numbers of persons employed in this sector over the remainder of this century. Clearly in the latter case, the use of machinery in agriculture must have as a primary goal augmentation of scarce resources such as land, water and purchased inputs rather than a net substitution of machines for labor.

Increases in rice production which have occured during the past decade may be attributed to two major sources - expansion in area under rice production and increased yields. Area expansion results from increases in the cultivated area and multiple cropping on existing land, primarily the result of investments in new and improved irrigation systems which permit cropping during the dry season. Higher levels of

fertilizer inputs, improved irrigation and wider use of modern varieties account for higher yields. Table 3 indicates that approximately 40% of the increases is from expended area and the rest is attributable to higher yields. The picture is highly variable among countries, reflecting differential access to additional land, appropriate yield increasing technology and the availability of funds and research resources. Accordingly, each country also reflects differences in the type, degree and composition of mechanization which is employed.

An Inventory of Rice Mechanization in Asia

National data on the number, size, composition, distribution and use patterns of agricultural machinery are nearly impossible to identify and the degree of reliability for those figures which are accessible is usually low or of indeterminant quality. The figures presented in this section should, therefore, be viewed with caution and interpreted as only orders of magnitude rather than as precise estimates.

The Asian Productivity Organization recently completed a regional survey of mechanization in which both cross-country and temporal comparisons are made. Table 4 presents estimates of the power used in rice production for eight countries. While these figures represent averages or regional approximations which conceal the wide variability which exists within countries, they do permit some useful interpretations. In the case of Japan, Korea and the Republic of China, labor use has been falling rapidly throughout the 1965-78 period. This reflects the increasing urbanization of these economies and a higher degree of mechanization (see Figure 1). Animal power is essentially nonexistent in Japanese rice production. Mechanical hours are also beginning to decline after a high of 170 in 1970, evidence of move to larger machines which permit more rapid completion of work. It is striking that although Japanese rice production is one of the most highly mechanized in the world, there is still a higher level of labor input that for many other countries in the region. Small farms (see Table 6) combined with the high support price for rice continues to make labor used in rice production highly profitable.

Labor use in the Philippines, India, Pakistan and Nepal has increased during the period, largely the result of using the modern rice varieties, although the rise has been partially mitigated by increasing use of mechanization, particularly for land preparation and threshing in the Philippines and Thailand. Thailand shows an increase in the number of machine hours, but with little change in unit labor requirements. Thailand has only recently begun to increasingly employ labor intensive modern rice varieties. The figures for India portray a local situation. Mechanization is not yet common in most of the major rice growing areas of the country, although it is common in the

wheat growing regions of East and West Punjab. Mechanical land preparation and threshing are only recent innovations in the rice production systems of Pakistan.

Table 5 indicates the average density of selected machines. With the exception of the three most advanced countries, one can characterize the most countries as being at an introductory or experimental stage of mechanization. This is clearly shown in Table 6 by the low levels of mechanical power available, although in some instances the estimates represent a high percentage of the total farm power supply. The limitation of these figures is they do not provide an indication of the degree to which the stock of mechanical power is utilized, i.e. how many hp-hrs/ha/crop do machines contribute to the total power needs of agriculture. Not do they given an indication of who uses the machines. Larger farmers may rely almost exclusively on mechanical power with the smaller farms relying on animal and human power. There are, however, a number of small micro surveys which indicate that machine services are being made available on a contract basis to a wide cross section of both large and small farming units (IRRI, 1978; Juarez, 1979; Monge, 1980; NCAER, 1980; Smith, 1979). These studies have regretably not resolved the issues of the distributional or employment impact of mechanization on small farmers or landless laborers in these countries.

The wage and price information contained in Table 6 allow us to draw some rough correlations between the farm wage (expressed in terms of rough rice) and the level of mechanization found in each country. There is a clear association in the case of countries from East Asia. Malaysia, Thailand and Burma also display a similar relationship, although the use of power tillers is not common in Malaysia and this technology does not contribute to the degree these smaller machines do in Thailand. The Philippines and Indonesia have similar wage levels, but exhibit dissimilar patterns of mechanization. Clearly these figures do not show the regional heterogeniety which exists in each country.

The information contained in Table 7 combined with Figure 1 allow a closer look at the conditions prevailing in Japan, Korea and Taiwan at comparable points in their adoption of mechanization. While the period in which mechanization began was different in Japan compared to Korea and Taiwan, they appeared to have passed through four distinct periods. The introductory and early stages were characterized by low but rising real wage rates and a heavy reliance on external sources of technology. During the second and third stages, there was an accelerated shift in the proportion of the labor force in nonagricultural occupations which served to raise the rural wage. Local adaptation and design transfer permitting the indigenous production of equipment became more pervasive, although importation of certain components continued. The source of much of the technology

used in Korea and Taiwan originated in Japan and joint venture manufacture of power tillers and other equipment was common. The stage of full mechanization at which there was one power tiller for each 10 hectares was reached much earlier in Japan than the other countries. The time period between introduction and full use was also much shorter in Japan than either of the other countries, reflecting Japan's high degree of industrialization at the time mechanization began (following World War II).

A clearer picture of the sequence, pattern and growth of mechanization is given in Table 8. The first mechanical technologies were focused on the control and management of rice pests and land preparation equipment. Because gravity irrigation and drainage systems were so well developed there is little evidence that water was a constraint to sustained rice output at this time and there were few water pumps employed. With increased industrialization, there was further movement to introduce machines which enhanced the productivity of onfarm labor. Larger four wheel tractors, threshers followed by binders and finally small combine harvestors all have been important. Since the mid-1970s there has also been a shift from two-wheel to larger four-wheel tractors. In the past five years the size of equipment has also incresed and the number of tractors on Japanese farms is beginning to decline.

The history of mechanization in the contemporary developing countries has paralleled that of Japan, Korea and Taiwan in several ways. The sequence has been similar. Land preparation equipment is inevitably the first technology employed. We also find that pest control equipment accounts for the largest number of machines in all countries. Almost all farmers either own or have access to a knapsack or pressure sprayer. In countries such as Pakistan which has a very limited water supply, irrigation pumps have been the priority mechanical technology. Recent evidence from the Philippines and Thailand indicates that threshing equipment has also begun to be used in large numbers (Juarez, 1978). With the exception of irrigation pumps, pest control equipment and some types of post-harvest machinery, most of these machines represent a clear substitution of capital for human and animal power. The evidence is not conclusive to demonstrate that tractors for example, have augmented the area under cultivation or increased either cropping intensities or crop yields. The rationale for mechanizing land preparation must therefore lie its profitability to the individual farmer and machine owner rather than in benefits attributable to increased output. There are clearly exceptions to this argument as in the case of bringing additional land under cultivation by supplementing existing onfarm power supplies with machines. An example for realizing this type of potential is found in many of the transmigration a reason the outer islands of Indonesia. Most farmers fail to cultivate the full allotment of land because of insufficient pwoer and the proper tools.

The Cost of Agricultural Machinery

A crucial question in the decision to invest in mechanized equipment is the initial cost. In Table 9, we present the unit cost and rankings for two types of machines used primarily for land preparation. Calculations using private costs indicate that Nepal and Pakistan sell 4-wheel tractors at a lower cost than Japan. Four countries sell 10 HP diesel power tillers for less than Japan, Korea and the Republic of China. While these costs may partially represent export strategy of machinery supplies or the higher level of sophistication embodied in the machines (power steering, hydraulic controls, etc. need in these countries as opposed to simple "bare bones" machines, there may also be a degree of hidden subsidy which is not expressed in the selling price. To carry the analysis further, we have converted the dollar cost (using the domestic paddy price) to a rice equivalent (kg/hp) representing the amount which a farmer must pay to acquire the machine. This figure reflects the real cost and would be the key element entering the decision to acquire a machine. In this instance, the rankings of machine cost closely parallels the level of mechanical power available in each country.

It is helpful to examine the degree to which prices have changed in these countries over time. Referring to Table 10, we find that in Japan, Korea and the Republic of China paddy prices have advanced more rapidly than the cost of machinery. Rural wages in the latter two countries have also shown a comparatively higher rate of increase than farm equipment. In most cases, fuel prices have risen more rapidly than either rice or other input costs, particularly during the past five years. This price increase is most evident in the cases of the Philippines, Pakistan and Thailand, countries which have few domestic petroleum resources. With the apparent exception of Korea, India and Nepal, the rise in the cost of fuel has not been compensated by a commensurate increase in the price of paddy. The price of draft animals has also risen substantially in a number of countries. While these indices should be accepted with caution, they are instructive in interpreting trends in the use of machinery in a number of the countries under review.

Mechanization and Other Inputs

There is an extensive literature on the adoption of the modern rice varieties in Asia (Herdt, 1981a; Palacpac, 1980; IRRI, 1975). It is generally accepted that the technology currently available is highly location specific, being most readily accepted in those areas with good soils, irrigation and access to supporting credit and input markets. There is also evidence indicating mechanization is most widely employed in many of these same areas (IRRI, 1975). Higher yields make adoption and use of machines more profitable to farmers and less risky to investors. For a specific case, we refer to

information from Laguna and Central Luzon Provinces in the Philippines. Table 11, taken from a 1978 household enumeration of eight villages in Central Luzon, a major rice growing area, shows that 60% of these farmers owned or used mechanized equipment for primary tillage. Many, however, used water bufallo for secondary tillage or owned them as insurance against nonavailability of tractors and power tillers. The same survey showed that farmers may change their choice of technique depending on the season, yield of the previous crop and cost of land preparation.

In Laguna, the pattern of adoption is clearly shown overtime (Table 12). Table 13 indicates the gradual increase in machine owners and decline in the number of water buffalo.

Mechanization and Employment

It was clear in examining the evidence from Japan, Korea and the Republic of China that the principal motivation in substituting machines for animal and human labor was a rising rural wage induced by industrialization, urbanization and the structural transformation of these economies. There appears to be a different set of forces at work in the labor-surplus countries of the region. While private profitability is the driving force in decisions to invest in agricultural equipment at the farm level, the presence of highly skewed patterns of access to and ownership of the means to production (land, water, credit) poses the danger of inequitable distribution of gains from increased agricultural productivity. There are many who voice concern that machines may exacerbate an already precarious level of income for small farmers and landless laborers (Herdt, 1981b; Sisler, 1979).

The data available indicate that as mechanized land preparation is introduced, it is primarily family and animal labor which is replaced. The evidence in Table 14 supports this finding. For operations such as threshing, which in many countries is traditionally performed by hired labor, there seems to be a much greater danger that these people will be replaced. In the absence of alternative employment opportunities, this can lead to a lower level of income. Survey work in the Philippines does support the contention that mechanical threshing reduces total labor requirements of which a substantial portion is hired (Table 15). While the relative proportion of hired labor and the real wage increases in the threshing operation, the total number of mandays required is reduced. The net effect is a reduction in earnings by hired labor. As much of this equipment is locally produced and maintained, it is unclear if new wage income have declined.

Private profitability provides the inducement to invest in the machine. It is not clear, however, whether the gap between the farmer's benefits and laborer's losses truly reflects society's gain from use of the machine. The research by David (1982) and Supachat (1982) in evaluating the Domestic Resource Costs of these innovations point to some distortions which have tended to subsidize the machines through special credit programs and (before 1988) subsidies on fuel in Thailand and the Philippines. The degree and nature of these subsidies and the policies which induce them need further evaluation.

Mechanization and Output

Farm mechanization can potentially effect output in four ways: (1) it can increase yields; (2) it can increase cropping intensity, (3) it can expand cultivated area and, (4) it can reduce losses and improve quality in post-harvest operations. In Table 16 we have attempted to assemble the available evidence describing the impact of mechanized land preparation on crop yields. If proper adjustments are made for the level of other inputs such as fertilzier there appears to be no significant difference in the output per hectare from farms using mechanical methods compared to those using animal or manual techniques. One exception is the study reported by Tan and Wicks (1982). There appears to be little physiological basis for yield increments resulting from land preparation methods under lowland conditions. Experiments conducted by Duff (1978) using five alternative land preparation methods failed to demonstrate significant differences in yield, although the experiment did show a direct relationship between weed population and yield. While the above generalization appears to be true for lowland rice, it is unlikely the same results will hold true for upland crops such as wheat, corn and sorghum which may react more positively to a higher quality seedbed than rice under flooded conditions.

It is clear that use of tractors and power tillers for land preparation represents only one possible source of higher yield. There is little debate that better methods of weeding, fertilizer application, and pesticide control can produce increased yields compared to many traditional methods. The high population of hand srayers found in all countries of Asia is strong evidence of this observation.

The second major source of potential production increases from mechanization is the impact which it may have on crop intensification or the number of crops grown each year. Those arguing for mechanization to achieve intensified cropping have cited the need for more timely harvesting and threshing combined with rapid land preparation for the second (or third) crop to maximize use of scarce water, land and solar energy resources. The evidence on the intensification issue is more ambigous than that for yields. Table 17

combines the results from a number of studies which have attempted to examine this issue. For the irrigated areas of the Philippine the effect appears to be positive, although with a wide degree of variability between sites and environments. Nepal and India also show slight gains from use of tractors and power tillers, although these were not statistically significant at any of these sites. The work of the Mechanization Consequences project in Indonesia shows slightly lower cropping intensity on farms employing mechanization than for those using traditional methods. Again, however, the differences are small tending to indicate power for land preparation is not a major constraint in these farming systems. Changes in the irrigation scheduling systems combined with efforts to foster a three crop system in West Java have increased concern that there may not be sufficient labor and animal power available to maintain existing cropping intensity without provision of supplemental power for land preparation.

The evidence from Japan, Taiwan and, more recently, from Korea shows that these countries achieved their maximum cropping intensities before the advent of mechanized land preparation, although the ability to sustain high levels of cropping intensity following structural transformation was clearly due to the availability of mechanical devices which supplemented available supplies of human and animal labor.

The use of mechanical threshing has also been examined in the Philippines (Table 18). The results are similar to those for land preparation. The ability to plant a second or third crop appears to be determined largely by the timing of water deliveries and the synchronous planting of groups of farmers to minimize the risk of pest damage rather than constraints on harvesting-threshing operations.

The third possible source of increased output resulting from mechanization is an expansion in the land under cultivation. The historical evidence from the United States, Canada, and the Soviet Union illustrates that it was the introduction and use of mechanical devices such as the McCormick reaper, the crawler tractor and the wheel tractor which allowed these countries to expand the area under crops during the period of the late 1800s and early 1900s. In most Asian countries, however, the land frontier is closed and the opportunity for expansion in cultivated area is limited. The data gathered by Binswanger describing the development of mechanization in Thailand supports the hypothesis that growth in the cultivated area over the past three decades is highly correlated with the introduction of tractors and power tillers. A similar potential appears to exist in Burma which has extensive unused land resources. The transmigration areas of Indonesia may also harbor similar opportunities. The data which we have available does not, however, indicate a clear relationship between mechanization and growth in the cultivated area.

As a general rule, it is unlikely that the use of mechanization will result in more land being brought under crops in countries where the land available for development is limited or the cost of development is high and the cost of alternatives such as labor and animal power are low.

Domestic Manufacture of Agricultural Equipment

Most Asian countries have moved rapidly in the past decade to internalize production of agricultural machinery. In some instances this has been a conscious effort on the part of planning agencies to maximize employment and provide backward linkages with the agricultural sector. In other cases, such as Thailand, there seems to have been little government intervention in the establishment of the agricultural machinery manufacturing industry. It appeared as a consequence of the demand for supplemental farm power. An expanding farm area coupled with large farm size may have induced these developments in the early 1960s (Binswanger, 1982).

The high cost and inappropriate nature of existing machinery from the developed world was another factor which has encouraged efforts to design and develop suitable low cost equipment for small rice farms. Most governments view these efforts with enthusiasm as they promote the development of small-scale manufacturing, enhance skills, provide employment in labor-intensive processes, reduce foreign exchange requirements and are seen as a means to decentralize industrial development. One of the most difficult problems facing countries in the region is the provision of gainful employment to those who move to large cities such as Manila, Jakarta, Lahore, New Delhi and Bangkok. This pattern of urbanization has created tremendous problems in the provision of services such as education, sanitation, law enforcement and housing. A solution suggested by some is to encourage small - and medium-scale industrial development in smaller regional cities (Hackenburg, 1980). These provide ready access to rural markets and would be better able to cope with problems induced by migration from the countryside.

A principal problem in encouraging regional or decentralized development is the identification of suitable industries which have a demand for their products in the agricultural sector. Agricultural equipment of simple design appears to meet this need. The remaining constraint has been provision of suitable designs which meet the technical and economic requirements of the small farmer.

There are many examples of industrial products which have emerged in response to a perceived demand in agriculture. The diesel engine and tubewell industry in Pakistan and the water pump and power tiller manufacturers in Thailand are excellent illustrations. In the Philippines, the hunder of small companies making Jeepney bodies

throughout the country also attest to the ability of local entrepreneurs (Cabanos, 1971). The Ford Motor Company's Fierra, an austere utility vehicle, represents a somewhat more formal attempt to maximize use of local resources while realizing the economies of mass production (Follosco, 1978).

For those responsible for and concerned with the planning and implementation of efficient agricultural development strategies, a key question is "what pattern of mechanization results in sustained increases in production while concurrently providing equity and social justice in the distribution of benefits?". It should be apparent the answer will depend greatly on the economic, cultural and technical conditions inherent in each specific environment. These conditions will differ among countries and between region within countries.

The following sequence of activities seems necessary (although not always sufficient):

Sequence of Activities	Main actors
1. Identification of needs	Interdisciplinary farmers engineers social scientists biological scientists research administrators policy planners
2. Conceptualization of suitable technology	Engineers
3. Transfer, adapt or development of technology	Engineers
4. Test and Evaluation	Engineers working with relevant interdisciplinary group
5. Industrial Extension of Technology	Engineers, manufacturers and policy makers
6. Farm Level Extension	Manufacturers, extension personnel and policy makers

The system must be responsive to review and evaluation at any step in the sequence of activities. For example, the need for a technology may be identified at step one, but prove intractable to solution at the conceptual or development stages. A more difficult case would be the instance when a technology passes through steps one to four, but upon review it is found the resulting machine would produce a potential net negative impact on incomes at the farm level.

With modifications reflecting local conditions, the system or variants has been implemented through IRRI's industrial extension program working closely with local agencies in sex Asian nations. After nearly 10 years of intensive effort, the result has been a significant increase in the number of local firms producing agricultural machinery utilized by a broad cross section of rice farmers. An additional benefit has been the demonstrated capacity of these firms to gradually assume and expand their participation in the R & D process. In a recent Philippine study, Mikkelsen (1981) reports that well over 40% of the firms participating in IRRI's industrial extension program were involved in formal "inventive" R & D. Only two of the 45 firms in the survey did not "innovative" (as contrasted with "inventive") work to improve the performance of the machine, to differentiate it from others being sold in the same market or to adapt it to the firm's manufacturing capabilities.

Priorities for Agricultural Planners, Engineers and Economists

There is a need to develop a consistent, consolidated and comprehensive strategy for the mechanization of small rice farms. We suggest the following as urgent topics for agricultural mechanization planning and research in the 1980s:

1. A clear identification of the engineering needs at the farm level with specific attention to local technical, economic, cultural and environmental conditions. Scarce research resources should only be commited to those design and development projects which potentially contribute a net positive benefit, weighing both the short and long run impact on benefits, costs and adjustments in the agricultural sector.

2. Clarify the benefits and costs of mechanization at both the micro and the macro levels. What impact do machines have on crop yields, intensity, cropping patterns and area under cultivation? What is the value of increased hp-hrs/ha? Who benefits? Is there a major difference between the private and social profitability of mechanization? Which criteria should be used in identifying the need for agricultural engineering technologies?

3. What are the immediate and long run income and employment effects of policies to encourage rural-based industrial activities? What are the multiplier effets of income generating developments in this subsector?

4. What is the likely impact of rising energy costs in the Asian region on agricultural development and what engineering innovations are needed to ensure these costs do not retard further increase in production?

5. In areas which have been untouched by the modern varieties, what can engineers contribute to improve the likely development and use of improved technology for the conditions found in these areas?

6. Lastly, what are the component elements and the minimum critical size of an agricultural mechanization development program?

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Table 1. Cross-country comparison of growth in gross national product, agricultural production and labor force in Asia.

Country	GNP/Cap. 1979 (US $)	Growth of real GNP 1971-80 (%)	Growth of ag. prod. 1971-80 (%)	Growth of labor for. 1970-80 (%)	Labor in agric. 1960 (%)	Labor in agric. 1979 (%)	Projected growth ag. L.F. 1977-2000
Japan	8718	5.5	1.2	1.3	33	13	-9.03
Rep. of China	1650	2.3	2.3	2.3	--	22	-3.84
Rep. of Korea	1500	3.9	3.9	2.8	66	36	-2.38
Malaysia	1370	4.0	5.0	2.6	63	51	.71
Philippines	600	6.1	4.1	2.4	61	47	1.74
Thailand	590	7.0	4.7	2.7	84	77	1.94
Indonesia	380	7.5	2.9	2.5	75	59	.97
Pakistan	270	4.5	3.0	2.6	61	57	1.86
Sri Lanka	230	4.0	2.0	2.0	56	51	.92
India	190	3.2	2.1	1.7	74	71	1.46
Burma	160	1.1	3.9	1.5	--	67	1.46
Nepal	130	2.2	1.5	2.1	95	93	--
Bangladesh	90	-0.1	1.9	3.3	87	74	1.68

Sources: As cited in Asian Productivity Organization 1981a, p.5. data for labor force in agriculture and country figures for Malaysia, Burma and Bangladesh from IBRD, World Development Report, 1981, pp. 134, 170-71. Projected labor force growth rates from Herdt, 1981a.

Table 2. Growth rates of total labor force, non-agricultural portion and resulting residual rate of growth in agricultural labor force, Asian countries, 1970-2000.

	Growth rate of labor force		Growth rate of non-ag. L.F.*	% of L.F. in non-ag.	Resulting calculated growth in ag. labor force	
	1970-77	1977-2000	1970-75	1977	1970-75	1977-2000
Thailand	2.5	2.3	3.5	23	2.20	1.94
Pakistan	2.4	2.8	4.1	42	1.17	1.86
Philippines	2.1	2.6	3.5	49	0.75	1.74
Bangladesh	2.3	2.7	6.3	22	1.17	1.68
Burma	1.4	1.9	3.8	45	-0.56	1.46
India	1.7	1.9	3.1	27	1.18	1.46
Indonesia	2.0	1.9	3.3	40	1.13	0.97
Sri Lanka	2.1	2.2	3.7	46	0.74	0.92
Malaysia	3.6	3.0	4.8	56	2.07	0.71
Korea	2.9	1.9	5.4	55	-0.16	-2.38
Taiwan	1.9	1.6	4.4	66	-2.95	-3.84
Japan	1.3	0.8	2.4	86	-5.46	-9.03

*Growth rate in urban population used as a proxy.

Source: Calculated from data in IBRD, World Development Project Report, 1979 and described in Herdt, 1981a.

Table 3. Growth rates of rice produciton, area and yield compared to growth rate in agricultural labor force, 1970-1978 (Herdt, 1981a).

	Growth rate (%/year)					
	Rice production	Rice area	Rice yield	Agricultural labor force	Output per worker	Labor per hectare
			Mainly rice based agricultural sector			
Bangladesh	1.97	0.58	1.39	1.17	0.80	0.59
India	2.46	0.68	1.78	1.18	1.28	0.50
Burma (projected L.F.[a])	3.07	0.99	2.08	-0.56	1.61[a]	0.47[a]
Indonesia	3.80	1.20	2.60	1.13	2.67	-0.07
Thailand	2.96	2.23	0.73	2.20	0.76	-0.03
Philippines	5.39	0.79	4.60	0.75	4.64	-0.04
			Other crops predominant in agricultural sector			
Pakistan (wheat)	4.95	4.76	0.19	1.17	3.78	-3.59
Sri Lanka (tea, spices)	4.99	4.78	0.21	0.74	4.25	-5.54
Malaysia (rubber, oil palm)	2.69	3.38	-0.69	2.07	0.62	-1.31
			Declining agricultural labor force countries			
Burma	3.07	0.99	2.08	-0.56	3.63	-1.55
Korea	4.37	0.53	3.84	-0.16	4.53	-0.69
Taiwan	0.40	-0.43	0.83	-2.95	3.35	-2.52
Japan	0.31	-1.00	1.31	-5.46	5.77	-4.46

Source: Rice growth rates calculated from USDA Foreign Agricultural Circular: Grains 79-20; other data from Table 1 or calculated from Table 1 and first 3 columns of this table.

[a]Uses the projected (1977-2000) rate of growth in agricultural labor force rather than the 1970-75 because the latter actually registered a decline.

Table 4. Estimated inputs of human, animal and mechanical power in rice production in selected countries of Asia, 1980 (hrs/ha).

Country	1965	1970	1975	1978
Japan				
Human	1401	1178	815	694[a]
Animal	15	2	--	--
Mechanical	144	185	179	148[a]
Rep. of China[b]				
Human	1088	985	778	601
Animal	122	103	51	36
Mechanical	40	56	84	98
Rep. of Korea				
Human	1356	1284	1176	937
Animal	92	101	80	56
Mechanical	4	8	18	48
Thailand[c]				
Human	490	480	470	462
Animal	170	165	160	146
Mechanical	10	15	20	30
India[e]				
Human	1218[f]	958	992	1285[a]
Animal	230[f]	247	221	125[a]
Mechanical	120[f]	na	na	113[a]
Pakistan				
Human	619	637	637	637[a]
Animal	312	308	284	128[a]
Mechanical	na	neg.	2	6[a]
Nepal				
Human	1200[f]	na	na	1448
Animal	312[f]	na	na	304
Mechanical	neg.[f]	na	na	2

Source: APO, 1981a.

Notes: [a] 1979, [b] refer to first season crop only, [c] refers to wet season crop, [d] 1977, [e] average of Tamil Nadu and Orissa, [f] 1968.

Table 5. Estimated inventory of selected agricultural machinery per 100 hectares of arable land.

Country	Water pumps	Power tiller	4-wheel tractor	Hand sprayer	Hand thresher	Power thresher	Reaper	Combine
Japan	-	50.4	26.9	-	-	55.5	29.6	16.2
Rep. of China	19.3	7.3	0.3	34.4	17.9	6.0	0.6	1.0
Rep. of Korea	9.0	11.4	0.1	41.3	13.2	9.7	0.6	0.02
Philippines	1.1	0.9	0.3	3.8	0.03	0.16	-	-
Thailand	2.0	1.4	0.3	5.9	-	0.03	-	-
Indonesia	0.03	0.02	0.01	2.1	0.01	0.009	-	-
Pakistan	0.89	-	0.38	0.08	-	0.08	-	-
Sri Lanka	1.1	1.0	1.8	1.5	0.01	0.05	-	-
India	0.24[a]	0.01	0.23	0.49	-	-	-	-
Nepal	0.39	0.02	0.11	0.12	0.80	0.01	-	-

Source: APO, 1981a.

Note: Dashed line indicates data not available or quantity used negligible.
Statistics cover years from 1979 to 1980.

[a] Includes simple water lifting devices such as Persian Wheels.

Table 6. Power tiller and tractor numbers, wage rates and rice prices, by country, 1971-75 average.

	Tillers per 1000 ha crop land	Wheel crawler tractors per 1000 ha	Farm wage rate US$ per day	Farm wage rate kg rough rice per day	Farm price rough rice US$ per mt
South Asia					
India	+[a]	1.0	0.26	2.1	125
Pakistan	+[b]	1.6	0.39	3.3	119
Sri Lanka	0.1	6.1	0.42	2.6	161
Bangladesh	+	0.3	0.68	3.3	206
Southeast Asia					
Malaysia	0.4	2.3	2.53[c]	12.9[c]	195
Thailand	8.0[c]	1.1	0.59	7.9	75
Philippines	4.1[c]	1.0	0.34	3.1	109
Indonesia	+	0.5	0.71[c]	4.3[c]	167[c]
Burma	0.1	0.8	0.39	7.0	56
East Asia					
Japan	615	48.5	8.78	15.6	563
Taiwan	38	0.6	2.80	17.1	164
Korea	20	0.1	2.07	9.3	223
China	130[d]	4.2	n.a.	n.a.	n.a.

[a] No data available, but authors estimate there are less than 0.5 per 1000 ha.

[b] No statistical estimates available, authors estimate less than 0.05 per 1000 ha.

[c] Refers to 1976.

[d] Refers to 1978.

Sources: Tiller numbers from the IRRI Agricultural Engineering Department. Tractor numbers from FAO Production Yearbooks, except tiller numbers in Thailand and China - from Ishikawa (1981). Wage rates from Appendix Tables (time series) or World Rice Statistics (IRRI). Rice price from Appendix Tables (16.4); World price averaged $310/mt of rice equal to about $200/mt of paddy over the period 1971-75.

Table 7. Farm level rice prices and wage rates during comparable periods of agricultural mechanization, Japan, Korea and Taiwan (Herdt, 1981a).

State of Mechanization		Period	Farm prices in Domestic currency: Rice/mt (paddy)	Farm prices in Domestic currency: Wages/day	Real wage kg paddy per day	Prices in US$: Rice/mt b/	Prices in US$: Wages/day	Prices in US$: World rice price
				Japan				
Initial	Introduction	Pre 1950	na	na	na	na	na	na
Early	2.5 tillers/1000 ha	1950-51	73,000	250	3.4	311	0.70	na
Take-off	20 tillers/1000 ha	1956	77,000	363	4.7	328	1.00	134
Full	100 tillers/1000 ha	1961	77,000	530	6.9	327	1.47	137
				Korea				
Initial	Introduction	1961	14,630	106	7.2	173	0.85	154
Early	2.5 tillers/1000 ha	1968	39,510	381	9.6	216	1.36	201
Take-off	20 tillers/1000 ha	1972	87,680	803	9.2	338	2.02	148
Full	100 tillers/1000 ha	1978	17,600	2,900	16.5	559	5.99	367
				Taiwan				
Initial	Introduction	1955-56	1,600	na	na	86	na	134
Early	2.5 tillers/1000 ha	1961[a]	3,595	35	9.7	98	0.88	137
Take-off	20 tillers/1000 ha	1970	4,734	71	10.1	176	1.77	143
Full	100 tillers/1000 ha[c]	1978	9,080	254	27.9	376	7.06	367

[a] Taiwan passed 2.5 tillers/1000 ha in 1958, but wage data are not available for that year. 1961 is the first year for which they are available.

[b] Paddy price shown in 1st col, converted to rice at .65, converted to US$ at official exchange rate.

[c] Taiwan had 70 tillers/1000 ha in 1978, the year for which data is shown. By 1979 or 1980, it had undoubtedly surpassed 100 tillers/1000 ha.

Table 8. Agricultural machinery in Japan (in thousands), 1950-1979 (Herdt, 1981a).

Year	Power tiller		Sprayers dusters	Rice planting machines[a]	Threshers	Combine
	Walking type	Riding type				
1950	13		16		n.a.	
1955	63		88		1,737	
1960	514		407		2,458	
1965	2,490	19	837		3,048[b]	
1971	3,201	267	2,400	46	3,279[c]	84
1976	3,183	721	2,899	1,046	n.a.	428
1979	3,168	1,096	2,618	1,601	n.a.	747

[a] Power machines. For 1971 through 1973 about 30,000 hand transplanting machines reported, but their number remained constant over the period and none were reported thereafter.

[b] Refers to 1964.

[c] Refers to 1968.

Sources: For all data except threshers: 1950-55 - Institute of Developing Economies, One Hundred Years of Agricultural Statistics in Japan, 1969; 1956-73 - M. Kikuchi, K. Moshida, Y. Hayami, "Rice Statistics in Japan," IRRI, 1975; 1976-79 - Ministry of Agriculture, Forestry and Fisheries, Government of Japan, Monthly Statistics of Agriculture, Forestry and Fisheries. For power threshers: H. F. McColly, "Agricultural Mechanization in Developing Countries, ed., M. Esmay and C. Hall (Tokyo, Shin-Norinsha and Co., Ltd., 1973).

Table 9. Ranking the nominal and real costs of 65HP diesel tractors and 10HP power tillers in selected countries of Asia, 1980.

Country	Nominal cost				Real cost[a]				Power available	
	65HP ($/hp)	rank	10HP ($/hp)	rank	65HP (kg/hp)	rank	10HP (kg/ha)	rank	(hp/ha)	rank
Japan	251	6	310	9	226	1	279	1	11.0	1
Rep. of China	177	3	220	5	421	2	523	3	2.14	2
Rep. of Korea	-	-	201	4	-	-	402	2	1.3	3
Malaysia	346	7	.264	7	1784	7	1360	7	na	-
Philippines	375	8	184	3	1932	8	948	5	.33	5
Thailand	246	5	120	1	1607	5	784	4	.16	8
Indonesia	413	9	440	11	1966	9	2095	9	.03	10
Pakistan	172	2	-	-	1387	4	-	-	.36	4
Sri Lanka	197	4	161	2	1728	6	1150	6	.28	6
Burma	na	-	242	6	na	-	3967	11	na	-
Nepal	128	1	316	10	1040	3	2569	10	.08	9
Bangladesh	na	-	300	8	na	-	1758	8	na	-

Source: IRRI Surveys of 1977 and 1981. APO, 1981. Rice price data from Palacpac, 1980. World Rice Statistics.

Note: [a] Real costs are calculated by dividing the nominal cost of the machine by the per kilogram farm gate price of rough rice.

Table 10. Price indices for paddy and farm inputs in selected countries of Asia (1975=100).

Country	Paddy price	Farm machinery	Fuel	Rural wages	Draft animals
Japan					
1965	42	57	47	---	---
1970	53	62	50	---	---
1975	100	100	100	100	---
1979	114	100	138	113	---
Rep. of China					
1965	37	57	67	---	---
1970	43	58	67	---	---
1976	100	100	100	100	100
1979	139	---	167	175	163
Rep. of Korea					
1965	17	27	21	---	---
1970	33	45	25	---	---
1975	100	100	100	100	100
1979	201	158	110	385	194
Malaysia					
1976	100	100	---	100	100
1980	93	150	---	235	118
Philippines					
1965	33	30	19	---	---
1970	38	51	25	---	---
1975	100	100	100	100	100
1979	105	150	279	122	198
Thailand					
1965	---	---	81	---	---
1970	44	44	81	---	---
1975	100	100	100	100	100
1979	113	277	280	148	334
Indonesia					
1965	---	---	---	---	---
1970	36	---	---	---	---
1975	100	---	---	100	100
1980	104	---	---	115	139
Pakistan					
1965	---	---	---	---	---
1970	42	38	86	---	---
1975	100	100	100	100	100
1977	116	114	237	115	1
India					
1965	65	40	33	---	---
1970	75	61	65	---	---
1975	100	100	100	100	100
1978	110	127	108	118	120
Nepal					
1965	65	40	33	---	---
1970	75	61	65	---	---
1975	100	100	100	100	100
1977	110	127	108	118	120

Source: Adjusted from APO, 1981a. Prices for draft animals from surveys. Price data for Malaysia from Palacpac, 1980. World Rice Statistics.

Table 11. Number of farmers by method of primary tillage used, 8 villages in Nueva Ecija, Philippines, wet season, 1978.

Method of primary tillage	No. of farmers	Percent
Animal	380	41.4
Two-wheel tractor	371	40.4
Four-wheel tractor	142	15.5
Two- and four-wheel tractor	25	2.7
Total	918	100.0

Source: Household census, Consequences of Small Rice Farm Mechanization Project, Ag. Eng. Dept. Int. Rice Res. Inst., Los Banos, Philippines.

Table 12. Adoption of mechanized land preparation in Laguna, Philippines, 1965-78.

Operation	1965	1970	1975	1978
	%			
Plowing	0	11	20	47
Harrowing	24	69	89	93

Source: Smith, J. and Fe Gascon. 1979. The Effect of the New Rice Technology on Family Labor Utilization in Laguna, IRRI Research Paper Series No. 42.

Table 13. Farmers owning tillage machines and water buffalo in Laguna, Philippines, 1965-78.

Classification	1965	1975	1978
	----------	%	----------
Mechanical	15.5	17.8	16.7
Water buffalo	75.6	57.8	35.6

Source: Ibid

Table 14. Labor inputs for riceproduction at three locations in Asia (man-days/ha).

Year	Season	Site		Irrigated rice			
				Manual	Animal	Part. Mech.	Mech.
1979	WS	Philippines	no. obs.	--	46	94	54
			Family	--	29.7	6.2	4.6
			Hired	--	53.9	58.5	54.1
			Total	--	83.6	64.7	58.7
1981	WS	Thailand	no. obs.	--	49	120	100
			Family	--	34	30	26
			Hired	--	26.2	24	20
			Total	--	60.2	54	46
1979-80	WS	West Java	no. obs.	55	76	117	27
			Family	36	59	14.7	28.2
			Hired	144.8	159.6	141.2	219.4
			Total	180.8	218.6	155.9	247.6
1979	WS	S. Sulawesi	no. obs.	--	82	--	76
			Family	--	54.1	--	28.2
			Hired	--	49.7	--	75.3
			Total	--	103.8	--	103.5

Source: Site reports from Mechanization Consequences Project. Agricultural Engineering Department, IRRI, 1982.

Table 15. Labor requirements for harvesting and threshing before and after adoption of mechanical threshers. 1978-79 wet and dry season, Iloilo, Philippines.

Item	Irrigated Iloilo	Rainfed Iloilo
	---------- m-days/ha ----------	
1. Before thresher:		
Hired system[a]	39.7	36.2
Contractual system[b]	51.9	--
Average	42.6	36.2
2. After thresher:		
Hired system	15.9	16.4
Contractual system	24.2	--
Average	18.4	16.4
3. Non-user:		
Hired system	45.7	42.0
Family system	34.0	--
Average	44.0	42.0

[a] The "hired" system employs labor paid a share of the crop and is open to all outside labor.

[b] The "contractual" system provides payment as a percentage of the crop and involves the responsibility for carrying out tasks such as weeding as a condition of access to the threshing operation.

Table 16. Summary of studies comparing yields on farms with animal or hand land preparation with farms using mechanical methods.

Author	Area	Comparison	Reported yield (t/ha)	Fertilizer (urea) (kg/ha)	Adjusted yield (t/ha)
Pudasaini	Nepal (without pumps)	Bullocks vs.	1.7	16	1.7
		Tractors	2.1	164	1.4
Pudasaini	Nepal (with pumps)	Bullocks vs.	2.1	214	2.1
		Tractors	2.3	264	2.1
Sinaga	West Java, Indonesia (wet, 1979/80)	Animal vs.	4.9	323	4.9
		Tractors	4.9	323	4.9
Sinaga	West Java, Indonesia (3 seasons, 1979-80)	Manual vs.	3.8	285	3.8
		Tractors	3.9	308	3.8
Sinaga	South Sulawesi (3 seasons, 1979-80)	Animal vs.	2.7	138	2.7
		Tractors	2.9	227	2.5
Tan and Wicks	Nueva Ecija, Philippines (wet, 1979)	Carabao vs.	2.6	89	2.6
		Tractors	3.0	129	3.8
Anuwat	Central Thailand (irri. transplanted)	Bullock vs.	2.6	32	2.6
		Tractor	2.8	48	2.6
Anuwat	Central Thailand (rainfed, broadcast)	Bullock vs.	0.2	3	0.2
		Tractor	0.2	2	0.2
Alam	Bangladesh	Bullock vs.	1.5	n.a.	1.5
		Power tiller	1.5	n.a.	1.5
Deomampo & Torres	Central Luzon, Philippines	Before vs. after	2.2	57	2.2
		Tractors & tillers	2.6	79	2.1
Antiporta & Deomampo	Philippines & province	Animals vs.	2.6	86	2.6
		Tractors & tillers	2.8	117	2.5

Table 17. Labor and fuel used in experiments on five alternative land preparation methods for rice production (average of 4 soil types, Philippines, 1973 wet season).

Tillage treatment		Labor (hr/ha)	Fuel (lt/ha)	Weeds (g/. $2m^2$)	Yield (t/ha)
Primary tillage	Secondary tillage				
64 hp tractor	Carabao	45	20	16.7	3.61
14 hp tiller	Carabao	49	15	12.3	3.56
7 hp tiller	7 hp tiller	29	36	11.0	3.81
Carabao	7 hp tiller	56	26	14.4	3.60
Carabao	Carabao	81	0	17.9	3.60

Source: Duff, 1978.

Table 18. Summary of studies on the impact of mechanized land preparation on cropping intensity in rice based systems, Asia.

Study	Area	Comparison	Cropping Intensity Effect
King, 1974	Central Luzon, Philippines	Carabao vs. Power tillers	1.03 (Poor irrigation) +5%
King, 1974	Central Luzon, Philippines	Carabao vs. Power tillers	1.70 (Good irrigation) +2%
IRRI, 1980	Central Luzon, Philippines	Carabao vs. Tractors	1.37 (Irrigated) +44%
IRRI, 1980	Central Luzon, Philippines	Carabao vs. Tractors	1.00 (Rainfed) 0
Pudasaini,1979	Bara District, Nepal	Animal vs. Tractors[a]	1.45 +14%
Pudasaini,1979	Bara District, Nepal	Pumpset vs. Tractors and pumpsets	1.55 +12%
NCAER, 1977	South, East India	Bullocks vs. Power tillers	1.41 +2%
Ahmed, 1975	Bangladesh	Bullocks vs. Power tillers	1.70 +10%
Narayana,1977	Andhra Pradesh, India	Bullocks vs. Tractors	1.04 +9%
Consequences Team 1981	South Sulawesi, Indonesia	Before vs. after tractor	1.83 (Rainfed sub-sample) -2%
Consequences Team 1981	South Sulawesi, Indonesia	Before vs. after tractor	1.92 (Irrigated sub-sample) -2%
Bagyo, 1981	West Java, Indonesia	Manual vs. Tractor	1.95 -11%
Bagyo, 1981	West Java, Indonesia	Animal vs. Tractor	1.93 -10%

[a] Combined tractor owning and tractor hiring farms.

Table 19. Summary of studies on the impact of mechanized threshing on cropping intensity in rice-based systems, Asia.

Study	Area	Comparison	Cropping Intensity Effect
Juarez, 1979	Iloilo, Philippines	Hand vs. Power threshing	1.68 (irrigated) + 13%
Juarez, 1979	Iloilo, Philippines	Hand vs. Power threshing	1.55 (Rainfed) + 4%
Juarez, 1979	Laguna, Philippines	Hand vs. Power threshing	1.43 + 22%
IRRI, 1980	Central Luzon, Philippines	Hand vs. Power threshing	1.78 (Irrigated) - 23%

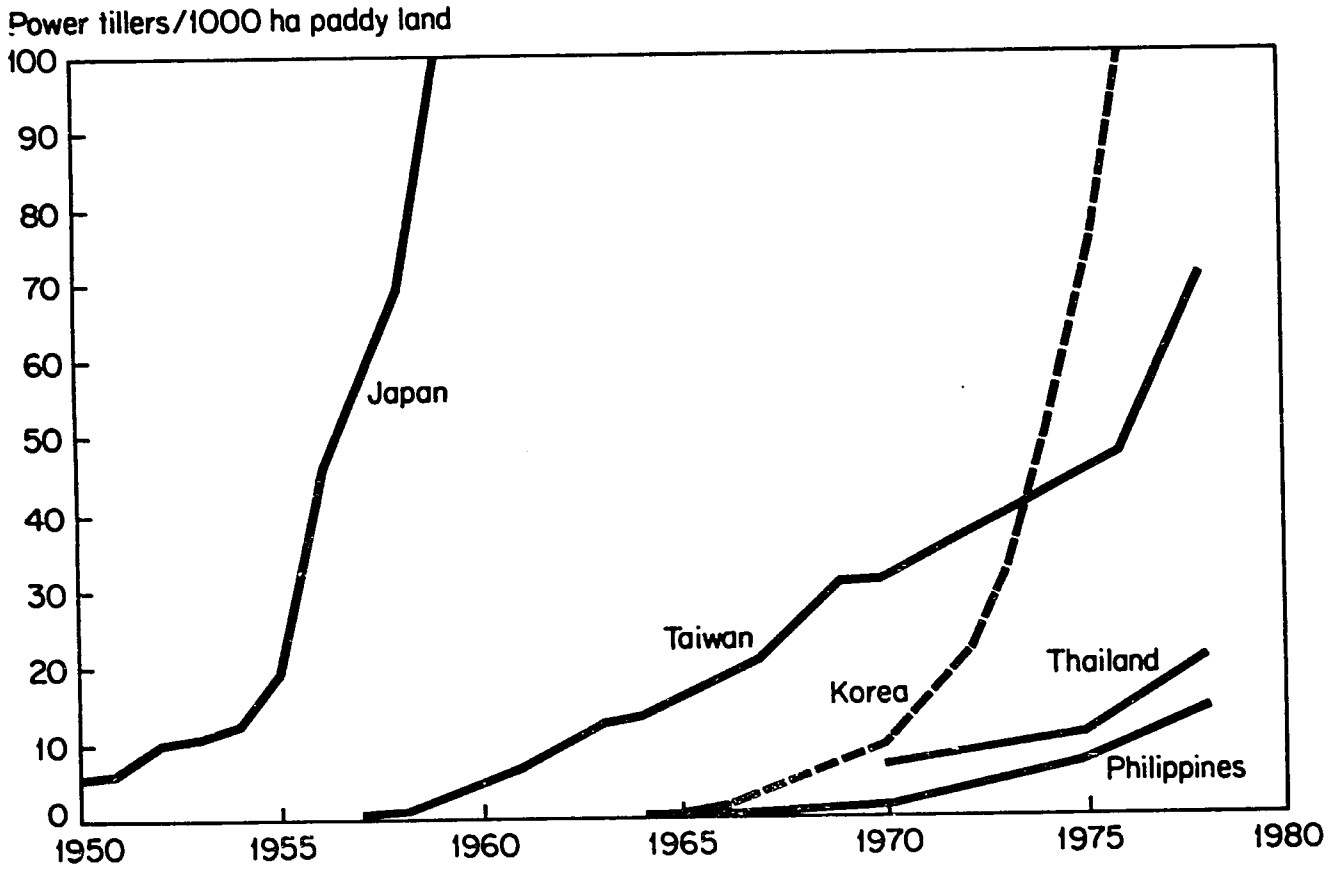

Fig.1. Number of power tillers per 1000 ha paddy land (Herdt,1982).

THE FARM POWER STRATEGY OF THAILAND*

Supachat Sukharomana**

ABSTRACT

This paper describes the evolution and development of farm mechanization in Thailand. The success of mechanization relied primarily on a laissez-faire attitude of government. Major contributions to the development of farm machinery by the Thai government and international institutions were in the form of research on and education in agricultural engineering.

The utilization and impact of farm mechanization are also discussed in the paper. The former is presented by region and agro-economic zone. The zones in the Central Plain have the highest machinery density. Tractors, water pumps, and threshers are the most important farm machines each yielding positive effects on total output and productivity of both land and labor. While tractors replace farm labor on the one hand, they solve the labor shortage during the peak season and make multiple cropping possible on the other hand. The study also discusses the indirect effects of mechanization on other sectors. The study concludes by calling for equal access to all farm mechanization policy benefits by all sectors.

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The Farm Power Strategy of Thailand

Supachat Sukharomana

This paper examines the farm power strategy of rice farming in Thailand and its effects on production, employment and income distribution. It also attempts to define the future of the local farm machinery industry.

1. Historical Background[1]

Farm mechanization in Thailand began in early 1981. The imported steam-powered tractors and rotary hoes (Howards) were unsuitable to paddy conditions and also quite expensive.

In the 1950's, the rice experimental station acquired several 4-wheel tractors to be used in promoting tractorization. Tractor services were sold at 15-58 baht per rai (about 93.75 - 112.50 baht per ha). The project however, was later abandoned.

Prior to 1967, Thai farmers relied heavily on animal, wind and water power. After a decade of low-cost farm machinery experimentation, the Debaridhi pump, a lowlift irrigation water pump, and a simplified 2-wheel tractor were successfully developed. In 1975, a modified version of the IRRI-designed thresher was successfully adopted by local farmers.

Following this enthusiastic response, at least three different types of 4-wheel tractors were developed by 1979.

Renewed importation of farm tractors, mostly Japanese 2-wheel models, reached a record high of 262 units between 1953 and 1955. In the meantime, important developments in axial flow pump design had been taking place at the Division of Agricultural Engineering. In 1957, the blueprint for the Debaridhi pump was released to local manufacturers and became an instant success. In 1961, the same division released a simplified 4-wheel tractor design called the Iron Buffalo powered by a 25 hp engine. This machine which took about 3 years to develop was suitable to paddy operation. Its high per unit price of 30,000 baht, however, couldn't compete with a cheaper imported model. Its production was eventually discontinued.

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During this period, several manufacturers had been simplifying the Japanese 2-wheel tractor. A successful model, with modified gear box, was definitely cheaper and more versatile than its Japanese predecessor. Demand for this tractor was phenomenal so that machine shops and factories quickly sprang up around Bangkok and the Central Region. By 1967, it was evident that Thailand's farm machinery industry was well established. [2]

Twelve years later, the invention of a simple gear system made commercial production of 3 different 4-wheel tractors possible. Somewhat later, another farm machine, the axial flow rice thresher, transformed Thai rice farming. In early 1975, IRRI sent its blueprint for an axial flow rice thresher to the of Agricultural Engineering Division of the Department of Agriculture in Bangkok which in turn promptly produced a prototype. When the design was released to a selected firm in Chachoengsao for commercial production, 10 units were immediately sold at 12,000 baht each. These units were subsequently returned to the manufacturer because the earlier threshing machine model seemed to do a better job. The IRRI design went back to the drawing board. IRRI and DAE refined it, and in late 1975 a new blueprint for an axial flow thresher was ready. Three selected firms modified the blueprint then produced a model according to it. When the threshers were released, they were enthusiastically adopted by farmers.

In 1977 IRRI sent another blueprint of a portable rice thresher which was both cheap and easy to operate. One firm produced and sold 9 units at 8,500 baht per unit. These machines were sent back to the manufacturers, because they had a lower capacity than the earlier machines. Furthermore, no post-sale services were available to customers.

The design and production of a reaper-harvester is currently generating much interest. A modified transplanter was also introduced into the market in 1978 but did not sell.

2. Government Intervention

The investment climate, resulting from a combination of fiscal measures, reflects the government's contribution to the national farm mechanization program. The prevailing policies are essentially price disincentives in the form of taxes applied to locally produced machines, government subsidies on imported machines and protective tariffs to benefit the local fledging diesel engine industry. They also include non-price incentives such as cheap credit, free irrigation water supplies, a good transportation network that reduces marketing costs; funds for research and development, and training and extension services. All these affect both the market

price of the machines and the buying decisions of the farmer. This paper will attempt to examine how these fiscal measures affected growth of the local farm machinery indusry.

What Government Intervention is Doing to Manufacturers and Farmers

The local farm machinery industry suffers from the low tariff charges on imported farm machinery and the excessive duties on components for locally built farm machinery. An imported CKD machine is subject to only 5 percent ad valorem tax, and a total of 8.76 percent in corporate business and municipal taxes.[3] In contrast, a locally manufactured machine utilizes imported components which are taxed separately and using different rates. Tariff charges, along with business and municipal taxes on a small imported diesel engine amount to 19.2 percent of the c.i.f. value. This results in a 9.6 to 12.5 percent increase in domestic cost. Actual taxes can even be higher than 12.5 percent because of double taxation.[4] The cost of engines for locally produced 2-wheel and 4-wheel tractors, and rice threshers constitutes about 65, 51 and 51 percent of the wholesale price, respectively.

Compounding the manufacturers' tax difficulties is the threat of an increase in the market share of imported second-hand tractors and Chinese-made small tractors, both of which are sold at very low prices.[5] Though the government is aware of this problem it has not taken any action. Pongpojkasem (1979) estimated the nominal effective rates and effective rate of protection, and concluded that government fiscal policies hurt rice, maize, sugarcane and cassava production. As mentioned earlier, non-price incentives to the agricultural sector include cheap credit, subsidized fertilizer, free irrigation water supplies, and a good transportation network. Benefits derived from these incentives are difficult to quantify. The low cost of fertilizer induces farmers to use more fertilizer resulting in higher yields. Cheap credit to eligible farmers can provide working capital and enable them to continue or expand operations through farm machines. Free irrigation reduces production costs and makes doublecropping possible. A good transportation network reduces marketing costs and ensures timely arrival of fresh produce at the market place. Some problems are evident. Water supply from irrigation projects are available only to a limited number of farmers located near irrigation systems.

Cheap credit through the Small Industry Finance Corporation has been made available in trickles. So far, only three firms have acquired loans from this institution. Ironically, many of these incentives are available only in the more fertile central region where farmers are more self-sufficient and are considered affluent.

Training, Research and Development[6]

Training and research in and development of the design, application, and maintenance of farm machines and implements have helped rationalize farm mechanization goals and objectives. Although several government agencies and international organizations are involved in these activities, much is to be desired in developing areas of cooperation among them.

Government institutes involved in research, and development and/or training are the Division of Agricultural Engineering, the Department of Agricultural, and the Departments of Agricultural Engineering at Kasetsart, Chiengmai and Khon Khaen Universities. The Division of Agricultural Engineering is involved in all three activities. The Department of Agricultural Extension should be involved in training and extension work to a greater extent than it is now. Although training of production engineers at the graduate level is a principal activity of the agricultural engineering department in universities, their inadequate research facilities limit further gains in this area.

Testing of improvements in farming conditions requires meaningful research and development. As of 1981, there were 5 research projects being undertaken by the Division of Agricultural Engineering namely: (1) the joint farm machinery development project between the Department of Agriculture and the International Rice Research Institute (IRRI) conducted over 1975-1985, (2) the Regional Network for Agricultural Machinery (RNAM) of the Economic and Social Commission for Asia and the Pacific (ESCAP) over 1979-1982, (3) the ongoing Asian-Australian Post-harvest Technology Project began in 1978/79, (4) The International Development Research Centre (IDRC) over 1979-1981, and (5) the current Agricultural Machinery Production Project of the UNDP/FAO began in 1981.

Among them, the joint projects between IRRI and the Agricultural Engineering Division provided the most promising and productive data. The IRRI-designed axial flow thresher is an outstanding product of this joint endeavor. Four other joint projects commenced in 1978/79, all aimed at strengthening the capability of the Division of Agricultural Engineering, as well as at rationalizing the farm mechanization program in Thailand at the farm and the manufacturer levels.

Cooperators actively involved in training programs are the Thai-German Agricultural Engineering Center (AFTC), and the Asian Institute of Technology (AIT). AFTC provides informal education on farm machinery and soil improvement, while AIT provides advanced education and research facilities.

Skills training and dissemination of farm engineering technology at both the fabrication and farm levels are extremely important. R & D efforts are rewarded and justified. It is clear that the Division of Agricultural Extension (Ministry of Agriculture) can have a major impact in this area of endeavor.

3. Number of Firms Engaged in the Manufacture of Farm Machinery and Implements

According to the comprehensive survey of the farm machinery industry by the Bank of Thailand (BOT) in 1979, there were 100 firms producing two-wheel tractors, 30 firms producing rice milling machines, 21 firms producing rice threshers, and 20 firms producing small four-wheel tractors. Three firms were engaged in large tractor assembly. In addition, there were others who manufactured corn shellers, water pumps and other farm implements (Table 1).

4. Domestic Production and Importation of Farm Machines

Stiff market and price competition exert pressure on local manufacturers to improve efficiency. In the end, however, the larger firms with more capital and cash flow resources generally procure a greater market share and higher profit margin.

Most 2- and 4-wheel tractors, rice threshers, corn shellers, and axial flow pumps are locally produced. Large tractors are domestically assembled using imported CKD (completely-knocked-down) components and accessories.

During the period 1974-78, locally produced 2- wheel and small 4-wheel tractors had the highest market share at 99 - 96 percent and 80 - 86 percent, respectively. Locally assembled large tractors account for 48-51 percent of total annual demand (Table 2).

An attempt has been made to assess the design and innovation efforts. The design of the locally made 2-wheel tractor has evolved over many years. Further improvements on design have increased costs. The rice thresher has been the only satisfactory design. The most distinctive innovative feature in the current Thai model is its greater capacity and self-propelling property. The machine's capacity was doubled from one to more than two tons per hour. Further modifications are also underway to reduce power requirements and increase threshing efficiency. Competition is the driving force behind these innovations.

Local manufacturers produce a range of farm machines which allows them to partially mitigate the seasonal fluctuation in demand and keep these facilities optimally employed.

Imported machines have a special place in the industry. The impressive development of local machines is the result of borrowing and modifying technology, particularly that of the 2- and small 4-wheel tractors, and the Chinese reapers. In contrast, importation of used tractors creates much anxiety among local manufacturers because they are significantly cheaper than locally made machines. Local manufacturers claim that the importation of machines, especially the used ones, should be regulated in order to save foreign exchange and to avoid the high maintenance cost of used machines.

5. Equipment Inventories

The stock of farm tractors in Thailand has rapidly increased since 1967. The stocks of 2-wheel, small and large 4-wheel tractors in 1979 amounted to 230,591, 31,158 and 33,280 units, respectively. Stocks of other types of farm equipment also exhibit similar increasing trends. The increasing stocks over the years are an indication of the strong trend toward farm mechanization in Thailand (Table 3).

6. Regional Zoning and Distribution of Farm Machines

Thailand was classified into 19 agro-economic zones by the Office of Agricultural Statistics based on soil condition, temperature, topography, type of crops, transportation facility and farm income. These zones cover all 71 provinces in the Northern, Northeastern, Central, and Southern regions. The Northeastern region includes zones 1-5, the Northern region zones 6-10 (except zone 7), the Central region zones 7 and 11-16, and the Southern region zones 17-19 (Appendix 1).

The greatest number of farm machines is found in the Central region followed by the Northern, Northeastern and Southern regions in that order. There are more 2-wheel tractors in the Southern than in the Northeastern region (Table 4). This is due to size differences between regions. The ratio of hp (horsepower) to hectare was used as an indicator of the degree of mechanization in each region, agro-economic zone, and crop type.

Combining the power from all types of farm tractors, the average hp per hectare of farm land in Central, Northern, Southern, and Northeastern regions are 0.49, 0.34, 0.14 and 0.057,

respectively. The Central region has the highest level of tractorization. The density of hp per hectare in each region varies according to zone. Zones in the Central region have densities ranging from 0.237 to 0.892 hp per hectare. Zones 11 and 14 whose main crop is rice, have the highest tractor densities (Table 5).

It is significant to note that more 2-wheel and small 4-wheel tractors were used in the Central region. Small tractors were more widely used in zones 11 and 14, but both large and small tractors were used in the same proportions in zones adjacent to zone 11 and 14. Small tractors were thinly distributed in the remaining regions.

A cross section analysis by Jongsuwat (1980) indicated that the widespread use of small 2-wheel tractors in the Central plain area was due to the relatively high agricultural wage rate structure versus other locations. In addition, incomes of farmers in this region were higher than those of the rest of the country. Farmers in the Central region enjoy the advantages of abundant irrigation water, very fertile soil, and a higher return on investments in farm machinery. High productivity and favorable crop prices over the last decade raised farm income in the Central region. Consequently, it has been easy to induce farmers in this region to adopt tractorization.

Small tractors are popular because of their suitability to paddy field operations. Two and small 4-wheel tractors are superior to the large tractor in this respect. Small tractors can also be used for a greater variety of farm jobs, such as pumping water, threshing, transporting farm supplies and produce. The lower price of a small tractor makes it a more attractive and reasonable investment for the small farm owner.[7]

In contrast, large tractors are suitable to large farms since they can prepare large tracts of land before the onset of the rainy season. Large tractors are mainly used for plowing paddies in the Central region before the monsoon season. However, they can only efficiently be used on farms with relatively few field dikes.

Zones 6 and 7 use large tractors to a greater extent (about 0.3 hp per hectare) than other zones. Principal crops in this zone are rice, maize and sugarcane. In the Northeastern region where rice and cassava are raised on a more extensive scale, large tractors are also used to a greater extent than small tractors. The national distribution of tractors by region, agroeconomic zone and by crop is shown in Tables 6, 7 and 8.

Like the farm tractor, water pumps are largely used in the Central region. The highest density of water pumps is recorded in zone 16 where the average land holding is large (3-4 ha). The

average hp for water pumps in this zone was 0.39 hp per hectare. Zones 11 and 14 have the highest utilization rates of tractors and water pumps. Notice that the Central region has not only the highest concentration of tractors but of water pumps as well.

Of the total number of rice threshers (3,955 units) reported by the Office of Agricultural Economics in 1975, about 1,312 and 1,633 units were reported in zones 11 and 13, respectively.

Of the total number of corn shellers in 1975 (5,721 units), approximately 2,146, 559 and 398 units were reported in zones 6, 8 and 5, respectively. Corn is extensively grown in these zones.

The average hp per hectare for rice threshers and corn shellers is not available. The utility of these two machines is, however, indisputable in the rice and corn cropping areas.

In contrast, surveys on mechanized post-production technology by crop and by region indicate that rice harvesting, threshing, cleaning, and drying in the Central region are all relatively highly mechanized operations. Maize post-production technology seems, however, to be the most developed of all field crops.

Post-production activities in non-mechanized areas are usually accomplished with human and animal labor using simple implements.

7. Accessibility to Farm Machinery

Accessibility to farm machinery depends on the type and condition of the machine, availability of credit facilities, farmers' purchasing power, and local farming conditions.

In 1979, unit prices of 2-wheel and large tractors, and water pumps were 1,540, 10,000, and 119.8 US dollars, respectively. On the other hand, the unit price of rice threshers in 1978 was US$1,072.

A farmer with adequate resources can easily own either an imported or locally made machine. The well-organized marketing system makes it easy for farmers to purchase machines from either dealers or directly from a local manufacturer. Credit sales are normally offered by local dealers, particularly in a new sales territory. A 50 percent down payment is usually required when purchasing a small tractor. Interest charges on the balance range from 12-48 percent, but the usual terms include a 24 percent rate with 6 months to pay (Taenkam, 1980).

Farmers who cannot afford the initial investment, particularly for larger tractors, may hire machine services through the contract market. The same is true in the case of rice threshers and corn shellers.

The contract rate for land preparation varies according to crop. In 1980, the rate for land preparation was about US$10.47-11.82 per ha for rice. The contract rate for a rice thresher is about US$4.37 per ton.

A farmer who wants to hire a small tractor can usually go to nearby tractor owners. The rate for land preparation (including plowing and puddling) in 1981 was about US$54.58 per ha.

Farmers with inadequate capital may obtain loans from government and non-government financing institutions to pay for contract machine services. Loans granted by government financial institutions, however, have been few (9.34 percent of farm households). Also, only members of farmer's organizations are eligible for credit.

Private financial institutions are more willing to give loans to farmers whose farms are in better locations. Funds for the purchase of farm machines, however, primarily came from the farmers' own savings. Pathnopas (1980) reports that 60 percent of funds invested in rice threshers came from the farmers' own savings, 30 percent from non-financial institutions, and the rest from the Bank of Agriculture and Cooperatives (BAAC). Farmers who own large tractors and rice threshers earned additional income from hiring out their machines which helped to defray some of the machine's initial investment cost.

8. Farm Tractor and Rice Thresher Use

While small tractors are used in 95 percent of total farm activity time, a large tractor can accounts for only 16 percent[8] of such time.

In terms of type of activity performed, both small and large tractors are mainly utilized for land preparation. Water pumping is the second most important activity for a small tractor while corn shelling ranks second for large tractors. Other activities such as transport, land clearing and levelling are of minor importance.

Several kinds of machine implements can be attached to a tractor making it more versatile. Example of these are the disc plow or mold board plow for the first plowing; a puddler for puddling rice paddies; an axial-flow water pump powered by a tractor using a V-belt; or a trailer attached to a tractor for transport. These implements are all available in the local market.

Rice threshers have little versatility, so that most of its capacity is hired out for contract work.

9. Effects of Farm Mechanization on Output

We shall now examine the effects of farm power on (1) total crop output and, (2) on yield per unit of input.

Land preparation can be done faster with mechanization thus increasing the total cultivated area. Machines are often introduced in conjunction with fertilizers and irrigation, all of which contribute to the increases in the productivity of land and labor[9].

The increase in productivity over the past two decades was made possible by the application of both extensive and intensive farming methods, an expansion in cultivated areas and the use of existing and improved technology. Extensive farming results in greater output. On the other hand, intensive farming in the farm of double cropping in irrigated areas increases productivity.

The shortage of suitable agricultural land has led to the opening of frontier lands requiring a high degree of machine power. Cultivated areas in Thailand increase at a rate of 7.5 percent per annum (Tables 8 & 9). Output of field crops increases at a rate of 11-24 percent while rice output increases by only 3.2 percent. The expansion of rice land proceeded at a rate of 1.93 percent (Table 10). Much of this expansion resulted in increases in irrigated area, while higher output was due largely to increased production efficiency.

A modern technology package, including mechanization, has made double cropping of rice possible in well-irrigated farms. Mechanization enables the farmer to achieve precision scheduling of land preparation, transplanting, broadcasting, and irrigation. With the help of the rice thresher, the farmer spends less time in post harvest activities allowing him more time for a second crop. In addition, the rice thresher saves the rice crop harvested early in the wet season when it is most vulnerable to moisture damage.

In areas where double cropping is not possible, tractor treading and mechanized rice threshing are seldom practiced (Pathnopas, 1980). In a few non-irrigated areas intensive farming is possible, but farmers must quickly harvest their wet season crop and prepare the land for the next crop while the residual soil moisture still assures germination and seedling growth. This is a very risky and therefore not prevalent practice.

Mechanization in irrigated areas is closely associated with high yielding varieties (HYV), chemical fertilizers, and pesticides. To isolate the effects of mechanization from other components in the rice technology package, Wongsangaroonsri (1982) used the wet season 1979/80 data from Supanburi Province, a sample area in Thailand covered by the Consequences of Small Rice Farm Mechanization Study. He employed the Cobb-Douglas production function in his study. The results indicated that use of small farm tractors in land preparation increased farm output and required less labor. The total effect of tractor input on rice output was 62.85 percent classified into two categories: direct effect of 28.83 percent, and indirect effect of 34.02 percent.

According to Inukai (1970), mechanization can increase rice yield. His study, however, did not take into account the effect of chemical inputs such as fertilizers and pesticides on yield. The statistical test of the coefficients for the mechanization index and yield were not presented. The study also concluded that water pump may increase crop yield. Control of water supply at pollination and maturing periods is critical to crop yield, but there is no a single study that conclusively shows that water supply control at various stages of crop growth yields appreciable economic returns.

Direct Effects of Farm Mechanization on Employment

The effects of mechanization on agricultural employment are best shown by the volume of labor replaced by the machine.

Labor savings are expressed as either the amount of labor saved per unit of land per season or per unit of output, or the reduction in the labor required for the care of draft animals. Only rice farming data is used.

According to information from NEDECO (1968), mechanization has reduced labor requirements by -37 percent and -25 percent, respectively (Table 11) in rice farms using broadcasting and transplanting techniques. Meanwhile, the Consequences Project survey in 1979 showed that irrigated rice farms using 2-wheel tractors required 33 percent less labor than farms using buffalo power. Farms using small 4-wheel tractors used 49% less labor than farms employing all buffalo power (Tables 12 & 13).

The labor requirements of land and seedbed preparation, planting and crop maintenance are also reduced. In contrast, the existence of labor saving in the threshing activity was not verified as all rice was threshed by (hired) mechanical threshers.

The uses of 2-wheel and 4-wheel tractors in land preparation can save labor by 63 percent and 74 percent, or a savings of 15.75 mandays and 18.37 mandays per season, respectively.

Threshing may be done either by hand beating, foot treading, animal treading, tractor treading or machine threshing. Kittikul (1980) reported that the threshing machine required the least amount of labor with only an average labor requirement of 5 manhours/ton.

Pathnopas' study (1980) indicated that tractor treading required 17.76 manhours per ton, while buffalo treading required 38.8 hours per ton. In contrast, a threshing machine required only 10.27 manhours per ton (including that of the machine operator and other labor), which is lower by 72.93% and 377.80%, respectively of the labor requirement of threshing with 2-wheel tractors and animals. Equivalently this is a savings of one man-day per ton of rice or of 3 man-days per hectare given the average 3 tons/ha yield. The combined use of small tractors and threshers for all farm activities can save between 18.75 - 21.37 mandays of labor per ha per season. This makes why it possible for farmers to achieve a high level of double cropping.

The saved labor resulting from a switching from draft animal management to machine power is usually overlooked. Although this activity is normally a child's task, the cost of animal management should be taken into consideration.

Does mechanization create unemployment? Evidence fails to support such a view. According to the preceding discussion, wage rates in the extensively mechanized areas were higher than those in the less mechanized areas. The high wage could mean a scarcity of labor supply. Sometimes there is an excess labor supply which is normally absorbed in the double-cropping areas in the Central region, Northern region and in the Northeastern region adjacent to the Central region. All these areas are characterized by a high cropping intensity index as well as high average machine hp per hectare (Table 14).

The effects of mechanization on labor productivity are positive, since the man to land ratio is reduced and the output to labor ratio is increased. For instance, rice farms using buffalo power, 2-wheel tractors and small 4-wheel tractors require 875, 613 and 482 manhours per hectare, respectively. The gross output-labor ratios of irrigated farms are as follows: 3:41 kg. (875 manhours) with buffalo power, 4:11 kg. (613 manhours) with a 2-wheel tractor, 6.38 kg. (482 manhours) with a small 4-wheel tractor.

Indirect Benefits of Farm Mechanization on Employment

Mechanization also generates employment in farm machinery and parts industries. The average annual demand for tractors was 37,000 to 42,000 units for 2-wheel; 4,000 to 5,000 units for 4-wheel; and 3,000 to 5,000 units for large tractors (BoT, 1979). The average annual growth rate from 1974-78 of demand for such machines were 20, 16 and 20 percent, respectively.

Small tractor manufacturers employed anywhere from 1,800 - 2,000 workers, while firms that assembled large tractors employed 120-150 workers (BoT, 1978). Employment must likewise be substantial in rice thresher manufacturing, because demand for these machines has been steadily increasing at an annual growth rate of 9-10 percent since late 1975. There were approximately 6,224 rice threshers in the market as of 1979/80.

Labor cost as a percent of total manufacturing cost for 2-wheel tractors is 12 percent, 10% for 4-wheel tractors and 15% for threshers. The c-k-d labor cost of locally assembled tractors, is estimated at only 1 percent (Sukharomana, 1981). The per unit marketing cost, which includes transportation, handling, interest and profit margin for the dealer, is about 15-20% of factory price.

The transportion cost of imported power engines, the only imported component of locally manufactured farm machines, represents 15-30 percent of the c.i.f. value. Besides providing this income to the shipping industry, employment is created for the transportation sector.

Linkages in the repair, maintenance and services sector are extensive. A farm machine owner may obtain any of these services from the local repair shop, the dealer and the small-scale local manufacturer. Large manufacturers, however, do not offer these services (Loohawenchit, 1981).

11. Farm Mechanization and Income Distribution

The urban-rural income gap in Thailand is acknowledged but there is more than a passing concern for the gap between the rich and the poor within the rural sector. The new rice technology includes a package of high yielding rice varieties, chemical fertilizers, pesticides, and mechanization which only rich farmers can afford. For reasons described earlier, farm machines in Thailand seem to be accessible only to certain groups of farmers, especially those in the Central region and surrounding provinces. Large farmers usually own large tractors while small farm holders have to hire tractor services.

New technology and mechanization become more attractive because an appropriate technology package can result in a greater net farm income derived from increased productivity of both land and labor. However, it is difficult to isolate the contribution of a farm machine to net farm income. Nevertheless, it is safe to conclude that the contribution of mechanization to the farmers' income is at least the net cost savings generated by mechanization. One may also conclude that mechanization increases income per unit of labor.

Income from hiring out large 4-wheel tractors is the main source of off-farm income, averaging about US$400 per year (Pak-uthai, 1981). In 1979 income from hiring out rice thresher services was about US$640 to 1,013 per unit or 86 percent of the total income derived from the use of threshers (Pathnopas, 1980).

According to 1979 data on farm households' income and expenditures from the Office of Agricultural Statistics, Ministry of Agriculture and Cooperatives, the gross income of farm households located in a machinery dense zone is higher than the income of farm households in a low density zone. The Northeastern and Southern regions are mostly characterized by a lower hp per hectare. Households with the lowest level of mechanization accounted for 40%, compared to only 26.2 and 19.8 percent in the Northern and Central regions, respectively (Table 15).

Farmers with highly mechanized farms are a small group whose 1979 income ranged from US$832 to 869. The income of farmers in the Northeastern region, which has a low level of tractorization, averaged only US$449 (Table 15). In 1979, the average income of farm households in the Central region was close to that of the urban area.

The average farm size, 4.26 ha/household appears too small to justify the mechanization described in this paper. Without irrigation water and fertile farm soils, mechanization would be most unsuitable. It would be more practical for some farms to hire in contract tractor services than to buy a machine. Preliminary analysis of the Consequences survey indicate that farmers who own a machine earn less per hectare than farmers who simply hire in machine service (Table 16). It is easy to see how this happens. The initial investment in a tractor, especially a 4-wheel, is sizeable, not to mention the interest payments, maintenance and repair expenses, depreciation, etc.

12. Some Important Considerations in the Acquisition or Hire Machines

Partial equilibrium and discounted cash flow analysis were used to evaluate the desirability of purchasing a tractor and a thresher. After deducting the depreciation and interest expenses for a machine, total revenue still exceeds total cost for large tractors, 2-wheel tractors and rice threshers. Despite yearly under-utilization and a higher investment cost, a small 4-wheel tractor yields a positive profit at a lower opportunity cost of capital (r = 8). A two-wheel tractor yields an average return of 12 percent[10].

Using a tractor usually means cost savings in time and buffalo care, and more effective land preparation. The return on investment might be low if only the on farm activities of the machine are taken into account, but it is reasonably high if the additional income from hiring out farm machines is also considered.

The partial equilibrium analysis shows that the rate of return on investment for a large tractor is around 13-15 percent. This analysis, however, assumed that the market for custom services was competitive.[11]

A rice thresher demonstrated a 40-45 percent higher rate of return on investment than other farm machines[12]. This is because the thresher is newer and less available in Thailand. Owners can recoup their investment faster through contractor services because of a lower level of competition.

Non-cash benefits derived from mechanization are a reduction in manhours, timely planting, and the reduction of farm drudgery (Table 17).

13. Contribution to Thailand's Economy

At this point, we might conclude that mechanization does improve the social condition of rural Thais and makes life in the villages more pleasant. Its contribution to the Thai economy, however, could not be quantified in this paper because of inadequate information on aggregate investment in mechanization capital and other parameters such as social costs and benefits attributable to mechanization. It is hoped that mechanization will provide the attractions for rural Thais to remain in the countryside. Furthermore, farm mechanization resulted in higher income, employment, and more training opportunities in other related industries.

14. Future of the Farm Machinery Industry

Thai farmers, especially those in the Central Region, are innovative. They have shown interest in trying most types of farm machines available in the market: water pumps, large tractors, small tractors, rice threshers, sprayers and locally fabricated trucks. Other new machines such as transplanters, reapers and combine-harvesters have high chances of being accepted by the Thai market. All three machines are still under field trial. Among these, the reaper appears to generate the most positive response from farmers.

Among field crop machines, the corn sheller, sorghum threshing machine, soybean and peanut threshing machines are the most welcome by farmers. These machines are not yet widely used and may require redesigning and further development as they are incompatible with local conditions and are to costly operation. Corn harvesters and sugarcane cutting machines, both imported machines, are hired on either a per hectare or per hour basis.

In less fertile regions, most farmers have no access to farm mechanization. Better hand tools and implements to complement animal power seem to be more practical. The extension specialists will be of great help in teaching farmers how to properly handle this equipment. Improvement of these farm tools and implements will increase animal and labor productivity. However, such improvement may require changes in farm practices. For instance, in order to substitute the iron plow for the wooden plow, the shape of the plow, the seed and fertilizer spreader, and the hand corn sheller may have to be modified and redesigned to be compatible with farm conditions.

The iron plow has been in use for the last 15 years, and several attempts have been made to redesign the traditional model to suit farmers' requirements and idiosyncracies. Farmers require that the iron plow have the same shape and weight as the wooden version, with a price that is not much higher. The plow blade modified by the Division of Agricultural Engineering was inefficient with its ploughing efficiency reduced by about 30 percent. Additionally, the hardwood raw material for the wooden plough is becoming scarce. Farmers will eventually have to turn to iron plows and so need to be educated in the features of iron plows. A rise in farm productivity in these regions can be expected with the modification of the seed and fertilizer spreader and hand corn sheller to suit regional conditions.

For those farmers who can afford it, decisions to mechanize depend largely on the costs of inputs and farm gate prices of crops, credit facilities and the availability of a good technology package. It is significant to note that farmers gave the following reasons

for their use of a tractor in land preparation: "to save time in farm work," "can plant on time," and, "easy and reduces drudgery" (Table 17).

One may conclude that the future of farm mechanization in Thailand depends on at least four major considerations: (1) fiscal measures that determine the business climate for the industry; (2) factors that either encourage or discourage farmers from utilizing farm machinery; (3) the existence of excellent credit facilities and (4) the presence of continuing and consistent extension, research and development efforts on machine design, production and utilization.

15. Conclusion

The farm power strategy of Thailand is remarkable in the sense that it has worked despite formidable odds. To enable the industry to sustain the gains already realized, government support is vital, and it must be made available quickly.

The government's most important contribution to the development of farm machinery industry appears to be the modification of small tractors. Despite little support from the government, the industry has flourished. The prevailing policies do not benefit all farmers, e.g. inequitable distribution of irrigation facilities, the inaccessibility to cheap credit by small farmers, and the lack of extension services. Furthermore, there are no patent procedures to protect the right of inventors. Another weak link in the strategy is the lack of cohesiveness of institutional efforts in research and development, and training and extension.

FOOTNOTES

[1] This part of paper is developed mainly from Jongsuwat, N., 1980 Taenkam, P., 1980.

[2] In 1968 the first high yielding variety rice (RD 1) was released.

[3] To calculate the tax rate charged on machine's body and accessories requires complicated data on amount, value, and the flow of inputs used through the input-output chain. This tax rate, therefore, was not calculated here. However, it should be noted that taxes charged on the production of locally made machine are about 1-2 percent of total production cost in 1979. See Sukharomana, S., 1980.

[4] Kerdpibule, U., 1981.

[5] The price of imported machines is sometimes higher than locally made products. Non-price competition, i.e. long term credit to farmer and dealer is given as an explanation.

[6] Information from Chak Chakkapak, Division of Agricultural Engineering, Ministry of Agriculture and Cooperative, (mimeographed).

[7] See Section 7, Accessibility to Farm Machinery.

[8] Work hours for small tractors were obtained from the Consequences of Small Rice Farm Mechanizationin Thailand, the 1981/82 wet season survey, whereas work hours for large tractor was obtained from Pak-uthai, V., 1981.

[9] See index of chemical fertilizer and farm machine in Annex.

[10] Preliminary analysis of small tractor investment from the Consequences of Small Rice Farm Mechanization in Thailand, (Forthcoming, MS (Ag. Econ.) thesis, Kasetsart University.

[11] Figures from Pak-uthai, V., 1981.

[12] For 1978 value of rate of return on investment, Pathnopas, R., 1980.

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Table 1. Number of manufacturers engaging in farm machinery and farm implement production, 1979.

Type of Machine and Implement	Number of Firm
Two-wheeled tractor	100
Small four-wheeled tractor	20
Large tractor	3
Rice thresher	21
Other grain threshing machine	19
Water pump (axial flow)	10
Water wheel	3
Plough	29
Disc plough for tractor and blade	11
Trailer	11
Puddler	3
Rotary hoe	2
Plough handle	2
Locally made truct for farm	1
Implement for sugarcane	3

*More than one product produced by a firm.

Source: Pisit Samahito and Karnket Kongkietngarm, "Farm Machinery and Farm Equipment Production: Part Farm Tractor and Power Tillers," Bank of Thailand, 1979.

Table 2. Imports and production by type of machine.

Product	Production Units	Production Percent	Import Units	Import Percent	Total Units	Total Percent
Two-wheel power tiller						
1974	24808	99.4	150	0.6	24958	100.0
1975	27860	93.9	1800	6.1	29660	100.0
1976	31766	93.0	2400	7.0	34166	100.0
1977	35465	92.2	3000	7.8	38465	100.0
1978	39568	95.9	1693*	4.1	41261	100.0
Small four-wheel						
1974	2324	97.9	50	2.1	2374	100.0
1975	2582	89.6	400	13.4	2982	100.0
1976	2914	85.4	500	14.6	3414	100.0
1977	3258	80.3	800	19.7	4058	100.0
1978	3808	86.3	605	13.7	4413	100.0
Tractor						
1974	-	-	912	-	-	-
1975	2426	54.4	2031	45.6	4457	100.0
1976	2332	48.6	2357	51.4	4589	100.0
1977	2380	50.2	2361	49.8	4741	100.0
1978	2158	51.9	2000	48.1	4158	100.0

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Table 3. Stock of selected farm machines in Thailand, 1975/76 - 1979/80 crop year.

Units

Type of Machine	Crop Year 1975/76	1976/77	1977/78	1978/79	1979/80	Average Compound Growth Rate
Tractor (>45 hp)	13,338	17,569	22,826	28,987	33,280	20.0%
Tractor (<45 hp)	14,575	16,427	23,942	26,984	31,158	16.41%
Two-wheel tractor	90,001	113,286	151,504	191,904	230,591	20.07%
Water pump	251,288	277,084	317,328	359,308	473,975	13.53%
Water wheel	56,891	68,219	81,923	89,775	107,730	13.62%
Rice thresher	3,955	4,430	4,962	5,557	6,224	9.49%
Winnower	42,342	47,423	53,114	49,488	66,806	9.55%

Source: Division of Agricultural Economic Research, Office of Agricultural Statistics, Ministry of Agriculture and Cooperatives, Thailand.

Table 4. Regional distribution of farm power, 1975/76 crop year.

Region	2T	4-TS	4-TL	Sprayer	Water Wheel	Water Pump	Corn Thresher	Rice Thresher
North	12.47	24.47	33.54	39.43	2.87	23.12	65.97	4.47
North Ease	3.40	8.34	23.72	16.21	4.03	18.46	18.81	2.38
Central	75.86	64.33	38.26	41.33	92.94	54.68	12.29	90.47
South	8.28	2.86	4.48	2.98	0.16	3.73	2.94	2.68
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
(Total Number)	90,001	16,792	13,338	46,317	56,891	251,288	5,721	3,955

Note: 2T = two-wheel tractor, 4-TS = small four-wheel tractor, 4=-TL = large tractor.
Source: Division of Agricultural Economic, Office of the Under-Secretary of State, Ministry of Agriculture and Cooperatives, Agricultueral Statistics, No. 54, "Agricultural Statistic of Thailand, crop year 1975/76. Table 20 pp. 183-190.

Table 5. Ratio of horsepower (hp) of selected farm machines to area of farm holdings by regio and agro-economic zone, 1979/80 crop year.

Unit: hp/hectare

Region	Agro-Econ. Zone	Farm Holdings Land (hectare) (1)	2-T (2)	4-TS (3)	4-TL (4)	Total (5)=(2)+(3)+(4)	Water Pump
I. North East	1	1,887,378	0.013	0.002	0.025	0.04	0.041
	2	1,062,872	0.004	0	0.002	0.006	0.01
	3	1,853,307	0.014	0.002	0.017	0.045	
	4	1,549,988	0.006	0.002	0.012	0.02	0.015
	5	1,534,646	0.005	0.007	0.136	0.198	0.067
Average			0.019	0.003	0.135	0.057	0.038
II. North	6	1,275,940	0.079	0.017	0.314	0.410	0.088
	8	1,167,176	0.164	0.012	0.117	0.293	0.089
	9	756,037	0.157	0.032	0.201	0.390	0.12
	10	704,914	0.17	0.015	0.087	0.272	0.136
Average			0.136	0.018	0.192	0.346	0.1
III. Central	7	685,633	0.13	0.077	0.332	0.544	0.122
	11	1,597,188	0.419	0.101	0.194	0.714	0.281
	12	768,246	0.091	0.03	0.163	0.282	0.144
	13	769,520	0.206	0.013	0.102	0.326	0.094
	14	132,486	0.751	0.014	0.127	0.892	0.290
	15	481,534	0.116	0.034	0.086	0.232	0.118
	16	249,934	0.244	0.003	0.096	0.341	0.39
Average			0.256	09.058	0.176	0.491	0.194
IV. South	17	1,360,095	0.108	0.007	0.062	0.177	0.031
	18	480,898	0.07	0.001	0.01	0.081	0.021
	19	312,805	0.044	0.006	0.021	0.071	0.029
Average			0.094	0.006	0.045	0.14	0.029
Overall Average			0.111	0.02	0.116	0.247	0.089

Note: 1 hectare = 6.25 rai
Assume that 2-wheel tractor (2-T) has a 9 hp engine,
small 4-wheel tractor (4-TS) has a 12 hp engine,
large 4-wheel tractor (4-TL) requires 65 hp engine and,
the water pump requires a 3.5 hp engine.

Source: 1. Thailand, Ministry of Agriculture & Cooperatives, Office of Agricultural Economics, Center of Agricultural Statistics, Crop year 1979/80, Table 28, pp. 148-53.
2. Thailand, Ministry of Agriculture & Cooperatives, Office of Agricultural Economics, Division of Policy and Agricultural Development Plan, "Selected Indicator Relating to Agriculture No. 84(5) 1981, Table I-7.2, pp. 27-33.

Table 6. Percent distribution of land utilization by agro-economic zone 1978/79.

Agro-Econ. Zone		Housing Area	Paddy Land	Under Field Crops	Under Fruit & Tree Crops	Under Vegetable and Flowers	Grass Land	Idle Land	Others	%	Total Hectare
1		2.18	65.78	21.12	1.04	0.20	0.5	6.31	2.87	100	1887378.1
2		1.60	81.62	8.21	0.76	0.43	0.42	5.89	1.07	100	1062871.8
3		2.06	76.09	17.49	0.88	0.08	0.70	1.71	1.0	100	1853306.7
4		1.92	85.96	9.13	0.82	0.08	0.0	0.86	1.22	100	1549988.5
5		1.61	54.55	34.50	1.14	0.09	0.45	3.88	3.78	100	1534645.6
	1	1.91	72.12	18.78	0.94	0.16	0.43	3.63	2.04	100	7888190.7
6		1.57	61.64	31.83	2.10	0.53	0.15	1.52	0.64	100	1275939.8
8		1.92	63.84	29.07	2.61	0.05	0.05	0.89	1.56	100	1167175.7
9		3.45	62.48	29.03	3.63	0.13	0.16	0.35	0.76	100	756036.8
10		3.36	77.16	12.60	4.87	0.60	0.01	0.86	0.54	100	704913.8
	2	2.36	65.26	26.99	3.05	0.32	0.10	0.99	0.92	100	3904066.1
7		1.98	45.62	49.00	1.76	0.21	0.31	0.43	0.70	100	685633.1
11		2.60	81.46	10.54	3.30	0.64	0.01	0.20	1.25	100	1597187.8
12		2.92	42.66	36.51	9.98	0.98	0.27	2.68	3.97	100	768246.1
13		1.53	70.87	13.70	3.93	0.14	0.17	2.87	6.78	100	769520.8
14		3.30	58.92	0.28	24.05	1.55	-	0.05	12.12	100	132486.7
15		1.66	18.18	62.93	12.82	0.13	0.21	0.42	4.55	100	481533.8
16		1.84	23.61	21.80	31.70	0.86	0.76	6.94	12.40	100	249933.6
	3	2.26	57.88	26.64	7.26	0.54	0.18	1.46	3.77	100	4684541.9
17		3.19	40.71	0.82	47.29	0.31	0.58	4.10	3.0	100	1360094.9
18		2.31	25.77	1.42	61.59	0.19	0.34	3.95	4.44	100	480898.1
19		4.47	31.13	0.16	62.42	0.03	0.11	1.23	0.44	100	312805.8
	4	3.18	35.98	0.86	52.68	0.24	0.46	3.65	2.94	100	2153798.8
4											
		2.24	62.92	20.40	8.95	0.30	0.30	2.53	2.35	100	18630597.4

Source: Office of Agricultural Economic, Ministry of Agriculture and Cooperatives, Agricultural Statistic of Thailand 1978/79.

Table 7. Distribution of land used by crop, 1978/79.

Agro-Economic Zone	Percent Distribution of Land Used, by Crop									
	Wet Season Rice	Maize	Cotton	Kenafe & Jute	Sugarcane	Cassava	Soybean	Mungbean	Peanut	Total
North East	75.75	5.58	0.38	5.34	0.78	11.46	0.11	0.20	0.38	100
1	76.44	7.38	0.53	4.66	2.38	7.66	0.40	0.23	0.33	100
2	92.52	0.08	0.04	5.62	-	1.54	-	0.02	0.17	100
3	81.24	0.49	0.01	5.84	0.64	11.53	0.01	0.07	0.11	100
4	87.19	2.36	-	6.14	0.21	3.45	-	0.08	0.56	100
5	45.62	16.42	1.28	4.61	-	30.70	0.04	0.56	0.76	100
North	59.23	22.47	0.74	0.05	1.83	0.59	3.92	9.46	1.69	100
6	43.93	38.68	1.28	0.08	1.01	0.72	2.34	11.54	0.42	100
8	67.22	14.75	0.05	0.04	2.43	1.13	1.29	12.73	0.35	100
9	61.19	10.91	1.17	-	4.46	0.50	10.33	7.54	3.90	100
10	81.99	7.20	0.06	0.09	-	-	5.21	0.77	4.68	100
Central	66.37	8.52	0.62	0.14	11.37	9.34	0.63	2.39	0.62	100
7	49.51	35.92	1.31	0.01	0.26	0.56	2.35	9.50	0.56	100
11	88.72	1.08	0.03	-	8.40	0.92	0.19	0.65	0.01	100
12	48.99	2.73	0.87	-	41.25	4.33	0.38	0.19	0.26	100
13	78.03	1.67	0.90	0.90	-	16.95	0.06	0.37	1.12	100
14	100.0	-	-	-	-	-	-	-	-	100
15	24.26	0.20	-	-	23.71	50.35	0.15	-	1.31	100
16	49.12	7.02	2.98	-	-	34.21	0.53	-	6.14	100
South	97.54	0.57	-	-	-	0.15	-	1.04	0.69	100
17	96.82	0.74	-	-	-	0.07	-	1.44	0.94	100
18	98.94	0.35	-	-	-	0.71	-	-	-	100
19	100.0	-	-	-	-	-	-	-	-	100
Whole Kingdom	70.11	10.40	0.51	2.40	3.83	7.58	1.21	3.17	0.01	100

Source: Office of Agricultural Economics, Ministry of Agriculture and Cooperatives, Agricultural Statistics of Thailand, Crop Year 1978/79.

Table 8. Index of land area and planted area.

Year	Field Crops Vegetable	Tree Crops	Total	Index	Planted Area All Crops
1956	100.00	100.00	100.00	100.00	100.00
1957	103.86	105.34	95.24	96.19	90.35
1958	109.59	109.32	96.63	97.14	100.77
1959	117.58	115.60	99.00	99.05	107.60
1960	142.21	116.80	100.19	100.95	110.18
Growth rate	7.30	3.15	0.04	0.19	1.96
1961	181.75	118.02	107.18	107.62	116.26
1962	197.63	127.74	110.46	111.43	120.59
1963	218.13	142.80	114.86	115.24	125.88
1964	244.32	165.15	120.73	120.95	129.04
1965	277.91	198.20	128.63	129.52	132.45
Growth rate	8.86	10.94	3.71	3.77	2.64
1966	276.16	192.38	132.82	133.33	150.39
1967	276.45	187.46	138.82	139.05	141.89
1968	278.17	183.68	146.04	146.67	151.41
1969	281.99	180.93	154.66	155.24	156.18
1970	287.84	179.24	164.88	165.71	159.05
Growth rate	0.83	-1.40	4.42	4.44	1.13
1971	295.89			178.10	162.44
1972	339.18	188.46	186.67	187.62	164.07
1973	411.26	207.55	202.56	203.61	183.77
1974	422.95	208.59	206.16	206.67	181.43
1975	431.19	216.70	210.85	211.43	194.30
	3,350.20*	1,824.16*	20,114.36*		13,782.24*
Growth rate	7.82	4.04	3.57	3.49	3.65
Overall	7.58	3.94	3.80	3.81	3.38

*Thousand hectare

Source: DAE/MOAC, Selected Economic Indicators Relating to Agriculture, No. 84(3), 1978, p.12.

Table 9. Index of area planted to rice.

Year	Planted Area Wet-Season	Planted Area Dry-Season	Total Planted Area
1956	100.00	100.00	100.00
1957	84.21	104.29	84.24
1958	95.59	94.29	95.58
1959	100.76	62.86	100.69
1960	98.31	91.29	98.29
Growth rate	-0.34	-1.81	-0.34
1961	102.40	98.57	102.39
1962	110.56	102.86	110.54
1963	109.57	118.57	109.58
1964	108.44	171.43	108.56
1965	108.63	201.43	108.80
Growth rate	1.19	15.37	1.22
1966	122.98	312.29	123.33
1967	109.87	462.29	110.52
1968	118.38	550.00	119.17
1969	128.24	775.71	129.44
1970	129.76	1,178.57	131.35
Growth rate	1.08	30.42	1.27
1971	133.11	1,915.71	134.74
1972	118.74	2,690.00	121.99
1973	126.78	1,868.57	127.09
1974	121.89	2,924.29	127.09
1975	139.92	3,661.43	146.47
	(8,413.12)*	(410.08)*	(8,823.2)*
Growth rate	1.00	13.83	1.68
Overall	1.69	19.72	1.93

*000 hectares

Source: Division of Agricultural Economics, Ministry of Agriculture and Agricultural Cooperatives.

Table 10. Index for gross domestic product originating from crops at 1962 prices.

Year	GDP Originating From Rice	GDP Originating From Maize	GDP Originating From Sugar-Cane	GDP Originating From Cassava	GDP Originating From Kenaf	GDP Originating From Rubber	GDP Originating From Other Crops	Total GDP Originating From Total Crops	Index
1956	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1957	96.18	80.56	161.05	654.17	124.14	59.00	71.21	84.59	157.20
1958	123.01	109.72	167.42	762.50	177.59	61.01	72.37	98.74	180.73
1959	116.90	187.50	193.63	1,691.67	251.72	75.49	72.27	100.98	271.60
1960	124.84	250.00	208.99	1,529.17	672.41	66.67	97.99	115.56	339.76
Growth rate	4.54	20.11	15.88	72.54	46.40	-7.79	-0.41	2.93	27.71
1961	130.42	275.00	154.68	2,162.50	858.62	73.36	94.53	118.79	370.39
1962	148.25	306.25	122.47	2,600.00	494.83	77.13	100.16	128.66	340.57
1963	159.99	394.44	183.52	2,641.67	756.90	78.16	107.95	140.59	432.25
1964	152.97	438.89	197.00	1,950.00	1,048.28	83.21	110.13	130.39	432.25
1965	147.05	503.47	135.96	1,845.83	1,768.97	85.59	118.90	142.03	518.66
Growth rate	2.43	12.86	-2.55	15.55	16.67	4.69	3.64	6.97	
1966	179.06	568.75	124.72	2,366.67	2,175.86	85.04	138.28	167.85	604.87
1967	148.38	615.97	126.97	2,254.17	1,679.31	85.52	136.31	153.12	555.98
1968	92.06	648.61	146.07	2,295.83	667.24	100.49	141.46	166.39	458.82
1969	97.72	810.42	238.20	3,379.17	1,462.07	119.71	151.92	178.67	702.23
1970	179.01	936.11	258.80	3,754.17	1,318.97	122.02	154.45	183.56	751.52
Growth rate	0.006	10.48	15.72	9.67	-9.53	7.49	2.24	1.81	4.44
1971	180.11	1,132.64	216.85	4,520.83	1,286.21	132.18	164.25	191.40	819.68
1972	156.45	640.28	353.93	5.441.67	1,527.59	140.88	175.43	185.61	823.33
1973	181.92	1,138.89	473.41	8,062.50	1,865.52	159 98	177.28	214.14	1,201,01
1974	175.61	1,293.06	511.61	7,633.33	1,291.38	158.52	199.34	218.42	1,201.01

Table 11. Labor requirement for rice growing, by operation and type of technique.

Unit: m-d/ha

	Type of Farming Technique			
	TB	TT	BB	BT
Land preparation (including nursery)	0.72	0.24	0.48	0.08
Sowing/planting	0.56	0.56	0.04	
Care	0.24	0.24	0.16	0.16
Harvesting and threshing	0.72	0.64	0.72	0.64
All Operations	2.24	1.68	1.40	0.88

Source: NEDECO: Project of land consolidation: Phase I (Bangkok Royal Irrigation Department, 1968).

Note: TB - Transplanting and buffalo.
BB - Broadcasting and buffalo.
TT - Transplant ng and tractor.
Bt - Broadcasting and tractor.

Table 12. Labor saved by farm machines in rice production employing manual transplanting.

Unit: man-day per hectare

Source of Data	Type of Tractor	
	2-wheel	Small 4-wheel
NEDECO	- 21.88 (18.75)	
Consequences Project	- 32.75 (15.75)	- 49.13 (18.37)

Note: 1. All figures are calculated from the difference in the total labor required for rice production employing buffalo power.
2. Figures in parentheses indicate the days saved in land preparation.
3. NEDECO's study did not indicate the type of tractor.

Source: 1. NEDECO, Project of Land Consolidation: Phase I, (Bangkok, Royal Irrigation Department, 1968).
2. Primary data of the project entitled "The Consequences of Small Rice Farm Mechanization on Income and Employment in Thailand", wet season 1979 crop year.

Table 13. Average labor requirement by type of farm power, transplanting irrigated rice farm, Suphanburi Province, Thailand 1979/80 crop year.

Activity and Inputs	Type of Farm Power			
	Buffalo		2-wheel Tractor	Small 4-Wheel Tractor
I. Labor input (hr/ha)				
1.1 Land preparation:		198.82	73.14	51.84
- with farm power	114.60		31.24	21.41
- only human labor	84.22		41.90	30.43
1.2 Seedling and sowing		271.07	225.88	183.60
1.3 Crop care		90.19	76.55	45.41
1.4 Irrigating		2.55	205.86	155.98
1.5 Harvesting		283.29	205.86	155.98
1.6 Threshing		23.19	28.35	27.27
Total Labor Input		875.35	613.18	482.29
II. Pesticide (kg/ha)		5.28	5.49	7.10
III. Fertilizer (kg/ha)		38.32	56.55	63.81
IV. Yield (kg/ha)		2,984.23	3,520.00	3,073.45
V. Farm size (ha)		2.50	3.04	4.28
VI. Average gross output/man-hour (kg/m-hr)		3.41	5.74	6.37
Number of Observations		3	62	29

Source: Field survey, "The Consequences of Small Rice Farm Mechanization on Income and Employment in Thailand, wet season 1979 crop year.

Table 14. Labor saved due to adoption of rice thresher.

Unit: man-day per ton

Threshing Method	Source of Information		
	Kittikul's	Pathnopas's	
		Suphanburi	Chachoengsao
Hand beating	1.86	-	-
Animal treading	1.02	3.84	-
2-wheel tractor	1.80	1.76	1.49
4-wheel small tractor	1.50	-	-
Large tractor	1.11	-	-
Labor input used by rice thresher	0.62	0.98*	0.73*

*Note: Threshing capacity in Chachoengsao Province = 0.60 ton/hour and 0.80 ton/hour in Suphanburi Province.

Source: Calculated from (1) Jirapa Kittikul, "Cost of Rice Threshing and Economic Input," Master's thesis, Faculty of Economics, Thammasat University, (Bangkok: 1980) Thai version. Table 4.2, p.67, and Table 4.3 p. 68. (2) R[illegible] Pathnopas, "The Economics of Rice Threshing Machines in Thailand: A Case Study of Chachoengsao and Suphanburi Provinces, Master's thesis, Faculty of Economics, Thammasat Univerity, (Bangkok: 1980).

Table 15. Distribution of farm holding land, average hp/ha, cropping intensity, farm size and net income by region and agronomic zone.

	% of Farm[1] Household	% of Paddy[2] Land	% of Field[2] Crop Land	% Total[2]	Cropping[3] Average[4] Intensity	Average[1] hp/ha Household	Net[1] Farm Size	Income
$/house-hold								
North-Eastern								
Zone 1	10.4	10.6	10.5	10.6	94.62	0.041	4.15	450.96
2	4.8	7.4	2.3	6.5	96.86	0.010	5.08	504.82
3	10.0	12.0	8.5	11.2	97.81	0.045	4.24	351.60
4	8.2	11.4	3.7	9.7	98.71	0.015	4.32	344.76
5	6.7	7.1	13.9	8.8	98.66	0.067	5.19	594.69
Average NE	40.1	48.5	38.9	46.6	-	0.038	-	499.37
North								
Zone 6	4.7	6.7	10.7	7.7	124.83	0.088	6.17	962.12
8	4.9	6.4	8.9	7.0	110.50	0.089	5.48	990.70
9	7.7	4.0	5.8	4.45	113.04	0.120	2.45	986.87
10	8.9	4.6	2.3	4.10	116.34	0.136	1.80	390.61
Average N	26.20	21.7	27.7	23.25	-	0.10	-	832.58
Central								
Zone 7	2.4	2.7	8.8	4.2	110.50	0.122	6.64	420.76
11	7.5	11.1	4.4	9.5	111.86	0.281	4.85	609.35
12	3.7	2.8	7.4	3.0	100.08	0.241	4.78	571.82
13	2.5	4.7	2.8	4.2	99.33	0.094	7.04	799.66
14	0.9	0.7	0.0	0.5	128.68	0.290	3.24	1,367.39
15	1.7	0.7	8.0	2.5	99.32	0.118	6.42	1,096.11
16	1.1	0.5	1.4	0.7	105.09	0.39	5.00	1,223.07
Average C	19.8	23.7	32.8	25.5	-	0.194	-	869.74
South								
Zone 17	8.5	4.7	0.3	3.6	100.63	0.031	3.63	629.02
18	2.7	1.1	0.2	0.8	100.27	0.021	4.10	606.84
19	2.6	0.8	0.0	0.6	98.67	0.029	2.70	579.78
Average S	13.80	6.6	0.5	5.0	-	0.029	-	605.21
Overall	4,377,613				105.25	0.089	4.26	576.49

Source: [1]From Appendix 3.1 and 3.3. [2]From Table 8,9. [3]From Appendix 3.2. [4]From Table 5.

Table 16. Average gross farm income by source of income and farm machine ownership, Suphanburi Province, Thailand, 1981/82 wet season.

Unit: Percent

Source of Income	4-T(O)	2-T(O)	4-T(H)	2-T(H)
Livestock and poultry	8.95	7.58	2.16	4.39
Crop	82.02	81.64	80.81	61.71
Off-farm employment	3.93	3.93	10.20	13.28
Hiring out farm machine	2.71	2.49	-	-
Land rent out	0.02	0.48	0.69	-
Non-farm income	2.37	3.85	5.86	20.36
Other income	0	0.03	0.28	0.32
Total income/season US$	2,568	2,090	1,169	1,242
Average income/ha	592	622	642	748
Number of observations	49	93	28	53
Average farm size	4.43	3.36	1.82	1.66

Note: 4-T(O) = Four-wheel tractor owner
2-T(O) = Two-wheel tractor owner
2-T(H) = Two-wheel tractor hire
2-T(O) = Two-wheel tractor owner
4-T(H) = Four-wheel tractor hire

Source: Field survey, The Consequences of Small Rice Farm Mechanization in Thailand, 1981/82 wet season.

Table 17. Reasons of farmers in irrigated areas adopt tractors, 1981/82 Suphanburi province, Thailand.

Reasons to Use Tractors	Percent
1. Save time in farm w rk	22.78
2. Can plant on time	20.28
3. Easy and reduces drudgery	18.56
4. Better plowing	12.32
5. Increases output	5.62
6. No animal and human labor available	4.21
7. Reduce weeding	3.74
8. Other reasons	3.42
Total Sample	222

Source: Survey the consequences of small rice farm mechanization in Thailand. 1981/82 survey.

Appendix 1. Provinces in 19 agro-economic zones.

Agro-Economic Zone	Province	Agro-Economic Zone	Province
1	1. Nong Khai	11	40. Ayuthaya
	2. Udon Thani		41. Sing Buri
	3. Sakon Nakhon		42. Nakhon Pathom
	4. Nahkon Phanom		43. Bangkok Metropolitan
2	5. Ubon Rathani		44. Ang Thong
	6. Yasothen	12	45. Kanchana Buri
3	7. Khon Kaen		46. Phetcha Buri
	8. Kalasin		47. Ratcha Buri
	9. Maha Sarakham		48. Prachuap Khiri Khan
	10. Rio Et	13	49. Chachoengsao
4	11. Si Sa Ket		50. Prachin Buri
	12. Surin	14	51. Samut Songkram
	13. Buri Ram		52. Samut Sakhon
5	14. Nakhon Ratchasima		53. Samut Prakan
	15. Chaiyaphum	15	54. Chon Buri
6	16. Phetchabun		55. Rayong
	17. Nakhon Sawan	16	56. Trat
	18. Loei		57. Chantha Buri
	19. Uthai Thani	17	58. Chumphon
7	20 Sara Buri		59. Surat Thani
	21. Lop Buri		60. Phattalung
8	22. Tak		61. Nakhon Si Thammarat
	23. Phitsanulok		62. Songkhla
	24. Phichit	18	63. Ranong
	25. Kamphaeng Phet		64. Phuket
9	26. Uttaradit		65. Satun
	27. Sukhothai		66. Phung-nga
	28. Lampang		67. Krabi
	29. Nan		68. Trang
	30. Phrae	19	69. Pattani
10	31. Chiang Mai		70. Yala
	32. Mae Hong Son		71. Narathiwat
	33. Chiang Rai		
	34. Lamphun		
11	35. Supan Buri		
	36. Pathum Thani		
	37. Nontha Buri		
	38. Nakhon Nayok		
	39. Chai Nat		

Appendix 2.1. Animal power (Index).

Year	Buffalo	Cattle	Total	Index
1956	100.00	100.00	100.00	100.00
1957	102.73	101.27	102.10	102.78
1958	105.55	102.60	104.27	104.63
1959	108.45	103.98	106.51	106.48
1960	111.43	105.43	108.83	109.26
Growth rate	2.19	1.06	1.71	1.79
1961	114.51	106.94	111.23	112.04
1962	117.68	108.51	113.71	113.89
1963	118.74	109.41	114.70	114.81
1964	120.43	113.29	117.34	117.59
1965	122.20	117.35	120.10	120.37
Growth rate	1.31	1.88	1.55	1.44
1966	124.06	121.61	123.00	123.15
1967	126.00	126.07	126.03	125.93
1968	125.96	129.51	128.68	128.70
1969	130.16	134.38	131.99	132.41
1970	132.30	140.89	136.02	136.11
Growth rate	1.29	2.99	2.03	2.02
1971	128.60	134.64	131.22	131.48
1972	123.70	135.39	128.76	129.63
1973	137.08	130.87	138.39	135.19
1974	137.19	133.80	135.72	136.11
1975	125.54	130.13	127.53	127.78
	(5,441.7)*	(4,310.7)*	(9,752.4)*	(138)*
Growth rate	-0.48	-0.68	-0.57	-0.57
Overall	1.14	1.33	1.22	1.23

*Thousand

Source: DAE/MOAC, Agricultural Statistics of Thailand, Bangkok, various issues.

Appendix 2.2. Agricultural labor force (index).

Year	Agricultural Labor Force
1956	100
1957	101.55
1958	103.13
1959	113.96
1960	115.73
Growth rate	2.96
1961	117.52
1962	119.35
1963	121.20
1964	123.08
1965	124.99
Growth rate	1.24
1966	126.92
1967	128.89
1968	130.89
1969	132.92
1970	134.98
Growth rate	1.24
1971	137.08
1972	139.20
1973	141.36
1974	143.55
1975	145.78
	(14,274.60)*
Growth rate	1.24
Overall	1.90

*Thousand

Source: DAE/MOAC, Selected Economic Indicators Relation to Agriculture, No. 84, 1975, p.11.

Appendix 2.3. Fertilizer consumption in Thailand (index).

Year	Import (1)	Domestic Production (2)	Non Agricultural Use (3)	Agricultural Use (1)+(2)-(3)
1956	100.00	-	-	100.00
1957	170.81	-	-	170.81
1958	124.50	-	-	124.50
1959	203.33	-	-	203.33
1960	221.76	-	100.00	220.68
Growth rate	17.27	-	-	17.15
1961	233.76	-	185.26	231.78
1962	283.69	-	72.11	282.91
1963	415.63	-	159.36	413.92
1964	465.14	-	1,011.16	454.30
1965	379.63	-	786.06	371.21
Growth rate	10.18	-	33.52	9.88
1966	603.65	100.00	700.30	614.55
1967	931.51	795.92	1,283.27	1,064.35
1968	1,134.00	622.97	2,572.51	1,221.18
1969	1,134.62	394.90	1,994.42	1,185.98
1970	1,065.52	921.50	1,437,45	1,219.84
Growth rate	12.04	55.92	15.45	14.70
1971	966.94	880.07	1,251.00	1,115.62
1972	1,636.02	718.42	3,229.08	1,733.74
1973	1,657.82	528.39	3,605.98	1,972.59
1974	1,431.24	672.07	4,026.69	1,511.88
1975	1,839.47	426.42	4,496.41	1,869.84
	(430,970)*	(18,400)*	(11,286)*	(438,084)*
Growth rate	13.73	-13.49	29.16	10.88
Overall	15.67	15.61	26.85	15.77

*Metric tons

Source: DAE/MOAC, Agricultural Statistics of Thailand, 1966, Table 100 and UN: ESCAP/ARCAP, Marketing and Distribution of Fertilizer in Thailand, (Bangkok, 1976) Annex - Table 6.

Appendix 2.4. Imports of selected farm machinery (index).

Year	Tractors	Water Pumps
1956	100.00	100.00
1957	66.09	22.26
1958	95.05	14.42
1959	110.15	10.06
1960	211.63	11.94
Growth rate	16.17	-34.63
1961	368.07	12.90
1962	334.90	12.69
1963	475.74	21.12
1964	852.97	28.81
1965	754.21	41.82
Growth rate	15.43	26.52
1966	958.42	65.17
1967	1,065.59	87.85
1968	893.56	161.89
1969	647.03	114.10
1970	436.39	146.21
Growth rate	-14.56	17.54
1971	597.52	112.43
1972	399.00	96.37
1973	424.50	160.56
1974	821.29	180.27
1975	1,702.23	159.41
	(6,877)*	(149,021)*
Growth rate	23.29	7.23
Overall	15.23	2.36

* Unit

Source: Customs Department, Ministry of Finance, Annual Statement opf Foreign Trade Statistics, Various Issues.

Appendix 3.1. Average farm holding per household.

Zone	Number of Farms	Farm Holding Land (ha)	ha/farm	Tractor HP/ha	Net Income/Farm
North East					
1	455,061	1,887,378	4.15	0.040	450.96
2	209,125	1,062,871.8	5.08	0.006	504.82
3	436,608	1,853,306.7	4.24	0.017	351.60
4	358,535	1,549,988.4	4.32	0.020	344.76
5	295,431	1,534,645.6	5.19	0.198	594.69
North					
6	206,784	1,275,939.8	6.17	0.410	962.12
8	212,836	1,167,175.6	6.64	0.544	990.70
9	336,824	756,036.8	5.48	0.293	986.87
10	390,686	704,913.8	2.45	0.390	390.61
Central					
7	103,310	685,633.12	1.80	0.272	420.76
11	329,158	1,597,187.8	4.85	0.713	609.35
12	160,849	768,246.08	4.78	0.283	571.82
13	109,260	769,520.48	7.04	0.326	799.66
14	40,845	132,486.72	3.24	0.892	1,367.39
15	74,979	481,533.76	6.42	0.237	1,096.11
16	50,062	249,933.5	5.00	0.341	1,223.07
South					
17	374,177	1,360,094.8	3.63	0.[illegible]7	629.02
18	177,222	480,898.08	4.10	0.081	606.84
19	155,861	312,805.76	2.70	0.071	579.78
Total	4,377,613	18,630,596	4.26		576.49

Source: Thailand, Ministry of Agriculture and Cooperatives, Office of Agricultural Economics Center for Agricultural Statistics, Agricultural Statistics Crop Year 1979/80, No. 134, Table 28, pp. 148-153.

Appendix 3.2. Average farm land per household, average hp of tractor used and cropping intensity index, by agro-economic zone, 1978.79.

Agro-Economic Zone	Farm Holding Land (hc/household)[1]	h.p. of Tractor Used (hp/ha)[2]	Cropping Intensity Index[3]				
			Single Cropping (%)	Double Cropping (%)	Triple Cropping (%)	More Than One (%)	Aggregate cropping (%)
1	4.15	0.04	92.69	1.93	-	1.93	94.62
2	5.08	0.006	96.73	0.13	-	0.13	96.86
3	4.24	0.017	97.68	0.13	-	0.13	97.81
4	4.32	0.02	98.50	0.21	-	4.95	98.66
5	5.19	0.198	93.71	4.95	-	4.95	98.66
6	6.17	0.41	97.75	26.82	0.26	27.07	124.83
8	5.48	0.293	96.95	3.54	0.01	13.55	110.50
9	2.45	0.39	96.62	16.22	0.20	16.42	113.04
10	1.80	0.272	99.04	17.15	0.15	17.30	116.34
7	6.64	0.544	96.95	13.54	0.01	13.55	110.50
11	4.85	0.713	98.42	13.42	0.02	13.44	111.86
12	4.78	0.283	98.71	1.37	-	1.37	100.08
13	7.04	0.326	98.83	0.50	-	0.50	99.33
14	3.24	0.892	98.22	30.00	0.03	30.46	128.68
15	6.42	0.237	98.32	1.0	-	1.0	99.32
16	5.00	0.341	95.58	9.49	0.02	9.51	105.09
17	3.63	0.177	99.4	1.23	-	1.23	100.63
18	4.10	0.081	98.92	1.35	-	1.35	100.27
19	2.70	0.071	98.67	-	-	-	98.67
Whole Kingdom	4.26	0.247	96.99	8.23	0.03	8.26	105.25

Source: [1]Appendix 3.1.
[2]From Table 5.
[3]Divison of Policy and Agricultural Development Plan, Ministryof Agriculture and Cooperatives, Selected Economic Indicators Relating to Agriculture, No. 84(5) 1981, Table II-12, p. 56.

Appendix 3.3. Average farm income of farm households in 1979/80 by agro-economic zone,(unit US$ per household).

Agro-Economic Zone	Cash Income From Farm (1)	Farm Product Consumed (2)	Income From Farm (3)=(1) + (2)	Off-farm Income (4)*	Gross Income (5)**=(3)+ (4)	Cash Expenses On Farm (6)	Net Farm Income (7) = (3)-(6)	Net Income (8) = (5)-(6)	Average tract H.P./ Hectare
North East									
1	321.00	228.97	558.98	9.00	558.98	108.02	441.96	450.96	0.04
2	425.87	290.70	716.58	1.52	718.10	213.28	503.30	504.82	0.006
3	268.86	209.44	478.31	2.26	480.57	128.97	349.34	351.60	0.017
4	250.27	209.15	459.42	1.03	460.45	115.69	343.73	344.76	0.02
5	710.33	237.09	947.42	24.55	971.96	337.27	570.14	594.69	0.198
Average	396.27	235.07	632.14	7.67	638.01	180.65	441.69	449.37	0.058
North									
6	1,173.73	151.89	1,325.63	135.02	1,460.65	498.52	827/10	962.12	0.410
8	1,681.11	118.45	1,799.56	34.63	1,834.19	843.48	956.07	990.70	0.293
9	1,326.96	129.86	1,456.81	15.94	1,472.75	485.88	970.93	986.87	0.390
10	535.37	71.91	607.28	50.81	658.09	267.49	339.79	390.61	0.272
Average	1,179.29	118.03	1,297.32	59.1	1,356.42	523.84	773.47	832.58	0.346
Central									
7	413.67	185.83	599.51	7.18	606.60	185.93	413.58	420.76	0.544
11	1,432.42	142.99	1,575.41	23.66	1,599.07	989.72	585.69	609.35	0.714
12	1,200.20	127.20	1,327.40	27.50	1,354.89	783.08	544.32	571.82	0.282
13	1,365.67	201.18	1,566.85	8.02	1,574.86	775.21	791.64	799.66	0.326
14	1,821.50	105.85	1,927.35	4.13	1,931.48	711.66	1,215.69	1,367.39	0.892
15	2,197.69	95.33	2,293.02	168.96	2,461.86	1,365.86	927.15	1,096.11	0.232
16	1,671.67	266.16	1,937.83	1.92	1,939.74	716.77	1,221.05	1,223.07	0.341
Average	1,443.26	160.65	1,603.91	34.48	1,638.39	789.75	814.16	869.74	0.491
South									
17	722.43	127.40	849.83	29.22	879.05	250.02	599.80	629.02	0.177
18	479.49	300.44	779.93	8.56	788.49	181.65	598.28	606.84	0.081
19	647.47	107.03	754.50	12.64	767.14	187.36	567.14	579.78	0.071
Average	616.46	178.29	794.75	61.81	811.56	206.34	588.41	605.21	0.14
Overall Average	732.96	179.24	912.20	24.63	936.84	360.35	551.84	576.49	0.247

Note: Include only animal and machine rent out.
Source: Division of Agricultural Economics, Office of the Under-Secretary of State Ministry of Agriculture and Cooperatives, Bangkok, Thailand, "Income and Expenditure of Farm Household in Thailand 1979/80" (Thai version).

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A BRIEF REPORT ON PAST, PRESENT AND FUTURE AGRICULTURAL MECHANIZATION POLICY*

Chak Chakkaphak and Bill Cochran**

ABSTRACT

In the past, research and development were the only forms of government contribution to farm mechanization in Thailand. The rapid and wide adoption of farm machinery convinced many government agencies to promote farm mechanization. Though many policies and schemes have been launched, no formal policy strategy was followed. Presently, the National Committee for Farm Mechanization attempts to document Policy and Strategy Guidelines on Agricultural Mechanization. The paper proposes the development of effective and permanent policies for the future.

*Paper presented at the Workshop on the Consequences of Small Rice Farm Mechanization held in Bangkok, Thailand, on November 10-11, 1983.

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A BRIEF REPORT ON PAST, PRESENT AND FUTURE AGRICULTURAL MECHANIZATION POLICY

Chak Chakkaphak and Bill Cochran

1. Increasing yield is clearly one of the objectives of the Fifth National Economic and Social Development Plan. To achieve this objective, the government should increase multiple cropping areas and promote the appropriate farm mechanization strategy, since there is much to follow land after the rice season.

2. Some characteristics of farm mechanization in Thailand.

2.1 Hand-tool technology predominates Thai agriculture. There is very little animal-draught or mechanical-power technology used in the country except for seedbed preparation, threshing and transportation activities.

2.2 Major agricultural machinery used in the country are either locally manufactured or assembled.

Table 1 compares the major agricultural machines of 1975-1976 with those of 1981-1982.

2.3 Private contracting services are very common and are a great contribution to farming operations.

3. The Agricultural Engineering Division was established to undertake research and development of suitable agricultural machines. A number of small machines for rice cultivation have ben developed by the founder of the division, M. R. Debbriddhi Devakul. During his term, the Iron Buffalo (small 2-wheel and 4-wheel tractor), "Debriddhi pump", paddy thresher, harvested grain storer, dryers and a small rice milling unit were introduced. Some other activities that were started under his direction included the training of farmers in the utilization and maintenance of machines, and the pilot project on ploughing services.

4. To serve the farmers' needs a small number of private manufacturers started their businesses over 1963-1973, notably Cholburi Mungthong Co. Ltd. in Cholburi, Ayudaya Tractor in Ayudaya, Thai Heng-long in Chachoengsao. Animal drawn ploughs, two wheel tractors, and the "Debriddhi" propeller pump were adopted by farmers in those provinces and in nearby areas. Since then, the private sector has been very dynamic in serving the country's farm mechanization needs.

5. An increasing number of machines has convinced government agencies and Institutions to include farm mechanization among their respective functions. The activities currently undertaken as follows:

5.1 A Bachelor Degree curriculum in farm machinery offered at Kasetsart and Khon Kaen University.

5.2 Farm machinery and related subjects offered in colleges and vocational schools.

5.3 The Department of Industrial Promotion and the Department of Agriculture jointly provide technical assistance to selected manufacturers by introducing new machines and improving their production processes.

5.4 Formation of the Thai Agricultural Engineering Association.

5.5 Formation of the Agricultural Machinery Section within the Industrial Association of Thailand.

5.6 Establishment of the Farm Machinery Section under the Department of Agricultural Extension.

5.7 Survey of Agricultural Machinery by the Office of Agricultural Economics.

5.8 Survey of and Studies on Agricultural Manufacturing by the Bank of Thailand.

5.9 Economic Studies on Manufacturing and utilization of farm machinery made by Thammasat and Kasetsart University.

5.10 Studies made by the Board of Investment.

5.11 Loans given by the Bank of Agriculture and Agricultural Cooperatives.

5.12 Establishment of the National Committee for Agricultural Mechanization.

5.13 Establishment of the "Working Group of Agricultural Mechanization for the Northern Region".

5.14 Ministry of Commerce's announcement on the control of importation of small used 4-wheel tractors and power tillers in 1982.

5.15 Standardization of the disc-plough by the Office of Industrial Product Standardization.

5.16 Participation by Thailand in ESCAP "Regional Network for Agricultural Machinery" Project.

6. All of the activities in No. 5 need to be strengthened and developed in a more systematic manner.

7. Agricultural Mechanization is a system by itself. It therefore need to have its own policies, strategies, planning efforts and projects.

Figure 1 illustrates the system of the agricultural mechanization program.

8. In view of the present situation, it is necessary for the country to form two organizations to undertake the major activities on a full-time and permanent basis. These organizations will be charged with the formulation of Government policy and strategy, planning, monitoring results, testing and evaluation.

9. The National Committee for Agricultural Mechanization is presently working on a document called "Policy and Strategy Guidelines on Agricultural Mechanization". The document will propose policies to the office of the National Economic and Social Development Board and to the Cabinet. For the first time the country will have such an agricultural mechanization policy.

10. In view of the Government policy stated in the current National Economic and Social Development Plan, the Policy Document will contain policy and strategy to promote agricultural mechanization in the following ways:

10.1 Provide strategy and guidelines for government agencies concerned that will strengthen their links with the private sector (farm equipment manufacturers and after sale services). These include determination of priority needs, selection of suitable agricultural machines, research and development, dissemination of information and extension services, provision of credit, coordination of activities, training of farmers and extension agents etc.

10.2 Assistance to local manufacturers to ensure their access to credit, technical assistance in the manufacture of new types of equipment, production techniques, imports and exports of agricultural machinery and promotion of joint-ventures.

11. The Government feels the benefits accured so far would have been greater with better planning and use of the available mechanical resources. This is partly due to the fact that there were no specific Government policies, and partly because to the lack of viable and strong organizations to provide the required support services. It is now the Government's aim to provide the required support services, viz, R&D, extension, credit, training, etc. in an efficient and organized manner.

12. The private sector has played a significant role in farm mechanization for the country. Further mechanization in both the highly mechanized and the less mechanized areas should be left to the free market system. Any government intervention should be confined to deterine what is needed to improve the ability of farmers to adopt mechanization.

Table 1. Volume of Agricultural Machinery in Thailand by Machine type.

	1975-76	1981-82
2-axle tractor over 45 hp	13,338	50,044
2-axle tractors under 45 hp	14,575	39,158
Single-axle tractors (power tillers)	90,001	284,351
Irrigation pumps	251,288	603,538
Rice winnowers	42,342	83,801
Maize shellers	5,721	11,287
Threshers	3,855	20,601
Rice mills	24,658	26,212

Source: Office of Agricultural Economics, Ministry of Agriculture and Cooperatives.

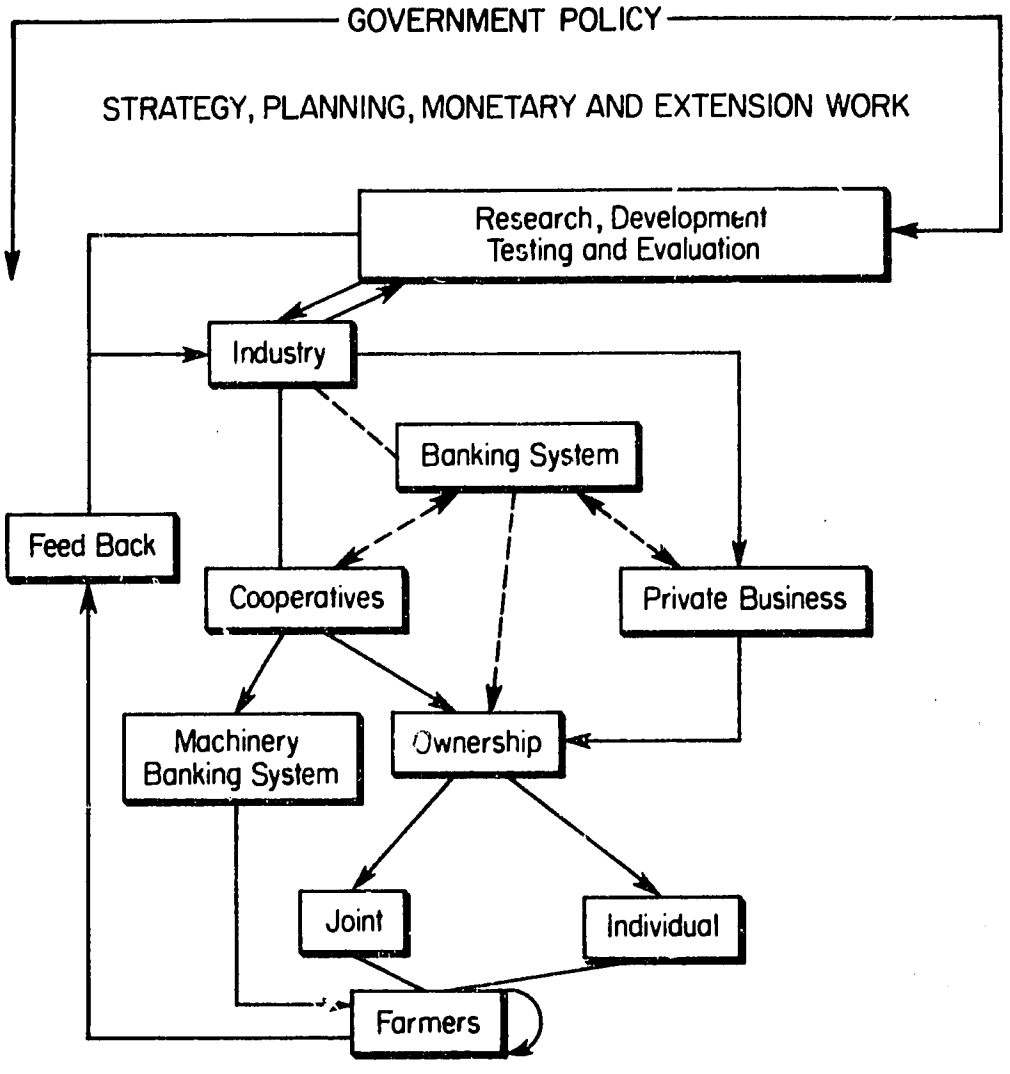

Fig.1. Agricultural Mechanization System.

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MECHANIZATION OF RAINFED AREAS: A MISSING LINK*

Winit Chinsuwan**

ABSTRACT

Despite the extensive use of farm mechanization in Thai agriculture, there were several constraints and biases towards its use. First of all, farm mechanization is widely adopted only in irrigated areas. Farmers in rainfed areas, the largest proportion of total cultivated land, have little or no access to farm machinery. Secondly, the Thai government makes no effort to improve simple hand tools, which are important in rainfed areas. Thirdly, farmers, particularly in the rainfed areas, have little or no choice of farm machinery. Most machines purchased under credit programs are specified by banks or credit sources. Fourth, there have been no supporting agencies established to coordinate governmental efforts. Most coordination is done through personal and informal contracts. Other than the Agricultural Engineering Division of the Department of Agriculture, there are no agencies to formally disseminate research informations to and get feed-back from farmers.

*Paper presented at the workshop on the Consequences of Small Rice Farm Mechanization in Thailand held in Bangkok, Thailand, on November 10-11, 1983.

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MECHANIZATION OF RICE IN RAINFED AREAS: A MISSING LINK

Winit Chinsuwan

Cultivated Area

The total land area of Thailand is about 321 million rai, of which 121.3 million rai are cultivated. How, only 20.2 million rai or 16.65% of the cultivated area are irrigated. These irrigated areas are distributed as follows:

Central region	12.1 million rai
Northern region	3.8 million rai
Northeast region	2.6 million rai
Southern region	1.7 million rai

Major crops

The cultivated areas are planted with the following major crop groupings:

Rice	73.5 million rai
Field crops	27.4 million rai
Fruit trees	11.4 million rai
Vegetables	0.3 million rai
Grass land	0.76 million rai

Irrigated vs. Rainfed Rice

About 74% of the total irrigated area is planted to rice. Figure 1 shows that the irrigated area for rice is approximately 20% of the total rice growing area. The average yield of rice in the irrigated area was approximately double that of the rainfed area. The farmers in the lowland area are more confident in investing their resources for fertilizers and pesticides. These additional input contribute to higher yield in the irrigated area. However, the rainfed area cannot be overlooked.

Other Crops of Irrigated Areas

The most common irrigated crops are vegetables and rice, respectively (Table 1). The irrigated area for rice is much greater than that of other crops. Sixty million rai of rice growing areas, however, are still rainfed.

Machinery Used for Rice Production

Machinery used for rice production in Thailand vary from hand tools or animal drawn implements to tractors for land preparation, and from hand tools to reapers and threshers and even combines for harvesting.

Hand tools are commonly used for rice production except for seedbed preparation and threshing. Very little animal drawn or mechanical equipment was used for these two operations.

Table 2 shows the amount of man-days per rai required for rice production operations. Approximately 60 percent of the man-days required for production operations utilize only hand tools. The 40 percent of plowing/harrowing and threshing/transporting operations utilize hand tools, animal drawn equipment, and mechanical equipment.

The data in Table 2 were obtained in 1975, but they are still true at present, especially for the rainfed areas. This means that in the last 8 years there was no systematic effort to improve the design or quality of the hand tools and animal drawn equipment.

Power Source for Draft

Buffalo provide most of the farm power for land preparation. Table 3 shows the number of buffalo in 1977-1981 for different regions. There was no significant change in buffalo population during this period for all regions even though the number of tractors has increased. The use of buffalo is highest in the Northeast, followed by the North where a high percentage of the area is rainfed. One can predict that buffalo will remain a major source of farm power for land preparation in the next decade. Unfortunately, there was very little or no effort to improve animal drawn implements.

Mechanical Power Machinery

The total number of mechanical power machinery for rice production, especially tractors, irrigation pumps, and threshers, rapidly increased (Table 4). These data indicate a growing trend in the use of mechanical power machinery for certain production operations. However, these machines were mainly used in the Central region (Table 5). Machines were used only in the well irrigated areas of the Northeast and the North.

Missing Links

The missing links of machinery for rice production may be grouped as follows:

1) Target area. The machines promoted by either the private or public sector such as tractors, reapers, and threshers, were suitable only for the irrigated areas. The majority of poor farmers, living in the rainfed areas get little or no benefit from these machines.

2) Type of equipment. The equipment used in Thailand for rice production as well as for that of other crops are mainly land preparation, harvesting, and post-harvest equipment. Equipment for production operations between land preparation and harvesting such as planters and weeders, are almost completely absent. These equipment are important especially for the rainfed areas.

3) Mechanization cannot be generalized. Due to the different environmental, technological, biological, and socio-economic constraints in the different locations, mechanization cannot be generalized. The equipment for all levels of power sources (man, animal and engine) should be made available. The farmers should be the ones to decide what equipment to use.

The study on different methods of planting rie in Phayao province (Table 6) indicated that broadcasting and linear transplanting resulted in higher yield than random transplanting. Furthermore, direct seeding has improved stability of rainfed rice production in the Northeast, since it allowed the crop to be planted early even in a dry year. Hence, there is sufficient time for vegetative growth. Under these conditions, it is obvious that the seeder and weeder are more appropriate than the transplanter.

4) Supporting agencies. AED is the main organization responsible for mechanization. Due to its limited staff and support the mechanization program cannot be effectively implemented. Coordination among the agencies is mostly on a personal and informal basis which is ineffective.

Table 1. Irrigated area by crop (x 1000 rai)

CROPS	TOTAL AREA	IRRIGATED AREA	PERCENT OF TOTAL
Rice	73,523	13,500	18.4
Sugarcane	3,857	438	11.4
Fruit trees	11,412	300	2.6
Field crops	27,384	168	0.6
Vegetables	300	81	27.0

Source: Agricultural Statistics of Thailand crop year 1981/82. Data on irrigated area by Royal Irrigation Department.

Table 2. Man-days per rai for rice production operation in the Chiang Mai Valley.

OPERATION	GLUTINOUS RICE	NON-GLUTINOUS RICE
Seedling preparation	0.89	0.98
Plowing/harrowing	3.44	3.52
Transplanting	2.89	3.30
Care of crop	1.73	2.54
Harvesting	3.68	4.14
Field transportation	0.96	0.96
Threshing/transporting	3.23	3.11
TOTAL	16.82	18.55

Source: Rijk, A. G., "Irrigation on Agricultural Mechanization for the Northern Region of Thailand", NADC, Chiang Mai, Thailand, December 1976.

Table 3. Number of buffalo in 1977-1981.

REGION	1977	1978	1979	1980	1981
Northern	1,287,892	1,260,999	1,339,874	1,215,759	1,340,346
Northeast	3,665,383	3,830,402	3,838,445	3,672,557	3,987,088
Central	586,154	593,041	561,919	533,892	557,943
Southern	288,033	274,292	287,657	228,586	238,642
TOTAL	5,827,462	5,958,734	6,027,895	5,650,794	6,124,019

Source: MOAC-Office of Agricultural Economics. Agricultural Statistics of Thailand Crop Year 1981/1982.

Table 4. Inventory of mechanical power machinery in 1975/76 and 1979/80.

	1975/76	1979/80
2-axle tractors over 45 hp	13,338	33,285
2-axle tractors under 45 hp	14,575	31,158
Single-axle tractors	90,001	230,591
Engine Driven puddlers	9,882	8,000
Sprayers (manual and engine)	1,310,464	1,604,884
Irrigation pumps	251,288	473,975
Rice winnowers	42,342	66,806
Rice threshers	3,855	6,224
Rice mills	24,658	25,682

Table 5. Regional inventory of mechanical power machinery (1975/76).

Region	2-axle tractors over 45 hp	2-axle tractors under 45 hp	Single axle tractors	Engine driven puddlers	Sprayers	Irrigation pumps	Rice winnowers	Rice threshers	Rice mills
Northern	4,624	4,024	11,275	266	19,122	61,195	9,830	177	6,737
Northeast	3,041	1,306	3,003	6	6,647	47,222	1,577	94	10,864
Central	5,103	10,383	68,271	9,577	19,158	190,284	27,862	3,578	3,170
Southern	597	153	7,452	33	1,381	9,478	3,073	106	3,887
Total	13,338	16,051	90,001	9,882	46,308	308,179	42,342	3,995	24,658

Source: MOAC-Office of Agricultural Economics, "Selected Economics Indicators Relating to Agriculture", Bangkok, No. 84 (4), 1979.

Table 6. Comparison among different methods of planting rice in Mae Jai, Phayao[1/]

FARMER	YIELD (kg/ha)		
	BROADCASTING	LINE SOWING	TRANSPLANTING[2]
Khun Muanjai	612	519	488
Khun Srimoa	656	628	418
Khun Sawang	693	546	3/
Khun Taa	568	568	414
Khun Intaa	627	629	4/
Khun Jampee	652	367	259
Mean	635	543	395

1/ Seeding rate for broadcasting and linear transplanting was 10 kg/ rai.

2/ Farmers' fields adjacent to the trial plots.

3/ Plenty of empty seeds, data not obtained.

4/ No data.

Source: Rainfed Crop Production Research and Development Project, Semi-annual Report, 1 March-31 August 1982.

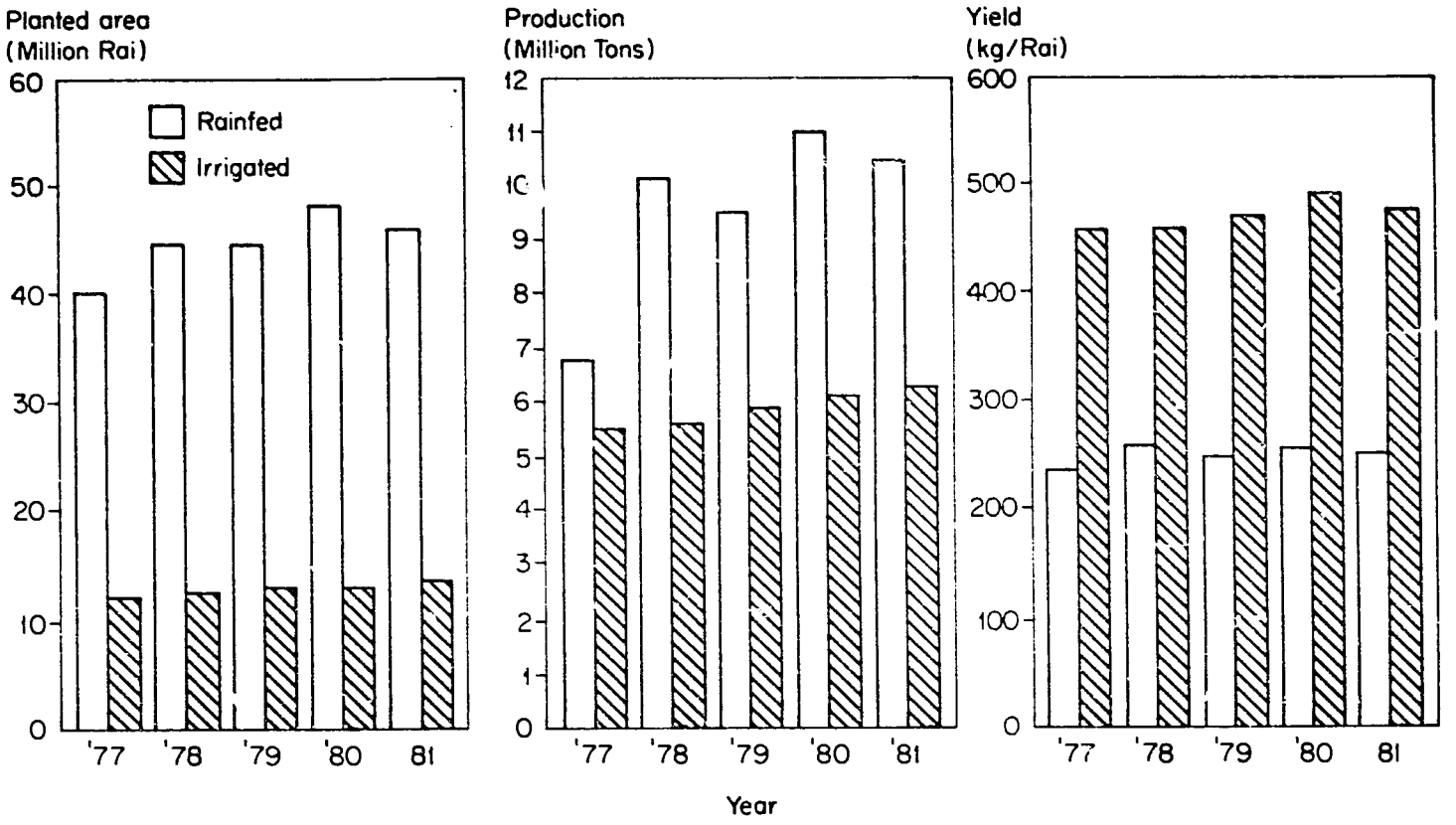

Fig.1. Comparative area, production and yield of rice under rainfed and irrigated condition.

SECTION II

THE IMPACT OF MECHANIZATION ON OUTPUT, EMPLOYMENT AND INCOME

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THE IMPACT OF AGRICULTURAL MECHANIZATION ON AGRICULTURAL PRODUCTION IN SELECTED IRRIGATED VILLAGES OF SUPHANBURI PROVINCE, THAILAND

Dermot Shields**

ABSTRACT

The study examined differences in agricultural production associated with 2 alternative machines used for land preparation - the 2- and 4-wheel tractors. Economic variables of interest were output, cropping intensity and costs and returns for the two machine types over the 1981/1982 wet and dry seasons. In general, farms using 4-wheel tractors were larger than those using two-wheel tractors in both seasons. The cropping intensities were not significantly different. Tractorization however improved productivities of both land and labor. In the wet season, yields of farms using 2-wheel tractors were higher than yields of those using 4-wheel tractors but the reverse was true in the dry season. This same pattern was observed with the return per unit of land. These differences were, however, all statistically insignificant. The total cost incurred by farms using 2-wheel tractors during the wet season was higher than that incurred by farms using 4-wheel tractors while the reverse again was true in the dry season. The profit of farms using 4-wheel tractors was higher than that of farms using 2-wheel tractors for both seasons, but the differences over the wet season were not statistically significant.

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THE IMPACT OF AGRICULTURAL MECHANIZATION ON AGRICULTURAL PRODUCTION IN SELECTED IRRIGATED VILLAGES OF SUPHANBURI PROVINCE, THAILAND

Dermot Shields

Introduction

Agricultural mechanization has been the focus of much debate and controversy for a long time. Now that mechanization is well established in some areas, such as Suphanburi Province, the debate has switched to the appropriateness of the different types of machines that are currently available. However, many of the issues remain the same and the problem for the policy maker is still the determination of the appropriate mechanization strategy.

As in the original debate over mechanization itself, it is still difficult to form definite conclusions, since data is either not available or is site specific and hence not readily generalizable. The aim of this paper is to set out the differences if any, in yields, inputs, cropping intensity, and cost and returns for the two alternative machines used in land preparation in Suphanburi - the 2-wheel tractor and the small 4-wheel trailer.

The Consequences of Mechanization study aimed to collect data on four sites in Southeast Asia where mechanization was either well established, or nearly so, in order to provide the sort of quantitative background data which is required for policy interventions.

In Thailand, the area chosen for the survey was Suphanburi Province in the Central Plains. The area is largely irrigated and tractorization is the dominant technique for land preparation. Five villages were purposively selected in order to give a large enough sample of 2-wheel and 4-wheel tractor users and within these villages households were randomly selected.

The survey was carried out in crop year 1981/82 and made use of the FAO Farm Management Data Collection and Analysis System (FMDCAS) together with supplementary questionnaire providing detailed information on machine use, as well as historical information about the cause and consequences of the change in the land preparation technique.

The majority of farm households in the area used either 2 wheel or small 4 wheel tractors. Only 5 out of the total cultivating sample of 250 were totally reliant on animal power for land preparation and this was an insufficient number to be statistically significant.

The analysis therefore focuses on the differences between 2 and 4 wheel tractor users, which have been further disaggregated into owners and hirers. The number of households in each classification group is given in Table 1. The classification system was based on land preparation techniques.

Background

The major crop in the area is rice, with over 90 percent of the cultivated area included in the survey planted to modern varieties, the dominant of which were RD 7 and RD11 (Table 2). This was true for all groups.

Transplanting was also the norm in the area, and most of the 25 percent of farmers broadcasted had large farm sizes of over 3 hectares (Table 3).

Nearly all the households were irrigated although the quality of distribution varied with the distance from the main canal. However, irrigation in general has been installed for some time now. The process of mechanization, was rapid from about 1965 and for the household in our sample, was nearly complete by 1978 (Figure 1). The growth of 2-wheel and 4-wheel tractors was indistinguishable having virtually the same slope throughout this period.

The mean number of draft animals per farm was surprisingly high suggesting that draft animals were kept as a form of insurance especially for households having machines (Table 4). If these animals are not replaced after their working lives then the mechanization process will be irreversible.

The age distribution of draft animals is shown in Table 5. This suggests that for the two-wheel tractor user, the draft animal population is at least not totally depleted and that there is still investment in new draft stock.

Socio-economic background

The age and educational background of all the surveyed farmers were similar, with a mean age of 47 years and average schooling of just over 3 years (Table 3). Average family size was about 6 although households hiring tractors had smaller family sizes than tractor owners.

The area owned by each group differed. As expected 4-wheel tractor users both managed larger farms and owned a larger share of the farm than 2-wheel tractor users. Owners and hirers owned roughly a similar share of the land that they manage but tractor-owners managed farms which were about twice as large as those of tractor hirers.

The wealth position of the survey farmers is difficult to assess since the value of assets such as land (which may never have been purchased) is very subjective. However Table 6 shows that for all farmers, land was the dominant asset. Since hirers have smaller farm sizes, land accounted for a smaller proportion of their total assets. Although mechanical assets accounted for a relatively high proportion of total assets for the hiring class, this was small in absolute terms. For hirers, animals particularly the productive animals were an important asset, and in absolute terms were greater than for the other groups.

Area cultivated

The mean planted area of 4-wheel tractor farms was 3.68 ha in the wet season (Table 7). This was 30 percent larger than for 2-wheel tractor using farms. The mean in the dry season was 3.43 ha which is also nearly 30 percent larger than for the 2-wheel tractor using farms. These differences are more noticeable when owners and hirers are compared with owners having mean cultivated areas roughly double that of hirers in both the wet and the dry season.

In the largest area class, farms greater than 5.0 ha, do not have any hirers and only very few 2-wheel tractor users. The issue of farm size and choice of machine is an important one which needs further analysis. Maranan et. al.[1] calculated that the breakeven point for 2-wheel tractors was about 3 ha and for 4-wheel tractors, 5 ha.

Cropping intensity

If there are power or time constraints which will limit the amount of land farmers can bring into cultivation in the dry season, then it would be expected that the larger tractors, with greater speed and horsepower, would overcome these constraints and enable farmers to increase land use in the dry season. Results from the study, however, showed that there were no significant differences in the rice cropping intensity between 2-wheel and 4-wheel tractor users, both with a mean of 181 percent (Table 7).

Owners had a higher intensity than hirers although the difference was very small. This is to be expected since the area was largely irrigated and from Table 8, it can be seen that some farmers did not cultivate a second rice crop. Hence the lower cropping intensity was due mainly to a reduction in the area cultivated by each farmer.

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[1]Maranan, C. et. al. The Economics of Mechanical Land Preparation: An Evaluation of Evidence from Suphanburi Province, Thailand.

Timeliness

In addition to quantative differences, there may also be qualitative differences between farm types due to more optimum timing and faster operating hours, and these may be equally important. However, some of these factors, visible at the level of the individual activity or parcel, were smoothed out at the level of household data subject as it is to a myriad of non-technical, socio-economic forces (as well as data aggregation). According to Lingard .... "Such factors as 'timeliness' and 'turnaround times' are extremely elusive concepts, difficult to define, observe and measure and impossible to relate to the broader aggregates found in farm survey data".[2]

Figure 2.3 shows that in the wet season there was little difference in the date of planting between 2-wheel and 4-wheel tractor users and between owners and hirers. However, in the dry season, the 4- wheel tractor farmers prepared their land faster than the 2-wheel tractor users (Figure 3.4). Four-wheel tractor users were roughly 3 weeks faster in preparing the first 60 percent of the land area. This suggests that turnaround times were faster for 4-wheel tractor users, although as to whether this contributes to the small yield difference in favor of 4-wheel tractors during the dry season is debatable.

Seasonal movement in classification

Majority of the households used the same machine type for land preparation in both season, except for households who rented 4-wheel tractors in the wet season (Table 8). This group split in the dry season, with the majority continuing to hire 4-wheel tractors but a sizeable majority switching to 2-wheel machines. However, this is not surprising, since the rental rate was the same for 2-wheel and for 4-wheel tractors and land preparation was easier at the start of the dry season. This would suggest a considerable degree of substitutability between 2-wheel and 4- wheel tractors. The choice of machine used for land preparation does not rest solely on technical constraints but will also depend on other factors.

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[2] Lingard J. "Measuring the Impact of Mechanization on Output". Working Paper No. 55. Consequences of Small Rice Farm Mechanization Project.

Yields and inputs

In the wet season, per hectare yields were about 12 percent higher on 2-wheel tractor using farms than on 4-wheel tractor using farms although the difference was not statistically significant (Table 9). Fertilizer use was also lower as was total labor input but neither were significantly different.

In the dry season, 4-wheel tractor users obtained the highest yields by a difference of 6 percent. Inputs of seed and fertilizer are similar for all groups.

Likewise, there were no significant differences between hirers and owners, for either season, although hirers had 11 percent higher yields in the wet season and 4 percent lower in dry season. Hirers also made more use of animals in land preparation and had much higher total labor inputs. The extra labor is almost entirely household labor since hired labor is about the same for hirers and owners, at around 36 mandays per season. This extra use of household labor is made possible by the smaller farm size that are found in the 'hiring' group.

Yields and Farm Size

The inverse relationship between productivity and farm size seemed to be roughly consistent with the yield data for small, medium and large farms in Tables 11 and 12. However, although mean yields were lower for large area classes the differences were more pronounced in the wet than in the dry season (about 33 percent lower in the wet season and 12 percent lower in the dry season). The wet season drop in per hectare yields as farm size increase were statistically significant and have important implications.

On the basis of this relationship the overall yield of a given land area is expected to be lower if farmed by larger rather than smaller farms. The danger of land accummulation by larger farms, which is often associated with mechanization and may lead to lower per hectare yields, therefore requires a lot of consideration. However, in a rice exporting country such as Thailand, the issue is not solely one of yield per unit area but also of the marketable surplus above home consumption per unit area. This can be expected to be higher on larger and more commercial farms.

Costs and returns analysis

Within the framework of a household analysis, decisions were made on the basis of economic values although these costs and return were based on the yield and input levels discussed previously.

Variable costs

Total variable costs were calculated by summing material costs, power costs, labor costs and other miscellaneous expence and by imputing a value for family labor (Tables 13 and 14). The value of family labor is not easy to quantify but given the different levels of family labor used by each group, especially the small 2-wheel tractor users, it would be misleading not to attempt to value this labor. This was therefore done by calculating the mean cost of labor for all farms, all activities and for all sources and using this value (40 baht per day) to compute a value for household labor. As a result there was no significant differences in variable costs between 2-wheel and 4-wheel tractor users and although the difference was greater for hirers than owners, this was not statistically significant.

Power costs for hirers were computed using actual rental rates and it included all mechanical equipment that was hired, such as tractors and threshers.

Own costs, however, do not include any imputed depreciation or interest and since this was also not recorded as an overhead, the costs for owners was understated.

Material costs were similar for all groups. This is a more reliable indicator of the value of fertilizer than the weight in kg (since the NPK composition of some types of fertilizer could not be determined).

The 'hirer' class spent a lower proportion of total pesticide cost on herbicides and consequently a very high labor input for weeding was required. However, there was very little variation across tractor groups in both wet and dry season, in either total variable cost or in its components. Dry season costs were about 10 percent lower than the wet season.

Returns

There was very little difference in price between 2-wheel and 4-wheel tractor users in the wet season and since yields were similar, the value of output were roughly the same (Table 15). In the dry season, 2-wheel tractor users obtained a lower price and with a corresponding low yield, their returns were lower compared to the 4-wheel tractor group. The reason for the low price was not clear but may be related to the longer turnaround times mentioned earlier, resulting in delayed sales at lower prices.

Overhead costs

Overhead costs were almost entirely rent and no attempt was made to apportion interest on outstanding loans, taxes, etc. on a per hectare basis. The high degree of land ownership for 4-wheel tractor users was reflected in the lower rent during the wet season. Likewise, reduced cropping intensity could be a result of not renting-in land, since rents during the dry season were markedly lower than in the wet season.

Productivity

Productivity is an index measuring the average return to a particular input. It can be expressed in physical quantity or monetary values.

Land productivity was measured in terms of yield per hectare. Results of the study showed no significant differences in yield per hectare between 2-wheel and 4-wheel tractor users (Tables 17 and 18). Yield per hectare was higher in the dry than in the wet season.

Labor productivity in terms of total labor use was the same for 2-wheel and 4-wheel tractor users in the wet season but much better for 4 wheel users in the dry season. This was due more to lower labor use than to higher yields. However, since the productivity of hired labor was roughly the same in the dry season, reduced family labor had resulted in this higher productivity. The reverse was true for hirers, who contributed more family labor in the wet season. For both seasons, hired labor ratios were similar.

Tractor productivity in the wet season was slightly better for 2-wheel than 4-wheel tractors. However, in the dry season, 2-wheel tractor users incurred about 25 percent higher productivity than farms using 4-wheel tractors.

Comparing owners and hirers in both seasons, tractor owners had higher productivities, the difference being more distinct in the dry season. The reason for this was not clear but since yields were roughly the same, the main variation could be from the tractor hours in land preparation. This suggests that reduced hours of land preparation by farmers hiring tractors is not a technical constraint to higher yields in the dry season.

Value productivities

All the value productivity ratios were similar between 2-wheel and 4-wheel tractor users in the wet season except for the value of output per power cost, which was higher for 2-wheel tractor users (Tables 19 and 20). In the dry season, the value of output for power cost for 4-wheel tractor users was much closer to that of the 2-wheel tractor users. Since yields were not very different, this may be due to the differences in the price of rice. Since 4-wheel tractor users planted earlier than users of 2-wheels, the reduced turnaround period may be a significant factor. However, as was noted earlier there were complex and elusive relationships that were difficult to quantify. In the dry season, returns per total costs and per variable costs were all better for four wheel tractor users although the difference were not statistically significant.

The value ratios were all roughly the same for owners and hirers, suggesting that custom rates were set close to the free market rates.

Conclusion

In this preliminarly analysis, few if any significant differences in output or input, has been observed between 2-wheel and 4-wheel tractor users. A more detailed analysis is required to look into the effects of farm sizes and costs of operating the machines. This lack of variation within the area studied suggests that some sort of equilibrium has been attained and that the acquisition of skills and knowledge associated with the new technology is available to and has been assimiliated by all farmers.

However, there may be advantages associated with earlier planting and subsequently higher prices. In this regard, 4-wheel tractors may be more efficient and faster thus enabling more land to be prepared in a shorter time.

Table 1. Distribution of households among classification groups for wet season 1981/82 and dry season 1982.

(a) Wet Season 1981/82

Classification	Animal	2 WT	4 WT	Ownership status
Owners	5	100	54	159
Hirers	-	63	32	95
Mechanization type	5	163	86	254

(b) Dry Season 1982

Classification	Animal	2 WT	4 WT	Ownership status
Owners	2	96	53	151
Hirers	-	69*	27	96
Mechanization type	2	165	80	247
Did not cultivate/moved		-	-	11

* Including 2 landless households from wet season 1981/82 who cultivated in dry season 1982.

Source: Consequences of Small Rice Farm Mechanization in Thailand.

Table 2. Percentage of area planted with different varieties in selected irrigated villages, Suphanburi Province, Thailand, wet season 1981/82.

Varieties	2 WT	4 WT	Own	Hire
		percent		
HYV				
RD 7	70	64	67	69
RD 11	17	28	24	16
Others	5	3	3	7
Total	92	95	94	92
Local	8	5	6	8
Total planted area (ha)	457	318	599	181

Source: Consequences of Small Rice Farm Mechanization in Thailand.

Table 3. Percentage of area planted by method of planting in selected irrigated villages, Suphanburi Province, Thailand, wet season, 1981/82.

Method	2 WT	4 WT	Own	Hire
		percent		
Broadcasting	19	33	26	23
Transplanting	81	67	74	77
Total planted area (ha)	457	318	599	181

Source: Consequences of Small Rice Farm Mechanization in Thailand.

Table 4. Characteristics of farmer and farmholdings in selected irrigated villages of Suphanburi Province, Thailand, wet season 1981/82.

Item	2 WT	4 WT	Owner	Hirer
Farmer's age (year)	47	48	47	47
education (year)	3.3	3.0	3.2	3.2
Family size	6.1	6.0	6.5	5.3
Land managed (ha)	2.95	3.80	3.98	1.93
Percentage of managed land which is owned	65%	104%	84%	77%
No. of draft animals per farm	0.58	0.55	0.48	0.90
No. of tractors per farm	0.83	0.91	1.28	0.10
No. of farmers in sample	163	86	159	95

Source: Consequences of Small Rice Farm Mechanization in Thailand.

Table 5. Percentage distribution of draft animals by sex for 2-wheel and 4-wheel tractor users in selected irrigated villages, Suphanburi Province, Thailand, wet season 1981/82.

Age	2 WT		4 WT	
	Male	Female	Male	Female
	percent			
less than 6 months	9	-	-	-
6 months - 1 year	14	12	7	5
1 - 3 years	32	27	31	35
over 3 years	45	61	62	60

Source: Consequences of Small Rice Farm Mechanization in Thailand.

Table 6. Mean assets and percentage composition of farm households in selected irrigated villages of Suphanburi Province, Thailand, wet season 1981/82.

Item	2 WT	4 WT	Own	Hire
Total assets	165,000	250,000	250,000	105,000
Of which:				
land	67	78	81	53
machinery	22	12	12	28
draft animals	3	4	3	6
productive animals	8	7	4	13

Source: Consequences of Small Rice Farm Mechanization in Thailand.

Table 7. Average level of cropping intensity of rice land for 2-wheel and 4-wheel tractor users, owners and hirers in selected irrigated villages in Suphanburi Province, Thailand, crop year 1981/82.

Item	2 WT	4 WT	Owner	Hirer
Cultivated area (ha)				
Wet season	2.82	3.68	3.82	1.90
Dry season	2.70	3.43	3.67	1.81
Cropping intensity	1.81	1.81	1.84	1.77
Sample size	162	86	153	95

Source: Consequences of Small Rice Farm Mechanization in Thailand.

Table 8. Movement of households in percentage farm types between wet season 1980/81 and dry season 1982 in selected irrigated villages in Suphanburi Province.

Farm class in wet season	Farm class in dry season 1980							Landless	Total no. of cases
	Animal	2 WT		4 WT		Did not cultivated			
		Owner	Hirer	Owner	Hirer	Remained	Moved		
					percent				
Animal	40	20	20	-	-	20	-	-	5
2 WT owner	-	92	3	3	2	-	-	-	100
2 WT hirer	-	3	75	2	11	10	-	-	63
4 WT owner	-	2	6	89	2	2	-	-	54
4 WT hirer	-	41	3	53	3	-	-		32
Landless	-	-	11	-	-	-	11	78	18
Total	2	96	69	53	27	9	2	14	272

Source: Consequences of Small Rice Farm Mechanization in Thailand.

Table 9. Yield and inputs in rice production for 2-wheel and 4-wheel tractor users and for owners and hirers in selected irrigated villages of Suphanburi Province, Thailand, wet season 1981/82.

Item	Type of tractor		Ownership	
	2 WT	4 WT	Owner	Hirer
	per hectare			
Yield (kg)	3604	3178	3311	3643
Material inputs (kg)				
Seeds	121	197	155	132
Fertilizer	286	233	270	267
Power inputs				
Animal	3	7	4	10
Tractor	49	49	52	44
Labour inputs				
Total (mds)*	81	74	76	91
Hired (mds)	34	37	34	36
Hired (%)	(41)	(50)	(46)	(40)

* One manday = 8 hours.

Table 10. Yield and inputs in rice production for 2-wheel and 4-wheel tractor users and for owners and hirers in selected irrigated villages of Suphanburi Province, Thailand, dry season 1982.

Item	2 WT	4 WT	Owners	Hirers
		per hectare		
Yield (kg)	3647	3861	3772	3609
Material inputs (kg)				
Seeds	117	130	122	119
Fertilizer	292	290	295	286
Power inputs				
Animal	2	0	1	3
Tractor	49	53	49	52
Labor inputs				
Total (mds)*	76	67	68	82
Hired (mds)	33	36	33	35
Hired (%)	(43)	(54)	(49)	(43)
No. of respondents	165	80	149	98

* One manday = 8 hrs.

Source: Consequences of Small Rice Farm Mechanization in Thailand.

Table 11. Mean yield by area class for 2-wheel and 4-wheel tractor users and for owners and hirers in selected irrigated villages in Suphanburi Province, Thailand, wet season 1981/82.

Area group	2 WT	4 WT	Owner	Hirer
		kg per hectare		
< 2.0 ha	3965 (64)	3864 (22)	4098 (24)	3877 (62)
2.0 - 5.0 ha	3204 (80)	3099 (41)	3289 (90)	2820 (31)
≥5.0 ha	2941 (18)	2664 (23)	2834 (39)	1845 (2)
All	3604 (162)	3178 (86)	3311 (153)	3643 (95)

Figures in parenthesis give the number of farms in each area group.

Source: Consequences of Small Rice Farm Mechanization in Thailand.

Table 12. Mean yield by area class for 2-wheel and 4-wheel tractor users and for owners and hirers in selected irrigated villages in Suphanburi Province, Thailand, dry season, 1982.

Area group	2 WT	4 WT	Owner	Hirer
<2.0 ha	3713 (69)	3867 (23)	3845 (27)	3713 (65)
2.0 - 5.0 ha	3468 (85)	3905 (42)	3745 (94)	3236 (33)
> 5.0 ha	3254 (14)	3470 (15)	3417 (28)	1941 (1)
All	3647 (168)	3861 (80)	3772 (149)	3609 (99)

Figures in parenthesis give the number of farms in each area group.

Source: Consequences of Small Rice Farm Mechanization in Thailand.

Table 13. Variable costs per hectare for rice production for 2 wheel and 4 wheel tractor users and owners and hirers in selected irrigated villages of Suphanburi Province, Thailand, wet season 1981/82.

Item	2 WT	4 WT	Owners	Hirers
Material costs (baht)		per hectare		
Seeds	420	652	544	423
Fertilizer	1661	1551	1581	1694
Pesticides	321	315	299	344
of which:				
insecticides (%)	71	65	67	72
fungicides (%)	2	3	2	1
rodenticides (%)	9	7	8	10
herbicides (%)	18	25	23	17
Total	2402	2528	2424	2461
Power costs				
- hired	681	655	267	1315
- own	796	1219	1425	135
Total	1477	1874	1692	1450
Labor costs				
- hired	1359	1544	1459	1318
- household*	1731	1221	1194	2247
Total	3090	2765	2653	3565
Other costs:	24	17	28	11
Total variable costs	6993	7184	6797	7487

*Imputed at overall mean cost of labor for all types, sources and for all activities.

Source: Consequences of Small Rice Farm Mechanization in Thailand.

Table 14. Variable costs per hectare in rice production for 2-wheel and 4-wheel tractor users and owners and hirers in selected irrigated villages of Suphanburi Province, Thailand, dry season 1982.

Item	2 WT	4 WT	Owners	Hirers
		per hectare		
Material costs				
Seeds	295	346	304	320
Fertilizer	1644	1586	1617	1631
Pesti ides	222	167	200	206
of which:				
- insecticide (%)	63	63	65	61
- fungicides (%)	3	2	2	3
- rodenticides (%)	10	10	7	14
- herbicides (%)	24	25	26	22
Total	2161	2099	2121	2157
Power costs				
- hired	558	538	276	965
- own	423	777	774	172
Total	981	1315	1050	1137
Labor costs				
- hired	1309	1689	1524	1268
- household*	1764	1331	1498	1887
Total	3073	3020	3022	3155
Other costs	7	13	14	1
Total variable costs	6222	6447	6207	6450

*Imputed at overall mean cost of labor for all types, sources and for all activities.

Source: Consequences of Small Rice Farm Mechanization in Thailand.

Table 15. Costs and returns summary for 2-wheel and 4-wheel tractor users and for owners and hirers in selected irrigated villages of Suphanburi Province, Thailand, wet season 1981/82.

Item	Type		Ownership	
	2 WT	4 WT	Owner	Hirer
	baht per hectare			
Value of output	11,371	10,784	10,885	11,488
Price of paddy	3.30	3.28	3.36	3.19
Total costs	8,591	7,925	7,900	9,153
overheads*	1,598	741	1,203	1,666
variable	6,993	7,184	6,797	7,487
Paid out costs**	6,860	6,704	6,706	6,906
No. of respondents	158	85	156	91

* Mostly rent.

**Excluding imputed cost of family labor.

Table 16. Costs and returns summary for 2-wheel and 4-wheel tractor users and for owners and hirers in selected irrigated villages of Suphanburi Province, Thailand, dry season 1982.

Item	2 WT	4 WT	Owner	Hirer
		baht per hectare		
Value of output	8579	10,406	8865	9581
Price of paddy	2.50	2.58	2.53	2.53
Total costs	6733	6984	6687	7015
overhead*	511	537	480	656
variable	6222	6447	6207	6450
Paid out costs**	4969	5653	5189	5128
No. of respondents	155	80	149	98

* Mostly rent.

** Excluding imputed cost of family labor.

Table 17. Productivity ratios for 2-wheel and 4-wheel tractor users and for owners and hirers in selected irrigated village, Suphanburi Province, Thailand, wet season 1981/82.

Item	2 WT	4 WT	Owner	Hirer
Yield				
per hectare (kg)	3604	3178	3311	3643
per total labor (md)	44	43	62	40
per hired labor (md)	106	86	97	101
per tractor hour (land preparation)	93	89	81	113
No. of respondents	158	85	156	91

Source: Consequences of Small Rice Farm Mechanization in Thailand.

Table 18. Productivity ratios in rice production for 2-wheel and 4-wheel tractor users and for owners and hirers in selected irrigated villages in Suphanburi Province, Thailand, dry season 1982.

Item	Machine type		Ownership	
	2 WT	4 WT	Owner	Hirer
Yield (kg)	3647	3861	3772	3609
per hectare				
per total labor (md)	48	58	55	44
per hired labor (md)	111	108	114	103
per tractor hour (land preparation)	141	112	101	176
No. of respondents	165	80	149	98

Source: Consequences of Small Rice Farm Mechanization in Thailand.

Table 19. Productivity ratios in rice production for 2-wheel and 4-wheel tractor users and for owners and hirers in selected irrigated village of Suphanburi Province, Thailand, wet season 1981/82.

Item	2 WT	4 WT	Owner	Hirer
		baht per hectaare		
Value of output:				
per hectare	11,371	10,784	10,885	11,488
per total cost	1.32	1.36	1.38	1.26
per variable costs	1.63	1.50	1.60	1.53
per paid out cost	1.66	1.61	1.62	1.66
per fertilizer cost	6.8	6.8	6.9	6.8
per power cost	7.7	5.8	6.4	7.9
No. of respondents	158	85	156	91

Source: Consequences of Small Rice Farm Mechanization in Thailand.

Table 20. Productivity ratios inrice production for 2-wheel and 4-wheel tractor users and for owner and hirer in selected irrigated villages of Suphanburi Province, Thailand, dry season 1982.

Item	Type		Ownership	
	2 WT	4 WT	Owner	Hirer
	baht per hectare			
Value of output:				
per hectare	8597	10,406	8865	9581
per total cost	1.28	1.49	1.33	1.37
per variable cost	1.38	1.61	1.43	1.49
per paid out cost	1.73	1.84	1.71	1.87
per fertilizer cost	5.2	6.6	5.5	5.9
per power cost	8.8	7.9	8.4	8.4
No. of respondents	155	80	49	98

Source: Consequences of Small Rice Farm Mechanization in Thailand.

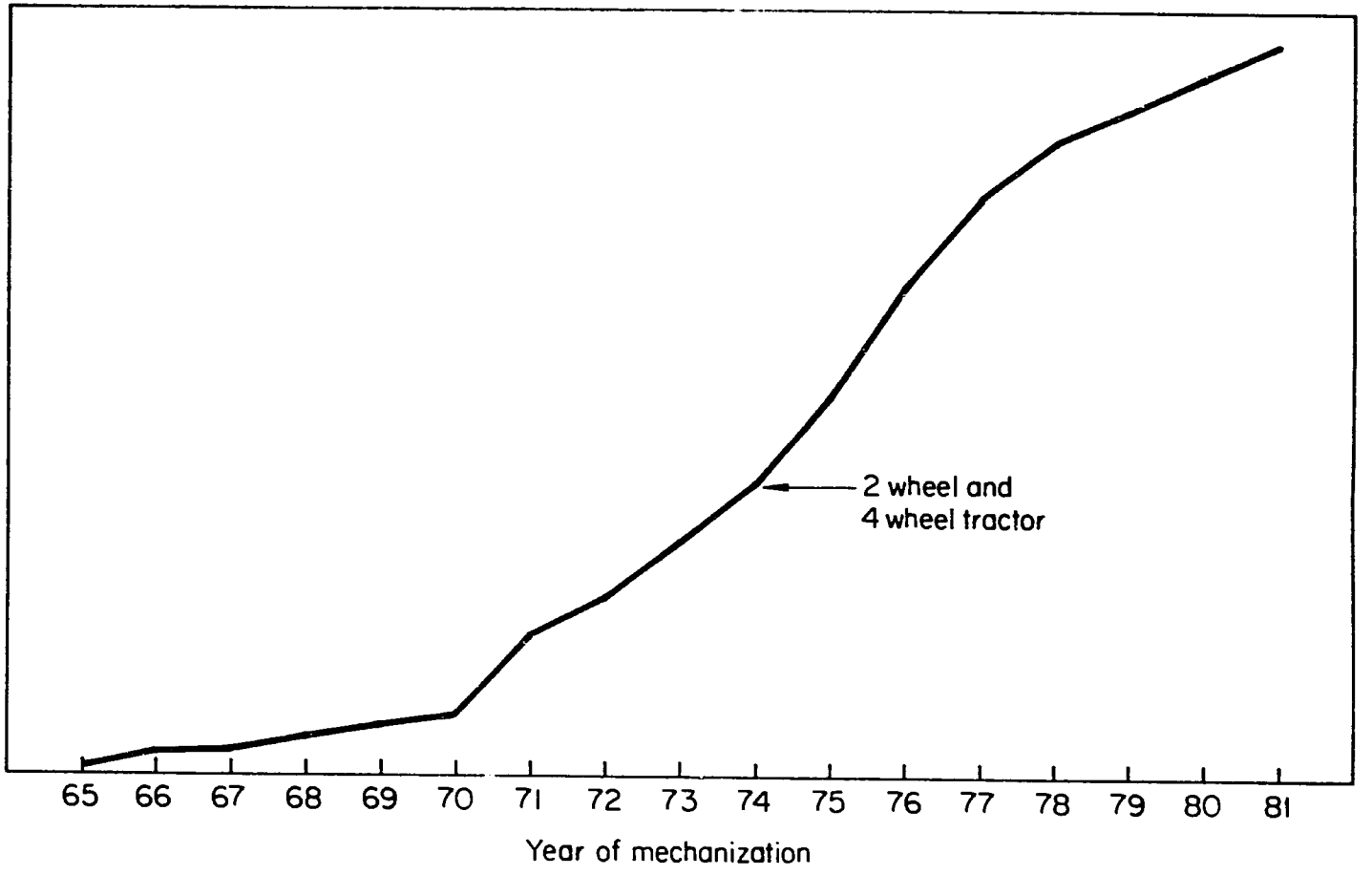

Fig. 1. Cumulative frequency of percentage of mechanized households by year of mechanization for selected irrigated villages of Suphanburi province, Thailand.

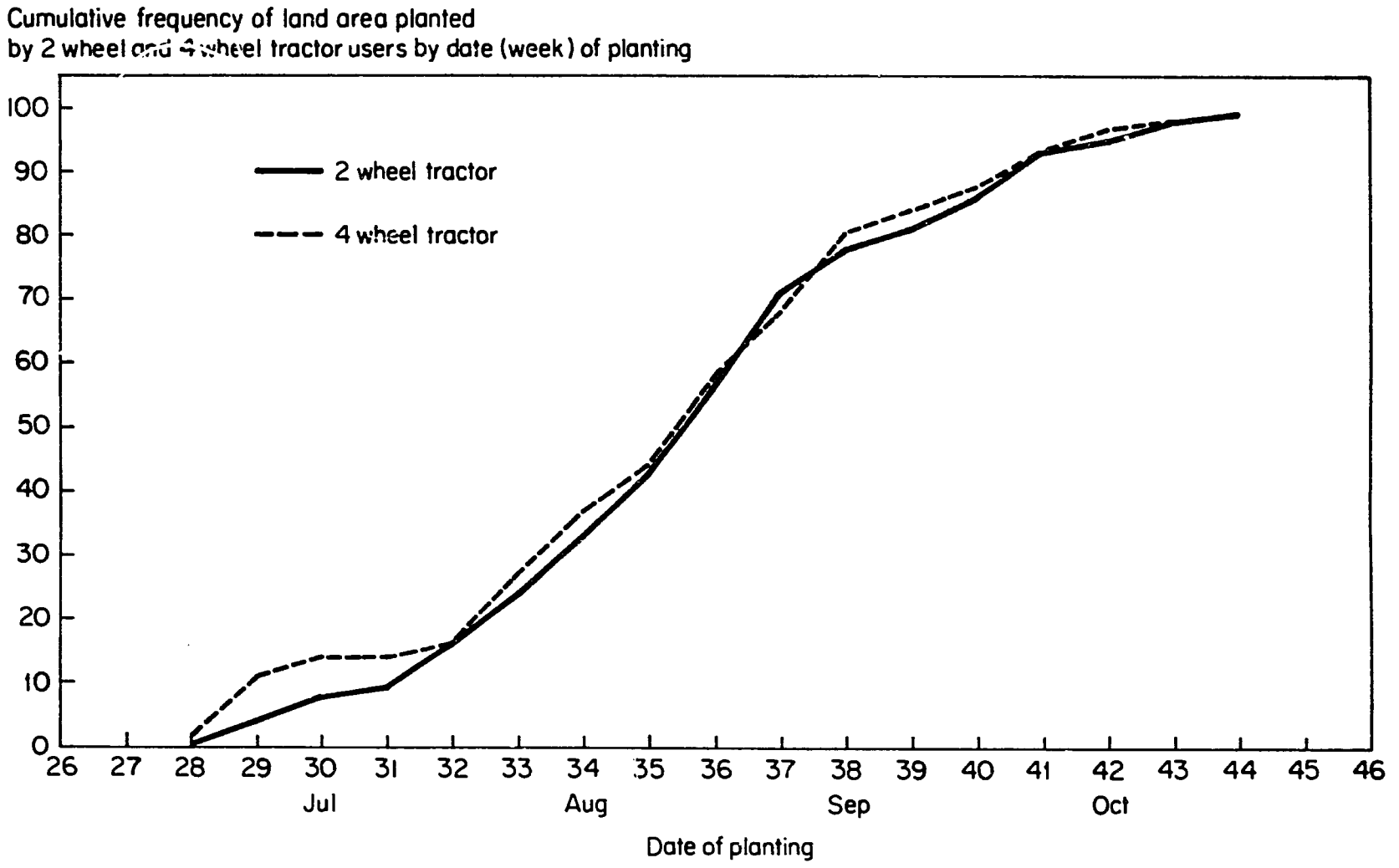

Fig. 2. Cumulative frequency of land area planted by 2 wheel and 4 wheel tractor users by week of planting, in selected irrigated villages of Suphanburi province, Thailand. Wet season, 1981.

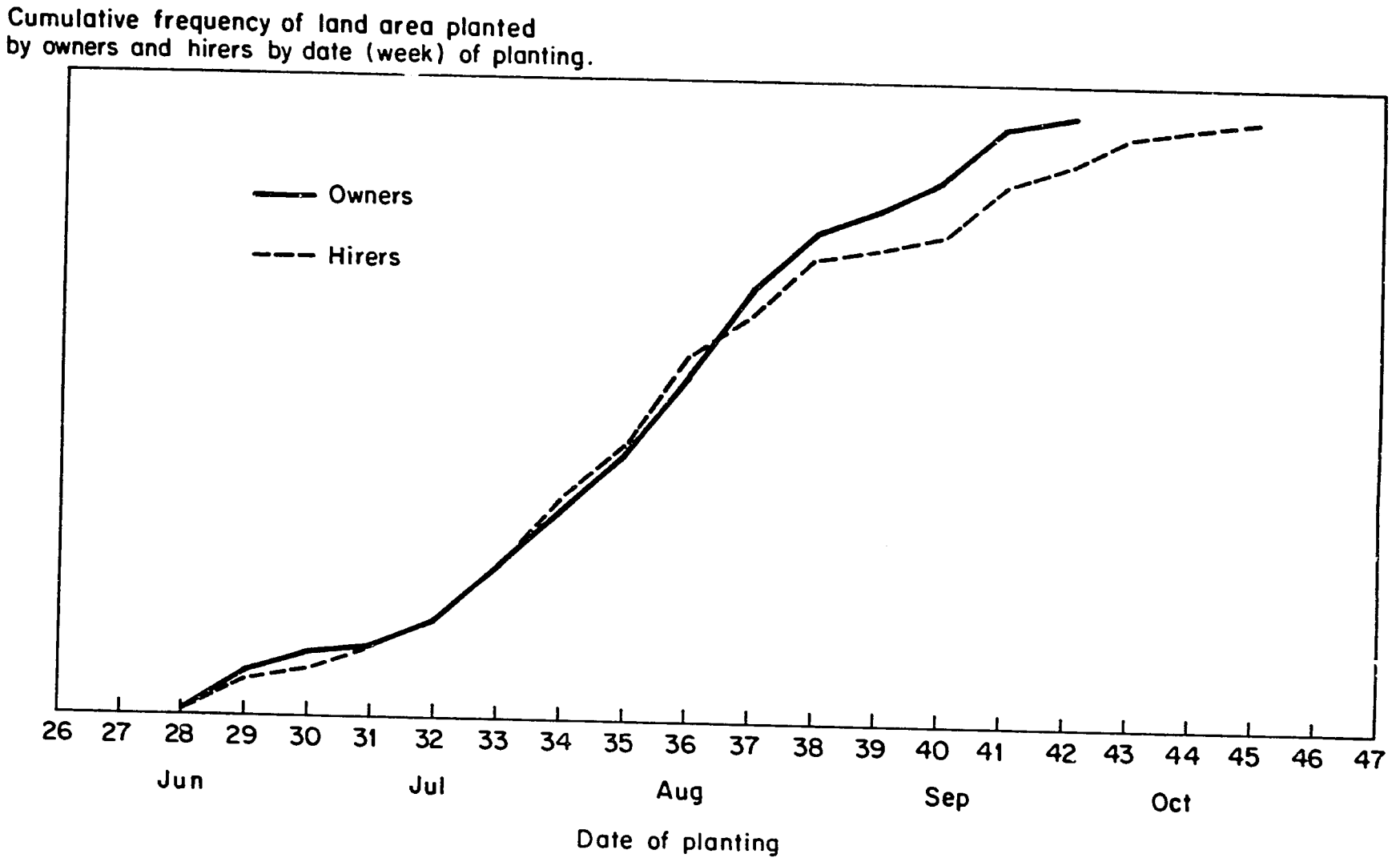

Fig. 3. Cumulative frequency of land area planted by owners and hirers by week of planting, in selected irrigated villages, Suphanburi province, Thailand, wet season 1981.

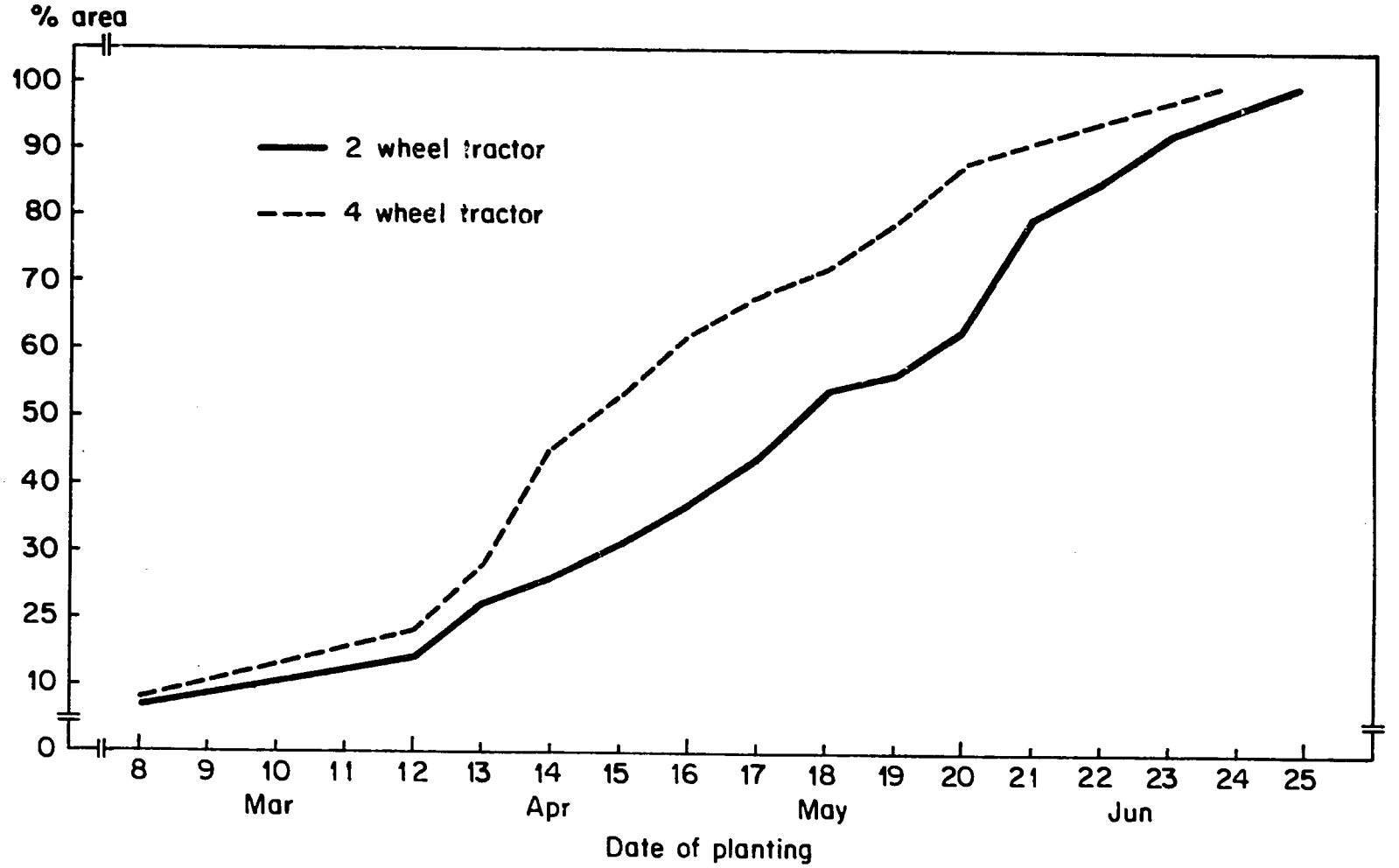

Fig. 4. Cumulative frequency of land area planted by 2-wheel and 4-wheel tractor users by week of planting, in selected irrigated villages of Suphanburi province, Thailand, dry season, 1981.

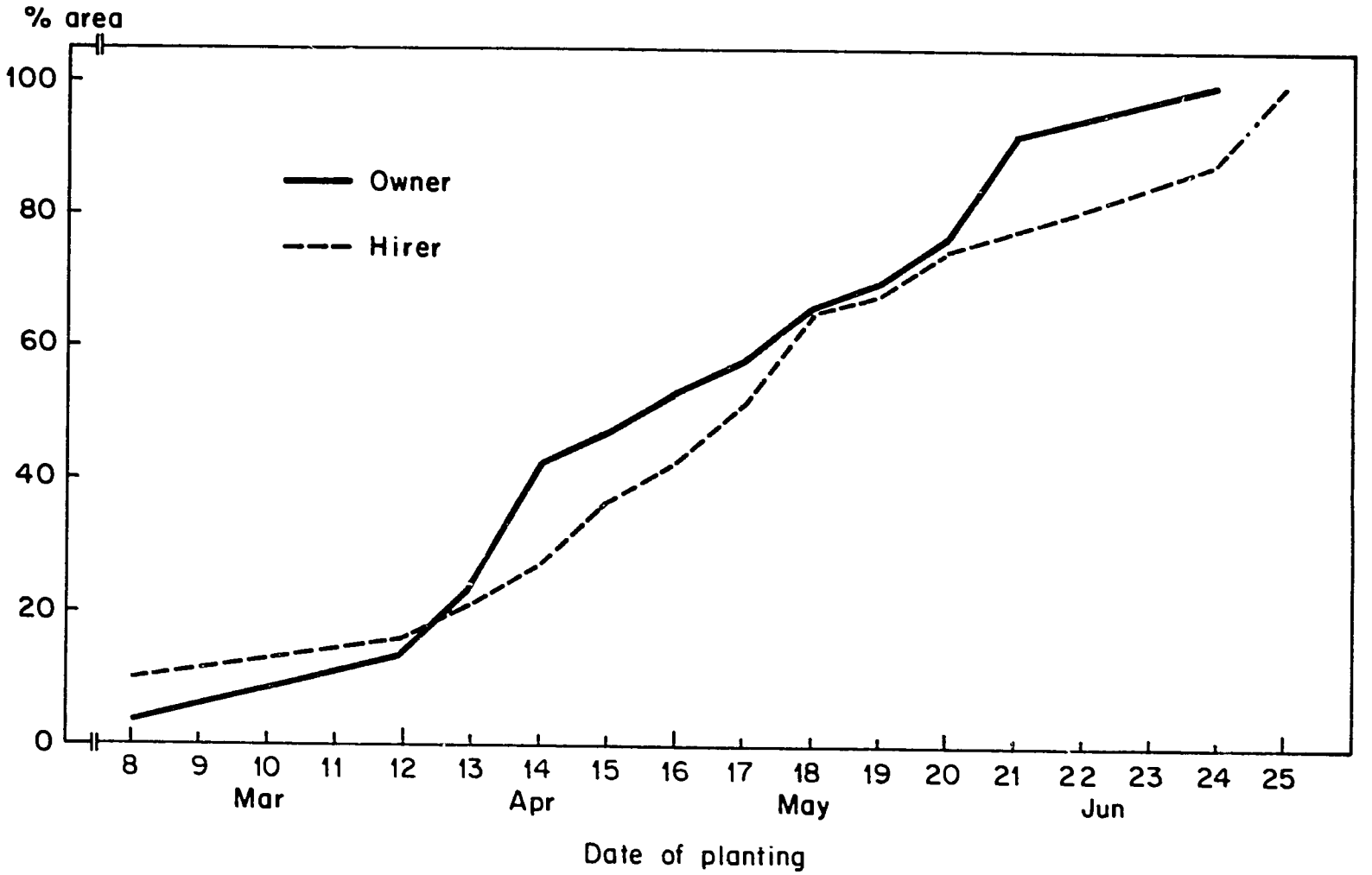

Fig. 5. Cumulative frequency of land area planted by tractor owners and hirers by week of planting, in selected irrigated villages, Suphanburi province, dry season, 1981.

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THE IMPACT OF MECHANIZATION ON RURAL INCOME AND INCOME DISTRIBUTION: THE CASE OF SUPHANBURI PROVINCE*

Somporn Saitan**

ABSTRACT

The Cobb-Douglas production function was used to evaluate the effects of tractor use on off-farm and non-farm incomes. Factor share analysis, an accounting procedure, was used to determine impacts of tractorization on farm income. Gini ratios and Lorenz curves depict the impacts on income distribution. The estimate was based on 1981/82 farm survey data from Suphanburi.

The empirical results indicate that tractorization significantly affected both off-farm and non-farm incomes while its effects on farm income were inconclusive. In contrast, tractor use had little effect on income distribution.

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**IRRI Research Scholar, Agricultural Engineering Department under joint IRRI/Kasetsart University graduate exchange program.

THE IMPACT OF MECHANIZATION ON RURAL INCOME AND INCOME DISTRIBUTION: THE CASE OF SUPHANBURI PROVINCE

Somporn Saitan

INTRODUCTION

Two of the most important sources of agricultural growth in Thailand are the expansion in the area adopting the new rice production technology and the continued development of irrigation systems (Hayami, Barker and Bannagen, 1976). Irrigation comes in many forms, ranging from hand lifted buckets to the massive reservoir systems. The new rice technology, includes improved crop varieties, chemical inputs and farm mechanization. Under present circumstances, it appears difficult to further expand the area under cultivation. The only possible way of increasing crop production is to improve the productivity of the existing cultivated area. Farm mechanization plays an important role in this strategy. It affects the extent of employment, makes possible double cropping, improves cropping yields and can increase farm income. Mechanization saves time in land preparation, harvesting and threshing and, thus allows the farmer to utilize time in supplemental employment opportunities. These jobs in turn increase the income of the farmer. Furthermore, farmers who own machines can earn additional income by rendering custom services to farmers who do not own machines or do not have sufficient machine capacity to meet their requirements.

Since mechanization affects the allocation of inputs for crop production, it is believed to cause a redistribution of income. Whether this redistribution increases the welfare of farmers or the income of other factor owners must be determined empirically. In addition to the redistribution problem, mechanization is hypothesized to discriminate in favor of rich farmers to the detriment of small farmers.

This paper focuses attention only on irrigated farms, and on the use of two-wheel and four-wheel tractors for land preparation.

The objectives are: 1) to trace the effects of tractor use on the structure of income; 2) to determine the impact of tractor use on income distribution among owners of factors of production and among earners and, 3) to examine the effect of tractor use on income inequalities.

METHODOLOGY

Information Gathered

Primary data were obtained from the farm survey of the Consequences of Farm Mechanization Project. The following data were obtained from a sample of 280 farmers: 1) a general socio-economic profile of the farmer and his family; 2) farm production and input use, including crop yields, fertilizers and chemical use, labor utilization and records of farm receipts and expenditures and, 3) an assessment of farm credit and product inventories.

Sampling Procedure

A proportionate number of samples were stratified into nine strata based on the type of irrigation and 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 4-wheel tractor
5. Irrigation and animal
6. Irrigation and animal + machine
7. Irrigation and 2-wheel tractor
8. Irrigation and 4-wheel tractor
9. Field labor (the landless labor)

In this study, both wet and dry season data of the 1981-82 crop year from strata 7 and 8 are used. All household samples in these strata were included. The distribution of household samples used in the study, by level of mechanization and type of operation, is shown in Table 1.

Analytical Framework

The investigation of the impact of tractor use on farm household income was undertaken using the Cobb-Douglas production function and the concept of factor shares using an accounting procedure. The method used in the analysis of income distribution were the share of total income in the sample, Gini ratios and the Lorenz curve.

FINDINGS

Socio-economic Characteristics of Farmers

Differences were observed in mean farm size, area planted and type of tenure among different tractor ownership classes (Table 2). These differences, in general, were higher among tractor owner farms than among tractor hiring farms. However, the average age of the farmers, level of education and the potential family labor available, i.e. the dependency ratio, were almost identical for all classes.

Income Structure

The term income in this study refers to "family labor income", i.e. the gross value of the family's total rice production and the gross receipts from contract work generated with their own equipment and labor. The term "farm household income" refers to income derived from farming plus off-farm and non-farm activities.

Data on farm income is presented in Tables 3 to 5. On the average, the farm household income of farms owning tractor was higher than for tractor hiring households in both the wet and dry seasons (Tables 3,4). The major source of this income was from farm activities. The lower farm income of tractor hiring farms can be attributed to the direct outlay for renting tractor services.

The data in Table 5 compares different sources of total household farm income in the 1981-82 wet and dry seasons. Total farm household income in the wet season was higher than in the dry season, although the contribution of on-farm, off-farm and other income to total farm household income was about the same in both seasons. The contribution of non-farm income was, however, greater in the dry than in the wet season, at 13% and 9% of total farm household income, respectively. The differences in total household income between the two seasons was caused by the difference in yield and the fluctuations in the prices of paddy.

Data on the comparative annual costs and returns show that net income per hectare by tractor ownership class varied by season (Table 6). In the wet season, net income was higher for tractor hiring farms than for tractor owning farms. In the dry season however, the situation was reversed. Further, regardless of tractor-ownership, the use of 4-wheel tractors gave higher net incomes than use of 2-wheel tractors. On average, the net income resulting from the use of 4-wheel tractors was 9% higher than that resulting from the use of 2-wheel tractors in wet season and 16% higher in the dry season. The average difference was 12% on an annual basis. In general, the net income per hectare in the wet season was 90% higher than in the dry season.

Impact of Tractor Use on Income

(i) Impact on off-farm income. Regression analysis showed that use of tractors significantly affected off-farm income (Table 7). Of the various components of off-farm income, man-hours spent in off-farm activities, machine renting and land rental were significantly affected by tractor use. This analysis shows that, regardless of tractor- ownership, use of tractors saved time for farmers in farm operations which they could utilize in off-farm income generating activities.

(ii) Impact on non-farm income. Like off-farm income, non-farm income was also affected significantly by tractor use (Table 8). However, only one component was affected significantly -- manhours spent on non-farm activities.

(iii) Impact on farm income. Factor share analysis was used to determine the impact of tractor use (based on type of tractor ownership) on rice production costs and returns (Table 9 and 10). Data on gross family factor income (GFFI) showed that the income of farmers was about 30% higher in the wet than in the dry season. In the wet season, the GFFI resulting from the use of the 4-wheel tractor was about 10% higher than that from the use of 2-wheel machines. Tractor owning farmers had a 50% higher income than tractor hiring farms. In the dry season however, the GFFI for 4-wheel tractors was nearly the same as that for 2-wheel tractors. Tractor owning farms showed a GFFI greater than that of hired-tractor farms by over 30%.

The residual in the factor share analysis, which constitutes the farm's profit, was 80% higher in the wet than in the dry season. In the wet season, the residual for tractor owning farms was 50% lower than that for tractor hiring farms. Profits were 40% higher when using the 4-wheel tractor than when using the 2-wheel tractor. In the dry season the residual was higher by 90% for tractor owning farms than for tractor hiring farms. The residual for 4-wheel tractors was (100%) higher than for 2-wheel tractors.

Estimated total costs including the imputed cost of unpaid family labor, owned land and capital show that labor, land and current input costs represent the largest portion of total cost. When summed together, they constituted about 84% of the total cost, regardless of tractor ownership and season. The imputed family labor cost on hired-tractor farms was much higher than on tractor owning farms. Conversely, the imputed cost for owned land was lower on tractor hiring farms than on tractor owning farms because the proportion of land owned was lower for tractor hiring farms. The data show, however, that owned land constituted the major portion of total cultivated land on all farms.

There were minor differences in total cost and total paid-out cost between tractor hiring and owning farms. In the wet season, higher capital costs on tractor owning farms was more than offset by a lower labor cost, so that total cost on tractor owning farms was slightly lower than on tractor hiring farms. Similarly, although the imputed value of family labor was much higher on tractor hiring farms, it was more than offset by a lower total labor cost on tractor owning farms. This finding together with the cost of rented land, which is highest on tractor hiring farms, means the total paid out cost on tractor hiring farms was slightly higher than on tractor owning farms.

Impact of tractor use on income distribution

Factor share analysis showed that among the factors of production, the share of labor and the residual were 5% and 6% lower respectively on tractor hiring farms (Table 11 and 12). Conversely, the share of land and capital were 2% and 6% higher respectively on tractor owning farms. The result indicates that the capital share was smaller relative to the labor share. This finding emphasizes that although investment in machinery is justified by its positive impact on all production factors, in the present case mechanization is more advantageous to the owners of labor resources than to the owners of capital.

Among earners, however, there were minor differences between the shares of hired labor, which was only 1% lower on tractor owning farms. Also the farmer's income was 6% higher on tractor owning farms than on tractor hiring farms. For income distribution effects, mechanized land preparation resulted in only a slight deterioration in the income distribution pattern. In the current environment, mechanization affects only family labor use while leaving hired labor earnings reasonably intact.

The relative shares of value added are shown in Tables 13 and 14. There were minor differences in the relative shares of land. This finding seems to result primarily from the lack of differences between the proportion of share cropped-in and rent-in land to total cultivated land. The proportion of owned land on tractor owning farms was higher than on hired tractor farms resulting in a higher share for landlords on tractor hiring farms.

Income inequality. The data illustrating the effect of tractor use on income inequality is shown in Tables 15 and 16 and Figures 5 to 8. It is difficult to determine if any significant degree of income inequality exists between tractor ownership groups. No apparent conclusions relating to the spread in income inequality by tractor ownership class can be made using the Lorenz curves. The Gini coefficient illustrates that income inequality between classes was

very low for different tractor-ownership groups during both seasons. The addition of total off-farm and non-farm income to farm income further lowered the Gini ratio's coefficient. This finding reveals that these income components play an important role in mitigating the problem of inequity in income distribution.

As more machinery is introduced, it is important that off-farm and non-farm job opportunities are created, although some of these will be provided by mechanization itself.

SUMMARY AND CONCLUSIONS

The results of the study show that the use of tractors for land preparation significantly affected income from off-farm and non-farm sources. The findings further show that farmers incurred greater expenses for labor and current inputs than for tractor cost (capital). This result emerges because the tractor is used for only a short time during land preparation. The share of current inputs and labor is greater than that of capital. For this reason, it is quite difficult to reach a firm conclusion regarding the impact of tractors used for land preparation on farm income.

The two methods used to estimate the impact of tractor use on income inequality (Lorenz curve and Gini coefficient) provided similar results in terms of small differences in income inequality among tractor ownership groups.

The results of the evaluation of the impact of tractor use on income distribution must be interpreted with caution. It is insufficient to study data for only one crop year and reach any firm conclusions. The present analysis also could not examine tractor use over an extended period using time series data, which would have allowed a more rigorous appraisal of the effect of tractor use on income. Provided off and non farm job opportunities continue to exist, these income sources will compensate for the reduced demand for farm labor.

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Table 1. Distribution of household samples by the degree of mechanization and ownership class.

Level of mechanization	Type of tractor ownership					
	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

Table 2. Socio-economic characteristics of sample farms by type of tractor ownership, Suphanburi, 1981-82.

Item	Type of tractor ownership			
	4-T(O)[1]	2-T(O)[2]	4-T(H)[3]	2-T(H)[4]
Mean farm size (ha)				
Wet season	5.06	4.03	2.43	1.67
Dry season	5.42	4.16	2.75	1.89
Percent area planted				
Wet season	32.18	48.29	7.64	11.90
Dry season	29.79	47.87	8.80	13.55
Type of tenure (%)				
Farmer operator				
Wet season	28.15	39.25	9.63	22.96
Dry season	26.13	43.24	9.01	21.62
Share tenants				
Wet season	23.81	59.52	7.14	9.52
Dry season	25.00	55.76	9.62	9.62
Leaseholder				
Wet season	6.52	34.78	23.91	34.78
Dry season	7.55	28.30	22.64	41.51
Age of farmer	66	66	62	70
Education of farmer	Pranthom 4	Pranthom 4	Pranthom 4	Pranthom 4
Size of household	6	5	6	5
Dependency ratio	1.9	1.9	1.6	2.4

1. 4-wheel tractor owned.
2. 2-wheel tractor owned.
3. 4-wheel tractor hired.
4. 2-wheel tractor hired.

Table 3. Total farm household income, 1981-82 wet season, Suphanburi, Thailand.

	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 4. Total farm household income, 1982 dry season, Suphanburi, Thailand.

	Tractor ownership									
	AT(O)		2T(O)		4T(H)		2T(H)		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 labor	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	-

Table 5. Sources of income, 1981-82 crop year, Suphanburi, Thailand.

	Tractor ownership				
	4T(O)	2T(O)	4T(H)	2T(H)	AVERAGE
Wet season					
On farm income	21,509	14,378	10,365	7,124	13,344
Off farm income	3,898	3,412	2,819	3,469	3,424
Non farm income	1,341	1,674	1,629	2,000	1,662
Other	-	16	78	94	63
Total farm household income	26,748	19,330	14,940	12,682	18,493
Dry season					
On farm income	13,030	10,231	5,285	4,164	8,177
Off farm income	629	1,852	1,301	3,256	1,760
Non farm income	1,049	1,215	4,064	1,376	1,926
Other	-	-	35	-	9
Total farm household income	14,708	13,298	10,685	8,796	11,872
Total income per year					
On farm income	33,539	24,609	15,650	11,288	21,521
Off farm income	4,527	5,314	4,170	6,725	5,184
Non farm income	2,390	2,889	5,693	3,376	3,588
Other	-	16	113	94	72
Total farm household income	40,456	32,828	25,626	21,483	30,365

Table 6. Comparative costs and returns per hectare by season and tractor ownership class 1981-82 crop year, Suphanburi, Thailand.

	Tractor ownership			
	4T(O)	2T(O)	4T(H)	2T(H)
Wet season				
Mean farm size (ha)	5.06	4.03	2.45	1.67
Percent area planted (%)	86	89	80	97
Total value of output	10,732	10,954	11,874	11,025
Total variable cost	4,896	6,256	6,450	5,760
Gross margin	4,836	4,697	5,425	4,710
Dry season				
Mean farm size (ha)	5.42	4.16	2.75	1.89
Percent area planted (%)	79	83	78	93
Total value of output	8,899	8,686	8,394	8,043
Total variable cost	5,800	5,900	5,940	6,060
Gross margin	3,099	2,787	2,454	1,983
TOTAL GROSS MARGIN PER YEAR	7,935	7,484	7,879	6,693

Table 7. Regression results of tractor use on off-farm income, 1981-82 crop year, Suphanburi, Thailand.

Variable	4T(0) Wet	4T(0) Dry	2T(0) Wet	2T(0) Dry	4T(H) Wet	4T(H) Dry	2T(H) Wet	2T(H) Dry
Constant (A)	3.9065** (6.93)	2.8808** (4.02)	4.5330** (8.12)	2.2475** (3.87)	0.9135^{ns} (0.89)	2.9739** (6.29)	2.8463** (3.07)	2.7730** (4.44)
X_1 (α_1)	-0.1077)^{ns} (-0.39)	-0.2801^{ns} (-0.69)	0.3808^{ns} (1.09)	-0.0599^{ns} (-0.16)	-0.1631^{ns} (-0.55)	-0.0334^{ns} (0.18)	-0.04953ns (-1.24)	-0.2481 (-0.77)
X_2 (α_2)	0.5817** (6.34)	0.7335** (6.01)	0.5443** (6.80)	0.8899** (10.44)	1.0977** (6.64)	0.7875** (5.54)	0.8432** (8.79)	
D_1 (β_1)	1.3572 (4.46)	2.7610** (2.54)	0.8307 (3.24)	0.9922* (2.65)	-	-	-	-
D_2 (β_2)	2.1275** (6.00)	-0.1459**^{ns} (-0.14)	0.9659** (2.80)	1.9186** (3.67)	1.0207* (2.47)	- -	-0.1939* (-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	20.28	56.08	12.61	39.82	
No. of samples	43	21	54	50	16	14	29	37

Notes: 1. The production functios is defined as:

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

where: Y_i = off farm income
X_1 = proportion of man-hours 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.

Table 8. Regression results of tractor use on nonfarm income, 1981/82, Suphanburi, Thailand.

Variable	4T0) Wet	4T0) Dry	2T(0) Wet	2T(0) Dry	4T(H) Wet	4T(H) Dry	2T(H) Wet	2T(H) 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^{us} (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^{ns}
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 production function is defined as:

$$\ln Y_i = A\ \alpha \ln P_i + \beta \ln \Omega_i$$

where Y_i = non-farm income
X_1 = proportion of man-hours 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.

Table 9. Rice production costs and returns per hectare, 1981-82 wet season, Suphanburi, Thailand.

Item	Tractor ownership				
	4T (O)	2T(O)	4T(H)	2T(H)	Average
A. Production cost					
1. Current inputs	2,598	2,917	2,625	2,468	2,722
2. Labor	2,527	2,570	2,538	2,820	2,605
a) Family labor	1,041	1,230	1,169	1,395	1,200
b) Hired labor	1,486	1,338	1,369	1,425	1,404
3. Land	2,688	2,837	2,823	2,768	2,773
a) Own land	2,274	1,855	1,626	1,768	1,978
b) Rent land	413	981	1,196	1,000	795
4. Capital	1,525	1,837	1,380	1,303	1,627
a) Own	1,351	1,554	418	323	1,243
b) Hire	174	282	962	980	384
5. Total cost	9,339	10,162	9,368	9,361	9,729
6. Total inputs paid out	2,074	2,602	3,528	3,405	2,583
B. Total output	10,732	10,954	11,874	11,025	10,893
C. Gross value added	8,134	8,036	9,249	8,557	8,171
D. Gross family factor income (GFFI)	6,060	5,433	5,720	5,151	5,587
E. Residual	1,393	790	2,505	1,664	1,164

Table 10. Rice production costs and returns per hectare, 1982 dry season, Suphanburi, Thailand.

Item	Tractor ownership				
	4T(0)	2T(0)			
A. Production cost					
1. Current cost	2,657	2,556	2,263	2,373	2,536
2. Labor	2,642	2,421	2,695	2,710	2,550
a. Family	1,110	1,106	1,067	1,531	2,550
b. Hired	1,531	1,314	1,628	1,178	1,388
3. Land	2,083	1,816	1,531	2,029	1,899
a. Owned	1,909	1,387	630	1,452	1,485
b. Rented	174	428	901	576	415
4. Capital	1,441	1,446	1,325	1,441	1,433
a. Owned	1,221	1,213	295	274	1,000
b. Hired	220	232	1,029	1,167	425
5. Total cost	8,825	8,240	7,815	8,554	8,419
6. Total input paid out	1,926	1,975	3,558	2,922	2,228
B. Total output	8,899	8,686	8,394	8,043	8,637
C. Gross value added	6,242	6,130	6,130	5,670	6,101
D. Gross family factor income (GFFI)	4,315	4,154	2,572	2,747	3,873
E. Residual	75	446	578	-510	217

Table 11. Factor and earner shares for rice production using four alternative methods of land preparation, 1981/82, Wet season, Suphanburi, Thailand.

ITEM	Tractor owner share 4T(O)	2T(O)	Average	Tractor hiring farm 4T(H)	2T(H)	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	25.11	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	10.69
Total	100	100	100	100	100	100	
Earner Shares							
1. Current inputs	24.21	26.64	25.64	22.11	2.59	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	56.47	49.61	52.43	48.17	45.64	46.72	57.29
Total	100	100	100	100	100	100	

Table 12. Factor and Earner shares for rice production using four methods of land preparation, 1981/82 Dry season, Suphanburi, Thailand.

ITEM	Tractor owner farm			Tractor hiring farm			Total Average
	4T(O)	2T(O)	Average	4T(H)	2T(H)	Average	
Factor shares							
1. Current input	29.86	29.42	29.60	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	15.79	17.92	11.67	
5. Residual	0.84	5.14	3.45	6.89	-6.35	-1.00	2.52
Total	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	48.09	30.63	34.16	32.74	44.84
Total	100	100	100	100	100	100	

Table 13. 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	70.50	61.83	58.96	60.21	68.38
Hired labor	18.26	16.64	17.32	14.80	18.03	16.65	17.19
Landlord	5.08	12.22	9.23	12.93	10.76	11.69	9.73
Hired capital	2.15	3.51	2.94	10.40	12.24	11.46	4.70

Table 14. Income share per hectare from rice production, 1981/82 Dry season, Suphanburi, province, Thailand.

ITEM	Tractor owner farm			Tractor hiring farm			Total average
	4T(O)	2T(O)	Average(H)	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	23.05	19.04
Owned land	30.59	22.64	23.72	25.62	19.29	24.34	
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	-9.01	-1.39	3..52
	69.15	17.77	68.30	41.95	48.47	45.78	63.47
Hired labor	24.53	21.45	22.65	26.55	20.78	23.17	22.76
Landlord	2.79	6.99	5.36	14.70	19.17	12.04	6.79
Hired capital	3.53	3.79	3.68	16.79	20.58	19.02	6.97

Table 15. Percentile measures of inequality for absentee tractor users, 1981/82 Wet Season, Suphanburi province, Thailand.

Group (%)	Percentile share							
	Net farm income				Farm household income			
	4T(O)	2T(O)	4T(H)	2T(H)	4T(O)	2T(O)	4T(H)	2T(H)
Bottom 20 percent	5.22	2.03	-	-	2.06	2.34	2.09	3.17
Bottom 30 percent	5.22	6.92	10.66	7.76	9.01	2.34	9.70	3.17
Bottom 60 percent	31.59	223.40	23.68	7.76	30.16	34.41	33.09	19.92
Top 40 percent	68.40	77.65	76.37	92.23	69.85	-	-	80.88
Top 30 percent	60.15	46.43	46.06	-	44.20	49.20	44.67	57.80
Top 20 percent	49.07	33.62	46.06	-	44.20	49.20	44.67	57.80
Top 10 percent	29.21	17.86	23.72	24.24	30.09	28.95	19.96	17.17
Top 5 percent	14.61	8.93	11.86	12.12	15.05	14.48	9.98	13.59
Concentration ratio	0.36	0.46	0.443	0.36	0.38	0.33	0.30	0.36
Average net farm earnings	21880	15050	10500	7388	28940	19930	14615	12560

Table 16. Percentile measure of inequality for absentee tractor users, 1981, Dry Season, Suphanburi, Thailand.

Group	Percentile share							
	Net farm income				Farm household income			
	4T(O)	2T(O)	4T(H)	2T(H)	4T(O)	2T(O)	4T(H)	2T(H)
Bottom 20 percent	2.43	3.91	-	-	1.38	1.93	-	-
Bottom 30 percent	2.43	3.91	-	-	1.38	1.93	6.51	8.37
Bottom 40 percent	14.44	3.91	-	-	12.43	13.41	6.51	8.37
Bottom 50 percent	19.95	22.02	19.39	15.72	22.12	13.41	10.84	24.66
Top 30 percent	80.04	58.00	80.61	84.28	60.59	67.65	63.49	-
Top 20 percent	45.98	31.40	54.72	44.01	51.34	45.13	36.36	59.29
Top 10 percent	32.59	22.63	30.78	27.04	35.65	22.02	13.60	13.60
Top 5 percent	16.30	11.32	15.39	13.52	17.87	11.01	13.27	6.80
Concentration ratio	0.40	0.34	0.53	0.49	0.37	0.32	0.45	0.38
Average net farm earnings	13830	11330	5850	4910	15450	14290	8900	

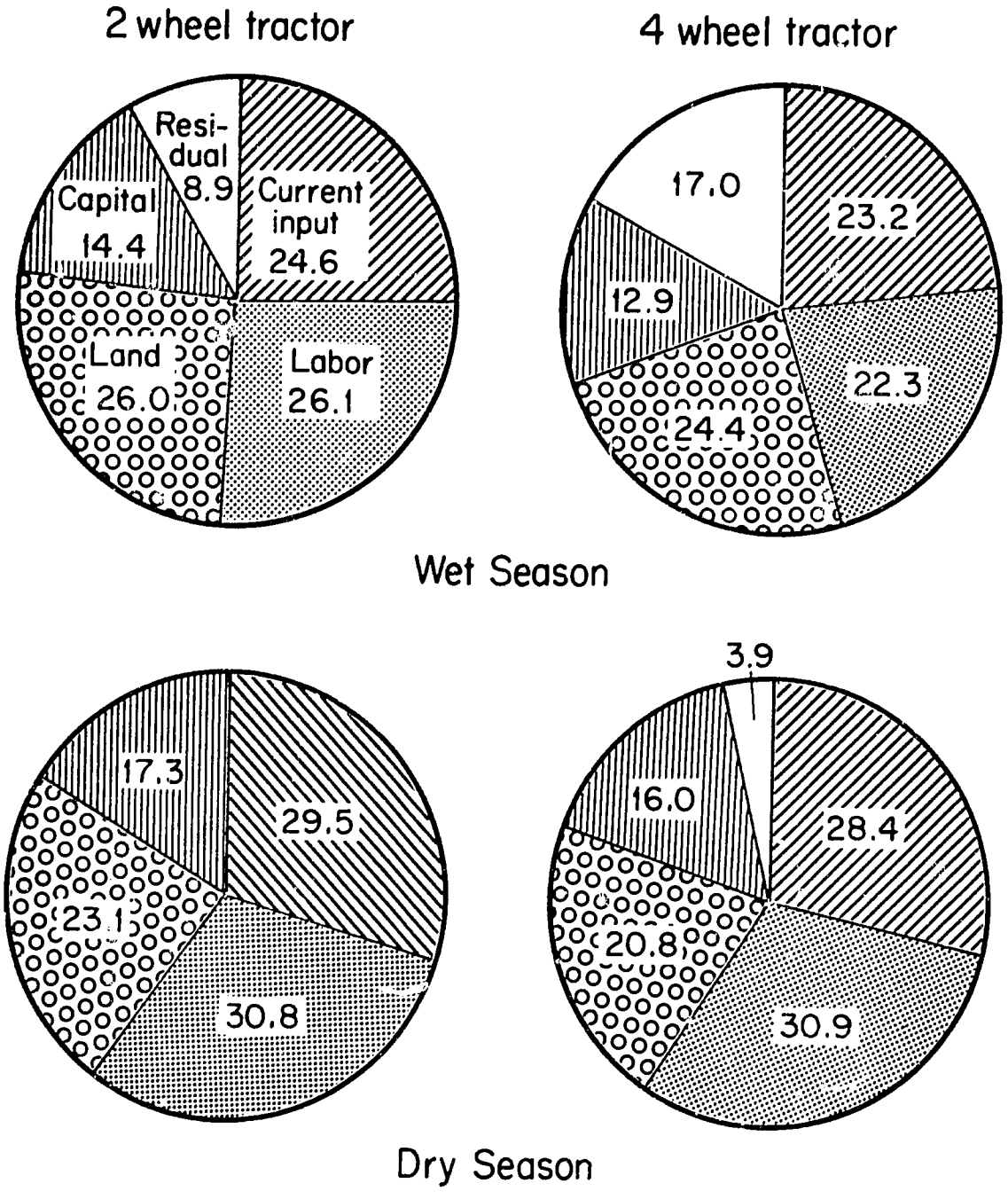

FIG. 1. RICE PRODUCTION AND DISTRIBUTION BY FACTOR USAGE AND TRACTOR TYPE, 1981-82 CROP YEAR, SUPHANBURI, THAILAND.

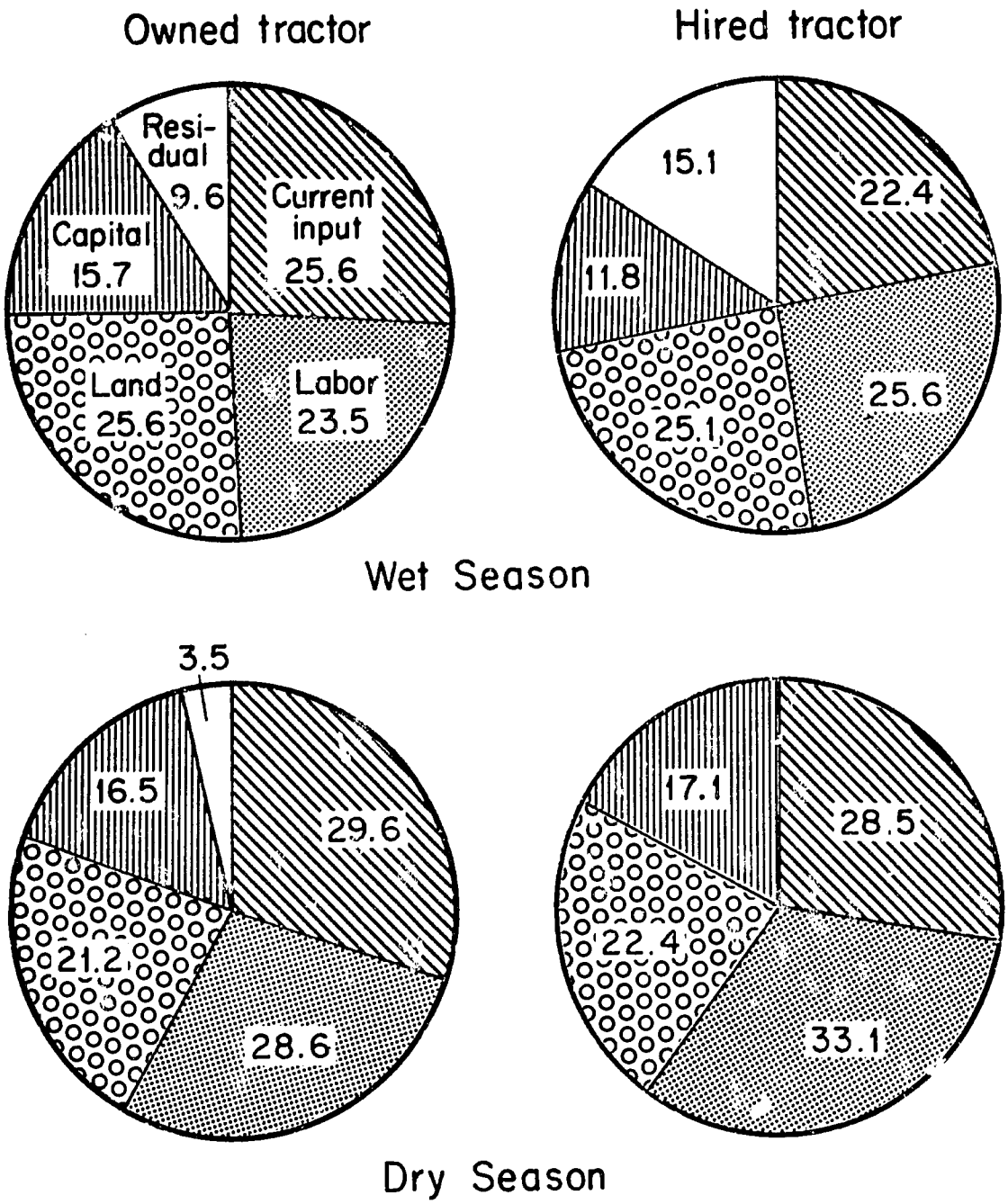

FIG. 2. RICE PRODUCTION AND DISTRIBUTION BY FACTOR USAGE AND TRACTOR OWNERSHIP, 1981-32 CROP YEAR, SUPHANBURI, THAILAND.

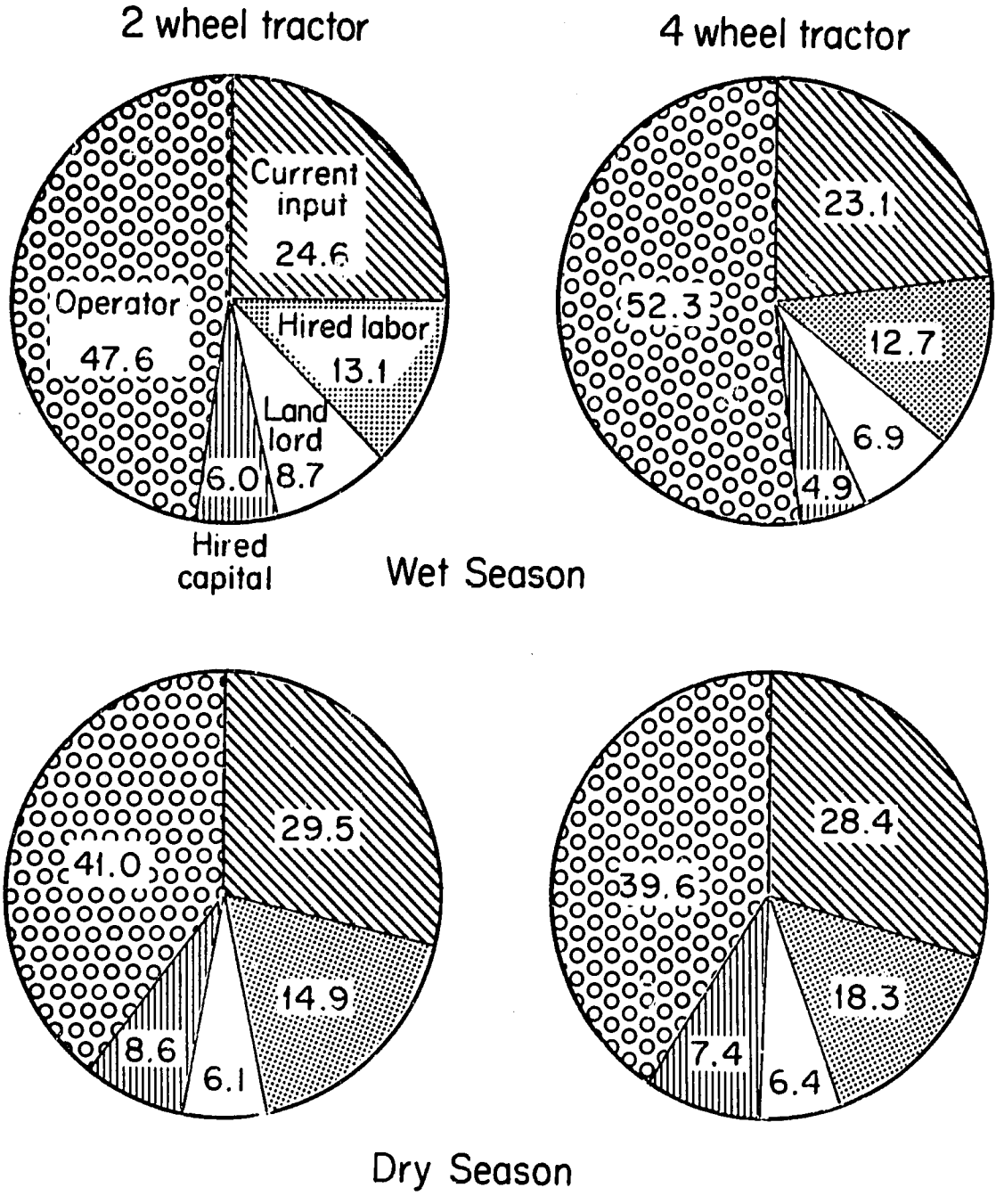

FIG. 3. RICE PRODUCTION AND DISTRIBUTION BY EARNER SHARE AND TRACTOR TYPE, 1981-82 CROP YEAR, SUPHANBURI, THAILAND.

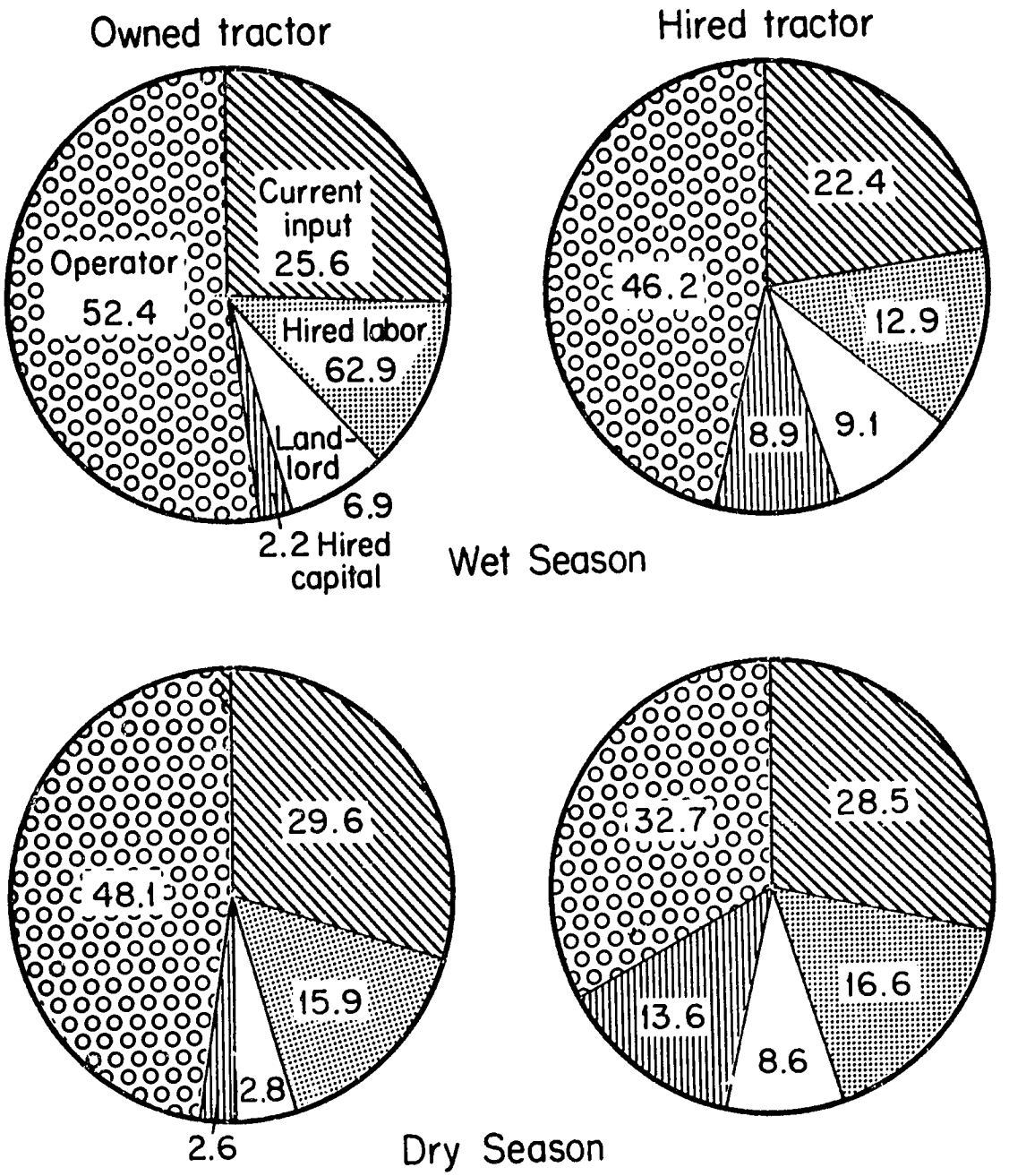

Fig. 4. Rice production and distribution by earner share and tractor ownership, 1981-82 crop year, Suphanburi, Thailand.

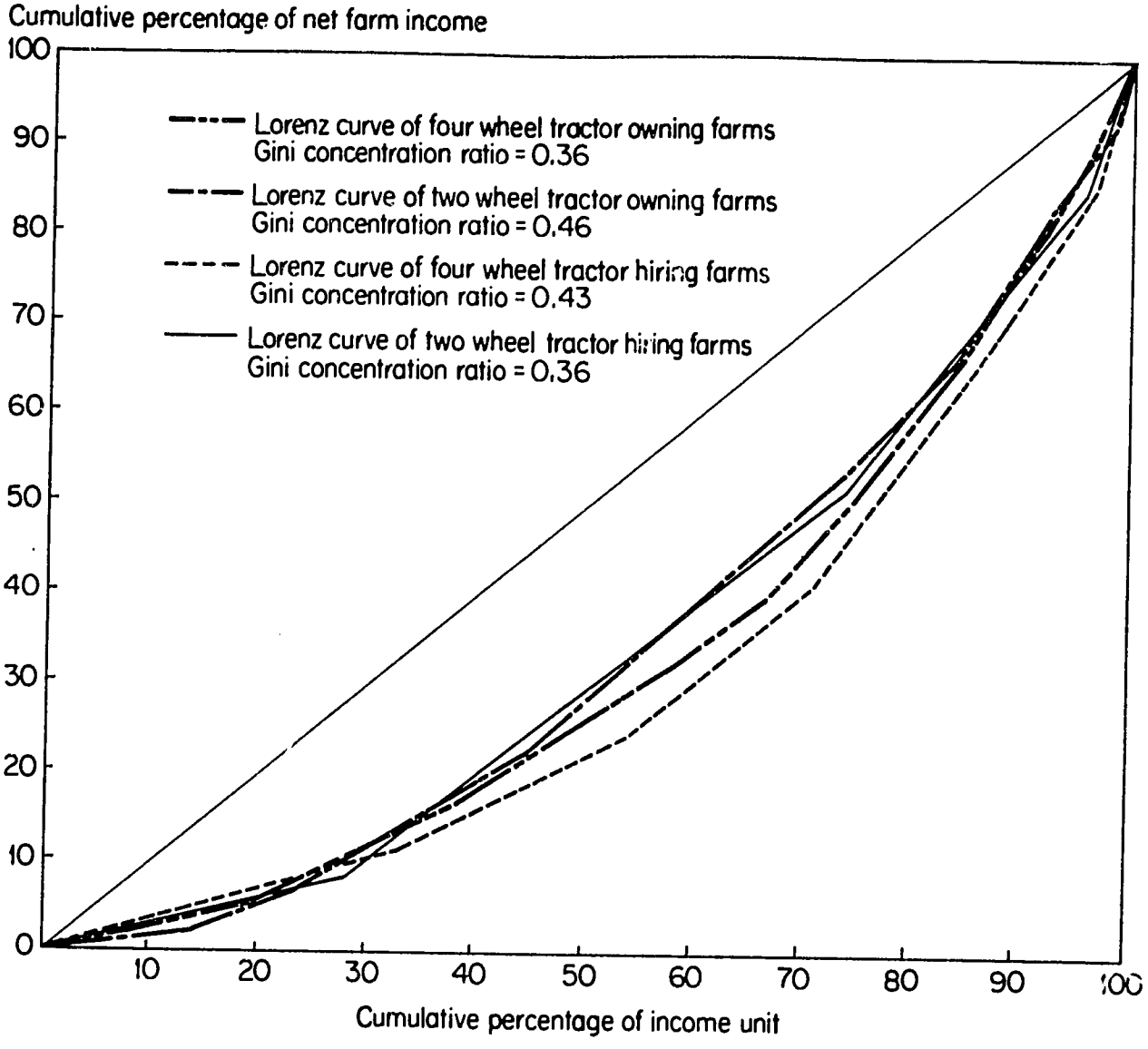

Figure 5. Lorenz curve showing the distribution of net farm income by type of tractor ownership. 1981-82, wet season, Suphanburi, Thailand.

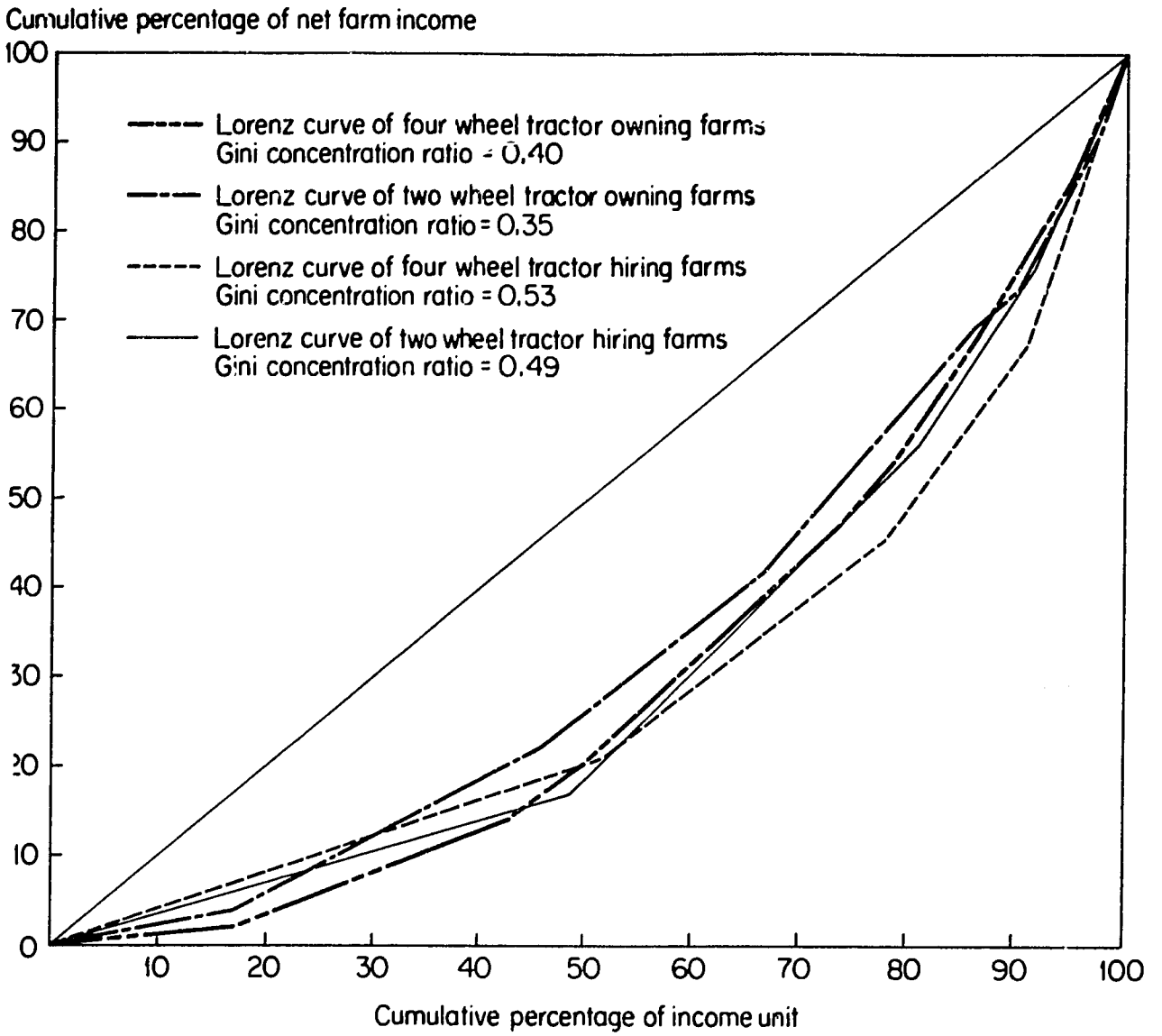

Figure 6. Lorenz curve showing the distribution of net farm income by type of tractor ownership. 1982, dry season, Suphanburi, Thailand.

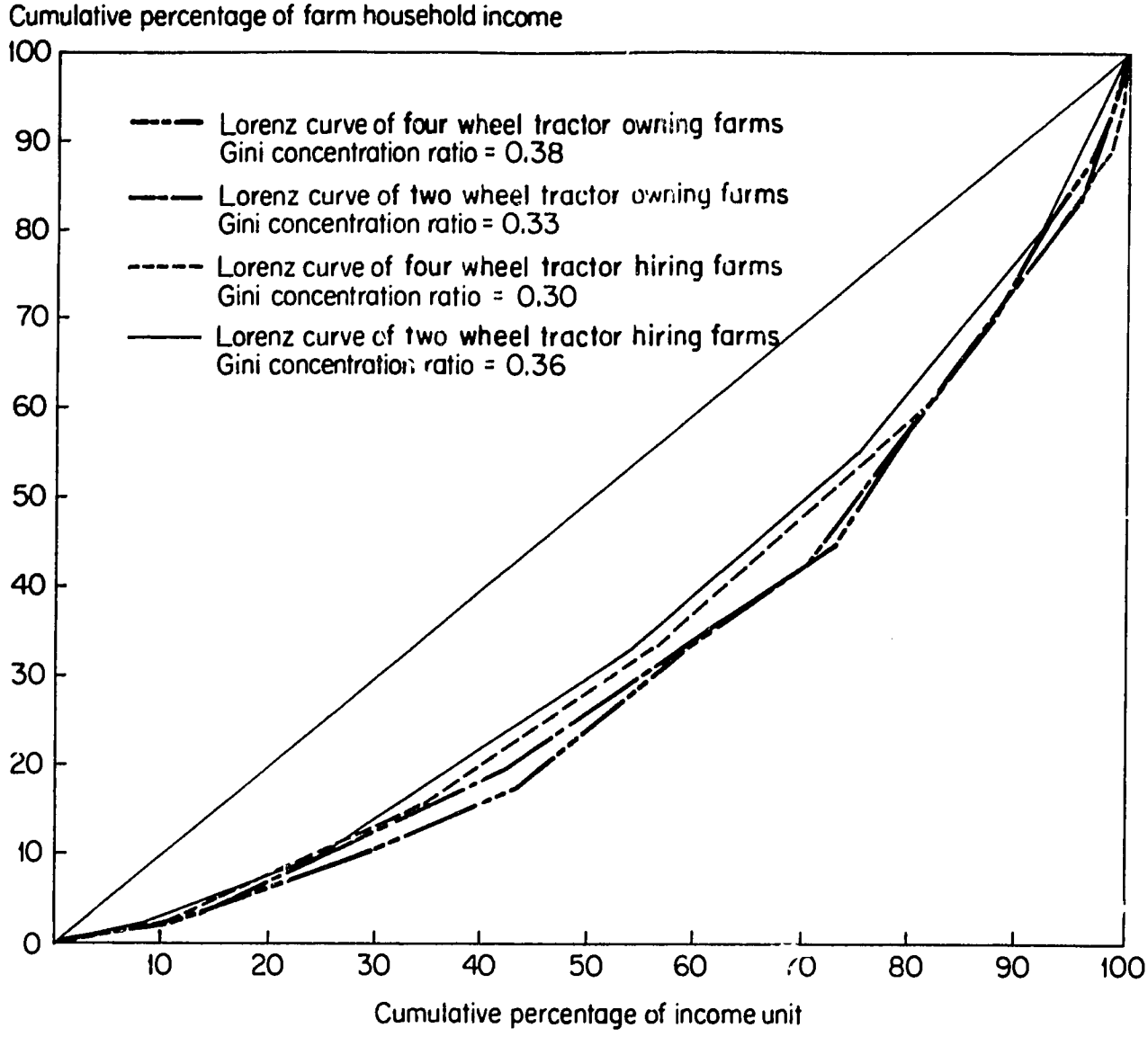

Figure 7. Lorenz curve showing the distribution of farm household income by type of tractor ownership.1981-82,wet season,Suphanburi,Thailand.

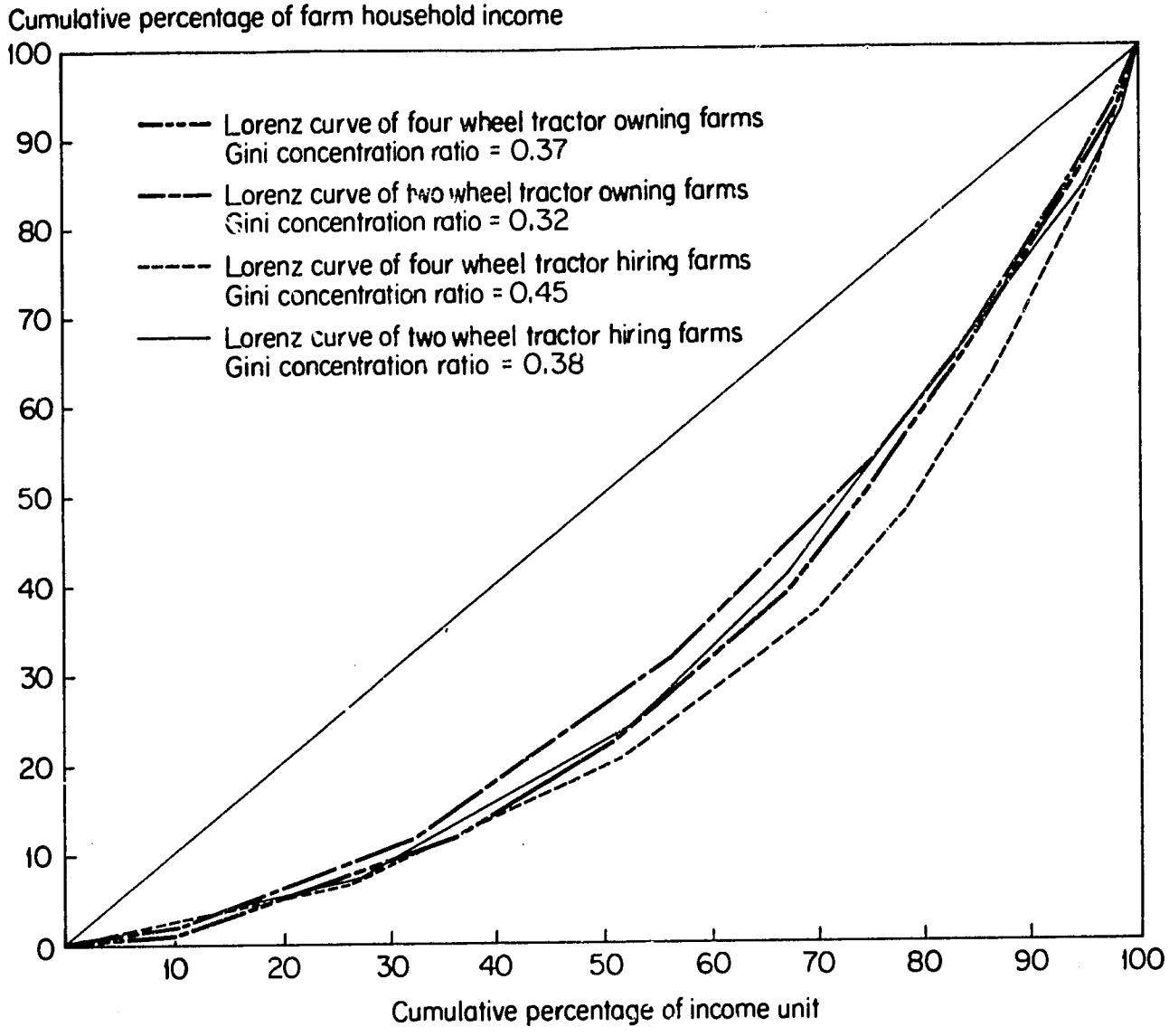

Figure 8. Lorenz curve showing the distribution of farm household income by type of tractor ownership. 1982, dry season, Suphanburi, Thailand.

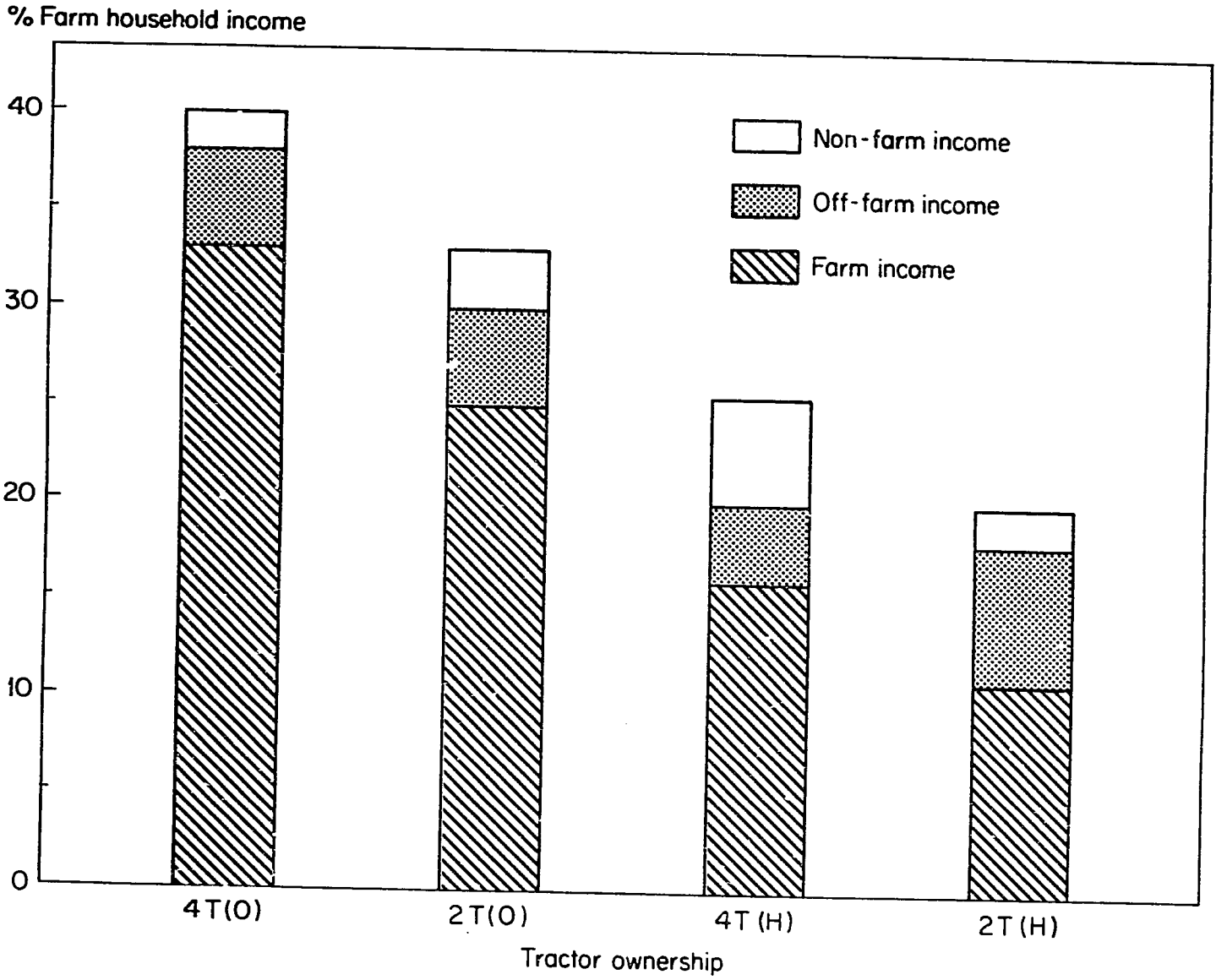

Fig.9. Household income from all sources by tractor ownership, Suphanburi, Thailand, 1981-82.

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LABOR USE IN SELECTED VILLAGES OF SUPHANBURI PROVINCE: AN ANALYSIS OF SURVEY RESULTS*

Dermot Shields**

ABSTRACT

This paper presents survey data on labor use by activity and source in selected villages of Suphanburi Province, Central Thailand, over the croping year 1981-82.

The analyses showed that farm size and the intensity of land preparation better determine total labor use per hectare than either mechanization class (2-wheel versus small 4-wheel tractors) or ownership class (owners versus hirers). Hired labor requirements per hectare varied little between classes and the variation in total per hectare labor was due primarily to variation in family labor and farm size.

Although total household labor was similar on a per farm basis for all farm classes, the smaller, often 2-wheel tractor hiring farms, spent a considerably larger amount of their time on off-farm activities. The impact of the existing accumulation of capital and land appears to have been limited since the landless and marginal families have relativelyt easy access to off-farm employment.

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LABOR USE IN SELECTED VILLAGES OF SUPHANBURI PROVINCE: AN ANALYSIS OF SURVEY RESULTS

Dermot Shields

The debate over the most approriate mechanization strategy is often hampered by a lack of empirical evidence on which to base the many, and often conflicting, views that are commonly held. Any mechanization strategy has an impact not only on productivity but also on employment and thereby on income distribution in rural areas. Further, the process of agricultural mechanization takes place within an environment of rural-urban migration and often increasing average farm sizes, which both determine and are determined by the type and form of mechanization.

The Consequences of Small Rice Farm Mechanization study aimed to collect data on four sites in South East Asia, where mechanization was either already well established, or in the process of becoming so, in order to provide the sort of quantitative background data, which is required for policy intervention.

The area chosen for the Thailand study was in the largely irrigated and highly mechanized Province of Suphanburi, located in the central plain, North of Bangkok. Five villages were purposively selected to give a large enough sample of 2-wheel and small 4-wheel tractor users: within the village households were randomly selected. The survey was carried out over the cropping year 1981-82.

The vast majority of households in the sample used power tillers for land preparation and so no comparison with animal land preparation techniques were possible. Hence the analysis focuses on differences between owners and hirers of 2-wheel and small 4-wheel power tillers. Further analysis investigated the effect of farm size and the intensity of land preparation.

BACKGROUND

The major crop grown in the area is rice, with over 90 percent of the cropped area planted to modern varieties such as RD 7 and RD 11. Transplanting was the preferred method of sowing and most of the 25 percent of households who broadcast seed had farms larger than 4 hectares.

Irrigation quality varied among the households depending on the location of the plot from the main canal. Most of the irrigation facilities had been installed sometime ago and the major water control problem was drainage, as the area is regularly subject to severe flooding.

The tractorization process started in 1965 and for irrigated households in the area was nearly complete by 1978. The growth of 2-wheel and small 4-wheel tractors was indistinguishable throughout this period, although since the introduction of mechanical thresher (about 1978) the preference of farmers switched towards the 2-wheel tractor version. Two-wheel power tillers average 8 hp and usually have a petrol driven engine, while the small 4-wheel tractor have a slightly larger engine (12 hp) and a diesel engine. There was a tendency for small 4-wheel tractors to be found in the larger upland farms. Also, the extra wheels were perceived to be beneficial for tractorized threshing which was common before the introduction of the thresher.

Non-farm employment is readily and easily available in Suphanburi, an area with good communications to Bangkok. Within the province there is one large sugar processing plant and numerous small industries, where non-farm job opportunities are readily easy to find. Further many households have family members working abroad in Singapore or Middle East.

DISCUSSION OF RESULTS

Farmer Characteristics

Both farm size and family size differed significantly between mechanization classes (Table 2). Four-wheel tractor using farms had larger average farm sizes than 2-wheel tractor using farms, while for 2-wheel classes, owners had farm sizes roughly double that of hirers. A similar pattern was found for family size. The land/labor ratios were particularly small for the 2-wheel tractor-hiring class.

Labor use by Activity

1. Comparative Analysis

Average total labor requirements for each class were 75 mandays per hectare in the wet season (Table 2) and 70 mandays per hectare in the dry season (Table 3). The differences between farm classes were relatively small, except in the case of 2-wheel tractor hirers who used 20 percent more labor than the overall average in the wet season and 10 percent in the dry season.

The major activities, in terms of mandays are land preparation, planting and harvesting and again the 2-wheel tractor hiring class have significantly higher labor requirements for all these activities. This is true for both seasons.

However, the more intensive use of labor on 2-wheel tractor hiring farms was not associated with higher average labor productivity (Table 4). Average labor productivities were calculated for both total labor and preharvest labor and in both cases were lower on the the 2-wheel tractor hiring farm than for the other farm classes. Yields per hectare were not significantly higher on 2-wheel tractor hiring farms. Average labor productivity varied considerably for 4-wheel tractor users, being lower in the wet season and much higher in the dry season. This however, was due to a significantly higher yield for 4-wheel tractor hirers in the dry season.

Measures of average productivity are extremely limited and often misleading, but before undertaking a marginal analysis of labor use, farms were reclassified on the basis of farm size, irrespective of type of machine or form of ownership (Tables 5 and 6). Lower labor requirements were found on larger farms in both the wet and dry season (Figure 1) and a similar trend was observed for land productivity (Table 7) where yields in the wet season were almost 20 percent lower on the largest farm size when compared to the smallest farm size group.

In terms of average labor productivity, measured either in kg per total labor mandays or kg pre-harvest labor mandays, the smallest farm size class showed considerably lower ratios to either of the other classes, (which did not differ significantly). In terms of farm size, the higher yields and higher labor inputs on the smallest farm size class resulted in lower average productivities than on the lower yielding, lower input, larger farm classes.

The distribution of farm size classes within each mechanization class (Table 8) showed that almost two-third of the 2-wheel tractor hiring class were small farms. Therefore this farm size effect needs to be controlled for before drawing conclusions about different tractor classes.

Given the comparative similarity between the machine types and also the land intensification measurement for owning and hiring households, farms were reclassified into land preparation groups based on tractor hours per hectare used for land preparation. Again, an area effect was observed with the most intensive machine use being applied to the smallest farms (Table 9). However, total labor requirements was found to be positively related to the intensity of land preparation (Figure 2).

Labor productivity, although much lower for the largest land preparation class (mostly containing small farm size) declined marginally with more intensive land preparation (Table 10). The distribution of land preparation group by mechanization classes showed that tractor owners prepared their land more intensively than tractor hirer (Table 11).

2. Marginal Analysis

Tabular analysis is both limited and perhaps misleading since there is no allowance for the confounding effects of excluded variables. Marginal analysis for total labor in mandays per hectare as a linear function of area planted and intensity of land preparation was carried out (Table 12). The intensity of land preparation was measured as the number of tractor hours per hectare spent on land preparation. Model I included an intercept shifter separating 2-wheel and 4-wheel tractor users, irrespective of ownership, while Model II separated ownership class, irrespective of machine type. Overall, the models were highly significant although only explaining less than 20 percent of the variation in yield.

In neither the wet or dry seasons, was the mechanization dummy significantly different from zero, suggesting that labor use was similar for both machine types. The area variable was negative and highly significant showing that labor use declined with farm size. Also, the land preparation parameter was significantly positive confirming the tabular analysis that total labor use increase with intensity of land preparation.

Model II was used to test the hypothesis that owners used more labor than hirers after allowing for farm size and the intensity of land preparation. The coefficients for area planted and land preparation intensity were similar to Model I. However, a weakly significant parameter for the ownership dummy suggests that, at least in the wet season, labor use was higher on tractor owning farms.

Labor Use by Source

1. Comparative Analysis

Several mechanziation studies have concluded that the major impact of mechanized land preparation is on family labor. Although this study was limited to an analysis of different tractor techniques, much of the variation in total labor per hectare is due to differences in family labor per hectare (Tables 13 and 14).

A similar pattern was exhibited by the tabular analysis for farm size classes (Table 15 and 16, Figure 1) where the variation in total labor per hectare. This was as expected since family labor is limited by family size and off-farm commitments and there is less variation in family size than in farm size. Therefore as farm size increases, family laborer hectare is bound to fall.

An interesting implication of this limit on family labor is that although hired labor per hectare appeared to be constant irrespective of farm class or farm size, it cannot be concluded that this represents the same job opportunities for landless and small farmers. In order to compensate fully for the reduction in the number of farms, caused by increased average farm size, and the fact that many 'amalgated' farmers become landless, an increase in hired labor per hectare wold be necessary on the larger farms in order to stand still in terms of employment. However, in Suphanburi, with the relative ease of access to non-farm employment, on-farm job opportunities are not as important an issue as for other areas or regions. However the evidence here is that on the larger farms, hired labor use has not increased with farm size, either in terms of increased job opportunities or to compensate for the displacement of small farms. Although, no evidence is presented here, it is undoubtedly true that mechanization and farm size are strongly associated.

2. Marginal Analysis

The models presented for total labor use were reestimated for hired labor per hectare. The explanatory power of the model was very low: none of the independent variables explain much of the variation in hired labor per hectare. However, the results are consistent with the tabular analysis and confirm that farm size had no effect on hired labor use, while intensity of land preparation had a little effect in the wet season, but a highly significant effect in the dry season. This is probably due to time constraints at the time of dry season land preparation which coincides with wet season harvest and also when tractors are required for threshing. However, the low explanatory power of model suggests that little of the overall variation in hired labor per hectare was explained.

Household Labor

The fall in per hectare household labor use, associated with both larger farm sizes and mechanization, may also provide benefits to the household in terms of either increased leisure or opportunities for off-farm labor.

There was no significant difference in mandays worked by household members when taken as a whole-roughly 33 mandays per household per season (Table 19, 20 and Figure 3). However, the composition of this work showed major differences between the contribution of farm and off-farm activities. For the 2-wheel tractor hiring class over 50 percent of the hours worked were off-farm while for owners of either 2-wheel or 4-wheel tractors less than 30 percent of their time was spent on off-farm activities. These differences were almost entirely due to farm size differences.

Off-farm labor opportunities are relatively easy to find in this area of Thailand and these results sugest that excess family labor was deployed on these activities rather than enjoying increased leisure.

CONCLUSIONS

The differences in labor use between 2-wheel and small 4-wheel tractor using farms were found to be minimal. However, farms hiring in either of the tractor types were characterized by relatively small farm sizes.

Total labor use was negatively related to farm size and positively related to the intensity of land preparation. However, hired labor per hectare was roughly constant irrespective of classification group. However, given the much larger farm sizes of the tractor owning farms, a rise in hired labor would have been expected on these farms, in order to compensate for the reduced family labor per hectare.

Although the issue is not crucial in Suphanburi, a government policy encouraging or permitting the accumulation of capital and land by machine ownership and farm size enlargement will tend to reduce the employment potential of the area. Smaller farms and the sharing of capital services through the hiring or knowing of machines are more likely to maximize employment opportunities within the area. In Suphanburi, where employment opportunities are readily available, other issues such as the maximization of marketable surplus may be an impoprtant focus of government policy. However, in many other areas of Thailand, where off-farm employment is not so readily available, the impact of mechanization on employment may have social costs that policy makers need to take into account.

Table 1. Characteristics of farmers and farm holding in selected irrigated villages of Suphanburi Province, Thailand, Wet Season, 1981/1982.

Characteristics	2-wheel tractor		4-wheel tractor		All
	Owner	Hired	Owner	Hired	
Farm size (ha)	3.58	1.62	4.39	2.47	
Family size	5.6	4.7	5.6	4.4	5.3
Labor force per household	3.7	3.3	3.7	2.7	3.5
Depending ratio	1.9	2.4	1.9	1.6	2.0
Land/labor ratio	0.97	0.49	1.19	0.91	
Land/family size ratio	0.64	0.34	0.78	0.56	
Sample size	94	59	53	31	240

Source: Consequences of Small Rice Farm Mechanization.

Table 2. Labor requirements for rice production by activity and mechanization class in selected villages, Suphanburi Province, Thailand, Wet Season. 1981/82

Activity	Animal	2-wheel tractor		4-wheel tractor		All
		Owner	Hired	Owner	Hired	
			Man-days per hectare			
Seedbed preparation	1	1	1	1	2	1
Land preparation	38	17	20	15	16	17
Planting	11	12	15	11	11	12
Apply chemicals	2	2	2	1	1	1
Irrigation	3	3	3	3	6	3
Cultivation	3	3	8	5	5	5
Pre-harvest	74	38	49	36	41	41
Harvesting	33	30	38	30	27	32
Post-harvesting	4	3	5	3	3	3
Total labor	111	71	92	69	72	76
Sample size	3	94	59	53	31	240

Source: Consequences of Small Rice Farm Mechanization.

Table 3. Labor requirements for rice production by activity and mechanization class in selected villages, Suphanburi province, Thailand, Dry Season, 1987/82

Activity	Animal	2-wheel tractor		4-wheel tractor		All
		Owner	Hired	Owner	Hired	
		Man-days per hectare				
Seedbed preparation	1	1	1	1	1	1
Land preparation	37	13	16	13	13	14
Planting	20	10	12	13	11	12
Apply chemicals	2	2	2	1	0	1
Irrigtaion	2	4	5	4	6	5
Cultivation	7	2	5	3	4	3
Pre-harvest	69	33	41	35	35	36
Harvesting	58	31	30	27	31	30
Post-harvesting	7	4	6	4	4	5
Total labor	134	68	77	65	71	71
Sample size	2	94	63	52	27	238

Source: Consequences of Small Farm Mechanization.

Table 4. Average productivity ratios by mechanization class in selected villages of Suphanburi Province, Central Thailand, Wet and Dry Season, 1981/82

Average Productivity ratios	Animal	2-wheel tractor		4-wheel tractor		All
		Owner	Hired	Owner	Hired	
Wet Season						
Yield:						
Per hectare	3080	3760	3770	3730	3550	3730
Per total labor	28	53	41	54	50	49
Per per-harvest labor	50	103	89	131	95	104
Per land preparation	102	275	249	356	253	287
Dry Season						
Yield:						
Per hectare	3190	4250	3970	39[illegible]	4660	4190
Per total labor	24	63	52	61	66	59
Per pre-harvest labor	53	139	130	130	175	138
Per land prepation	75	356	399	338	480	375
Sample size (WS)	3	94	59	53	31	240
(DS)	2	94	62	52	27	237

Source: Consequences of Small Rice Farm Mechanziation Project.

Table 5. Labor requirements for rice production by activity and mechanzation class in selected villages, Suphanburi Province,Thailand, Wet Season, 1981/82.

Activity	Small	Medium	Large
		Man-day per hectare	
Seedbed preparation	2	1	1
Land preparation	20	18	15
Planting	14	12	12
Application of chemicals	1	2	2
Irrigation	4	3	3
Cultivation	6	5	4
Pre-harvest	48	41	37
Harvesting	37	32	27
Post-harvesting	5	4	2
Total labor	89	76	66
Sample size	60	107	73

Source: Consequences of Small Rice Farm Mechanization Project.

Table 6. Labor requirements for rice production by activity and mechanization class in selected villages, Suphanburi Province, Thailand, Dry Season, 1981/82

Activity	Small	Medium	Large
	Mandays per hectare		
Seedbed preparation	1	0.5	0.5
Land preparation	17	14	12
Planting	14	11	11
Apply chemicals	2	2	2
Irrigation	7	5	2
Cultivation	5	2	2
Pre-harvest	46	34	30
Harvesting	36	28	27
Post-harvest	6	5	3
Total labor	87	67	59
Sample size	66	111	61

Source: Consequences of Small Rice Farm Mechanization Project.

Table 7. Average productivity ratios by farm size class, for selected villages in Suphanburi Province, Central Thailand.

	Small (< 1.6 ha)	Medium (1.6 - 4.0 ha)	Large (> 4.0 ha)
Wet Season			
Yield			
Per hectare	4010	3950	3300
Per Total labor	45	52	50
Per pre-harvest labor	94	110	104
Per land preparation labor	263	295	277
Dry Season			
Yield:			
Per hectare	4300	4130	3890
Per total labor	49	62	66
Per pre-harvest labor	119	146	143
Per land preparation	362	381	378
Sample size (Wet)	60	107	73
(Dry)	66	110	61

Source: Consequences of Small Rice Farm Mechanization Project.

Table 8. Percent distribution of sample by farm size class and farm mechanization class, in selected villages, Suphanburi Province, Central Thailand, Wet Season 1981/82.

Farm size class	Animal	2-wheel tractor		4-wheel tractor	
		Owner	Hired	Owner	Hired
		Percent			
Small (< 1.6 ha)	100	8	64	3	22
Medium (1.6 - 4 ha)	-	51	16	19	12
Large (> 4 ha)	-	44	5	42	7
Sample size	3	94	59	53	31

Source: Consequences of Small Rice Farm Mechanization Project.

Table 9. Regression result for hried labor per hectare as a functiuon of farm size and machine type and ownership class.

Explanatory variable	Model I		Model II	
	Wet Season	Dry Season	Wet Season	Dry Season
Intercept	26.69***	22.02***	22.7***	2.71***
	(6.40)	(6.97)	(7.26)	(6.61)
Farm size	-0.14	-0.11	0.22	0.13
	(0.19)	(0.16)	(0.31)	(0.20)
Soil preparation	0.22*	0.36***	0.23*	0.36*
	(2.38)	(4.33)	(2.53)	(4.24)
MECH (0, 1)[a]	2.21	5.45*		
	(0.80)	(2.17)		
OWN (0, 1)			6.80**	0.95
			(2.65)	(0.40)
R^2	0.03	0.09	0.05**	0.08***
Fvalue	2.04	7.66	4.23	6.03
CV	59%	52%	58%	53%
N	234	224	234	224

Dependent variable is hired labor mandays per hectare.
(a) MECH is dummy variable with value 0 if 2-wt, and 1 if 4-wt.
(b) OWN is a dummy variable with value 0 if owner and value 1 if hired.

*** Significant at 99.9%.
** Significant at 99%.
* Significant at 95%.

Table 10. Average labor productivity ratios by land preparation classes in selected villages, Suphanburi Province, Central Thailand, Wet and Dry Season, 1981/82.

	Land Preparation class*				
	0 - 20	20 - 25	25 - 30	30 - 40	40+
Wet Season					
Yield:					
Per hectare	3420	3870	3630	3680	4160
Per total labor	51	56	49	49	42
Per per-harvest labor	111	119	108	104	76
Per land prep. labor	352	310	270	258	195
Dry Season:					
Yield					
Per hectare	3950	4200	3880	4590	4210
Per total labor	63	63	61	57	48
Per pre-harvest labor	156	156	128	128	96
Per land preparation	478	425	322	312	224
Sample size (Wet)	55	49	42	49	45
(Dry)	66	62	37	33	39

*Defined by the tractor hours spent on land preparation.

Source: Consequences of Small Rice Farm Mechanization Project.

Table 11. Percentage distribution of land preparation classes by mechanization group, in selected villages, Suphanburi Province, Central Thailand Wet and Dry seasons, 1981/82

Land preparation Group	Animal	2-wheel tractor		4-wheel tractor		All
		Owner	Hired	Owner	Hired	
Wet Season				Percent		
Per hectare						
1: < 20 hours	100	16	33	19	19	23
2: 20 - 25 hours		18	21	19	30	20
3: 25 - 30 hours		19	10	23	15	17
4: 30 - 40 hours		25	16	21	15	20
5: > 40 hours		22	19	19	22	20
Dry season						
Per hectare						
1: < 20 hours	100	14	27	21	39	23
2: 20 - 25 hours		18	24	25	16	20
3: 25 - 30 hours		21	10	23	13	19
4: 30 - 40 hours		26	20	18	10	20
5: > 40 hours		21	19	13	23	19
Sample size						
WS	3	94	59	53	31	240
DS	2	94	63	52	27	238

Source: Consequences of Small Rice Farm Mechanization Project.

Table 12. Regression equation for total labor in mandays per hectare to test whether there are significant labor difference between different tractor classes and different ownership group.

	Model I		Model II	
	Wet season	Dry season	Wet season	Dry season
Intercept	66.81*** (9.48)	60.58*** (10.57)	58.84*** (11.61)	58.30*** (12.57)
Farm size (ha)	-3.70*** (3.48)	-3.03*** (3.21)	-3.55*** (3.44)	-2.84*** (3.10)
Tractor hours (ha) Soil preparation	0.72*** (5.16)	0.51*** (4.27)	0.75*** (5.54)	0.52*** (4.43)
Mechanization (0.1)[a]	-3.84 (0.94)	+2.29 (0.65)		
Own (0,1)[b]			+10.74** (2.85)	4.31 (1.30)
R^2	0.18***	0.13***	0.20***	0.14***
Fvalue	16.59	11.14	19.51	11.63
CV	39%	37%	38%	37%
N	234	224	234	224

Dependent variable is total labor per manday per hectare.

[a] Mech. is a dummy with value 0 if 2-wt, and value 1 if 4-wt.

[b] Own is a dummy with value 0 if hired, and value 1 if owned

***Significant at 99.9%

**Significant at 99%

Table 13. Distribution of labor requirements for rice production by source, in selected villages, Suphanburi Province, Central Thailand, Wet Season, 1981/82.

Source of labor	Animal	2-wheel tractor		4-wheel tractor		All
		Owner	Hired	Owner	Hired	
			Mandays per ha.			
Total labor	110	71	92	69	71	76
Hired labor	10	31	37	38	33	34
Family labor	100	40	55	31	39	42
Sample size	3	94	59	53	51	240

Table 14. Distribution of labor requirements for rice production by source, in selectred villages, Suphanburi Province, Central Thailand, Dry Season, 1981/82.

Source of labor	Animal	2-wheel tractor		4-wheel tractor		All
		Owner	Hired	Owner	Hired	
			Man-days per ha.			
Total labor	134	68	77	65	71	78
Hired labor	10	32	33	36	38	34
Family labor	124	36	44	30	33	37
Sample size	2	94	62	52	27	237

Source: Consequences of Small Rice Farm Mechanization.

Table 15. Total, hired and household labor by farm size class in selected villages, Suphanburi Province, CentralThailand, Wet Season, 1981/82.

Source of labor	Small (< 1.6 ha)	Medium (1.6 - 4 ha)	Large (> 4 ha)
Wet season			
Total labor	89	76	66
Hired labor	33	34	34
Household labor	56	42	32
Sample size	60	107	73

Source: Consequences of Small Rice Farm Mechanization Project.

Table 16. Total, hired and household labor by farm size class in selected villages, Suphanburi Province, Central Thailand, Dry Season, 1981/82.

Source of labor	Small (< 1.6 ha)	Medium (1.6 - 4 ha)	Large (> 4 ha)
Dry Season			
Total labor	87	67	59
Hired labor	46	34	30
Household labor	37	32	33
Sample size	66	110	61

Source: Consequences of Small Rice Farm Mechanization Project.

Table 17. Total, hired and household labor by land preparation class, in selected villages, Suphanburi Province, Central Thailand, Wet season, 1981/82

Source of labor	Land Preparation Class*				
	0 - 20	20 - 25	25 - 30	30 - 40	40+
	Man-days per hectare				
Total	67	69	74	75	99
Hired	31	35	29	32	43
Household	36	34	45	43	56
Sample size	55	49	42	49	45

*Defined by the tractor hours spent on land preparation.

Source: Consequences of Small Rice Farm Mechanization Project.

Table 18. Total hired and household labor by land preparation class in selected villages, Suphanburi Province, Central Thailand, Dry Season, 1981/82

Source of labor	Land Preparation Class*				
	0 - 20	20 - 25	25 - 30	30 - 40	40*
	Man-day per hectare				
Total	62	67	63	81	88
Hired	86	34	36	39	38
Household	36	33	29	43	50
Sample size	66	62	37	33	39

* Defined by the tractor hours spent on land preparation.

Source: Consequences of Small Rice Farm Mechanization Project.

Table 19. Regression equation of household labor in man-days per hectare to test the hypothesis that after controlling for farm size, there is no significant difference in household labor requirement between different tractor class.

Explanatory variables	Model I Wet	Model I Dry	Model II Wet	Model II Dry
Intercept	56.61*** (11.05)	43.20*** (10.80)	53.50*** (15.39)	40.85** (14.29)
Area	-4.04*** (4.36)	-3.06*** (3.88)	-4.39*** (4.78)	-3.13*** (4.00)
MECH (0,1)[a]	-7.36* (2.06)	-3.31 (1.09)		
OWN (0, 1)			2.91 (0.80)	+2.95 (1.04)
R^2	0.11***	0.07***	0.10**	0.07***
Fvalue	14.37	8.97	12.44	8.92
CV	62%	65%	62%	65%
N	234	224	234	224

Dependent variable is household labor in mandays per hectare.

[a]MECH is a dummy variable with value = D if 2-wheel tractor and value = 1 if 4-wheel tractor.

[b]OWN is a dumy variable with value = 0 if tractor is owned and value = 1 if tractor is hired.

*** Significant at 99.9%.

** Significant at 95%.

Table 20. Distribution of family, labor between farm and off-farm activities, in selected villages, Suphanburi Province, Central Thailand, Wet Season, 1981/82

	Animal	2-wheel tractor		4-wheel tractor		
		Owner	Hired	Owner	Hired	All
				Man-days per farm		
Farm labor	44	24	15	23	21	21
Off-frm labor	4	10	16	8	11	11
Total family	48	34	31	31	32	33
% of farm	8%	29%	52%	26%	34%	33%
Sample size	3	94	59	53	34	33

Source: Consequences of Small Rice Farm Mechanization Project.

Table 21. Distribution of family labor between farm and off-farm activities in selected villages, Suphanburi Province, Central Thailand, Dry 1981/82.

	Animal	2-wheel tractor		4-wheel tractor		
		Owner	Hired	Owner	Hired	All
				Man-days per farm		
Farm labor	40	30	18	34	18	26
Off-farm labor	2	7	10	4	10	7
Total family labor	42	37	28	38	28	33
% off farm	5%	20%	36%	11%	36%	21%
Sample size	2	94	62	52	27	37

Source: Consequences of Small Rice Farm Mechanization Project.

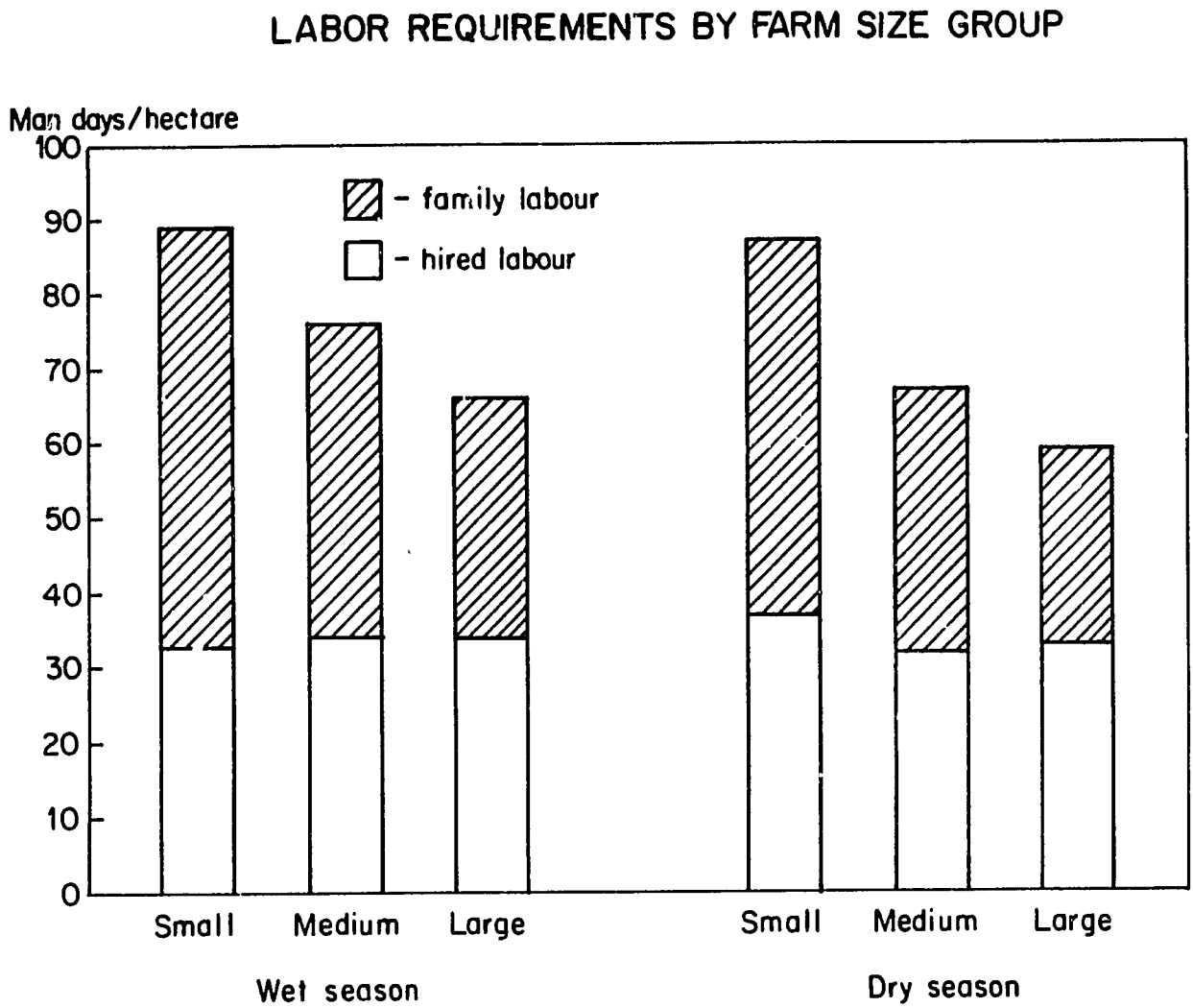

Fig. 1. Total labour requirement for more production in man-days per hectare by area class in selected villages, Suphanburi Province, Central Thailand, 1981 - 1982.

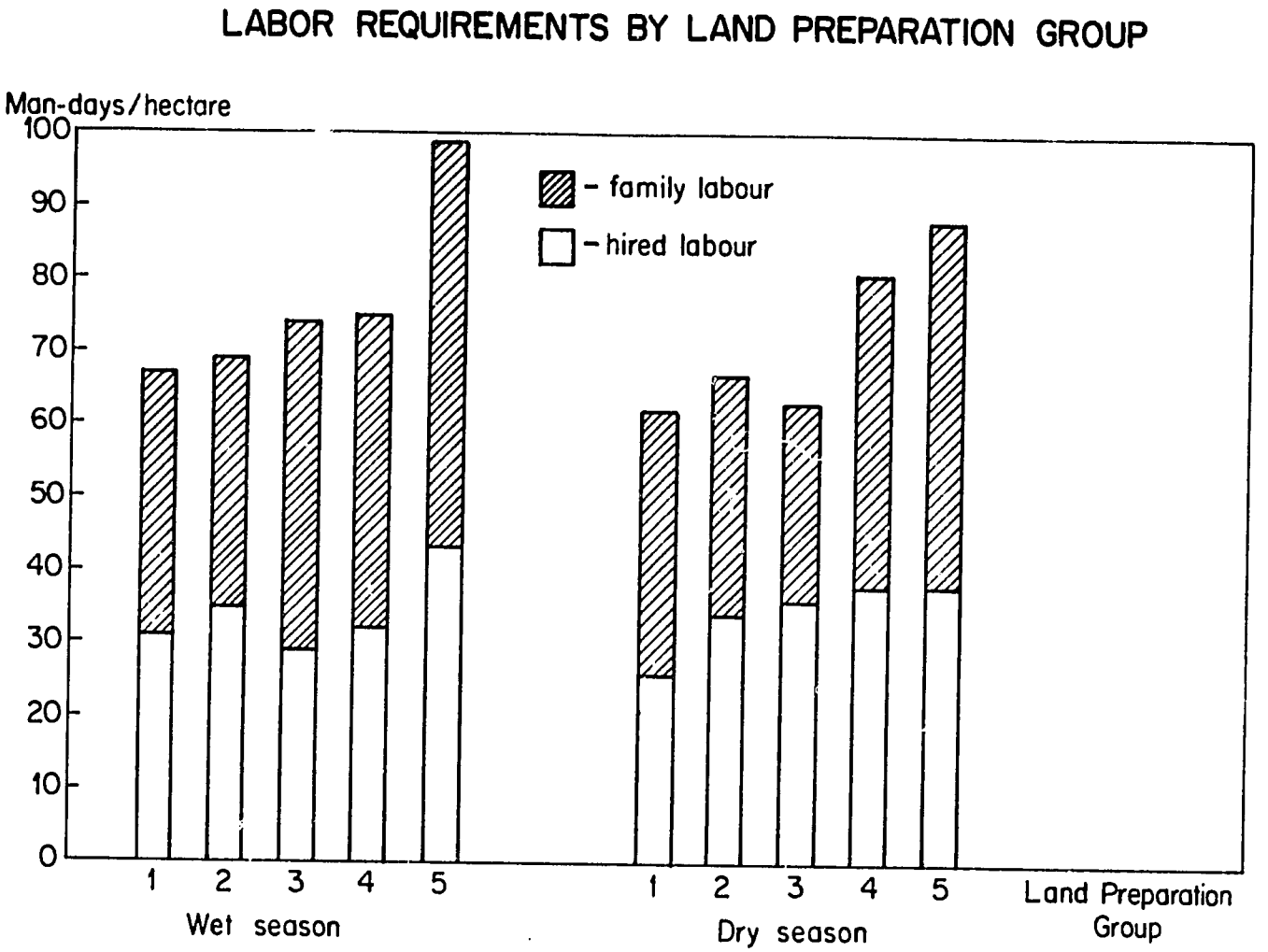

Fig. 2. Total labour requirement for more production in man-days per hectare by land preparation group in selected villages, Suphanburi Province, Central Thailand, 1981-1982.

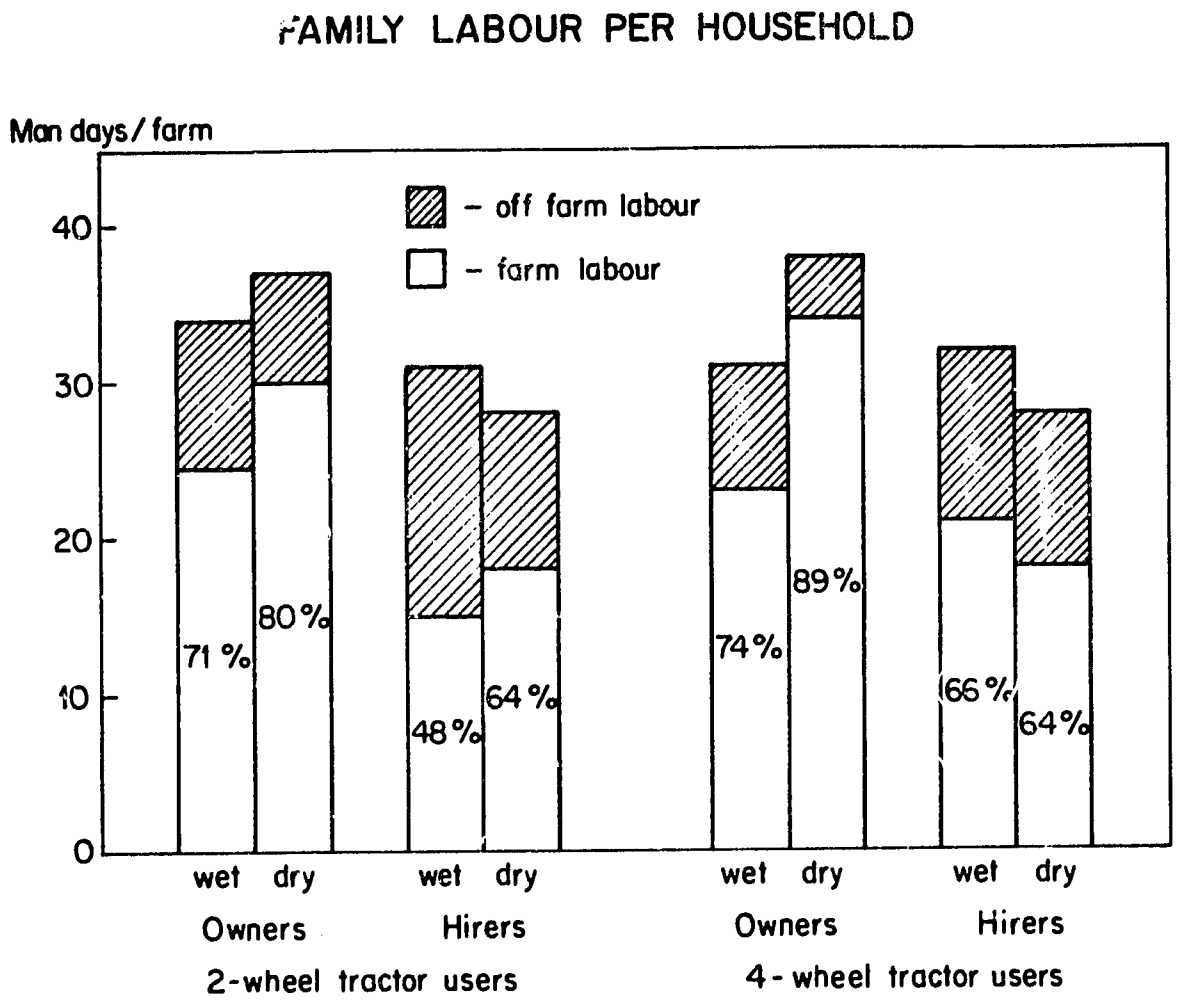

Fig. 3. Proportion of household labour spent on farm and off farm employment in selected villages, Suphanburi Province, Central Thailand, wet and dry season 1981-1982.

SECTION III

THE ECONOMICS OF MECHANIZATION

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THE ECONOMICS OF MECHANICAL LAND PREPARATION: AN EVALUATION OF EVIDENCE FROM SUPHANBURI PROVINCE*

Celerina Maranan, Dermot Shields and S. Sukharomana**

ABSTRACT

A cost-benefit analysis was used to determine the break-even point and payback period for two- and four-wheel tractors during the wet and dry seasons of the 1980/81 cropping year. Given present utilization levels and the existing contract rate, both types of tractor were profitable through the undiscounted cost-benefit ratio of the former was higher than that of the latter. With a constant contract rate, rising fuel and oil prices led to a decline in the cost-benefit ratio associated with both types of tractors, and an increase in the break-even points. The reverse was true when prices were held constant while the contract rate per hectare was increased. The changes in fuel and oil prices, and in the contract rate produced similar effects on the payback period.

*Paper presented at the workshop on the Consequences of Small Rice Farm Mechanization in Thailand held in Bangkok, Thailand, on November 10-11,1983.

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THE ECONOMICS OF MECHANICAL LAND PREPARATION: AN EVALUATION OF EVIDENCE FROM SUPHANBURI PROVINCE

Celerina Maranan, Dermot Shields, and S. Sukharomana

INTRODUCTION

Estimates up to 1980 indicate there were over 60,000 four-wheel tractors and over 200,000 two-wheel tractors operating on farms in Thailand. The annual growth rate in the stock of these machines ranged from 16 to over 20% per year for the 1975-80 period. The composition of the tractor fleet centers on locally built two- and small four-wheel machines. An appreciable number of larger four wheel machines have been imported and, in recent years, there has been an emerging market for small, second hand imported tractors which are reconditioned and sold in the country.

Small two wheel walking tractors are almost exclusively employed in wetland paddy production, primarily in the Central Plain. The small four-wheel units are used for land preparation in paddy producing areas, although not normally under flooded or wetland conditions. Larger tractors are used primarily for contract plowing, powering corn shellers and provision of transportation.

As part of the Consequences of Small Farm Mechanization project in Thailand, an extensive body of information was gathered to provide details on the operation of two- and small four-wheel tractors owned or hired by survey respondents in Suphanburi Province. The objectives in gathering data describing use of tractors in the area were:

1. to compare the financial viability of alternative mechanical land preparation techniques.
2. to evaluate tractor use patterns.
3. to assess problems of repair, maintenance and sustainability.
4. to examine factors which affect the profitability of machine investments, e.g. fuel costs and contract rates.

The Farmer

Table 1 shows the general characteristics of the groups of respondents, namely: two-wheel tractor owners, four-wheel tractor owners. The respondents did not vary so much in average age (47 to 54 years), with draft animal owners being the oldest among the three groups. Likewise, they all had the same level of educational

attainment of around 4 years and came from households of similar size. The draft animal owning group reported the longest farming experience at 25 years on the average, and two-wheel tractor owners had the least number of years in farming at 20 years. A majority of the parcels being cultivated by the respondents from each group are owned, 56% and 59%, for two- and four-wheel tractor owners. Twenty-two and seventeen percent of the households respectively, rented-in land which involved different rental arrangements such as: fixed rental fees; varied rental fee and several parcels which were used free of cost. A very small percentage of the parcels were rented out using similar arrangements.

Farm Description

Among the three farmer groups, the four-wheel tractor owners owned the largest farms with 4.57 ha on the average, followed by the two-wheel tractor owners at 3.77 ha (Table 2a & b). The total cultivated area of each farm were however slightly smaller. Soils on more than one-third of the total farm parcels owned by both two- and four-wheel tractor owners contained a high percentage of clay and the rest were either clay-loam, loam, sandy, sandy loam or others.

The most common problems reported by respondents regarding land conditions were general infertility and water logging for two- and four-wheel tractor owners and general infertility, erosion and sandiness on draft animal owning farmers.

Diversion structures in secondary canals was the source of irrigation for all three groups. The only land improvements noted were levelling and clearing.

Farming Practices

Seventy-three percent of the two-wheel, sixty percent of the four-wheel tractor owners and seventy-eight percent of the draft animal owners reported that paddy was generally transplanted (Table 3). Similar practices were used during the dry season. The transplanting method was also used on relatively larger parcels than those planted using the broadcast method. An exception was the animal owning group.

Improved varieties were planted by the majority of the respondents and the average parcel area planted to these varieties was also larger.

Tractor Ownership and Use

Tractor purchase decision. The decision to purchase a tractor is one of the important decisions of the farm household. The farmer needs

to consider the different advantages and disadvantages of such decision and also the size of the capital investment involved. The tractor owners interviewed indicated that there were usually several people involved in their decision to buy the tractor (Table 4). Other family members were cited by 78% of the two-wheel tractor owners and 64% of the four-wheel tractor owners. Another major influence in the purchase decision mentioned was other farmers. Others acknowledged to have affected their decision were extension workers, machine dealers, farmer's organization and the village leader.

There were perceived advantages in owning a machine. Examples were more timely operations, time saving, cheaper land preparation, better quality land preparation; better control of weeds, increased yields and expanded farm size, easier operation, and less drudgery.

Tractor operator. Generally, a prospective tractor owner had not operated a tractor before he purchased one. Table 5 shows that only 7% of the two-wheel tractor and 2% of the mini four-wheel tractor owners had previous training or experience in operating machines such as two-wheel tractors, four-wheel tractor and an irrigation pump. These people who had previous training were trained either by the machine dealer, extension worker or a farmer's organization member. More than half of the respondents were members of a government organization in the area.

Tractor use pattern. Both two- and four-wheel tractors were utilized principally on the farmer's own farm (Table 6). Ninety-one percent of the two-wheel and ninety-two percent of the four-wheel tractor units were utilized on the owner's farm during the wet season. The same was true during the dry season, although off-farm use increased to 18% and 14%, respectively.

The total area serviced by the two-wheel tractors during the dry season was lower than the area in the wet season on the average. The mini four-wheel tractor units, however, increased from 33.2 rai during the wet season to 36.25 rai during the dry season.

Farm tasks performed by both tractor types included land preparation, irrigation pumping, threshing and transportation.

Tractor breakdowns. Out of the 97 two-wheel units and 52 four-wheel units, 43 and 28 units, respectively, reported breakdowns during the wet season and 23 and 8 units, respectively, during the dry season in the same crop year (Table 7).

The mean horsepower of the two-wheel tractor units was around 9.2 hp while it was 11.3 hp for the four-wheel tractors. The two-wheel units which broke down during the wet season were relatively older (8 years) than those reported during the dry season (5 years on the average), while the mean age of four-wheel tractor units which broke down were 7.5 years during the wet and 9.5 years during the dry season. Most units were diesel powered.

Tractor owners reported most frequent breakdowns of the engine component for both types and seasons, followed by the transmission system and implements.

When breakdowns occur, machines were not usually operable until repairs were completed as reported by half the respondents during the wet season. Forty-six percent of two-wheel tractor units were reported to be running but were dangerous to the operator. Seven and twenty-nine percent of the two- and four-wheel tractor units reported their machine to be no longer usable during the wet season, while about a third of both types were out of order during the dry season.

Tractor repairs. Repairs on 30% of the two-wheel and 25% of the four-wheel tractors were delayed during the wet season, and 25% and 12%, respectively, during the dry season (Table 8). Some reasons cited were lack of money for repairs and spare parts, or that there was no time available during the period of the breakdown. Some mentioned spare parts were not readily available although many indicated they had to either wait for the spare part, find substitute parts, or order the parts through direct contact with the supplier.

Spare parts for mini four-wheel tractors were generally more expensive than for the two-wheel tractors. A majority of the tractors of both types were repaired at local shops or on the farm. Some 5% of the two-wheel tractor owners reported having repairs performed at the local dealer's shop.

Minor repairs were usually carried out by family members or the tractor operator. About 3 hours of family labor were used for tractor repair. If hired labor was used a mean value of 3.4 to 3.7 hours was required for two-wheel tractor units during wet season and the dry seasons. Four-wheel tractor units required a greater number of hours for repairs for both seasons, 21 and 18 hours, respectively.

Hired labor for repairing tractors were paid an average fee of 79 baht for two-wheel units and 98 baht for small four-wheel units. It was relatively higher during the dry season for both types, i.e., 206 baht and 185 baht, respectively.

Two-wheel tractor owners were generally satisfied with the repairs done on their machines while one-fourth of the small four-wheel owners indicated dissatisfaction.

The distance to the repair site from the field ranged from about 3 to 4.25 km on the average for both types and both seasons. Cost to transport of the machines to the repair site averaged to 24 baht and 36 baht for two- and small four-wheel units, respectively, during the wet season and 10 baht and 1 baht for dry season, respectively.

Tractor cost analysis. The two- and four-wheel tractors in the study were almost all the same age, 5.0 to 5.4 years, or average, while the mean horsepower of two-wheel units was 9 hp and four-wheel tractors was 11.5 hp (Table 9). There were 95 two-wheel tractor units reported during the wet season with a mean acquisition cost of 19,724 baht. The 50 mini four-wheel tractors on the other hand, were acquired at an average cost of 29,512 baht each.

From the sets of data taken from the survey plus other information, a cost and returns analysis was developed for both tractor types.

Fixed cost components included depreciation and interest on average capital investment. Depreciation was computed using the straight-line method over the life of the machine. It was estimated that the useful life of the tractor was 10 years and salvage value was charged at 10% of initial cost. The formula used was:

$$\text{Depreciation} = \frac{\text{Initial Cost less Salvage Value}}{\text{Estimated Useful Life}}$$

Interest on average capital investment was calculated using a 13% interest rate per annum, based on the average prevailing rate, computed as follows:

$$\text{Interest} = \frac{\text{Initial Cost plus Salvage Value}}{2} \times \text{Interest Rate}$$

Total annual fixed cost is the sum of depreciation and interest. Since the analysis is seasonal, total annual fixed cost was divided by 2, i.e., assuming 2 cropping season a year. Variable costs include fuel, oil, repairs and maintenance, and driver's fee. The first three items were taken from the survey data and the last was 6.25 baht per rai, the prevailing rate in the area.

Average machine capacity was 5.28 hours per rai per land operation. For purposes of computation, total tractor utilization was assumed to be for land preparation activities only. Total cost is the sum of total fixed cost per season plus total variable cost per ha multiplied by seasonal utilization in hectares.

Total benefits were calculated by multiplying the prevailing contract rate/ha by total use in hectares. The contract rate was 200 baht per rai or 1250 baht per hectare. The prevailing rate was used because of insufficient data to measure benefits directly. Nearly all tractor owners in our survey used their tractors only on their own farms.

A crude undiscounted benefit-cost ratio, break-even point and payback period were calculated and the results were at the bottom of Table 9.

Two-wheel tractors showed a profitable investment with an average BCR of 1.20. This finding illustrates that at present utilization levels and at the existing contract rate/ha, two-wheel tractors need to cover 18.54 rai (2.97 ha) per season, or be used for only 10 seasons to recover the capital invested.

For four-wheel tractors, however, the estimated BCR was only 0.99 which meant its total cost was slightly greater than the benefits derived. This was due to the lower utilization levels during the wet season. The dry season analysis, however, indicated improved results for both tractor types.

Financial Characteristics

To assess their financial position, tractor and animal owners were interviewed to determine the financial assistance used to purchase the tractor. Thirty-four percent of the two-wheel, 37% of the mini four-wheel used outside financial assistance.

Different types of financial resources were tapped by respondents during both seasons. There were credits, loans and mortgages.

Credit was in kind whereas loans were in cash. A majority of those using financial assistance obtained cash. Some, however, took financing in kind while a number of two-wheel and small four-wheel tractor owners mortgaged their properties.

The most common sources of financing were the Bank of Agriculture and Cooperatives, cooperatives, friends and relatives, middlemen, commercial banks, landlords, input dealers and others. Collaterals used to obtain loans were land titles, personal notes, crops/buildings and agricultural products.

When asked the purpose for incurring the liabilities, respondents mentioned: long term agricultural investment, seasonal farm expenses, family expenses/consumption, and machine purchase.

Of all financing sources, commercial bank gave the longest maturity for two-wheel tractors with an average of 17 months to repay, followed by the Bank of Agriculture and Cooperatives. For small four-wheel tractor owners, however, the Bank of Agriculture and Cooperative provided the longest debt maturity.

Sensitivity Analysis

To examine the impact of changes in cost components such as the price of fuel and oil on the profitability of investing in a machine, three fuel and oil cost increases levels were projected, i.e., 10%, 25%, and 50%. Similarly, contract rates were also assumed to rise by 10%, 20% and 30% . Tables 10 to 15 show the results of these changes. These values have not been discounted. Thus, the changes in costs and benefits do not reflect value changes over time.

The undiscounted benefit/cost ratios for both tractor types and both seasons declined as fuel and oil prices increased and the contract rate remained constant. The reverse was true when prices were held constant and the contract rate per hectare was increased. To maintain a set level of viability an increase in any cost component would be accompanied by a proportional increase in the contract rate.

The break-even point increased as the fuel and oil prices increased with no change in the contract rate. The opposite occurred as the as contract rate increased with fuel and oil prices unchanged. These changes in fuel and oil prices and contract rate produced similar effects on the payback period.

CONCLUSION

Two-wheel and four-wheel tractors in the Suphanburi Province seem to be a good investment although use of the machines was restricted almost exclusively to the owners. Examining profitability using the prevailing contract rate and prices showed utilization at an acceptable level. Additional use would mean higher benefit-cost ratios for the owners.

The number of samples for the draft animal owning group prevented a more conclusive comparison among other types of technology.

While frequent breakdowns appeared to plague most machine owners, the length of time breakdowns kept machines out of order was not highly detrimental. Because most machines are of local manufacture, spare parts and technicians to affect repairs appeared to be readily available. It is probably true that a higher cost machine produced

using better quality standards would have fewer breakdowns. It is uncertain, however, whether accessability to spare parts and the experitse to maintain more sophisticated equipment could keep these machines operating at the high level of availability noted in current machines used in Thai agriculture.

Increased costs of petroleum products will increase the operational expense of mechanized land preparation. There are, however, effectively no short run alternatives available to replace the tractors used in Suphanburi. These farmer owner machines do not appear to be earning excess profits and are operating in equilibrium at or near the cost of contractors operating in the same area. They are employed at or above their breakeven levels and, as has been noted in the paper by Saitan, do not appear to be the cause for maldistribution in income amongst farm groups. Without this technology it is likely rice production in the Suphanburi area would suffer serious declines.

Table 1. General profile of two- and four-wheel tractor and draft animal owning farmers in selected irrigated villages of Suphanburi Province, Thailand, wet and dry seasons 1980-81.

Item	Farm Type		
	2 WT Owners	4 WT Owners	Draft Animal Owners
Farmer characteristics			
Average age of farmers	48	47	54
Average educational attainment, years	4.0	3.7	3.5
Years of farming experience	20	24	25
Average household size	6.5	6.4	6.1

	Wet Season 1980-81			Dry Season 1981		
	2 WT	4 WT	Animal	2 WT	4 WT	Animal
	% Reporting					
Number of farmers reporting	97	52	5	88	50	2
Tenure status by parcel						
Owned	56	59	100	59	64	100
Rented-out						
Fixed rental fee	2	6	-	2	7	-
Varied rental fee	1	5	-	1	4	-
Free	3	2	-	4	2	-
Rented-in						
Fixed rental fee	22	17	-	25.0	14	-
Varied rental fee	8	5	-	6.0	3	-
Free	8	6	-	3.0	6	-

Table 2a. Farm characteristics, two- and four-wheel tractor and draft animal owning farmers in selected irrigated villages of Suphanburi Province, Thailand, wet and dry seasons, 1980-81.

Item	Wet Season 1980-81			Dry Season 1981		
	2 WT	4 WT	Animal	2 WT	4 WT	Animal
No. of respondents	97	52	5	88	50	2
Average farm size, ha	3.77	4.57	2.12	3.92	4.88	2.08
Total cultivated area, ha	3.58	4.39	2.12	3.44	4.15	2.08
Total number of parcels	202	129	9	196	126	3
			% Reporting			
Soil texture, by parcel						
Clay	35	38	-	36	38	-
Clay-loam	14	12	-	14	12	-
Loam	3	1	-	3	1	-
Sandy	14	19	33	13	20	-
Sandy loam	18	15	22	18	11	33
Others	16	16	45	16	18	67
Soil color						
Red	18	11	22	19	13	33
Brown	18	15	22	17	12	-
Black	42	47	22	43	47	67
Grey	13	5	11	12	8	-
Others	9	22	23	9	20	-
Topography						
Flat	69	70	56	69	67	67
Sloping	23	26	33	23	29	33
Steep	2	-	11	2	-	-
Very steep	1	-	-	1	-	-
Terraced	2	3	-	3	3	-
Others	3	1	-	2	1	-

Table 2b. Farm characteristics, two- and four-wheel tractor and draft animal owning farmers in selected irrigated villages of Suphanburi Province, Thailand, wet and dry seasons, 1980-81 (continued).

Item	Wet Season 1980-81			Dry Season 1981		
	2 WT	4 WT	Animal	2 WT	4 WT	Animal
	% Reporting					
Restricting factors						
None	54	57	22	56	59	-
Water logging	11	6	-	10	6	-
General infertility	27	27	22	25	25	33
Errosion	0.5	-	22	1	-	-
Sandiness	1.5	1	11	1	1	33
Marshiness	1	4	-	1	4	-
Salinity	1	-	-	1	-	-
Others	4	5	22	5	5	34
Source of irrigation						
None	-	3	-	-	2	-
Technical system	1	-	-	1	-	-
Brush diversion	90	83	100	91	82	100
Pumped from surface	9	14	-	8	16	-
Others	-	-	-	-	-	-
Improvements done on land						
None	76	76	33	73	75	33
Land clearing	7	9	-	7	10	-
Levelling	16	14	67	19	14	67
Land consolidation	1	-	-	1	-	-
Others	-	1	-	-	1	-

Table 3. Farming practices, two- and four-wheel tractors in selected irrigated villages of Suphanburi Province, Thailand, wet and dry seasons, 1980-81.

Items	Wet Season 1980-81			Dry Season 1981		
	2 WT	4 WT	Animal	2 WT	4 WT	Animal
	% Reporting					
Farming practices						
Planting method						
Broadcasting	23	40	22	32	29	25
Transplanting	73	60	78	66	69	75
Transplanting/ broadcasting	4	-	-	2	2	-
Variety planted						
Improved variety	87	89	100	94	95	4
Local variety	13	11	-	6	5	-
Area planted (rai)						
Improved variety	10.25	12.31	6.5	10.80	11.92	6.75
Local variety	7.75	5.8	5	12.15	13.11	-
Area planted by method (rai)						
Broadcast	8.67	10.14	10.5	9.59	10.63	6.67
Transplant	10.15	13.31	5.1	11.44	12.70	7.12
Transplant/broadcast	14.03	-	-	12.65	-	-
Others	-	-	-	8.00	-	-

Table 4. Factors affecting farmer's decision to purchase farm machine, two- and four-wheel tractor owners in selected irrigated villages of Suphanburi Province, Thailand by season, 1980-81.

Item	Wet Season		Dry Season	
	2 WT	4 WT	2 WT	4 WT
	% Values			
Person influencing decision on machine purchase:				
Family member	78	64	60	40
Fellow farmer	10	21	40	40
Extension worker	1	3	-	20
Machine dealer	2	3	-	-
Farmer's organization	1	1	-	-
Village head	2	-	-	-
Others	6	8	-	-
Perceived advantage of machine ownership:				
Timeliness	34	21	43	20
Save time	21	22	14	20
Cheaper	2	-	14	40
Better quality land preparation	11	15	29	-
Easier operation/less drudgery	10	23	-	20
Increase yield + farm size	5	2	-	-
Increase income	2	-	-	-
Others	15	18	-	-

Table 5. Characteristics of tractor operators for two- and four-wheel tractors in selected irrigated villages of Suphanburi Province, Thailand, 1980-81.

Item	Tractor Type	
	2 WT	4 WT
	% Reporting	
1. Had previous training or experience in machine operation:		
Yes	7	2
No	93	98
2. Machine type operator was trained to operate:		
None	93	97
Two-wheel tractor	4	1
Four-wheel tractor	2	2
Irrigation pump	1	-
3. Who trained the operator:		
None	93	98
Extension worker	1	-
Machine dealer	4	1
Farmer's organization	1	-
Others	1	1
4. Membership in any organization:		
None	40	35
Private organization	9	6
Government sponsored organization	51	59

Table 6. Tractor use pattern, two- and four-wheel tractors in selected irrigated villages of Suphanburi Province, Thailand, wet and dry seasons, 1980-81.

Items	Wet Season 1980-81		Dry Season 1981	
	2 WT	4 WT	2 WT	4 WT
Number of tractor units reported	97	52	88	50
Average horsepower	9	11.5	9	11.5
Average area serviced by location, rai:				
a. Own farm	22.4	27.4	21.5	25.9
b. Off-farm	7.8	5.8	3.6	10.3
TOTAL	30.2	33.2	25.1	36.25
Location of tractor service:		% Reporting		
a. Own farm	91	92	82	86
b. Off-farm	9	8	18	14

Table 7. Tractor breakdown by type and season in selected irrigated villages of Suphanburi Province, Thailand, crop year 1980-81.

Item	Wet Season 1980-81		Dry Season 1981	
	2 WT	4 WT	2 WT	4 WT
No. of tractors reported	43	28	23	8
Tractor characteristics				
Average horsepower	9.0	11.3	9.4	11.5
Average tractor age, years	8	7.5	5.0	9.5
Fuel type used:		% Reporting		
gasoline	16	-	17	-
diesel	84	100	83	100
Tractor breakdown by component:				
Engine	57	57	74	39
Transmission system	17	29	12	32
Implements	13	-	10	25
Hydraulic system	9	-	2	4
Irrigation	-	-	2	-
No answer	4	14	-	-
No. of same breakdown since machine was acquired	2	2	2	2
Seriousness of breakdown:				
Machine not operable	47	46	29	50
Machine runs but dangerous	46	25	38	12
Machine no longer usable	7	29	33	38
Average no. of days field activity was delayed	2.2	2.0	2.0	2.2

Table 8. Tractor repairs by type and season in selected irrigated villages of Suphanburi Province, Thailand, 1980-81.

Item	Wet Season 1980-81		Dry Season 1981	
	2 WT	4 WT	2 WT	4 WT
No. of tractors reported	43	28	23	8
Tractor repair:				
Whether machine was repaired		% Reporting		
Yes	100	100	96	100
No	-	-	4	-
Whether machine repair was delayed				
Yes	30	25	25	12
No	70	75	75	88
Action taken if spare part availability caused delay in the repair:				
- Substitute parts	2	14	-	-
- Ordered spare parts	2	-	-	-
- Wait for spare part's availability	12	18	21	-
- No answer	84	68	79	100
Average value of spare parts, Baht	1180	1301	1158	2270
Location of repair site				
- On farm	30	57	33	25
- Local repair shop	60	39	63	63
- Local dealer	5	-	-	-
- Others	5	4	4	12
Labor used for tractor repair, hours:				
Family labor	2.4	2.9	3.2	3.1
Hired labor	3.4	21.0	3.7	17.5
Payment for hired labor for repairs, Baht	79	98	206	185
Satisfaction with the repair:				
Yes	98	75	92	75
No	2	25	8	25
Distance from repair site, km (average)	4.25	3.9	3.3	2.9
Transport cost to repair site, Baht	24	36	10	1

Table 9. Cost analysis for two- and four-wheel tractors in selected irrigated villages of Suphanburi Province, Thailand, wet and dry seasons, 1980-81.

Item	Wet Season 1980-81		Dry Season 1981	
	2 WT	4 WT	2 WT	4 WT
Number of tractors reported	95	50	88	50
Average age of tractors, years	5.3	5.0	5.4	5.4
Initial cost of tractor, Baht	19,724	29,512	19,822	30,297
Fixed cost per season				
Depreciation	888	1,328	892	1,363
Interest	705	1,055	708	1,083
TOTAL FIXED COST	1,593	2,383	1,600	2,446
Variable cost/rai[a]				
Fuel	44.63	47.49	49.58	53.04
Oil	7.84	8.42	10.00	10.02
Repairs and maintenance	28.59	41.71	16.71	8.00
Driver's fee	33.00	33.00	33.00	33.00
TOTAL VARIABLE COST	114.06	130.63	109.29	103.95
Seasonal use (rai)	30.16	33.18	25.06	36.25
Average contract rate/rai, Baht	200	200	200	200
Machine capacity, hrs/rai	5.28	5.28	5.28	5.28
Total Cost Per Season	5,033	6,717	4,339	6,214
Total Benefits Per Season	6,032	6,636	5,012	7,250
Benefit-cost ratio, undiscounted	1.20	0.99	1.16	1.17
Break-even point, rai	18.54	34.35	17.64	25.46
Payback period, seasons	10.45	23.67	12.66	12.63

[a]6.25 rai = 1 ha.

Table 10. Effect of changes in fuel and oil price and contract rate per rai on the benefit-cost ratios of two- and four-wheel tractors in selected irrigated villages of Suphanburi Province, Thailand, wet season 1980-81.

Machine Type	Changes in Price of Oil and Fuel			
	Prevailing Price[a]	10% Increase	25% Increase	50% Increase
1. Two-wheel Tractor				
Contract rate				
a. Prevailing rate[b]	1.20	1.17	1.12	1.04
b. 10% increase	1.32	1.28	1.23	1.14
c. 20% increase	1.44	1.40	1.34	1.25
d. 30% increase	1.56	1.51	1.45	1.35
2. Four-wheel Tractor				
Contract rate				
a. Prevailing rate[b]	0.98	0.96	0.92	0.87
b. 10% increase	1.09	1.06	1.02	0.95
c. 20% increase	1.19	1.15	1.11	1.04
d. 30% increase	1.28	1.25	1.20	1.13

[a]Prevailing market price during the survey as reported by the respondents.

[b]Prevailing contract rate at 200 baht per rai or 1250 baht per hectare.

Table 11. Effect of changes in fuel and oil price and contract rate per rai on the benefit-cost ratios of two- and four-wheel tractors in selected irrigated villages of Suphanburi Province, Thailand, dry season 1981.

Machine Type	Changes in Price of Oil and Fuel			
	Prevailing Price[a]	10% Increase	25% Increase	50% Increase
1. Two-wheel Tractor				
Contract rate				
a. Prevailing rate[b]	1.16	1.12	1.06	0.99
b. 10% increase	1.27	1.23	1.17	1.08
c. 20% increase	1.39	1.34	1.28	1.18
d. 30% increase	1.50	1.45	1.38	1.28
2. Four-wheel Tractor				
Contract rate				
a. Prevailing rate[b]	1.17	1.12	1.07	0.98
b. 10% increase	1.28	1.23	1.17	1.08
c. 20% increase	1.40	1.35	1.28	1.18
d. 30% increase	1.52	1.46	1.39	1.28

[a]Prevailing market price during the survey as reported by the respondents.

[b]Prevailing contract rate at 200 baht per rai or 1250 baht per hectare.

Table 12. Effect of changes in fuel and oil cost and contract rate/ha on the break-even point of two- and four-wheel tractors in selected irrigated villages of Suphanburi Province, Thailand, wet season 1980-81.

Machine Type	Changes in Fuel and Oil Price			
	Prevailing Price[a]	10% Increase	25% Increase	50% Increase
	Hectare			
1. Two-wheel Tractor				
Contract rate				
a. Prevailing rate[b]	2.97	3.16	3.50	4.27
b. 10% increase	2.41	2.53	2.75	3.20
c. 20% increase	2.02	2.11	2.26	2.56
d. 30% increase	1.75	1.81	1.92	2.13
2. Four-wheel Tractor				
Contract rate				
a. Prevailing rate[b]	5.50	5.98	6.88	9.20
b. 10% increase	4.26	4.55	5.06	6.21
c. 20% increase	3.49	3.67	4.00	4.68
d. 30% increase	2.95	3.08	3.30	3.76

[a]Prevailing market price during the survey as reported by the respondents.

[b]Prevailing contract rate at 200 baht per rai or 1250 baht per hectare.

Table 13. Effect of changes in fuel and oil price and contract rate/ha on the break-even point of two- and four-wheel tractors in selected irrigated villages of Suphanburi Province, Thailand, dry season 1981.

Machine Type	Changes in Fuel and Oil Price			
	Prevailing Price[a]	10% Increase	25% Increase	50% Increase
	Hectare			
1. Two-wheel Tractor				
Contract rate				
a. Prevailing rate[b]	2.82	3.02	3.38	4.20
b. 10% increase	2.31	2.44	2.67	3.16
c. 20% increase	1.96	2.05	2.21	2.54
d. 30% increase	1.70	1.77	1.88	2.12
2. Four-wheel Tractor				
Contract rate				
a. Prevailing rate[b]	4.17	4.37	4.88	6.08
b. 10% increase	3.44	3.57	3.91	4.64
c. 20% increase	2.92	3.02	3.26	3.75
d. 30% increase	2.54	2.62	2.79	3.14

[a]Prevailing market price during the survey as reported by the respondents.

[b]Prevailing contract rate at 200 baht per rai or 1250 baht per hectare.

Table 14. Effect of changes in fuel and oil price and contract rate per rai on the payback period of two- and four-wheel tractors in selected irrigated villages of Suphanburi Province, Thailand, wet season 1980-81.

Machine Type	Changes in Price of Fuel and Oil			
	Prevailing Price[a]	10% Increase	25% Increase	50% Increase
	Seasons			
1. Two-wheel Tractor				
Contract rate				
a. Prevailing rate[b]	10.5	11.4	13.2	18.0
b. 10% increase	7.9	8.5	9.4	11.6
c. 20% increase	6.4	6.7	7.3	8.6
d. 30% increase	5.3	5.6	6.0	6.8
2. Four-wheel Tractor				
Contract rate				
a. Prevailing rate[b]	23.7	27.8	37.7	92.4
b. 10% increase	15.4	17.1	20.4	30.0
c. 20% increase	11.5	12.4	14.0	17.9
d. 30% increase	9.1	9.7	10.6	12.8

[a]Prevailing market price during the survey as reported by the respondents.

[b]Prevailing contract rate at 200 baht per rai or 1250 baht per hectare.

Table 15. Effect of changes in fuel and oil price and contract rate per rai on the payback period of two- and four-wheel tractors in selected irrigated villages of Suphanburi Province, Thailand, dry season 1981.

Machine Type	Changes in Price of Oil and Fuel			
	Prevailing Price[a]	10% Increase	25% Increase	50% Increase
	Seasons			
1. Two-wheel Tractor				
Contact rate				
a. Prevailing rate[b]	12.7	14.0	16.6	24.2
b. 10% increase	9.6	10.3	11.7	15.0
c. 20% increase	7.7	8.2	9.0	10.9
d. 30% increase	6.5	6.8	7.4	8.5
2. Four-wheel Tractor				
Contract rate				
a. Prevailing rate[b]	12.6	14.0	16.7	24.2
b. 10% increase	9.7	10.5	11.9	15.3
c. 20% increase	7.9	8.4	9.3	11.2
d. 30% increase	6.6	7.0	7.6	8.8

[a]Prevailing market price during the survey as reported by the respondents.

[b]Prevailing contract rate at 200 baht per rai or 1250 baht per hectare.

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THE ECONOMICS OF MECHANICAL RICE THRESHING IN THAILAND*

Renu Sukharomana**

ABSTRACT

This paper provides a description of the impact of changes in rice threshing technology on the Thai economy. The invention and modification of mechanical threshers resulted from the research and development work of the International Rice Research Institute (IRRI) and was disseminated to Thailand through a cooperative agreement between local manufacturers and the THAI/IRRI program. The adoption of rice thresher depends on the following factors: irrigation, double cropping, HYV rice, marketing of contractor service, the ability to invest in the machine, establishment of local farm machinery industry, and demonstration effects. Adoption of rice thresher generates benefits to those who are engaged in its production and marketing, thresher investors, thresher users, and those in repair and maintenance sectors.

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THE ECONOMICS OF MECHANICAL RICE THRESHING IN THAILAND

Renu Sukharomana

I. INTRODUCTION

Rice threshing is one of the post-production activities. In Thailand, rice threshing methods include the most traditional ones to those fully mechanized.[1] Example of traditional methods are foot treading, hand beating, animal treading, and tractor treading. Rice threshed by a rice thresher is a form of mechanical rice threshing. Traditional methods of threshing require the subsequent separation of foreign materials and husk from the paddy which is a step not required for mechanically threshed paddy.

Rice threshing methods vary among different regions of Thailand. In the Central Region, more farmers employ rice threshers than in the other three regions (North-Eastern, Northern and Southern regions). Some farmers who grow floating-rice varieties, however, still use the tractor treading method because the rice thresher cannot work the long straw properly and results in a much lower threshing rate and hence higher cost. Traditional methods, especially animal treading, are hardly practiced in the Central Region. Hand beating and foot treading methods have never been used in the Central region. In the North-Eastern Region, the hand beating method is widely practiced. Rice threshers and tractors were first used in the irrigated areas. In the North, farmers like to keep the rice straw long in order to mulch the soil for a second crop. Most farmers therefore employ hand beating. The wireloop-type thresher is also used but is not as popular as the traditional method. In the Southern Region, the method of rice harvesting determines the method of rice threshing. Traditionally rice harvested with the ani-ani knife is threshed by foot treading while those harvested with a sickle are threshed by hand beating. The rice thresher was recently introduced to the Southern Region. The rice threshers are either wireloop or axial-flow models.[2] The former model is appropriate for rice harvested with the ani-ani knife while the latter for rice harvested with a sickle. Threshers in the Southern Region are found mostly in irrigated areas where a second crop of rice can be grown.

Rice threshers in 1975 totalled 3,955 units. Of those, about 90 per cent were found in the Central Region. The Northern, Southern, and North-Eastern regions owned the remaining 4.6, 2.7 and 2.3 per cent respectively.[3] (Table 1). Recent statistics from the survey by the Division of Agricultural Engineering,[4] indicated that in the Southern Region the number of rice threshers as of February 1981 stood at about 1,165 units[4] while figures for other regions were unavailable.

II. CHANGE IN RICE THRESHING TECHNOLOGY.

Since 1975, rice threshing technology in Thailand has changed from the traditional method to one using the rice thresher. The pattern and speed of technology change differ among regions. The Central Region seems much more receptive to change than other regions. Reasons behind the change can be explained in three steps of technology change: invention, innovation, and diffusion.[5]

1. Invention, Innovation, and Technology Transfer[6]

The invention and innovation of the axial-flow rice thresher resulted from research and development efforts by the International Rice Research Institute (IRRI) at Laguna, Philippines. Modification and development of the original design to suit local conditions was made possible by the cooperation of local manufacturers in Thailand with the office of Thai/IRRI Program.

Blueprints of IRRI-3 Axial-Flow thresher were first sent to the Office of Thai/IRRI in Bangkok in early 1975. Before distributing to the public, the Thai-IRRI program conducted a test and then modified the machine to suit the local conditions. They later released the modified blueprint to Chaiwat Panich, a local manufacturer who became the first thresher producer in Thailand. The first 10 units were produced and sold at 12,000 baht each. However, all of these machines were sent back because of technical problems such as a shaken screen and high separation loss.

At the end of 1975, while the IRRI-3 thresher design was being reviewed,the THAI/IRRI Office received the blueprint of the IRRI-5 Axial-Flow thresher. Three manufacturers--Chinadit Shop (Chachoengsao Province), Chaiwat Panich (Chachoengsao Province) and Kaset Thai (Cholburi Province)-- asked for the blueprint and started producing the IRRI-5 thresher by the end of that year. Chinadit was the only manufacturer who succeeded in modifying the IRRI-5 thresher to suit local conditions. Other firms in nearby areas subsequently copied this model. (Figure 1).

In 1976, the blueprint of a portable thresher (TH-6, TH7) was sent to the Thai/IRRI Office in Bangkok. These new models were smaller, easier to transport, and required less labor for operation than the IRRI-5 thresher. Chaiwat Panich produced 9 units and sold them at 8,500 baht each. However, these small threshers did not gain popularity with the farmers as there existed a market for the larger thresher service.

2. Diffusion

The diffusion of thresher technology among Thai farmers depends on the farmers' conditions and reasons for adopting the machine. Among the factors believed to influence thresher adoption are: (1) irrigation and double cropping, (2) high yielding rice varieties, (3) the net benefit from using and investing in rice thresher, (4) the ability of farmer to purchase rice thresher, (5) the contract service system, (6) the establishment of the local farm machinery industry, and (7) the demonstration effect. These are discussed below.

1. Irrigation and Double Cropping

The most important factor influencing thresher adoption is irrigation. Almost all farmers located in irrigated areas use a tractor as well as a rice thresher. Farmers in non-irrigated areas usually employ the traditional land preparation and threshing methods. The underlying reason may be the fact that irrigation will allow double cropping which creates a labor shortage problem during the peak period of harvesting, threshing, and land preparation for the next crop. Double cropping therefore necessitates a change in the threshing system leading to the rapid adoption of the thresher for increased efficiency, speed and ease of operations.

2. High Yielding Rice Varieties

The high yielding varieties proved to be one of the most important factors that make double cropping possible. The HYV reduce the length of the production period and makes rice production independent of the day length. High yielding varieties require a new type of cultural practice, chemical fertilizer applications, etc. These requirements further aggravate the labor shortage felt between two consecutive seasons. The adoption of the rice thresher can help solve such a problem.

3. The Net Benefit from Using and Investing in the Rice Thresher

The net benefit is the most important economic factor that can induce farmers to switch from traditional methods to the use of the rice thresher.

Kittikul, J. (1980)[8] showed that the average total cost and total variable cost of rice threshing by a thresher is lower than that of any other alternative method, (Table 2). These results however did not include the other benefits that a thresher might generate (such as custom service). Moreover, the rice thresher is a durable capital which does not wear off within a year. The total benefit of a thresher should include all those that may accrue over its life span. In 1980, Pathnopas, R. employed cost-benefit analysis to evaluate the benefit of the rice thresher under different conditions. The study showed that investment in a thresher yielded a high return to the investor, (Table 3).

4. Ability of Farmer to Purchase the Rice Thresher

Even though farmers know that the investment in a rice thresher yields a net benefit, not all farmers can invest in one. The price of a machine is relatively high when compared to their income therefore only high income farmers can afford the machine.

Most rice threshers (69 per cent) were bought in cash from personal savings[9]. Farmers who do not have enough funds may borrow from either financial or non-financial institutes. The interest rate charged by financial institons was 12 - 15 percent whereas non-financial institutions charged 20 - 30 per cent. The availability and source of funds are an important factor in determining thresher investment.

5. Contract Service System

Farmers who cannot invest in a rice thresher have access to the services of a rice threhser through the contract service system. The contract rate was about 80 - 100 baht per ton. This charge is paid in cash and covers only the labor cost of the thresher operator, fuel and oil, transportation, and machine service. Another 5 - 6 laborers are needed to work in conjunction with the thresher. Their wages are shouldered by the hiring customer.

Farmers who own threshers usually hire out their machines to non-owning farmers in the contract market. In Chachoengsao and Suphanburi provinces it was found that the quantity of rice threshed using custom work is much higher than that threshed on the owners

farms. The content operations in these two areas accounted for volume equivalent to around 83 - 89 percent of the total rice threshed for thresher owners.

Apart from farmers who participate in the contract system, merchants and other thresher investors also enter the market of thresher service because of its high profitability.

Barriers to entry into the contract market hardly exist because of the absence of laws, regulations, or market monopoly which restrict new entrants. This characteristic is believed to be a major factor in making machine services rapidly and extensively available to farmers. The more new contractors the lower is the quantity of rice threshed by established contractors. The market expands and holds down any increase in the contract charge rate as only by maintaining or lowering the existing rate can the thresher investors protect their market shares. Moreover, since services are demanded over a very short period, the faster the thresher speed (output/hour) the larger is the market share. This factor led to the development of bigger threshers with 2 - 3 tons/hour capacity [10] resulting in economies of scale in rice threshing. The contract charge rate remained unchanged over 1975-1982 because of this competitive pressure.

The existence of keen competition in the market for rice thresher services has so far been beneficial and has hastened the widespread adoption of mechanical threshing. However, these market situations exist mainly in the Central Region where irrigation is available and double cropping is possible. The contract market for rice threshers is also developing in the irrigated areas of other regions where double cropping has just been introduced. The example of the Central Region should be followed in these developing areas.

6. The Establishment of the Local Farm Machinery Industry.

The local manufacturers have supplied all the rice threshers since the adoption of the machine (1975). The number of firms producing rice threshers increased from 2 - 3 firms in 1975 to 24 firms in 1981. However, in addition to the rice thresher these firms produce other farm machines and farm implements. The total number of rice threshers produced by local manufacturers has never been reported.

Entry into rice thresher production is because there are no legal barriers and there is no monopoly. Moreover, the established firms producing other types of farm machines can switch their production resources to rice thresher. The absence of patent rights to the machine design also facilitates the copying of other firms' products.

7. Demonstration Effect and Other Factors.

The other factors that may affect thresher adoption are the demonstration effect, the level of education, and attitude.

Demonstration effects play the most important role in the early age of machine adoption. Investment in new agricultural technology involves a high risk because farmers are not familiar with and therefore cannot ascertain the outcome of new technology. The government and manufacturers may not succeed in promoting the use of new farm machines if the farmers feel that a very high risk is involved in the adoption. This might be a reason why the introduction of the farm tractor in the early 1950's by the government and importers did not succeed. The rice thresher on the other hand was enthusiastically adopted the same year it was introduced.

The rapid adoption in such a short period may be accounted for by the fact that farmers in the Chachoengsao area (first area of thresher adoption) were already familiar with new technology and were economically capable.[11] Also, the guarantee that local manufacturers would take care of any performance problems that might arise substantially reduced investment risk in these threshers.

Demonstration of the use of rice threshers by the Division of Agricultural Engineering and local manufacturers may have the effect of reducing the risk in the early adoption of the rice thresher. The extensive information on mchine performance is a way of reducing the risk involved in the use of the rice thresher.

The attitude of farmers may affect rice thresher adoption. The farmers' decision of switching from traditional methods to the use of the rice thresher may depend not on economic factors but on their attitude. Some farmers in Chachoengsao Province did not adopt the thresher because they already had tractors that could tread rice and because they did not want to pay cash (Pathnopas, 1980).

III. IMPACT OF RICE THRESHER ADOPTION

The impact of thresher adoption is discussed in two parts: (1) the impact on the agricultural sector, and (2) the impact on the manufcturing and service sectors.

1. Agricultural sector

The impact on the agricultural sector will be considered in terms of employment, output, and income of farmers.

1.1 Impact on Employment.

The rice thresher requires less labor input than any other alternative method.[12] (Table 4). However, the resulting reduction in labor demand will not generate unemployment among farmers as there is excess demand for labor during the harvesting period. The adoption of the rice thresher would therefore increase farmers' productivity and at the same time release farmers to other jobs. Farmers in Chachoengsao and Suphanburi spent their saved time in land preparation for the next crop in leisure.[13] (Table 5).

The existence of the contract market for thresher service is also believed to augment employment. A thresher requires 6 - 8 persons to operate. The adoption of thresher therefore increases demand for labor which will come from family exchanged, and hired labor.

1.2 Impact on Output.

The impact of the thresher is not clearcut. Rice threshers may release time for planting second crop. However, magnitude of the contribution of the thresher to output could not be identified. In Thailandm, the use of the thresher increases the per cent of grain loss by 0.54 - 0.72 per cent.[14]

The rice thresher also reduces the threshing period of the second crop that is harvested in the wet season. The use of the thresher reduces the proportion of otuput damage due to high moisture and rain. However, rice millers complain that paddy processed by the rice thresher has a high moisture content which makes storage difficult. The rice millers claimed that with the help of the rice thresher farmers can thresh rice with a high moisture content which the traditional method could not do.[15]

1.3 Impact on Income

Farmers who adopt rice threshers will receive either explicit or implicit income from costs saved. The amount of cost saved for farmers who switch from animal treading to the rice thresher was 95.00 baht/ton. Farmers switching from tractor treading to the rice thresher gain 53 - 64 baht/ton.[16]

Farmers who invest in the rice thresher also gain a higher income augmented by custom service. The average income/year was about 13,000 and 20,600 baht in Chachoengsao and Suphanburi provinces, respectively in the 1978/79 crop year.[17]

Farm labor hired to work with the thresher also earned income from the thresher service market. The market wage rate of farm labor during the harvesting period was 80 baht per day.

2. The Manufacturing and Service Sectors.

The increase in demand for the rice thresher also increases the demand for inputs of the manufacturing, wholesale and retail, and maintenance service sectors. The growth rate of demand for the rice thresher was approximately 8 - 9 percent per year. The value added contributed by a rice thresher represented about 60 percent of production cost, or 9,155 baht/unit of thrsher.[18] This value added was not included in the value of the power engine that was imported from abroad. Direct labor cost in thresher production was 2,290 baht per unit of thresher.[19] The rest of the value added came from domestic material cost.

The thresher also generated additional value added for the wholesale and retail farm machinery market. Usually the additional cost, over and above the production cost, that is charged for wholesale and retail services was 15 - 20 percent of the total cost of production.

The thresher is a durable capital good requiring repairs and maintenance. The rapid adoption of the rice thresher in Thailand resulted in increased demand for repair and maintenance services. However, the amount of value added from such a service has never beeen figured out.

When the number of threshers (6,224 units in 1979/80) are multiplied by the unit value added, the impact of the rice thresher on manufacturing and service sectors becomes substantial. It was about 71 - 76 million baht using 1981 production costs.[20]

IV. CONCLUSION AND REMARKS

Rice threshing technology in Thailand includes the traditional as well as mechanical threshing methods. The change to mechanical threshing began in 1975. Reasons for the change can be explained in the three steps of technology change: invention, innovation and diffusion.

The invention and modifications of the rice thresher took place at IRRI at Laguna, Philippines but the spread of rice thresher technology in Thailand arises from the cooperation between local manufacturers and the Thai/IRRI program in Bangkok. Adoption of technology by farmers depends on various factors: irrigation, double cropping, HYV rice, the contract service system, benefits accrued to thresher users and investors, the ability to invest in the rice thresher, the existence of a local farm machinery industry, and demonstration effects. Among these factors, the first three are the preconditions for thresher adoption. The rest contribute to the forming of a favourable attitude towards the rice thresher. The adoption of the rice thresher in Thai agriculture has employment,

output, and income effects. Its adoption does not aggravate unemployment problems since it is used during the harvesting period where the demand for labor is at its peak.

On the other hand, the use of the thresher increases labor productivity. Output impact is negative, manifesting itself in loss of grain in both quantitative and qualitative terms. But the loss is minimal when compared to the benefit. Farmers and investors also earned an additional income from providing thresher services to others.

Thresher adoption also has an impact on production, marketing, and maintenance through linkage effects. Its adoption therefore generates private benefits for all those who are engaged in economic activities related to the rice thresher: producers, marketing people, thresher users, and investors.

Rice thresher adoption is concentrated mainly in the Central Region. Development of new irrigated areas in other regions, the increase in the practice of double cropping, and the emergence of a contract market for machine service would promote thresher adoption and magnify its impact. The market structure of machine services in the Central Region should be promoted in other regions (Northern and Southern regions) where the use of the rice thresher is imminent. Further research on and development and demonstration of the axial-flow thresher and wireloop-type thresher should be attempted for the Northern and Southern regions.

FOOTNOTE

[1]Data from (1) Department of Agriculture, Ministry of Agriculture and Cooperatives, "Survey on Post Production Practice in Thailand, 1976," Bangkok, 1976. (2) Chulalongkorn University, Social Research Institute, "Reduction of Post Harvest Loss of Rice," Bangkok, 1983.

[2]Division of Agricultural Engineering, Department of Agriculture, Ministry of Agriculture and Cooperatives, "Testing and Evaluation of Rice Thresher for the South," Bangkok, 1980, p. 2.

[3]Distribution of rice thresher by regions obtained from Sukharomana, S. (1981). Table 4. Percent of distribution calculated from Agricultural Statistic of Thailand Crop Year 1975/76, Table 90, pp. 183-90.

[4]Department of Agriculture, Ibid.

[5]According to Schumpeter, Joseph A. The Theory of Economic Development: An Inquiry into Profits, Capital, Interest and the Business Cycle. (Cambridge, Mass.: Harvard University Press, 1934).

[6]Pathnopas, R. (1980).

[7]Pathnopas, R. Ibid.

[8]Kittikul, Jirapa. (1980).

[9]Pathnopas, R. Op cit.

[10]Observed information gained from the field survey on The Consequences of Farm Mechanization in Thailand, November, 1982.

[11]Ronald Ng found that Thai farmers who employ new technology usually have relatively good economic means and a good educational background. For farmers in Chachoengsao, the same is true in the case of economic means but no correlation is exhibited for the level of education. However, good education should not be measured only by the level of education but also by the degree of technology perceptiveness.

[12]Supachat Sukharomana, "The Impact of Farm Power Strategy in Thailand," A paper presented at the International Seminar on Farm Power, 25 - 29 October 1982, Agrarian Research and Training Institute, Colombo, Sri Lanka, Table 14, p. 68.

[13]Pathnopas, R. op cit., Apendix Table F, p. 142.

[14]Krishnasreni, S. and other, "Threshing Method in Thailand," A paper presented at Grain Post-Harvest Workshop, Kuala Lumpur, Malaysia, January 1980. p. 8.

[15]Comments of rice millers in Suphanburi Province and Khonkaen Province in 1982 and 1983, personal survey.

[16]Pathnopas, R. op cit., Table III-7, p. 63.

[17]Loohawenchit, C. and Pathnopas, R., "Evolution and Role of Farm Machinery in Thailand," Thammasat University Journal, Vol. 10, no. 3, September 1981, p. 54. (Thai version).

[18]Sukharomana, S. op cit.

[19]Ibid.

[20]Calculated using the number of rice threshers produced in 1979/80 and the value added of rice thresher production plus the wholesale and retail value added.

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Thailand, Ministry of Agriculture and Cooperatives, Department of Agricultural Engineering, Farm Machinery Document, Various Issues.

Table 1. Regional distribution of farm power, 1975/76 crop year.

Region	2-T	4-TS	4-TL	Sprayer	Water Wheel	Water Pump	Corn Thresher	Rice Thresher
North	12.47	24.47	33.54	39.43	2.87	23.12	65.97	4.47
North Ease	3.40	8.34	23.72	16.21	4.03	18.46	18.81	2.38
Central	75.86	64.33	38.26	41.33	92.94	54.68	12.29	90.47
South	8.28	2.86	4.48	2.98	0.16	3.73	2.94	2.68
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total (Number)	90,001	16,792	13,338	46,317	56,891	251,288	5,721	3,955

Note: 2T = two-wheel tractor, 4-TS = small four-wheel tractor, 4-TL = large tractor.

Source: Division of Agricultural Economics, Office of the Undersecretary of State, Ministry of Agriculture and Cooperatives, Agricultural Statistics, No. 54, "Agricultural Statistics of Thailand, crop year 1975/76. Table 20 pp. 183-190.

Table 1b. Number of manufcturers engaged in farm machinery and farm implement produciton, 1979.

Type of machine and implement	Number of firms*
Two-wheel tractor	100
Small four-wheel tractor	20
Large tractor	3
Rice thresher	21
Other grain threshing machine	19
Water pump (axial flow)	10
Water wheel	3
Plough	29
Disc plough for tractor and blade	11
Trailer	11
Puddler	3
Rotary hoe	2
Plough handle	2
Locally made truck for farm	1
Implement for sugarcane	3

*More than one product produced by a firm.

Source: Pisit Samahito and Karnket Kongkietngram, "Farm Machinery and Farm Equipment Production: Part I Farm Tractor and Power Tillers," Bank of Thailand Bangkok, 1979.

Table 2. Average cost of rice threshing by threshing method.

Unit: baht/ton

Threshing method	Fixed cost (1)	Variable cost (2)	Total cost (3)=(1)+(2)
1. Hand beating			
- on basket	14.35	63.51	77.86
- on mat	4.52	62.18	66.70
2. Buffalo treading	39.40	94.20	133.60
3. Two-wheel tractor			
- imported	19.63	102.83	122.46
- diesel engine	10.38	102.29	118.67
- gasoline engine	14.22	104.94	119.16
4. Small four-wheel tractor			
- imported	27.17	95.10	122.27
- domestic	19.65	93.81	113.46
5. Tractor treading			
- life span 8 years	24.76	71.92	96.68
- life span 10 years	28.00	72.10	100.10
- life span 12 years	30.36	72.10	102.42
6. Axial-flow thresher			
6.1 Diesel engine			
- life span 6 years	10.97	63.15	74.12
- life span 7 years	12.40	63.23	75.64
- life span 10 years	15.80	63.23	79.03
6.2 Gasoline engine			
- life span 6 yeras	8.54	65.50	74.04
- life span 7 years	9.66	65.56	75.22
- life span 10 years	12.30	65.56	75.66

Source: Jirapa Kittikul, "Cost of Rice Threshing and Its Economic Impacts," Master thesis, Faculty of Economics, Thammasat University, Bangkok, 1980, Table 3.8, p. 55, in Thai.

Table 3. Cost-Benefit rtios at different discount rates by investment yer, 1975-78.

Discount rate (%)	Investment year 1975	1976	1977	1978
Chachoengsao				
12	1.59	2.34	1.93	1.41
15	1.52	2.27	1.90	1.41
25	1.32	2.05	1.80	1.41
Suphanburi				
12			2.14	1.39
15			2.09	1.39
25			1.96	1.39

Source: F.Juarez and R. Pathnopas, "A Comparative Analysis of Thresher Adoption and Use in Thailand and the Philippines," September 1981, Working Paper no. 28, Tble 21.

Table 4. Labor input used in rice threshing method.

Unit: man-day/ton

Threshing method	Source of information		
	Kittikul's	Pathnopas'	
		Supahanburi	Chachoengsao
Hand beating	1.86	-	-
Animal treading	1.02	3.84	-
2-wheel tractor	1.80	1.76	1.49
4-wheel small tractor	1.50	-	-
Large tractor	1.11	-	-
Rice thresher	0.62	0.98*	0.73[8]

*Threshing capacity in Chachoengsao Province = 0.60 ton/hour and 0.80 ton/hour in Suphanburi Province.

Source: Supachat Sukharomana, "The Impact of Farm Power Strategy in Thailand," A paper presented at the Intenational Seminar on Farm Power, 25 - 29 October 1982, Agrarian Research and Training Institute, Colombo, Sri Lanka, Table 14, p. 68.

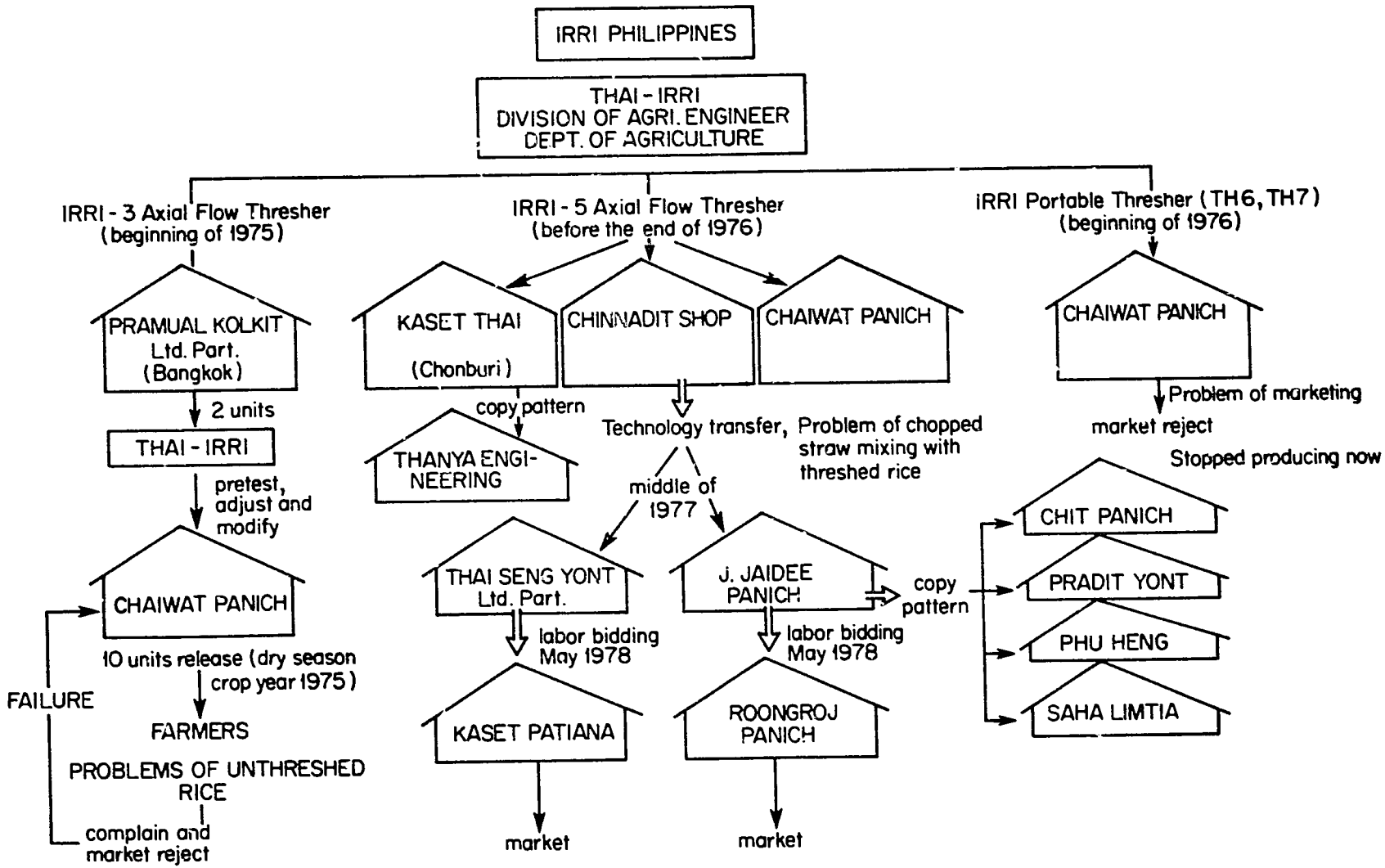
Table 5. Utilization of time saved.

Activity	Farmer owners		Farmer user	
	Household	%	Household	%
Leisure	16	24.4	45	28.8
Land preparation for next crop	34	54.0	19	12.2
Hire out thresher	19	30.2	0	0
Labor for land preparation	1	1.6	12	7.7
Labor for harvesting	0	0	2	1.3
Exchange labor for threshing	1	1.6	4	2.6
Fishery	4	6.3	16	10.2
Government officer	1	1.6	1	10.2
General job	7	11.1	16	10.2
No answer	0	0	44	28.2
	(n = 63)		(n = 156)	

n is the number of sample size.

Source: Renu Pathnopas, "The Economics of Rice Threshing Machines in Thailand: A Case Study of Chachoengsao and Suphanburi Provinces," Master thesis, Faculty of Economics, Thammasat University, Bangkok, 1980. Appendix Table F, p. 142.

Figure 1. Flow chart of the development of technology transfer and the adaptation of locally made rice thresher (a historical background).



SOURCE: Renu Pathnopas, "The Economics of Rice Threshing Machines in Thailand: A Case Study of Chachoengsao and Suphanburi Provinces," a Master's Thesis, Faculty of Economics, Thammasat University, Bangkok, 1980, Table II-7, p. 30.

SECTION IV

NATIONAL POLICIES, MANUFACTURING AND SUPPORTING INFRASTRUCTURE FOR MECHANIZATION

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AN EX ANTE EVALUATION OF SMALL RICE FARM MECHANIZATION POLICIES IN THAILAND*

Thammanun Pongsrikul**

ABSTRACT

The paper presents current utilization system and controversial issues of farm mechanization in Thailand. The IRRI Rice Policy Model is employed to simulate the ten-year trends and to determine impacts of farm mechanization, irrigation and fertilizer policies on output, exports, income and income distribution, and employment. The policies when implimented produce positive changes on the economic variables. The policy on irrigation investment has the largest effect and is the most costly policy. The farm mechanization policy is the only policy that has an adverse influence on farm employment. A set of guidelines in the promotion of farm mechanization is recommended at the end of the study.

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AN EX ANTE EVALUATION OF SMALL RICE FARM MECHANIZATION POLICIES IN THAILAND

Thammanun Pongsrikul

Though Thailand has been one of the major rice exporters for several decades, her rice yields have been lower than those in many Asian countries. Efforts to increase total rice output has primarily been in the form of the expansion in cultivated land through deforestation. The forest area declined from 49.8% of total land area in 1967 to 31.3% in 1981 (Pongsrikul, 1983). The decline has convinced the government that the potential for further expansion in cultivated land has reached its frontier and that existing paddy land is not fully utilized. As a result, the Thai government had implemented many intensification programs. In spite of these programs, rice yields still fluctuated over the 1975-1981 period. The reason for this is the heavy dependence of Thai agriculture on rainfall with only 22.3% of paddy land irrigated as of 1981/82. Furthermore, most irrigation in Thailand used not only for the rice fields but also hydroelectric power generation and flood protection. Lower fertilizer application rates vis-a-vis those in other Asian countries may also contribute to low yields (Pongsrikul, 1983).

The introduction of new technologies and the boom in the domestic tractor industry in the 1970s stimulated the expansion of tractorization. Use of farm machinery power, however, leads to many controversial issues such as displacement of farm labor and worse income distribution.

It has been hypothesized that tractorization displaces farm labor and consequently generates high unemployment in the countryside. This implies a downward shift in demand for farm labor. A fall in farm labor demand and higher unemployment rates reduce wage rates in the agricultural sector as supply for labor remained unchanged or increases. Low wage rates imply low incomes for hired labor. Furthermore, the displaced farm labor also depress wage rates in other industries. Obviously, income is redistributed from the working class who are the majority of population. The decline in purchasing power of the majority will be detrimental to economic strength in the future. On the other hand, an appropriate farm mechanization program may generate positive effects on employment and income through an increase in cropping intensity and the cultivated land area. Farm mechanization may also create non-farm employment such as mechanical jobs.

Since the effectiveness of farm mechanization depends on the availability of modern agricultural technology and infrastructure, this study will examine the effects of alternative combinations of agricultural policies on Thai agricultural performance. Target variables of interest are fertilizer availability, irrigation levels, and the extent of farm mechanization. Different combinations of farm mechanization and other agricultural inputs, given a target rate of population growth, will be used to evaluate policy impact on yield and total output, foreign trade, income and income distribution, employment, and policy cost to the government. The study begins with a discussion of the present status and key issues of farm mechanization in Thai agriculture. An analysis of the simulated results will be presented. The simulation model to be used is the IRRI Rice Policy Model, originally developed by Dr. R. W. Herdt and et. al. Policy recommendations are given at the end of this study.

FARM MECHANIZATION IN THAILAND

Historical Background

The first tractor in Thai agriculture was imported from Australia for governmental experiments in Rangsit area in 1907. It was not until 1910 that tractors were first introduced to farmers. They did not gain popularity, however, because they were too large and heavy for Thai conditions. During this time, a lot of attention was given to improving rice production technology. For its part, the government established an Agricultural Experimental Station under the Department of Agriculture, Ministry of Agriculture and Cooperatives in 1919 charged with the improvement of rice varieties, fertilizer, soil testing, and the use of farm machinery. In the early 1950s, experimental stations rented out imported tractors to nearby farms at a service charge of 95-115 baht/ha, but the service was discontinued shortly after due to budgetary difficulties.

In 1953, the Rice Department was established to stimulate rice production via new technology. The research on and testing of farm machinery was assigned to the Research and Testing Section of the Agricultural Engineering Division. The division also modified imported machines and invented farm machines to suit Thai conditions. This division, under the leadership of M.R. Debaridhi Thevakul, successfully developed the "Debaridhi Pump" in 1955 and the "Iron Buffalo" in 1958. The former, a modification of the wooden water wheel, used a 4-5 horsepower engine. The Machine was first adopted in 1957 and is still widely used today (Jongsuwat, 1980). The Iron Buffalo was modified from the design of a small hand tractor, developed by M. R. Debaridhi in 1953. After several modifications effected during the early 1960s, the Iron Buffalo was released to private producers. Its production, unfortunately, ceased in 1967 due to production inefficient and keen competition from other machines.

In addition to the Agricultural Engineering Division, the Department of Agricultural Extension also carried out research, testing and evaluation of harvesting machines, threshers, and storage methods. This department recently reorganized and adopted new systems and procedures for extension work. As a result, a Farm Mechanization Subsection has been established in the Crop Production Division of the Department of Agricultural Extension to monitor the socio-economics and the implementation of farm machinery. In 1979, the National Committee on Agricultural Machinery was formed to advise the government on policy matters. The committee also formed a sub-committee to carry out actual day to day work.

Additionally, international organiations also provide technical assistance to and carry out joint research projects with government agencies. The Agricultural Engineering Division has collaborated with IRRI in the research on small-scale farm machinery since 1971. The research efforts resulted in the introduction of the portable axial flow threshers, and transplanters to Thai manufacturers in 1975, 1977, and 1978, respectively. The axial flow thresher is the most successful among these machines, and is still currently used and manufactured in Thailand. The Agricultural Engineering Division also has joint research projects with other international agencies; namely, the Asian-Australia Post-harvest Technology Project (since 1978/1979) and the Agricultural Machinery Production Project of the UNDP/FAO (since 1981).

Apart from the government, a number of private firms have designed and produced both two- and four-wheel tractors by modifying small japanese tractors. The two-wheel tractors, which were first produced by Kamnan Prung Takkeaw in 1963, were marketed in 1965. At the same time, a group of firms in Ayuttaya, Cholburi, and Chachoengsao designed simple two- and four-wheel tractors with included a hydraulic system. These firms also produced other types of farm machines, e.g., irrigation pumps and threshers. Their production ranges from about 100 to 1,000 units per year. They, however, do not produce all the parts of these machines. The government presently allows foreign manufacturers to assemble tractors in Thailand.

Present extent of mechanization

Utilization of farm machines in Thailand has expanded rapidly over the past fifteen years. Table 1 lists the commonly used farm machines in Thailand during the period covering 1975-1981. The widely adopted farm machines are tractors, hand sprayers, water pumps, and threshing machines. This study will focus only on thresher and tractor utilization. Total number of threshers increased from 3,955 units in 1975 to 20,601 units in 1981. Tractors are the most important machines in modern Thai agriculture. Among them, power tillers are the most popular, with the number of units increasing from 90,000 in 1975 to 234,851 units in 1981.

Approximately 86% of the tractors' working time is engaged in tilling. The main implements used are disc plows, disc harrow, rotary tillers and tailers. Large tractors are primarily used for land preparation on large farms growing upland crops and in prepararing fields for broadcasting rice. Small tractors, on the other hand, are suitable for paddy cultivation and land preparation in small wetland farms. In general, two-wheel tractors perform better than small four-wheel tractors in the wetland farms. The latter, however, work better in upland farms. Sometimes a combination of different tractor sizes is necessary. A study in 1973 by the Agricultural Engineering Division concluded that the ideal tractor system for farms ranging from 20 to 40 hectares in size in Thailand is the use of large tractors for plowing dryland and of small tractors to cover seeds after watering and seeding.

Marketing and maintenance of machinery

Farm machinery in Thailand is distributed through one or a combination of the following channels: wholesalers, retailers, farmer groups and agricultural cooperatives. The distribution patterns depend on the size of the manufacturer. The marketing channels for tractors are presented in Figure 1.

According to Figure 1, tractor manufacturers and importers sell 35% of their product directly to farmers while 5% is sold to agricultural cooperatives and farmer groups. They sell 20% and 40% of their products to wholesalers and retailers respectively. The wholesaler sells 18% to retailers and sells the remaining 2% directly to farmers. Thus, retailers handled 58% of the tractors at the final distribution stage.

Among tractor markets, those for power-tillers are the most competitive because of the low degree of product differentiation. Most large and medium-scale firms are situated in the central region and produce other types of farm machinery besides tractors, while small-scale firms are scattered in outer provinces and produce in accordance with the seasonal orders of local customers. Large firms generally sell their products through wholesalers, with the wholesalers selling to retailers or individual farmers on either cash or credit basis. In addition to being sales agents, the wholesalers also provide repair services and parts to customers, and gather information on customers' needs at different locations. Small manufactuers on the other hand sell their products directly to customers. They also provide repair services and parts. Unlike large firms, their customers are generally small farmers. Small firms protect their market shares by emphasizing their product lines to local demand and maintaining close contact with customers. Regular customers usually obtain privileges from manufacturers such as long-term and flexible credit terms. In general, tractors are purchased through credit arrangements available from sale agents

without collateral requirements; financial institutions play a very limited role. Downpayments range from one third to half of the purchase price, and payment periods for the balance average at 18 months at an interest rate of 15-16%. Funds for downpayments usually came from savings, relatives, or private money lenders.

Ownership patterns and tractor contractors

There are two major types of ownership patterns; individual and joint ownership. Nearly all farm machines are owned by individual farmers, and only 0.5% are woned by farmer groups or are jointly owned by several farmers (Intachaisri, 1983). In general, farmers buy tractors for their own operation, but also hired out their tractors after completing work on their farms. Approximately 95% of large tractors are hired out for custom services. Contractors serviced only nearby neighbours, with the contract consisting of a direct agreement between the farmer and the tractor owner. Since the competition becomes more keen with an increase in tractor owners, the contract agreements are sometimes made through agents who solicit contracts and earn a commission for the effort. Tractor owners sometimes have to make a long journey to provide the services. The cost of custom services vary with soil conditions and type of crop. Most farmers, particularly small farmers who cannot afford their own tractors, have access to tractor services under the tractor contractor system.

The government's role

The Thai government provided low-cost loans to assist farmers in purchasing farm machines. The loan was granted in kind to prevent farmers from using the money for other purposes. Another form of governmental assistance was the establishment of institutions and agencies to carry out research and to test and develop quality control standards for farm machinery. In addition, the government also established the Industrial Service Institute with the support of UNDP to assist farm machinery manufacturers in technical and managerial services. As far as marketing is concerned, the Thai government played a limited role in farm mechanization.

On the academic front, a Bachelor's Degree course in Agricultural Engineering is presently being offered at both Kasetsart and Khon Kaen universities, while Chiang Mai University is expected to offer such a course in 1985. In addition to universities, graduate study in this field is offered by the Division of Agricultural and Food Engineering at the Asian Institute of Technology, an institution sponsored by various countries and international organizations. The Asian Institute of Technology offers both master's and Doctorate programs for Thai and foreign students. Besides degree levels, a number of vocational agricultural training institutions also provide

general education on farm machinery. The Thai-German Agricultural Engineering Center, established under Germany's bilateral assistance program, gives informal education on farm machinery and its development, soil and land improvement, and irrigation science. Over the past five years, this center has trained more than 4,000 enrollees including extension workers, cooperative members, and farmers.

Controversial issues in the farm machinery industry

There are several distinctive controversial issues relevant to the farm machnery industry as follows:

(1) Over-importation of used tractors

The high rate of global inflation raises prices of imported farm equipment. The high prices of new machines resulted in an increase in imports of small second-hand tractors from developed countries, particularly from Japan and China. These machines are imported for reconditioning and eventual resale at prices ranging from 60 to 80% of the cost of new units, making the prices of second-hand imported tractors competitive vs. locally made units while being more efficient and versatile. To remain in business, domestic producers have to use rebuilt automotive parts for their produced machines and sell them at prices ranging from 50 to 70% of the cost of new units (Chancellor, 1983). While this arrangement keeps tractor prices down, problems and difficulties arise. Among these are the over-importation of used tractors and the substandard quality of locally made tractors, which hurt not only domestic manufacturers but also farmers. Replacement parts will be unavailable when these imported machines need repair, because these are currently neither used nor produced in their originating countries. Another problem is the assessment for tariff purposes of these imported machines which are not on tariff assessment lists. These difficulties can be avoided by prohibiting the importation of second-hand tractors.

(2) Inequitable tariff structure

Prior to 1982, the import tariff was biased against domestic tractor production, since imported engines were subject to a 15% import tariff rate while imported tractors with implements were subject to only a 5% rate. The pressure from domestic producers forced the Thai government to raise import duties on tractors from 5% to 33% in 1982. A study showed that prior to 1982 a total tax of 24.4% was imposed on imported tractors. After the tariff adjustment in 1982, imported tractors were subject to a 52.4% tax while locally produced tractors were subject to only 35.6% (Loohawenchit, 1983). This development produced negative effects. The high level of protection resulted in farmers paying higher prices for tractors and in inefficient factories remaining in the business. The resulting

resource misallocation and excess burden lead to low social well-being of farmers.

(3) Underdevelopment of the industry

The farm machinery industry in Thailand is only at the adolescent stage, composed mostly of small firms employing simple fabrication technology. Small firms do not enjoy economies-of-scale and lack adequate financial means to conduct their own research geared toward designing better farm machines. Many of them cannot even handle their own imports of inputs and parts.

(4) Lack of skilled labor

Most small firms must train their own workers and have difficulty keeping them due to the lack of skilled labor in rural areas. Furthermore, demand for farm machinery is a derived demand of agriultural products. Since prices of agricultural products are seasonally uncertain, manufacturers may have to execute a sub-optimal production plan. All of these involve extra costs to domestic manufacturers.

(5) Inappropriate technology

Very little or no attention is paid to improve small and simple farm tools. Most of the research and development work is devoted to farm machinery. Dissemination of information to farmers is limited since the research is conducted and tested at Kasetsart and Khon Kaen Universities. In addition, many of the agricultural extention workers at the field level have no knowledge or training in farm mechanization. On the other hand, most agricultural engineers have very little or knowledge of local agricultural conditions. To compound the problem, research units do not receive direct feed-back from farmers. As a result, research work on farm machines is usually not suitable to local conditions. Local manufacturers copy and modify imported machines without proper engineering designs which leads to sub-standard designs and many operational accidents.

IRRI RICE POLICY MODEL

The conceptual framework of this model is based on a quantitative accounting technique embodying provisions for rice policies employed in many Southeast Asian countries; i.e. fertilizier policies, irrigation policies, and demand and consumption analyses (Herdt and Webster, 1982). It is a partial equilibrium model with demand and supply sides.

Supply side

Total output is produced on both large and small farms with output dependent on total land area, fertilizer usage and response levels, degree of farm mechanization and labor requirement. Rice land consists of four levels of quality each differentiated by the degree of water control which depends on the government's investment in irrigation. The fertilizer response function, together with the relative prices and availability of fertilizer, determine rice yields and fertilizer usage on each specific quality of land through the profit maximization process. The supply of fertilizer is determined by the government's policy. The response function takes the form:

$$Y_{il} = a_i + b_i F_{il} + c_i F_{il}^2 \qquad (1)$$

where a_i, b_i and c_i are parameters, which i and l are subscripts denoting land quality and season, respectively. F_{il} is the amount of fertilizer used in land of quality i in season l.

When the amount of fertilizer used for each land class is known, yield can be obtained from expression (1). Total output from each land class is the product of yield and planted area:

$$q_{ijl} = A_{ijl} \cdot Y_{ijl} \qquad (2)$$

where q_{ijl} = rice output of the ith land class produced by the jth farm class in the lth season.

Y_{ijl} = rice yield of the ith land class produced by the jth farm class in the lth season.

A_{ijl} = total planted area of the ith land class, j^{th} farm class, and l^{th} season.

For the economy as a whole, total rice output without farm mechanization is determined by the expression (3).

$$Q_1 = \sum_{i=1}^{4} \sum_{j=1}^{2} \sum_{l=1}^{2} q_{ijl} \qquad (3)$$

where Q_1 = total rice output without mechanization

The model treats farm machinery as having possible impacts on yield and total output. The extra rice output due to the complementary use of machinery in each season is:

$$q_{kl} = N_{kl} \cdot C_{kl} \cdot R_{kl} \qquad (4)$$

where q_{kl} = the extra rice output due to the use of kth machine in the lth season.

N_{kl} = the number of kth machine used in the lth season

C_{kl} = the capacity of kth machine use in the lth season

R_{kl} = the change in yield resulting from uses of kth machine in the lth season.

The extra total output for the economy as a whole, Q_2, due to the use of the kth machine in the lth season is:

$$Q_2 = \sum_{k=1}^{5} \sum_{l=1}^{2} q_{kl} \qquad (5)$$

The total rice output, Q, is defined as:

$$Q = Q_1 + Q_2 \qquad (6)$$

Labor used in the model consists of family and hired labor. Total labor used without the existence of farm mechanization, Tl_1, is defined as:

$$Tl_1 = \sum_{i=1}^{4} \sum_{j=1}^{2} \sum_{l=1}^{2} (A_{ijl} \cdot L_{ijl})(h_{ijl} \cdot f_{ijl}) \qquad (7)$$

where: A_{ijl} = Total areas of the ith land class used by the jth farm class in the lth season.

L_{ijl} = Labor requirements per hectare in the ith land class used by the jth farm class in the lth season.

h_{ijl} and f_{ijl} are the proportion of total labor represented by hired and family labor employed on the ith land quality by j^{th} farm class in the lth season.

In addition to yields, farm mechanization also has impacts on labor use, which is defined as:

$$Tl_2 = \sum_{k=1}^{5} \sum_{l=1}^{2} (N_{kl} \cdot C_{kl})(h_{kl} + f_{kl}) \qquad (8)$$

where: Tl_2 = the change in total labor use due to the complementary use of farm machinery.

h_{kl} and f_{kl} are percentage changes of hired and family labor due to the complementary use of farm machinery.

Thus, total employment in a given year, TL, is defined as:

$$TL = Tl_1 + Tl_2 \qquad (9)$$

Demand side

There are five economic classes; landless farmers, small farmers, large farmers, urban, and non-farm rural. Each class has the Cobb-Douglas type of demand function, which takes the form:

$$D_g = A_g \cdot P^{E_g} \cdot I_g^{N_g} \qquad (10)$$

where: D_g = quantity of demand by the gth economic class.

A_g = Intercept

P = domestic

E_g = price elasticity of demand for rice of the gth class.

I_g = per capita income of the gth class.

N_g = income elasticity

g = economic classes

Since price is assumed to be fixed, excess demand and supply will be offset by imports and exports of rice, respectively. On the other hand, incomes flow to the owners of resources and rice output. There are four types of income in the model: farm income, rental income, labor income, and other income. Each population may receive income from one or more sources.

Total farm income, YF, is defined as:

$$YF = \sum_{i=1}^{4} \sum_{j=1}^{2} \sum_{l=1}^{2} \{(q_{ijl} \cdot p_j) - TC_{ijl}\} \qquad (11)$$

where: p_j = paddy prices received by class j^{th} farm.

TC_{icjl} = annual cost of ith land class of jth farm class in the lth season, which is the sum of $(Rt_{ijl} \cdot p_j) + (FU_{ijl} \cdot PF) + AMC_{kl} + OC_{ijl}$.

where: Rt_{ijl} = rent paid on i^{th} land class by j^{th} farm class in l^{th} season.

FU_{ijl} = fertilizer usage on i^{th} land class by j^{th} farm class in l^{th} season.

PF = fertilizer prices

AMC_{kl} = annual cost of kth machine in l^{th} season.

OC_{ijl} = other annual costs on i^{th} land class of jth farm class in l^{th} season

Total wage income, YL, is defined as:

$$TL = \sum_{i=1}^{4} \sum_{j=1}^{2} \sum_{l=1}^{2} (A_{ijl} \cdot L_{ijl} \cdot h_j)W_j + \sum_{k=1}^{5} \sum_{j=1}^{2} (N_{kjl} \cdot C_{kj} \cdot h_{kj})W_j \qquad (12)$$

where: W_j = wages paid by the jth farm class

Total rental income, YR, is defined as:

$$YR = \sum_{i=1}^{4} \sum_{j=1}^{2} \sum_{l=1}^{2} \{A_{ijl} \cdot Rent_{ijl} \cdot (1-OWN_j) \cdot P_j\} \qquad (13)$$

where: $Rent_{ijl}$ = rent paid for i^{th} land class by the jth farm class in the lth season.

OWN_j = farm land owned by the jth farm class in the lth season.

Since each population groups may receive income from one or more sources, income per capita of the gth groups, YY_g, is expressed as:

$$YY_g = \{TR_g + YF_g + YO_g\}/N_g \qquad (14)$$

where: YR_g = rental income of the gth population class which is determined by $YR.OWN_{jg}$

OWN_{jg} = proportion of class j^{th} farm land woned by the gth population group.

YF_g = farm income of the gth group is the product of hired labor and wage rates.

YO_g = Other income of the gth group which is an exogenous variable.

N_g = population level of class g^{th} group.

Policy instruments and costs

The current version of the model includes policy instrument in four areas: fertilizer, irrigation, farm mechanization, and population control. Each policy instrument has a cost associated with it.

The policy instrument in the population program is the control of population growth. To reduce the current rate of the target rate involves costs; the greater the cost of population control. The policy cost is defined as:

$$PC = C\{100.(CU - TA)/IY\}^3 \qquad (15)$$

where: PC = policy cost

C = constant term

CU = current rate of population growth

TA = target rate of population growth

IY = number of years simulated

The fertilizer policy consists of two instruments. The first is a subsidy on fertilizer uses. The policy cost of this instrument is the difference between world and local prices of fertilizer. The second instrument is the rate of growth in fertilizer availability. The policy costs of this instrument is given by:

$$PC = FA\{(TR - CR)/100\}x\{SPF - MPF\} \qquad (16)$$

where: FA = current fertilizer availability

TR = target rate of growth of fertilizer availability

CR = current rate of growth of fertilizer availability

SPF = subsidy prices of fertilizer

MPF = market prices of fertilizer

Two irrigation policy instruments are included: development of new irrigation and rehabilitation of old system. New irrigation investment upgrades land from rainfed to different qualities of irrigated land, while the rehabilitation investment improves the dry season irrigated land. Policy costs are the products of the size of irrigation (or rehabilitation) areas and the unit cost of irrigation development.

The mechanization policies involve two policy variables: a direct subsidy on farm machinery and the rate of increase in the machinery stocks. Direct subsidies include subsidies on capital costs and fuel prices. Policy cost of the first instrument is the product of subsidy per machine and number of machines. Policy cost of the second instrument is defined in the same fashion as the expression (16).

EMPIRICAL ANALYSES

The algorithm for simulating the IRRI model, initially written by Dr. J. P. G. Webster, will be manipulated to obtain policy impacts of alternative policies on economic variables. According to Table 11, with existing agricultural conditions and policies, total rice output will increase over the ten years simulated. Rice surplus (exports) also have increasing trends because domestic production increases faster than domestic consumption. Per capita income of all economic classes increase, but that of the landless farmers have the slowest upward trend because they own neither rice land nor farm machines. In contrast, the per capita incomes of small and large farmers increase the most, since they own the major share of the rice land and farm machines. The per capita income of the urban-class, after increasing from base year, has a decreasing trend. This is due to the migration of population from rural to urban areas is incorporated in the model. Both total labor and hired labor used have rising trends, but the latter increases at a higher rate than the former. Finally, policy costs to government also increase because of the subsidies on fertilizer and irrigation.

The impact of each policy is determined by the difference between the simulations with and those without the policy instrument.

Impact of farm mechanization

To examine the effects of this policy, policies on population, irrigation and rehabilitation, and fertilizer are held constant. Under the given conditions, the impact of farm mechanization can be obtained from the results presented in Tables 11 and 12.

The removal of farm mechanization leads to lower total rice production since total rice output in Table 12 is lower than that in Table 11. The lower output caused a decline in the surplus available for exports given unchanged domestic consumption. The per capita incomes of all classes increase when farm mechanization is removed from the model, but the incomes of large farmers slightly change after the fourth year of the simulation. This indicates that tractorization is not profitable for small farms and incomes are distributed against farmer classes. On the other hand, the per capita incomes of urban and rural non-farm classes remain the same because they own no farm machinery. The policy cost to government is not affected because there is no direct subsidy given to farm mechanization. Tractorization apparently replaces both family and hired labor as total and hired labor increase when the farm mechanization policy is removed.

Impact of irrigation investment

To capture this impact, policies on population, fertilizer, and farm mechanization are held constant. Without government's investment in new irrigation and rehabilitation, all economic variables except per capita income of the rural non-farm class and policy costs have decreasing trends (Table 11). This is because the absence of investment in new irrigation and rehabilitation means lower land quality and smaller total cropped land due to land depreciation. The decline in cultivated land causes total production, employment, and incomes to fall. Per capita income of the rural non-farm class has an increasing trend, because this income is obtained from non-farm sources. The policy cost has an increasing trend because of the subsidy policy on fertilizer. However, values of all economic variables except that of income of the large farmers increase slightly over the ten years when rehabilitation is positively related to rice output, surplus, employment, income and income distribution, and policy costs. Therefore, investment in irrigation and rehabilitation has positive effects on economic variables.

Impact of fertilizer use

Policies on population, irrigation, and farm mechanization are held constant to evaluate the impact of fertilizer usage. Even when the growth rate of fertilizer is zero, values of all economic variables have increasing trends. The growth rate of fertilizer use has positive effets on total output, surplus, per capita income and small farmers, and policy costs. But it has no effect on the remaining economic variables (Table 11 and 14).

SUMMARY AND POLICY RECOMMENDATION

Farm mechanization in Thailand has a long history extending back to the early nineteenth century, developing primarily in a lassez-faire environment. The government plays roles in research and designing and testing of machines but disseminates information poorly to farmers and local manufacturers. Consequently, many farm machines do not have proper engineering designs resulting in many unreported accidents during operation. The large manufacturers are usually situated in the Central Plain, particularly in Bangkok, while the small manufacturing firms are scattered throughout the country. It is the small manufacturers in provinces that play important roles in the progress of farm mechanization in Thailand. They not only sell farm machinery to farmers but also provide parts, repair and financial services. Because the government adopts a low-cost credit policy not beneficial to the small farmers, most of these farmers cannot afford to buy tractors. They have access to tractors via the contract system. Like other countries, farm mechanization raises many issues

and problems. The most controversial issues are those of the displacement of labor and worsened income distribution. The opposing view argue that new technology and farm mechanization also create a loc of new jobs, which should absorb the displaced labor. Furthermore, an increase in the intensity of land use should also increase farmers' incomes.

To evaluate the arguments, this study uses the IRRI Rice Policy Model to stimulate effects of agricultural policies on total rice output, surplus, incomes and income distribution, employment and policy costs. Empirical results indicate that implementation of agricultural policies are positively related to total output, exports, income, employment, and policy costs. The policy on irrigation investment has the largest effect and is the most costly policy. The farm mechanization policy is the only policy that has adverse influences on incomes and income distribution, and employment. It is important to note that the conclusions are based on results computed from a model with a priori built-in restrictions/assumptions, such as fixed wages and prices.

Policy recommendations

Perhaps, laissez-faire is an ideal way of improving farm mechanization, but it is impossible due to government intervention in other sectors; the market prices do not reflect the shadow prices. The distortion also reduces farmers' incomes. Therefore, government intervention is necessary. An isolated, independent policy cannot improve farm mechanization. The policy recommendations should be coordinated with policies on agriculture, industry, trade, and energy.

(1) Agricultural and Industrial policies

The available of adequate infrastructure and modern technology are prerequisites for effective use of farm mechanization. High priority should be given to the provision of irrigation facilities the use of HYV and fertilizer, and transportation. Sufficient irrigation and adoption of modern agricultural technology leads to successful multiple cropping which requires tractor services for land preparation and amelioration of labor shortage in peak periods.

An increase in farm size is desirable to obtain economics of scale, since the average farm size in Thailand is relatively too small for farm mechanization, particularly tractorization. The government may use land refarm policy to enlarge farm size and enforce agricultural zoning to prevent the agricultural land from being used for other purposes. Alternatively, the government may encourage farmers or domestic investors to form large corporate farms.

National and regional centers for farm mechanization should be established. The former collects all information on international and national developments in farm mechanization as well as other relevant information, while the latter should be situated in all four regions to train agricultural extension workers. These persons can train and advise farm in the areas around thier stations. The training course should focus on operation and proper care of farm machines, since the useful life of machines is a function of proper operation and maintenance. Mobile units should be formed to advise and check farm machines in remote areas. Furthermore, the government should provide proper engineering design for domestic manufacturers and check the standard of machines to avoid operational accidents.

On the industrial side, the government should encourage small manufacturers of simple equipment as well as small scale industries in the rural areas. The promoted industry should use more labor intensive technology in order to absorb the surplus labor resulting from farm mechanization and rapid population growth. Higher employment generates higher incomes and a better standard of living for the rural people. The higher purchasing power of the majority of the population will provide strong bases for industrial development in the future. Moreover, this approach also checks the rural migration to the urban areas.

(2) Credit policies

The present low-cost credit policy is beneficial to only large farmers, because the banks' collateral requirements prevent small farmers from gaining access to agricultural credit. To complement the agricultural policies, low-cost loans should be given to small farmers for buying and fixing farm machines. Farmers should choose their own machines. The invoice and bill are directly sent to the banks or government's financial agencies that provide the loans. The down and succeeding payments should be sufficiently small, in order to be affordable to small farmers. Financial institutions should grant more non-collateral loans to small and remote farmers by encouraging them to form their own groups and act as guarantors for one another. This credit scheme would enable small farmers to own farm machines and avoid the conflicts in schedule for hiring mahcines. They may also earn extra income by hiring out their tractors during the off season. The same type of loans should be available to small manufacturers of farm equipment and machines in the outer provinces, so that they may charge farmers low interest rates. The Bank for Agriculture and Agricultural cooperative may take over the manufacturers' credit given to farmers by charging a minimum financial fee to provide them more liquidity. This is the key because the overdue payments which are difficult to collect and eventually force manufacturers to reposses the machines have become a major problem. Special loans with moderate interest rates and long pay-off period may be made available for the expansion and improvement of manufacturers' factories and technology.

(3) Trade policies

The government should provide farmers with market information of all agricultural products. Marketing has always been the most difficult task in Thai agriculture. In addition to the distorted information on agricultural products, the export tax policies depress prices and incomes for farmers. To improve farmers' incomes, an effective price-support program and abolition of high export tax rates are needed. A phasing out of the high export tax on rice is probably the most desirable measure in order to raise paddy prices, because foreign demand for Thai exports is highly elastic. This proposition is hard for the government to accept because of budgetary and political difficulties (Pongsrikul, 1983).

As far as farm mechanization is concerned, small tractors, water pumps, rice threshers, and simple equipments should be exempted from import tariff. In contrast, the government should impose moderate tariff rates on imports of large tractors and prohibit imports of used tractors. By doing so, demand for tractors will shift from large tractors to small tractors due to lower relative prices of the small units. To encourage domestic producers imports of accessory inputs and engines for farm machines should be exempted from tariff. This measure and the credit scheme will lower domestic cost of production. However, the import tariff should be gradually abolished.

(4) Energy policies

Rising oil and gas prices have an adverse influence on farm mechanization, because the soaring prices lead to higher cost of machine operation and lower utilization. Under this situation, the government should provide cheap gasoline to small farmers and tractors contractors, particularly during the land preparation phase. The government also should develop alternative sources of energy for agricultural production such as solar energy, biomass and biogas, or even windmill power to operate irrigation pumps.

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Table 1 Number of farm machines in use in Thailand by origins, 1975-1981.

	1975		1976		1977		1978		1979		1980		1981		Growth, 1975-1981		Density of 1981 (10^3 ha)
	Total	Domestic	Total	Domestic	Total	Domestic	Total	Domestic	Total	Domestic	Total	Domestic	Total	Domestic	Import (%)	Dom. (%)	
Power tillers	62,141	27,860	81,520	31,766	101,782	49,722	139,467[a]	52,281	176,467	54,124	229,591[a]	51,000	234,851[a]	49,500	277.9	77.7	29.6
Small 4-wheel tractors	11,993[a]	2,582	13,513	2,914	19,374[a]	4,568	21,953	5,031	26,238[a]	4,920	31,258[a]	4,900	34,308[a]	4,850	186.1	87.8	4.1
65-80 hp tractors	13,338	-	17,569	-	22,826	-	28,987	-	33,285	-	37,177	-	50.044	-	275.2	-	5.2
Motor rollers	9,882	-	9,000	-	8,700	-	8,200	-	8,000	-	-	-	-	-	-	-	-
Hand sprayers	-	929,251	-	978,159	-	1,029,642	-	1,083,832	-	1,138,025	-	1,159,000	-	1,175,000	-	26.4	122.5
Water wheel engine	56,891	-	68,219	-	81,923	-	107,730	-	107,730	-	125,811	-	146,927	-	158.3	-	15.3
Irrigation pump	251,288	-	277,084	-	317,328	-	473,975	-	473,975	-	517,975	-	603,458	-	140.2	-	62.9
Cleaning machine	42,342	-	47,423	-	53,114	-	59,488	-	66,806	-	74,782	-	83,801	-	97.9	-	8.7
Shelling equipment	5,721	-	6,407	-	7,175	-	8,036	-	9,000	-	10,079	-	11,287	-	97.3	-	1.2
Threshing	3,955	-	4,430	-	4,962	-	5,557	-	6,224	-	18,394	-	20,601	-	420.9	-	2.1
Feed miller	374	-	419	-	469	-	525	-	588	-	-	-	-	-	-	-	-
Wind miller	1,937	-	2,169	-	2,429	-	2,721	-	3,407	-	-	-	-	-	-	-	-
Sugar-cane cutter	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-
Rice mill	24,658	-	24,914	-	25,170	-	25.428	-	25,682	-	25,947	-	26,212	-	6.3	-	2.7

Source: Center for Agricultural Statistics, Ministry of Agriculture and Cooperative. Agricultural Statistics of Thailand Crop Year, 1980/81 and 1981/82.

Table 2 Population: total and by economic classification, 1971-81.

	Total population		Agr. population		Population by economic classification[a]				
	Person (thousand)	Growth (%)	Person (thousand)	% of total	Urban	Small farmer	Large farmer	Rural non-farm	Landless farmer
					- Thousand -				
1971	37,348	2.7	28,285	75.7	5,438	15,792	5,987	3,625	6,506
1972	38,389	2.5	28,461	74.1	5,957	15,900	6,015	3,971	6,546
1973	39,350	2.6	28,664	72.8	6,411	16,020	6,051	4,274	6,593
1974	40,418	2.9	28,792	71.2	6,976	16,106	6,064	4,650	6,622
1975	41,602	2.8	28,968	69.6	7,580	16,211	6,094	5,054	6,663
1976	42,772	3.0	29,080	68.0	8,215	16,287	6,105	5,477	6,688
1977	44,062	2.3	29,252	66.4	8,886	16,386	6,138	5,924	6,728
1978	45,081	2.2	29,324	65.0	9,454	16,438	6,141	6,303	6,745
1979	26,085	2.0	29,405	63.8	10,008	16,490	6,152	6,672	6,763
1980	46,960	2.0	29,454	63.0	10,504	16,523	6,157	7,002	6,774
1981	47,910	2.5	29,450	61.4	11,076	16,528	6,148	7,384	6,775
Average of 1971-81		2.5							

Sources: Center for Agricultural Statistics, Ministry of Agricultural and Cooperatives, Selected Economic Indicators relating to Agriculture, 1979 and other issues.

Economic Office, Asian Development Bank, Key Indicators of Developing Member Countries of ADB, 1981 and 1982.

Note: [a] Computed from above sources.

Table 3 Total land endowment by farmer group, land quality, and season, 1981

Farm sizes	Small farms				Large farms			
Season	1st quality	2nd quality	3rd quality	4th quality	1st quality	2nd quality	3rd quality	4th quality
	(10^3 hectares)							
Wet season	136	292	1,088	2,098	166	334	1,329	2,565
Dry season	107	221	121	234	133	271	148	284

Sources: Center for Agricultural Statistics, Ministry of Agriculture and Cooperatives, Agricultural Statistics of Thailand Crop year 1980/81.

Note: Technicall .rrigated land is considered land of the first quality. The moderately and simply irrigated systems are considered of the second and third quality, respectively. Rainfed areas are considered land of the fourth quality.

Table 4 Rents payable by group of farmers, land quality and season.

Farm size	Small farmers				Large farmers			
Season	1st quality	2nd quality	3rd quality	4th quality	1st quality	2nd quality	3rd quality	4th quality
	(Baht/ha)							
Wet season	900	840	800	700	935	900	850	830
Dry season	958	850	810	0	1,057	930	900	0

Sources: Estimated from Tables 9 and 10.

Note: Assumed that rents are paid according to land quality and farm sizes.

Table 5 Other costs of rice production by farm group, land quality and season.

Farm sizes	Small farms				Large farms			
Season	1st quality	2nd quality	3rd quality	4th quality	1st quality	2nd quality	3rd quality	4th quality
				(Kg/ha)				
Wet season	50	50	50	50	61	61	61	61
Dry season	53	53	53	53	63	63	63	63

Soruces: Estimated from Tables 9 and 10.

Note: Assumed that land quality does not affect other rice production costs and large farms have slightly higher costs than those of small farms.

Table 6 Labor requirements by farm group, land quality and season, 1981.

Farm sizes / Seasons	Small farms				Large farms			
	1st quality	2nd quality	3rd quality	4th quality	1st quality	2nd quality	3rd quality	4th quality
	(Mandays/ha)							
Wet season	75	77	78	70	76	78	79	72
Dry season	136	138	140	150	137	138	140	160

Sources: Estimated from unpublished data of the Office of Agricultural Economics, Ministry of Agriculture and Cooperative, and also in Sakurat montreevat, 1983.

Note: One manday = eight manhours

Table 7 Coefficients of yield response functions by land quality and season.

Land quality	1st			2nd			3rd			4th		
	a_i	b_i	c_i	a_i	b_i	c_i	a_i	b_i	c_i	a_i	b_i	c_i
Wet season	572.5	22.4	-0.04	421.5	19.8	-0.06	389.3	15.7	-0.07	254.5	9.05	-0.08
Dry season	810.6	30.1	-0.01	556.7	25.4	-0.03	479.8	20.5	-0.09	0	0	0

Sources: Estimated by regression technics.

Notes: The the fertilizer response function takes the following form:

$$Y = a_i + b_iF + c_iF^2$$

The experiment was performed on Alluvial Soil and the RD7 variety, Central Plain.

Table 8 Effects of tractors and threshers on employment and yield.

Type of machine	Employment (manday/ha)				yield (kg/ha)		Service Life
	Wet season		Dry season		Wet season	Dry season	(year)
	Family Labor	Hired Labor	Family Labor	Hired Labor			
Two-wheel tractor	-12,4	+4,2	-12,4	+4,2	0	0	8
Small four-wheel tractor	-14,7	+1,9	-14,9	+4,2	0	0	10
Large four-wheel tractor	-15,6	+1,9	-15,6	+1,1	0	0	10
Thresher	-5,0	-5,0	-5,0	-5,0	50	50	10

Sources: Estimated from Table 2,13 and 2,14 of Power input Utilization and Substitution in rice rice production, 1983, by Sakurat Montreevat.

Table 9 Cost of Thai rice production in wet season, 1977/78-1980/81.

Items	Cost			
	1977/78	1978/79	1979/80	1980/81
	(Baht per ha)			
Variable cost	2,656.8 (77.21)	3,193.6 (79.82)	3,702.8 (80.08)	4,226.5 (80.80)
-Human labor (wage)	1,467.6 (42.65)	1,735.8 (43.38)	1,983.9 (42.95)	2,156.7 (41.23)
-Animal power	265.9 (7.73)	580.0 (14.50)	628.8 (13.53)	774.2 (14.81)
-Machanical power	498.6 (14.49)	379.3 (9.48)	508.3 (11.00)	631.2 (12.07)
-Seed	148.6 (4.32)	127.8 (3.19)	147.4 (3.19)	183.2 (3.50)
-Fertilizer	126.4 (3.67)	209.1 (5.23)	234.2 (5.07)	181.6 (3.47)
-Pesticide	19.5 (0.56)	15.9 (0.40)	20.9 (0.45)	24.7 (0.41)
-Others	130.4 (3.79)	145.7 (3.64)	179.3 (3.88)	277.9 (5.31)
Fixed cost	784.2 (22.79)	807.3 (20.18)	920.2 (19.92)	1,004.2 (19.20)
-Land (rent)	751.4 (20.84)	718.9 (17.97)	839.3 (18.17)	935.8 (17.89)
-Depreciation of farm equipments	32.8 (0.95)	88.4 (2.21)	80.9 (1.75)	68.4 (1.31)
Total	3,441.0 (100.00)	3,912.5 (100.00)	4,623.0 (100.00)	5,230.7 (100.00)

Sources: Office of Agricultural Economics, Ministry of Agriculture and Cooperative, (Unpublished data), also in Sakurat Montreevat, 1983,

Note: Figures in parentheses are in percentage of total costs,

Table 9b Cost of Thai rice production in dry season, 1977/78-1980/81,

Items	Cost			
	1977/78	1978/79	1979/80	1980/81
	(Baht per ha)			
Variable costs	4,586.0 (91,58)	5,038,1 (88,55)	6,059,6 (89,15)	6,930.6 (90,68)
-Human labor (wage)	na	na	na	na
-Animal power	na	na	na	na
-Mechanical power	na	na	na	na
-Seed	na	na	na	na
-Fertilizer	na	na	na	na
-Pesticide	na	na	na	na
-Others	na	na	na	na
Fixed cost	422,9 (8,45)	651,9 (11,45)	738,8 (10,85)	713,1 (9,32)
-Land (rent)	na	na	na	na
-Depreciation of farm equipment	na	na	na	na
Total	5,008,9 (100,00)	5,689.4 (100.00)	6,796,9 (100,00)	7,643,2 (100.00)

Sources: Center for Agricultural Statistics, Office of Agricultural Economics, Ministry of Agriculture & Cooperatives, Agricultural Statistics of Thailand Crop Year 1980/81,

Note; Figures in parentheses are percentages of total costs,
na = not available,

Table 10 Estimated coefficients of demand function for each population group.

Item	Income/cap (Baht)	Coefficients		
		Intercept	Price elasticity	Income elasticity
Landless	6,805	15	-o.3	0.35
Small farmer	7,238	60	-0.10	0.10
Large farmers	11,231	75	-0.05	0.07
Urban	13,347	15	-0.02	0.25
Rural non-farm	8,680	25	-0.20	0.25

Sources: Estimated from Tables in Selected Economic Indicators Relating to Agriculture, by Office of Agricultural Economics, ministry of Agriculture and Cooperatives.

Note: Coefficients are estimated by the regression technique.

Table 11 Simulation results of model incorporating present agricultural conditions.

I.R.R.I. Rice Policy Model
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Policy summary:

-Population: present growth rate = 2.30%; growth rate in 10 years = 2.00%;
government cost = 0.01 million baht per annum

-Fertilizer: starting supplies =300.00 thou. tonnes; growth rate = 5.00% pa;
government subsidy per tonne of urea = -64350.00 baht

-Land: depreciation rate = 5.00% pa;
rehabilitation rate =100000 ha pa, costing -4842 baht per ha.
new irrigated land =200000 ha pa, costing -25250 baht per ha.

-Mechanisation policies:

FPower tiller
numbers in use =234,851 projected rate of increase = 5 %, subsidy per machine = 0 baht.

DPower tiller
numbers in use = 49,500 projected rate of increase = 5 %, subsidy per machine = 0 baht.

D.small tractor
numbers in use = 4,850 projected rate of increase = 5 %, subsidy per machine = 0 baht.

F.small tractor
numbers in use = 34,308 projected rate of increase = 5 %, subsidy per machine = 0 baht.

Large tractor
numbers in use = 50,044 projected rate of increase = 5 %, subsidy per machine = 0 baht.

Power Thresher
numbers in use = 20,601 projected rate of increase = 5 %, subsidy per machine = 0 baht.

Results summary:

Yr	Popln	Fert	Yield	Export	- Per Capita incomes -					Totlab	Hirelab	GovtCost
	m.	'000t	mt	mt	L/L	S.f.	L.f.	Urb	Rn-f	million mandays		m.baht
0	-	-	-	-	6805	7238	11231	13347	8680	-	-	-
1	47.90	300.00	19.64	9.35	8287	9027	12642	13647	8811	712.4	408.97	-24839.20
2	48.99	315.00	20.26	9.47	8296	9041	12655	13634	8814	720.0	414.79	-25804.40
3	50.08	330.75	20.90	9.92	8306	9054	12668	13622	8818	727.5	420.72	-26818.00
4	51.19	347.29	21.55	10.38	8317	9066	12683	13612	8821	734.8	426.71	-27882.10
5	52.31	364.65	22.21	10.87	8328	9079	12698	13602	8825	742.0	432.76	-28999.50
6	53.43	382.88	22.90	11.37	8341	9091	12713	13592	8829	749.0	438.83	-30172.80
7	54.56	402.03	23.60	11.89	8353	9103	12730	13584	8834	755.6	444.90	-31404.70
8	55.71	422.13	24.32	12.43	8367	9115	12747	13576	8839	761.9	450.94	-32698.30
9	56.85	443.24	25.06	12.99	8381	9127	12764	13568	8844	767.7	456.93	-34056.50
10	58.01	465.40	25.82	13.57	8395	9139	12783	13561	8849	773.1	462.84	-35482.60

Table 12 Simalation results of model without farm machinery inputs,

I.R.R.I. Rice Policy Model
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Policy summary:

-Population: present growth rate = 2.30%; growth rate in 10 years = 2.00%;
government cost = 0.01 million baht per annum

-Fertilizer: starting supplies =300.00 thou. tonnes; growth rate = 5.00% pa;
government subsidy per tonne of urea = -64350.00 baht

-Land: depreciation rate = 5.00% pa;
rehabilitation rate =100000 ha pa, costing -4842 baht per ha.
new irrigated land =200000 ha pa, costing -25250 baht per ha.

-Mechanisation policies:

FPower tiller
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 baht.

DPower tiller
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 baht.

D.small tractor
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 baht.

F.small tractor
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 baht.

Large tractor
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 baht.

Power Thresher
numbers in use = 0 projected rate of increase = 0 %, subsidy per machine = 0 baht.

Results summary:

Yr	Popln m.	Fert '000t	Yield mt	Export mt	- Per Capita incomes - L/L	S.f.	L.f.	Urb	Rn-f	Totlab million	Hirelab mandays	GovtCost m.baht
0	-	-	-	-	6805	7238	11231	13347	8680	-	-	-
1	47.90	300.00	17.87	7.58	8842	9353	12642	13647	8811	1119.7	568.69	-24839.20
2	48.99	315.00	18.40	7.53	8873	9379	12655	13634	8814	1147.6	582.50	-25804.40
3	50.08	330.75	18.94	7.88	8908	9402	12668	13622	8818	1176.4	596.81	-26818.00
4	51.19	347.29	19.50	8.25	8944	9427	12683	13612	8821	1206.3	611.61	-27882.10
5	52.31	364.65	20.06	8.63	8982	9451	12702	13602	8825	1237.0	626.91	-28999.50
6	53.43	382.88	20.64	9.02	9023	9476	12735	13592	8829	1268.7	642.68	-30172.80
7	54.56	402.03	21.23	9.42	9066	9502	12769	13584	8834	1301.4	658.94	-31404.70
8	55.71	422.13	21.83	9.84	9111	9528	12802	13576	8839	1334.9	675.69	-32698.30
9	56.85	443.24	22.45	10.27	9158	9554	12835	13568	8844	1369.4	692.91	-34056.50
10	58.01	465.40	23.07	10.71	9208	9581	12869	13561	8849	1404.9	710.62	-35482.60

Table 13 Simulation results of model without irrigation investment.

I.R.R.I. Rice Policy Model
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Policy summary:

-Population: present growth rate = 2.30%; growth rate in 10 years = 2.00%;
government cost = 0.01 million baht per annum

-Fertilizer: starting supplies =300.00 thou. tonnes; growth rate = 5.00% pa;
government subsidy per tonne of urea = -64350.00 baht

-Land: depreciation rate = 5.00% pa;
rehabilitation rate = 0 ha pa, costing -4842 baht per ha.
new irrigated land = 0 ha pa, costing -25250 baht per ha.

-Mechanisation policies:

FPower tiller
numbers in use =234,851 projected rate of increase = 5 %, subsidy per machine = 0 baht.

DPower tiller
numbers in use = 49,500 projected rate of increase = 5 %, subsidy per machine = 0 baht.

D.small tractor
numbers in use = 4,850 projected rate of increase = 5 %, subsidy per machine = 0 baht.

F.small tractor
numbers in use = 34,308 projected rate of increase = 5 %, subsidy per machine = 0 baht.

Large tractor
numbers in use = 50,044 projected rate of increase = 5 %, subsidy per machine = 0 baht.

Power Thresher
numbers in use = 20,601 projected rate or increase = 5 %, subsidy per machine = 0 baht.

Results summary:

Yr	Popln m.	Fert '000t	Yield mt	Export mt	- Per Capita incomes - L/L	S.f.	L.f.	Urb	Rn-f	Totlab million mandays	HireLab	GovtCost m.baht
0	-	-	-	-	6805	7238	11231	13347	8680	-	-	-
1	47.90	300.00	19.64	9.35	8287	9027	12642	13647	8811	712.4	408.97	-19305.00
2	48.99	315.00	19.68	8.88	8242	8977	12632	13627	8811	689.5	399.45	-20270.20
3	50.08	330.75	19.72	8.75	8197	8927	12623	13609	8811	665.6	389.59	-21283.80
4	51.19	347.29	19.76	8.62	8152	8878	12615	13593	8811	640.8	379.37	-22347.90
5	52.31	364.65	19.81	8.50	8107	8829	12607	13578	8811	614.9	368.77	-23465.30
6	53.43	357.91	19.77	8.28	8062	8780	12599	13564	8812	587.9	357.77	-24638.60
7	54.56	346.95	19.72	8.06	8017	8733	12592	13551	8813	559.8	346.32	-25870.50
8	55.71	336.29	19.68	7.85	7971	8686	12586	13540	8813	530.5	334.42	-27164.10
9	56.85	325.93	19.64	7.65	7925	8641	12580	13529	8814	499.9	322.03	-28522.30
10	58.01	315.86	19.62	7.47	7878	8596	12575	13519	8816	467.9	309.12	-29948.40

Table 14 Simulation results of model without fertilizer application.

I.R.R.I. Rice Policy Model
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Policy summary:

-Population: present growth rate = 2.30%; growth rate in 10 years = 2.00%;
government cost = 0.01 million baht per annum

-Fertilizer: starting supplies =300.00 thou. tonnes; growth rate = 0.00% pa;
government subsidy per tonne of urea = -64350.00 baht

-Land: depreciation rate = 5.00% pa;
rehabilitation rate =100000 ha pa, costing -4842 baht per ha.
new irrigated land =200000 ha pa, costing -25250 baht per ha.

-Mechanisation policies:

FPower tiller
numbers in use =234,851 projected rate of increase = 5 %, subsidy per machine = 0 baht.

DPower tiller
numbers in use = 49,500 projected rate of increase = 5 %, subsidy per machine = 0 baht.

D.small tractor
numbers in use = 4,850 projected rate of increase = 5 %, subsidy per machine = 0 baht.

F.small tractor
numbers in use = 34,308 projected rate of increase = 5 %, subsidy per machine = 0 baht.

Large tractor
numbers in use = 50,044 projected rate of increase = 5 %, subsidy per machine = 0 baht.

Power Thresher
numbers in use = 20,601 projected rate of increase = 5 %, subsidy per machine = 0 baht.

Results summary:

Yr	Popln	Fert	Yield	Export	- Per Capita incomes -					Totlab	HireLab	GovtCost
	m.	'000t	mt	mt	L/L	S.f.	L.f.	Urb	Rn-f	million mandays		m.baht
0	-	-	-	-	6805	7238	11231	13347	8680	-	-	-
1	47.90	300.00	19.64	9.35	8287	9027	12642	13647	8811	712.4	408.97	-24839.20
2	48.99	300.00	20.19	9.39	8296	9040	12655	13634	8814	720.0	414.79	-24839.20
3	50.08	300.00	20.74	9.76	8306	9050	12668	13622	8818	727.5	420.72	-24839.20
4	51.19	300.00	21.30	10.14	8317	9061	12683	13612	8821	734.8	426.71	-24839.20
5	52.31	300.00	21.87	10.53	8328	9071	12698	13602	8825	742.0	432.76	-24839.20
6	53.43	300.00	22.46	10.93	8341	9080	12713	13592	8829	749.0	438.83	-24839.20
7	54.56	300.00	23.05	11.34	8353	9090	12730	13584	8834	755.6	444.90	-24839.20
8	55.71	300.00	23.66	11.77	8367	9099	12747	13576	8839	761.9	450.94	-24839.20
9	56.85	300.00	24.28	12.21	8381	9108	12764	13568	8844	767.7	456.93	-24839.20
10	58.01	300.00	24.91	12.66	8395	9116	12783	13561	8849	773.1	462.84	-24839.20

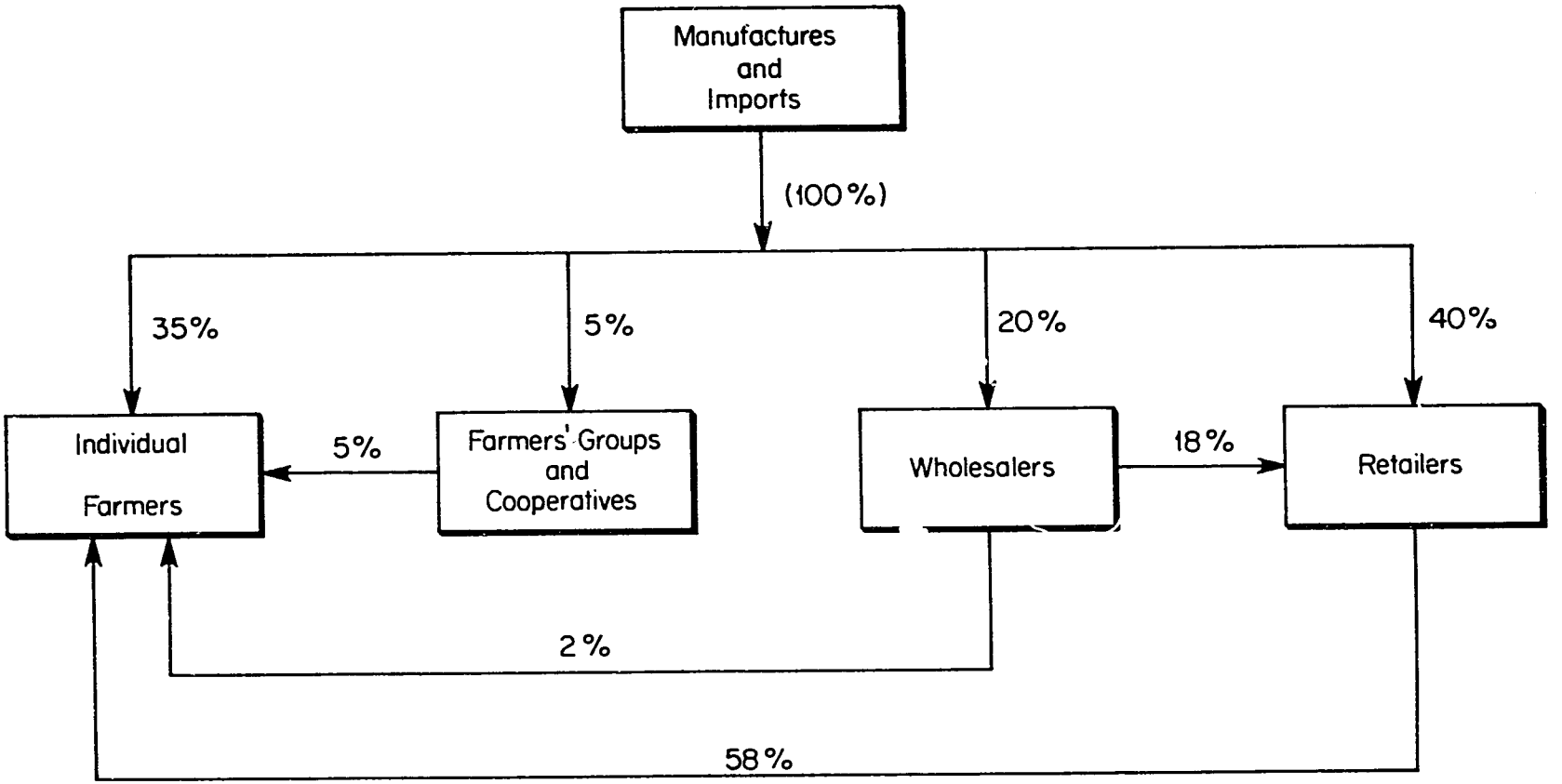

Figure 1. Marketing channels of tractors.

A LOOK AT SOME ASPECTS OF THE FARM MACHINERY INDUSTRY*

Chesada Loohawenchit**

ABSTRACT

Despite the negative protection resulting from the import tariff structure, the farm machinery industry managed to achieve high growth. The over-importation of second-hand tractors in 1982 produced a setback in this industry. Consequently domestic manufacturers pressured the Thai government to formulate protection policies. As a result, both tariff and non-tariff (quota) measures against foreign competition have been adopted.

High tariff protection is detrimental to the strength of the industry and economy in the long-run, since it provides no incentive for domestic manufacturers to improve their production efficiency. The protection is also at the expense of farmers because they have to pay higher prices. This results in a reduction in demand for and growth of the farm machinery industry.

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A LOOK AT SOME ASPECTS OF THE FARM MACHINERY INDUSTRY

Chesada Loohawenchit

INTRODUCTION

As Thailand entered the 1980s along with the implementation of the Fifth National Economic and Social Development Plan, a lot of excitement was generated among policymakers. The anticipate by the end of the plan period in 1986 the country would have emerged as a semi-industrialized economy with gross domestic product from manufacturing being as great as that from agriculture. In the past few years, therefore, a great deal of interest has been shown towards industrial development. Although most of the attention and publicity were directed to large scale industrial projects mainly concentrated in the Eastern Seaboard area, there has also been increasing attention paid to some smaller scale industries. One of these is the farm machinery industry.

The interest in the farm machinery industry is evidenced by the increasing volume of research and literature devoted to it. Both the Bank of Thailand and the National Economic and Social Development Board have undertaken separate studies on the industry. Furthermore, international organizations such as the International Labour Organization (ILO), the Wrold Bank (IBRD), the International Rice Research Institute (IRRI) and the local academic community have also been actively involved in studying the industry.

One major reson for the interest shown towards this industry no doubt lies in its relationship to the agricultural sector which is usually the most important sector in LDCs. Thailand is no exception. Another reason is the fact that the development of such a basic home grown industry can help to provide an impetus for the further development of more sophisticated local industries.

This paper attempts to outline some of the main features and the development of the farm machinery industry.[1] It also hopes to look into the prospects of the industry and the potential impact on the agricultural sector and the industry of government policy.

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[1]The main focus of the paper is on two wheel and four-wheel power tillers.

THE ROLE OF THE LOCAL INDUSTRY IN PROMOTING FARM MACHINERY UTILIZATION

Farm machinery has had a long history in Thailand. Its existence dates to as far back as the late nineteenth century.[2] However, it was not until after the Second World War that farm machinery became better known to Thai farmers. The widespread acceptance of farm machinery started to take place rapidly in the sixties and seventies. Among ASEAN countries, Thailand is now known for being the country which utilizes the most machinery.

Nevertheless, the acceptance of farm machinery did not take place overnight. There were many factors which gradually worked to influence the use of farm machinery. Some of the major factors include:[3]

(a) The introduction of irrigation systems and double cropping

(b) The introduction of high yielding varieties (HYV)

(c) The net economic Benefit from machinery use

(d) The increase in the buying power of farmers

(e) The market for contract service in farm machinery

(f) The natural environment

(g) The demonstration effect and the learning process

(h) Other non-economic factors

In addition to the above factors, the local farm machinery industry has also been cited as a major factor contributing to the

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[2]David Feeny, "Technical and Institutional Change in Thai Agriculture, 1880-1940," unpublished Ph.D. dissertation, University of Wisconsin (Madison: 1976), p. 115.

[3]Chesada Loohawenchit and Renu Pathnopas, "Evolution and Role of Farm Machinery in Thailand," Thammasat University Journal, September 1981. (in Thai).

acceptance and utilization of farm machinery.[4] Local producers of farm machinery were able to modify their machinery to suit local tastes. Machines were designed to be less complicated than the imported ones. The simple design does not require a high level of domestic technical know-how and in addition, the reduction of unnecessary costs makes it more affordable to farmers both in terms of purchase price and maintenance costs. The uncomplicated structure of the machinery also makes it easier to handle and service. In fact, with types of repair jobs, farmers are able to do themselves. Since engines are not installed on the power tillers, customers choose their engines. The design also makes it easier for farmers to use the engines of their power tillers for other purposes such as pumping water.

Most successful firms were located near potential markets. This was necessary not only because if physically facilitated selling but also because it made interaction with farmers and the consequent introduction of modifications and improvements possible. These firms usually started from a small local base. Only after having acquired a reputation locally did they turn to other markets. There they operated through dealerships.

LOCAL PRODUCTION CAPACITY

Initially, all of the early farm machinery in Thailand was imported. But in the 1950s, the government through the Division of Agricultural Engineering began to experiment and produce prototypes of local machinery. The first documented machine to be built locally was the Tebariddhi water pump. This was followed by the Iron Buffalo (a locally built power tiller) and a small four-wheel tractor.

However, production of farm machinery on a commercial scale did not take place until the mid-1960s. Since then, local production capacity has expanded rapidly as shown in Table 1. In the late 1970s and early 1980s the growth of production capacity may have levelled off with very few new firsm coming into existence. The present production capacity is probably not much different from that of the 1978 estimate made by the Bank of Thailand. This is due to the fact that factories have been generally underutilized even during good years while a number of them have gave out of business. Additionally,

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[4]Chesada Loohawenchit, "The Farm Machinery Industry: A Case Study of a Small Home-Grown Industry in Thailand" a research paper prepared for the Seminar on ASEAN Comparative Study of the Development of Labor Intensive Industry, 28-31 October 1980, Pattaya, Thailand.

imported product have been competing aggressively in the last couple of years.

Table 2 shows that the total production capacity of the industry in 1978 was approximately 67,000 units composed of 57,000 two wheel power tillers, 7,000 four wheel power tillers and 3,000 tractors. Actual production of these three machines were 39,568, 3,808 and 2,158 units, respectively. This illustrates that production capacity had not been utilized fully in the industry.[5]

Of the 64,000 units of output, about 18.8 percent were from small firms while 25.0 percent were from medium-sized firms. More than half of all production units were from large firms.

In terms of production value, the industry generated about 780 million baht for tractors, four wheel and two wheel power tillers. The major share of 64.1 percent was that of tractor production with the remaining 26.9 and 9 percent were accounted for by the two and four wheel power tillers respectively. A rough estimate made by the BOT study found that the three products generated about 135.8 million baht of value added.

FACTOR INTENSITY AND FACTOR PRODUCTIVITY

Statistics obtained from a study in 1980 revealed that the amount of fixed assets per worker was approximately 90,300 baht.[6] This was lower than the fixed assets per worker of the machinery industry as a whole of 114,700 baht as found by another study in 1978.[7] Given that total price inflation between 1978-1980 was about 36% it seems that the farm machinery industry was probably less capital intensive than the other machinery industries. Furthermore, looking at the fixed asset to labor ratio for the manufacturing sector as a whole suggests that the farm machinery industry was also generally more labor intensive.

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[5]The production capacity as estimated by the Industrial Service Division is larger. It was 87,000 units for two wheel tillers and 7,300 units for four wheel tillers in 1979.

[6]Loohawenchit, op. cit.

[7]Somsak Tambunlertchai, "Employment Effects of Small-and Medium-Scale Industries in Thailand, Faculty of Economics Research Report Number 9, Thammasat University, November 1978.

When classified according to firm size, the average capital-labour ratios were 69.7, 71.3 and 109.3 thousand baht for small, medium and large size firms, respectively (see Table 3). This is proof that larger firms tend to be more capital intensive. However, within each of the three groups, large differences in the capital-labour ratio were also found. This seems to indicate that there is a wide range of substitution possibilities between labour and capital in the industry.

The higher capital-labour ratio in the larger firms translated into a higher labour productivity. The value added per worker for small, medium and large firms were 24.9, 65.6 and 104.6 thousand baht, respectively. The figures however, show that the increase in labour productivity was much larger (163%) than the increse in the capital-labour ratio (2%) as one moved from the small size to the medium-sized firm. Although this could be due to the inclusion of capital such as land and buildings used for residential purposes into the measure of capital making the difference in fixed asset per worker between the two groups insignificant, the very large increase in labour productivity makes it seem likely that medium-sized firms are more efficient that the small ones. As for large firms, the higher labour productivity versus medium-sized firms seemed to be more or less in line with the higher capital intensity.

SOURCE OF TECHNOLOGY AND DESIGN

Almost all factories use machine designs copies and modified from machines that were already available in the market.[8] The domestic design with the most widespread influence on local producers is the Prapadaeng model.[9] Among foreign designs, the Japanese models were the most widely mentioned. Although almost all producers copied their designs from others, they also introduced modifications to suit local terrain and tastes. The present design and technology of power tillers, seems to have been established without any more significant changes taking place. Existing factories are reluctant to change their design and technology since they feel their products are now generally accepted by farmers. In addition, the cost of innovation may be high especially when the market in the past few years has been adversely affected by bad weather.

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[8]Pathom Taenkam, The Small Tractor Industry, an M.A. Thesis, Faculty of Economics, Thammasat University. June 1980.

[9]For a discussion of various domestic models, see Pathom Taenkam, The Small Tractor Industry, an M.A. thesis. Faculty of Economics, Thammasat University, June 1980 and the Bank of Thailand. "The Power Tiller Industry" an unpublished report. 1978.

Quite a number of factories obtained their designs and production technology when they started their operations directly from those factories already in operation. Some obtained their know-how through the pirating of skilled and able workers from existing factories. Others obtained theirs from their own experiences or from relatives and workers who used to work in factories producing farm machienry or related products.

The institutional sources of design and technological knowledge most factories relied on were the Agricultural Engineering Division (AED), the local office of the International Rice Research Institute (IRRI) and the Industrial Service Division (ISD). So far, the assistance received has been mainly in the form of information. Factories in general did not feel they have received much help in the area of power tillers. Factories have heard of rice threshers and transplanters from AED and the IRRI. A number have in fact, been quite enthusiastic about obtaining such information from the AED and IRRI and would like to get more help in this area.

PUBLIC POLICY TOWARDS THE FARM MACHINERY INDUSTRY

Prior to 1982, there was not much attention paid by the government to the farm machinery industry. Except for the large tractor firms no promotional privileges or financial help was provided to firms by the government. In the case of power tiller producers, not only was assistance not provided but a number of them even felt that the government had not treated them fairly in terms of taxes and tariffs. Imports were subjected to a duty of 5 percent of the import (C.I.F.) price; a business tax of 3 percent of the retail price; a standard profit tax of 11 percent of the retail price; and a local tax of 10 percent of the business tax. Domestic products were also subjected to such taxes except the import duty although the latter is comparatively small. An imported engine has an import duty of 15 percent which is three times higher than the import duty on an imported power tiller. Ball bearing and iron chains which are also important inputs are impose duty of 15 and 30 percent, respectively.

In 1982, due to the increasing pressure from imported machinery, producers of power tillers lobbied intensively for increased protection through the Association for Thai Industries. The government in response raised the tariff rates for imported machinery and imported engines to 33% of the C.I.F. value in both cases. In addition to raising and equalizing the tariff rates for both farm machinery and engines, the Ministry of Commerce (MOC) was also given the power to control the number of imported machines through licensing. The quotas established by the MOC ammounted to 5,337 units for two-wheel power tillers and 705 units for four-wheel power tillers. As can be seen in Table 4, this was quite a drastic action since the import of power tillers and tractors amounted to as much as 15,480 units in 1981 which is almost three times the combined quota level.

The examples in Tables 5-6 present the amount of taxes paid for an imported machine and a locally produced machine both before and after the tariff adjustment. The calculation was based on the assumption that the cost of a locally produced machine was the same as the C.I.F. price of an imported machine making comparisons possible. Marketing margins were also excluded since they are probably similar for both imported and locally produced machinery.

The results confirm that local producers paid a larger amount of taxes prior to the tariff adjustment in 1982. The amount paid was 24.14% of the cost of production as compared to 20.32% of the C.I.F. price from imported machinery. After the tariff adjustment in 1982, however, imported machines were made to pay total taxes of about 52.4% of the C.I.F. price as compared to 35.6% of the cost of production for locally produced machines. In short, the farm machinery industry was not protected prior to 1982. Since then, the government has changed its policy and provided both tariff and non-tariff barriers against foreign competition. The amount of protection is in fact much greater than the difference in the tax rates on imported and locally produced machines. This can be observed by the low level of import quotas set by the MOC.

Although the import tariff adjustment and the import quotas in 1982 would no doubt help protect local producers from foreign competition, it is doubtful that such a policy would benefit the economy and industry in the long term. The rapid growth of the farm machinery industry in the past has brought with it many inefficient factories and it may have reached the stage that these firms should be weeded out. The protectionism provided by the government would make such an adjustment slower. Local producers would be less inclined to innovate and cut their cost of production to compete with foreign imports.

In the end, farmers will end up paying much higher prices for their machines. This would not only hinder agricultural development but would limit the market for farm machines, since it may not be worthwhile to utilize machinery in agriculture. The most distasteful aspect of the policy however, is again the government's protection of an industry at the expense of farmers comprising the poorer majority of the country. Farmers are made to pay for the inefficiency of local firms.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The farm machinery industry started in the latter half of the 1960s and grew quite rapidly in the 1970s. The prospects of the industry in the eighties, however, do not seem as bright especially for the two and four wheel power tillers as the market may soon be exhausted (see Table 7). This is not to say that most farmers in

Thailand either own or utilize a power tiller or a tractor. It is still true that the majority of farmers do not own or utilize these machines. But due to the lack of farmers' buying power, the inability to double crop, low productivity, inadequate transport routes, lack of markets, and other constraints, the expansion of the machinery market to the under-developed agricultural areas will be a difficult task.

Most of the problems in the agricultural sector could be solved given more and better irrigation facilities. As it is, the adoption and acceptance of new agricultural inputs including machinery are confined mainly to well irrigated areas. It seems likely therefore, that in the long-run the growth rate of the industry will depend to a large extent on the pace of agricultural development.

One possible way of sustaining the industry's growth in the eighties is for factories to shift their production to newer and more promising machines such as rice threshers, transplanters, etc. This would open up a whole new market for the manufacturers. To do this, the industry needs help in the form of information on new machines. This is where the government can be most effective. The provision of machine blueprints or models and other technical information would help local producers in initiating the production of machinery. Once this is done, the adaptation and modification of the machinery to local conditions and tastes of customers can be left to these firms. The government can then proceed to provide more sophisticated technical advice on more difficult problems.

After a decade of high growth, the farm machinery industry should be slowly reaching the stage of maturity. Technological factors which are usually more important during the initial stages of product development must now give way to the emphasis on marketing strategy and production efficiency. The large influx of imported machinery from the People's Republic of China shows very clearly that there has been no substantial significant change in local designs which would help keep local producers competitive versus foreign competition. Imported farm machinery, after experiencing setbacks from domestic competition in the late 1970s, have fought back and seem to have caught up with the local producers by providing cheap and more suitable machines than in the past.

Instead of letting the local farm machinery industry readjust itself and become more efficient and innovative, the government has chosen to protect the local producers. It should be pointed out that the strong performance of local producers in the past no doubt came about through indigenous innovation in the face of strong foreign competition. They were however, more than able to compete with these foreign imports despite negative protection. There is no reason why the industry cannot again gear itself to compete with imports. The government policy of protecting local producers would only take away the pressure on and incentive to try to innovate and compete. This could gradually bring about a decay of the local industry.

Furthermore, it should also be said that even without foreign competition, many of the less efficient industries would go out of business anyway. The industry has reached a stage wherein the smaller and less efficient firms have to be weeded out. The stronger and larger firms will acquire a bigger share of the market. This may lead to greater economies of scale in production and marketing and better quality control.

Under a protected local industry, the distribution and use of farm machinery may be somewhat constrained. The price of machines may be higher due to less pressure to cut production costs. Furthermore, new innovations may be executed at a much slower pace. Despite the short experience with tariff adjustments and import quotas effected 1982, it is about time for a review of government policy. It is also about time for someone to stand up for the farmers.

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Table 1. Year operation started

(no. of respondents)

Year	Loohawenchit (1980)	1981 Survey
Prior to 1966	1	10
1969-1970	8	11
1971-1975	21	20
1976-1979	5	18
1980-1981	n.a.	3
Total	35	62

Source: 1) Chesada Loohawenchit, "The Farm Machinery Industry: A Case Study of a Small Home Grown Industry in Thailand", a research paper presented at the Seminar on "Asean Comparative Study of the Development of Labour Intensive Industry" organized by ARTEP, ILO, 28-31 October 1980, Pattaya, Thailand.

2) A survey conducted in 1981 by Renu Pathnopas.

Table 2. Capacity utilization and production value, 1978.

	Type of Product			
	2 w. tiller	4 w. tiller	Tractor	Total
Production capacity (units/year)	57,000	7,000	3,000	67,000
Production (units)	39,568	3,808	2,158	45,534
Capacity utilization (percent)	69.4	54.4	71.9	-
Value of production (million B)	210 (26.9)	70 (9.0)	500 (64.1)	780 (100)
Average domestic price (baht/unit)	5,307	18,382	231,696	-

Figures in parentheses are percentages.

Source: Bank of Thailand.

Table 3. Capital, labor, output and value added.

Item	Small	Medium	Large	Total
Number of firms	8	14	4	26
Fixed assets (million B)	2.72	22.95	40.00	65.67
Employees (persons)	39	322	366	727
Output value (millions B)	1.96	59.85	99.05	161.54
Value added (million B)	0.97	21.12	38.30	62.41
Output value/worker (thousand B)	50.3	186.9	270.6	222.2
Output value/fixed assets (thousand B)	0.72	2.61	2.48	2.50
Fixed assets/worker (thousand B)	69.7	71.3	109.3	90.3
Value added/worker (thousand B)	24.9	65.6	104.6	85.8
Value added/fixed assets	0.36	0.92	0.96	0.95

Table 4. Production and import of power tillers and tractors.

Year	Local production				Import	
	2-wheel (1) (unit)	4-wheel (2) (unit)	tractor (3) (unit)	Total (4) = (1)+ (2) (unit)	Total (5) (unit)	Market share (6) = (5)/(4) x 100 (%)
1970	-	-	-	-	688	-
1971	-	-	-	-	1,367	-
1972	-	-	-	-	109	-
1973	-	-	-	-	274	-
1974	24,808	2,324	-	27,132	1,112	4.1
1975	27,860	2,582	2,426	30,442	4,231	13.9
1976	31,766	2,914	2,332	34,680	5,257	15.2
1977	35,465	3,258	2,380	38,723	6,167	15.9
1978	39,568	3,808	2,158	43,376	4,298	9.9
1979	38,756	4,142	-	42,898	3,348	7.8
1980	50,075	6,853	-	56,928	3,892	6.8
1981	60,000	7,000	-	67,000	15,840	23.6
1982	-	-	-	-	3,820*	-

* Jan-Feb., only.

Source: Bank of Thailand and Department of Customs.

Table 5. A hypothetical case comparing taxes paid on an imported machine and a locally produced machine before the import tariff adjustment in 1982.

1. Imported machine

unit: baht

(1)	C.I.F. price			18,000
(2)	Import tariff @ 5% of (1)		900	
(3)	Standard profit tax @ 11% of (1)+(2)		2,079	
(4)	Business tax (net)			
	(a) 3% of (1)+(2)+(3)	629.37		
			} 616.78	
	(b) a reduction of 2% of (a)	-12.59		
(5)	Local tax @ 10% of (4)		61.68	
(6)	Total taxes paid			3,657.15
(7)	C.I.F. price + total taxes			21,657.15
(8)	Overall tax rate $\frac{(6)}{(1)}$ x 100			20.32%

2. Locally produced machine

(1)	Cost of production (net of import on engine)			18,000
(2)	Import tariff on engine @ 15% of 10,000 baht/engine		1,500	
(3)	Standard profit tax @ 11% of (1)+(2)		2,145	
(4)	Business tax (net)			
	(a) 3% of (1)+(2)+(3)	649.35		
			} 636.36	
	(b) a reduction of 2% of (a)	-12.99		
(5)	Local tax @ 10% of (4)		63.64	
(6)	Total taxes paid			4,345
(7)	Cost of production + total taxes			22,345
(8)	Overall tax rate $\frac{(6)}{(1)}$ x 100			24.14%

Table 6. A hypothetical case comparing taxes paid on an imported machine and a locally produced machine after the import tariff adjustment in 1982.

unit: baht

1. Imported machine

(1)	C.I.F. price			18,000
(2)	Import tariff @ 33% of (1)		5,940	
(3)	Standard profit tax @ 11% of (1)+(2)		2,633.40	
(4)	Business tax (net)			
	(a) 3% of (1)+(2)+(3)	797.20		
			} 781.26	
	(b) a reduction of 2% of (a)	-15.94		
(5)	Local tax @ 10% of (4)		78.13	
(6)	Total taxes paid			9,432.79
(7)	C.I.F. price + total taxes			27,432.79
(8)	Overall tax rate $\frac{(6)}{(1)}$ x 100			52.40%

2. Locally produced machine

(1)	Cost of production (net of import tariff on engine)			18,000
(2)	Import tariff on engine @ 33% of 10,000 baht/engine		3,300	
(3)	Standard profit tax @ 11% of (1)+(2)		2,343	
(4)	Business tax (net)			
	(a) 3% of (1)+(2)+(3)	709.29		
			} 695.10	
	(b) a reduction of 2% of (a)	-14.19		
(5)	Local tax @ 10% of (4)		69.51	
(6)	Total taxes paid			6,407.61
(7)	Cost of production + total taxes			24,407.61
(8)	Overall tax rate $\frac{(6)}{(1)}$ x 100			35.60%

Table 7. Stock and increase of farm machines in Thailand, 1975/76 - 1981/1982.

(unit)

Type of machine	Crop year						
	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82
1. Tractor (>45 hp)							
- stock in use	13,338	17,569	22,826	28,987	33,285	37,177	50,044
- net increase	-	4,231	5,257	6,161	4,298	3,892	12,867
2. Tractor (<45 hp)							
- stock in use	14,575	16,427	23,942	26,984	31,158	36,158	39,158
- net increase	-	1,852	7,515	3,042	4,174	5,000	3,000
3. Two-wheel tractor							
- stock in use	90,001	113,286	151,504	192,004	230,591	280,591	284,351
- net increase	-	23,285	38,218	40,500	38,687	50,000	3,760
4. Water pump							
- stock in use	251,288	277,084	317,328	359,308	473,975	517,975	603,548
- net increase	-	25,796	40,244	41,980	114,667	44,000	85,573
5. Water wheel							
- stock in use	56,891	68,219	81,923	87,775	107,730	125,811	146,927
- net increase	-	11,328	13,704	7,852	17,955	18,081	21,116
6. Rice thresher							
- stock in use	3,955	4,430	4,962	5,557	6,224	18,934	20,601
- net increase	-	475	532	595	667	12,170	2,207
7. Winnower							
- stock in use	42,342	47,423	53,114	59,488	66,806	74,782	83,801
- net increase	-	5,081	5,691	6,374	7,318	7,976	9,019

Source: Division of Agricultural Economic Research, Office of Agricultural Statistics, Ministry of Agriculture and Cooperatives.

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THE SUSTAINABILITY OF MECHANIZATION IN THAILAND*

William Chancellor**

ABSTRACT

The technical sustainability of machines in Thai agriculture has been demonstrated by the rapid growth in machine numbers and uses, and the availability of parts and low-cost services. Both imported and locally made parts are nearly always available, particularly during the peak seson, at the provincial manufacturers and machine distributors. Capability for maintenance and repair are incresed greatly during the past 20 years due to broad training programs on mechanical skills offered by government agencies, technical schools, large-tractor distributors, local manufacturers and mechanic shops. The large number of mechanics results in the low-cost maintenance and repair to the farmer and a high rate of machine availability.

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THE SUSTAINABILITY OF MECHANIZATION IN THAILAND

William Chancellor

In countries where mechanization of agriculture has only recently been introduced, concerns frequently arise as to whether there will be sufficient technical capability and capacity to sustain the working ability of machines by effecting the needed repairs on an efficient basis. During the past 15 years, development of this technical capability in Thailand has been dynamic and has encompassed many unique features. The technical sustainability of machines on Thai farms has been marked by:

a) intensive and severe use of large tractors with a related high rate or repair requirements,

b) rapidly incresing numbers of small 2- and 4-wheel locally-made tractors of very simple design necessitating low repair requirements,

c) large flows and broad availability of new and used imported spare parts and a sizable local industry for spare parts manufacture, and

d) broadly distributed knowledge of mechanical repair techniques and the resulting availability of low-cost mechanical services at all hours of the day.

The number of farm tractors in use in Thailand is given in Table 1. Typically two or more drivers have been used per tractor, so thta if operators were to be trained, the minimum number requiring training would be on the order of 85,000 per year. The demand for mechanics has been found to range from 38 percent of operator time for large four-wheel tractors (Chancellor, 1970) to 17 percent of operator time for small two- and four-wheel tractors (Maranan et al., 1983). Operator time ranged from approximately 200 hours per year for the smaller units to about 100 hours per year for the larger machines.

Despite the rapidly increasing numbers of small tractors, the mechanical work performed by the large units still dominated the scene in 1981, as is shown in Table 2.

The large tractors have been mainly used in tillage of partially cleared upland areas using disc plows or disc tillers. These implements, when in these typically rough conditions, do not have their tail wheel continuously engaged with the soil. As a result, side-thrust shocks have been frequently applied to the hydraulic lift linkage of the tractor. Although most large tractors in Thailand have had this linkage reinforced, rapid wear and deformation has been

common. Resistance to the side-thrust is generated by steering the front tractor wheels so as to compensate for the yawing torque applied. This has resulted in rapid wear and deterioration of the fron axle and steering parts. The rough and partially cleared terrain has caused extensive tire damage. Frequently a carrying platform has been fasted to the front of the tractor, and in remote areas both fuel and grain have been commonly transported on this platform over areas both fuel and grain have been commonly transported on this platform over rough terrain. This has imposed severe loads on the front axle assembly.

When these large tractors have been used in tilling rice fields, field borders were frequently crossed by driving the tractor into them at high speed. This also tended to overload the front axle. About 10 percent of the large tractors have been equipped with rotary tillers for rice-field and tobacco cultivation. Torsional shocks on the power-take-off system and axial thrusts on this system when lifting and lowering the rotary tiller has caused frequent failures in elements of the power-take-off drive train.

The large tractors have been primarily operated on a custom-hire basis in which very intensive use of the tractor occurred (engine operated at full power, and multipie drivers used to achieve 12 to 20 hour-per-day scheduling). Clutch failures have been common and general deterioration has been rapid for machines operated 240 or more hours per month. This intensive use has been resorted to in order that income per unit capital cost could be increased, since most large tractors have been sold on credit terms.

When local sales agents have competed severely for sales, they frequently have done so by reducing the amount of down payment required. In cases where the down payment ws unusually low (20 percent or less of the purchase price) 24-hour-per-day operation of the tractor in combination with non-payment of purchase installments allowed buyers to make money even though the tractor was repossessed after 6 to 8 months. Tractors operated under these economic circumstances received a minimum of attention to maintenance.

With proper economic management of credit sales for large tractors, the local sale agents have been charged with assuring the credit-worthiness of buyers, and received most of their commission from the periodic payments of buyers. These agents were thus in a position to know when a tractor in custom-hire service has broken down (periodic payments don't arrive) but they were also in a position to stock spare parts and retain trained mechanics so that the tractor could be put back in working order. Distributors who held the credit contracts, also depended on the tracotrs continuing to operate, and they were in a position to import spare parts or to have them locally manufactured. Distributors also acted as a center for mechanic

training. Thus, a properly designed and managed credit contract tended to keep all participants in the tractor custom-hire system focusing their attention, and the resources within their efficient command, on the sustained field performance of the tractors.

In an early survey (Chancellor, 1970) it was found that about 19 percent of the local sales agent's revenue was from spare parts sales. In 1982 the sales of spare parts for large tractors in Thailand amounted to approximately 500 million baht, or 10,000 baht per tractor per year.

Data from the above-mentioned study, and those from a study done in 1979 (Wattanutchariya, 1981) are presented in Tables 3 and 4, respectively to give some indication of the costs of repair and maintenance for large tractors operated in custom-hire service in Thailand.

The locally made small two- and four-wheel tractors have been produced by small-scale manufacturers, and distributed primarily in the local area surrounding the manufacturing firm. The designs (Fig. 1) used have been particularly simple and rugged. Mechanical components used were all commonly available in the local market. Certain key parts n some designd were made using used automotive parts, mostly imported from Japan. The two-wheel tractor, in particular, has been very low priced (5000 baht without engine in 1983) and suited to both the economic and physical conditions associated with rice production in Thailand. It was thus adapted to owner use and operation on small-scale farms, and consequently did not have to be operated a great number of hours annually to be economically feasible.

Fifteen years ago this two-wheel tractor was usually found equipped with an air-cooled gasoline engine. However, because of the fuel price increase and the greater efficiency of diesel engines, the current state of technical and economic knowledge among farmers in Thaland has allowed most buyers to now know the advantages of buying the tractor equipped with the more expensive (but longer-life) liquid-cooled diesel engine. These engines typically (in 1983) cost 2 to 3 times the price of the two-wheeled tractor chassis. The engines have been, therefore, used for water pumping, boat propulsion and for powering a locally made transport vehicle, when not used on the tractor. Thus the engine has been frequently operated many more hours each year than was the tractor. This was done to make more efficient use of the capital sunk in the engine.

Currently about 80 percent of these diesel engines sold in the country in 1983 were supplied by two local manufacturers licensed by Japanese companies. These manufacturers are scheduled to increase the percentage of local content in the engines each year.

Data for these locally-made tractors (Maranan et al., 1983) for the 1980-81 year indicated that repair costs were about 49 percent of fuel costs (as compared with the 125 percent of fuel costs for large tractors reported by Wattanuchariya, 1981). About 57 percent of the breakdowns reported by Maranan et al. (1983) were related to the engine. These figures point to the ruggedness of the simple design of these locally made tractors. For field work the two-wheel tractors have used steel wheels. The four-wheel units used retreaded truck tires. Old truck tires have been also used with the two-wheel units for road transport. The truck tire carcasses are very strong and thus resistant to the high incidence of tire problems found with larger tractors by Chancellor (1970).

Information on axial-flow type rice threshers during 1978 (Pathnopas, 1979) indicated that maintenance costs were about 130 percent of fuel costs, but only 12 percent of revenue (as opposed to 30 percent of revenue for large tractors) when these threshers were operated in the custom-hire mode.

Status and Development of Repair Skills

During the past 20 years the level of generally held knowledge on the maintenance and repair of motorized equipment has increased greatly in Thaland. An indication of this is that about half of the taxis in Bangkok are 20-year-old models. In the intervening years nearly all these cars have been fitted with replacement engines, with air-conditioners and with LP gas carburetion systems. This points to the capability of the local technical sector to respond rapidly to economic incentives.

Training in mechanical repair skills has for several years been in general demand. A number of technical schools have been offering this sort of training. The Ministry of Agriculture and Cooperatives has been operating training centers at three locations in Thailand at which a 110-day course in technical agriculture has for many years been offered to sons and daughters of member sof farmers' associations. About 1,000 persons per year in the country have completed this course which emphasizes farm equipment selection, maintenance and repair, among other things. Chancellor (1970) found that persons who had completed this course were able to manage tractors with much reduced repair costs and with fewer problems than was the case for persons not having had any formal training. These trained persons were also found effective in training others who worked with them in tractor operation and management.

Despite the effectiveness of this training for the individuals involved, the 1,000 per year trained has been an insignificant fraction of the approximately 85,000 new tractor operators who have taken the controls of machines each year since 1975.

Distributors of large tractors have provided training for 100 to 150 mechanics each year. Because training has been focused on specific machines, considerable depth and detail has been achieved. The persons trained were those employed by local sales agents or those hired by the distributors as mobile service team members. In 1968 over 20 different brands of large tractors were being sold in Thailand. In 1983, three or four main brands dominated the market. Distributors surviving the competition were those providing strong support services in terms of mechanic training and spare-parts availability.

The two firms manufacturing diesel engines for agricultural use in the country have also been providing training courses for approximately 200 (total) mechanics per year. As with tractor distributors, these mechanics were employees of franchised sales agents, or were members of mobile service teams operated by the manufacturers.

Most of the mechanical services used by tractor owners were obtained from local workshops. Owners of small, locally-made tractors did about 30 percent of their own repairs and called on the local shops for about 60 percent (Maranan et al., 1983). For large tractors in 1968, Chancellor (1970) found that owners did about 40 percent of their own major repairs, local workshops did another 40 percent, and dealers and distributors were relied upon for about 20 percent.

Because a tractor or implement breakdown can be critical during the main working seasons, mechanics, workshops and tire repair shops were prepared to work during the night and on weekends and holidays. Despite the demand for mechanics' services, the rates of charge found by Maranan et al. (1983) averaged only about 12.5 baht per hour (slightly less than twice the official minimum wage for non-metropolitan areas).

The excellent state of road transport in Thailand aided greatly in the distribution of spare parts. These parts could be dispatched in the afternoon in response to a telephone or telegraph order, and reach the recipient the next day. Individuals could also use overnight bus transport to go to Bangkok to obtain the needed parts and return home within 24 hours. Larger tractor distributors had extensive networks of spare-parts sales agents. Local manufacturers frequently offered repair services in conjunctin with their factory operations. These factory-related repair shops could easily make or substitute for any part of a machine they had produced.

In some few cases these manufacturers chose not to engage in the repair business, and thus attached a nameplate to the tractors produced which listed only the name of the wholesaler ordering the tractors. Such cases, however, appeared to be limited to the two-wheel tractor which was so common and so simple in construction that any well-equipped workshop could effect repairs.

Summary

In Thailand the technical sustainability of agricultural machinery systems has been marked by:

a) intensive use of large tractors with a minimum of attention given to prevention of machine deterioration,

b) locally manufactured small tractors of exceptionally simple and rugged design so that few complex repairs have been required,

c) an extensive general knowledge of machine repair techniques, a wide availability of low-cost machine repair services and a well-developed network of spare-parts supplies from import and domestic sources, so that repairs could be quickly effected, and

d) a remaining strong potential for the training of farm machine operators so that the economies of reduced machine breakdown could be realized on a more general basis.

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Table 1

	1975	1981	Average annual increase
Two-wheel tractors	90,001	284,351	32,392
Small, four-wheel tractors	14,575	39,158	4,097
Large, four-wheel tractors	13,338	50,044	6,118
Total	117,914	373,553	42,607

Table 2

Type of tractor	Number	Typical horsepower	Thousand of hp available	Typical annual hours	Millions of hp-hrs annually
Two-wheel	284,351	8	2,275	200	455
Small four-wheel	39,158	16	627	400	251
Large four-wheel	50,044	60	3,003	1,000	3,003
Total			5,904		3,709

Table 3*

Repair and Maintenance of 50-70 Hp Tractors (1968)

1. Tractors were disabled 26% of the time during the main work season.

2. Repair labor was 131 man-days (8 hrs) per year per tractor (38 percent of driver labor).

3. Repair cost breakdown:

A)	Mechanical repairs of tractor	48%
B)	Tire repairs for tractor	34%
C)	Mechanical repairs of implements	18%

4. Repair costs during any year =

(initial tractor price) x [2% + (4% x age in years)]

At 6.5 years of age, total repair costs = initial price

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* Data from Chancellor (1970)

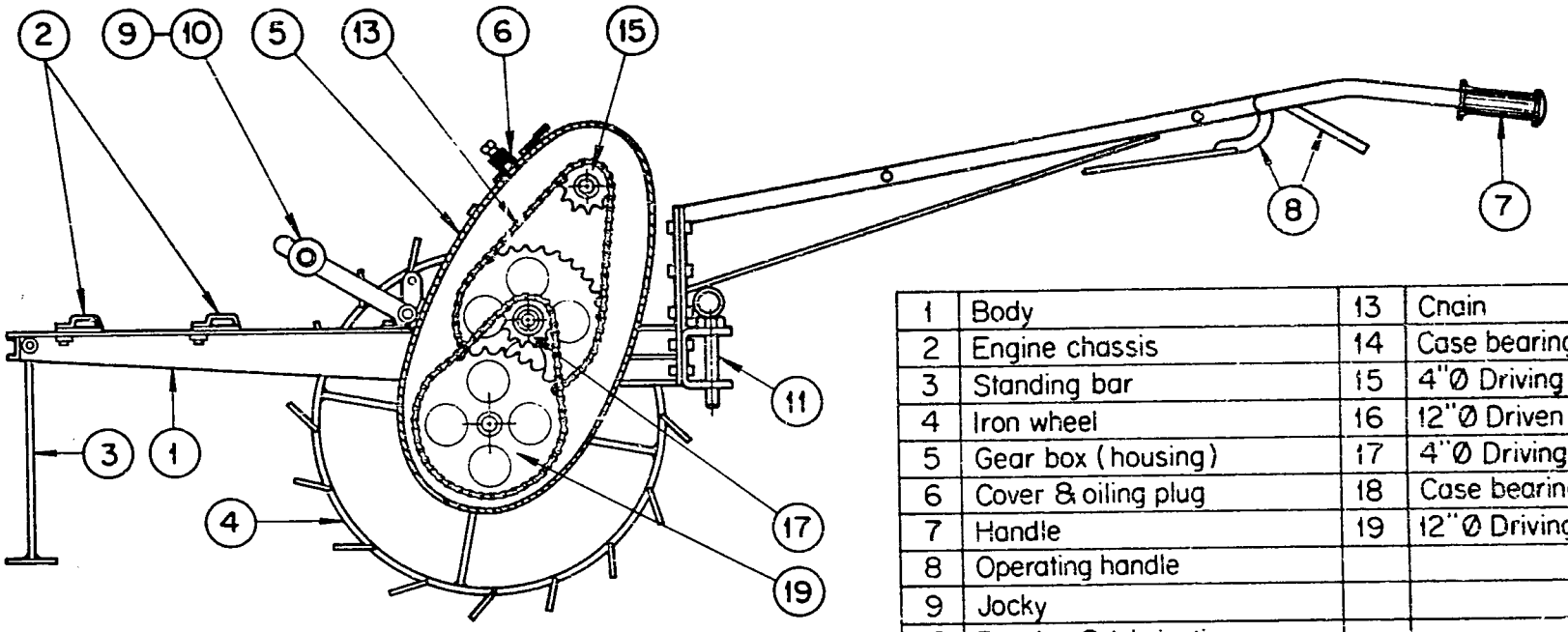
Table 4*

Operating Costs for 50-70 Hp Tractors (1979)

Total annual revenue per tractor	70,771 baht
Total annual cash costs	64,443
Annual repair and maintenance costs	21,548
Annual fuel costs	17,308
Annual driver wages	3,087

Repair and maintenance = A) 123 baht/hectare
B) 1.25 x fuel costs
C) 30% of revenue

*Data from Wattanutchariya (1981)



SIDE ELEVATION

1	Body	13	Chain
2	Engine chassis	14	Case bearing & housing
3	Standing bar	15	4"Ø Driving sprocket
4	Iron wheel	16	12"Ø Driven sprocket
5	Gear box (housing)	17	4"Ø Driving sprocket
6	Cover & oiling plug	18	Case bearing housing
7	Handle	19	12"Ø Driving sprocket
8	Operating handle		
9	Jocky		
10	Bearing & lubrication		
11	Attaching pin		

THAI POWER TILLER

SCALE: 1/8 : 1 Inch 6-21-'74

Fig. 1. Cross-sectional view of the two-wheeled tractor chassis manufactured by numerous small-scale factories in Thailand. The figure is taken from: Pinthong, Chirmsak, 1974. Economics of small tractor production in Thailand. Master of Economics thesis, Thammasart University, Bangkok, Thailand.

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FARM MECHANIZATION POLICY IN THAILAND*

Tongroj Anchan**

ABSTRACT

The paper reviews the general situation and impact of farm mechanization. Impacts on output, employment, income and income distribution remains unclear and inconclusive. Despite the absence of specific policies for farm mechanization, many economic policies directly and indirectly affect the utilization of machine and the farm machinery industry. Many policies are inefficient and ineffective, while others have adverse influences on certain sectors. The improvement of simple farm equipments in rainfed areas should have higher priority.

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FARM MECHANIZATION POLICY IN THAILAND

Tongroj Onchan

INTRODUCTION

Agriculture in Thailand is in a transitional stage. During the past twenty years, the relatively high growth rate of agriculture has been achieved mainly through the expansion of cultivated areas. This pattern of growth can no longer continue since Thailand has now reached its land frontier. Therefore, a new strategy for agricultural development has been adopted and emphasis has been placed on the increase of agricultural productivity. This can be achieved only if new technology is available and is widely adopted.

Agricultural development in Thailand must also take into account the fact that the growth rates of population and labour force have been quite high. In the past, agriculture was able to absorb most labour by means of expansion of land areas. Since this pattern of growth cannot be continued, an increase in cropping intensity of existing farm lands must take place. Furthermore, labour intensive techniques of farming will be desirable to help absorb the increasing farm labour force. The problem of employment has received great attention from the present government and it has been given one of the highest priorities in the next development plan.

Another policy issue of interest to the Thai government concerns the interrelated problems of rural income, rural poverty, and income distribution. Even though past development efforts have resulted in a significant decline in rural poverty (from 61 percent in 1962/63 to 25 percent in 1978), rural poverty is still a very serious problem especially in the poorest region, the Northeast, where poverty is severe. Income distribution gaps among regions and between farm and non-farm sectors are quite serious and appear to be worsening over time.

Any discussion on agricultural policy will have to bear in mind all these issues. Farm mechanization[1] is, at the present time,

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[1] Farm mechanization means here the introduction and use of mechanical procedures into farm operations in an area where these procedures have not previously been used. Several types are included, namely tractorization, improved pumps, means of transport, improved implements and first state processing of farm products (Southnorth and Barnett, 1974, pp. 335-336).

still in its early stages and much confusion surrounds the subject. This is quite understandable since mechanization involves a complex of problems-technical, economic, social, political - that must be faced by decision makers at several levels, i.e. among farmers, manufacturers and distributors of farm machinery, policy makers and administrators of public programs.

This paper attempts to present an overview of farm mechanization in Thailand, its extent, utilization and impact. Some policies which directly or indirectly affect farm mechanization will also be reviewed and discussed. Finally, some mention of farm mechanization approaches and strategy will be made.

CURRENT STATE OF FARM MECHANIZATION

There have been attempts at farm mechanization in Thailand ever since 1910 when steampowered tractors and rotary hoes were imported by the government. Only in the mid 1950s, however, did farm machinery (in the form of tractors and water pumps) become better known to Thai farmers. In 1955 the total import of tractors was 262 vehicles. This increased to 1,487 in 1961 and 2,414 in 1971. Of the 6,877 such vehicles imported in 1975, 4,231 were farm tractors. Evidently tractorization has become quite widespread since the 1970s. The use of water pumps has also increased remarkably, as indicated by increases in imports from 11,166 units in 1960 to 212,319 units in 1975. From 1975 to 1981, imports of both farm tractors and water pumps also increased to 12,867 tractors and 491,052 water pumps (Table 1).

Commercial domestic production of tractors actually began in the early 1970s. Data on domestic production since 1974 is available. In that year 24,808 two-wheel power tillers and 2,324 four wheel power tillers were produced. Since 1974, domestic production of power tillers, both two-wheel and four-wheel, shows an increasing trend. However, the number of tractors produced appears to have decresed slightly over time.

Data in Table 2 shows the stock in use of different types of tractors and other types of farm machinery during the period of 1975/76 to 981/82. It is clear that the number of all types of farm machinery has increased. As for tractors, two-wheel tractors had the greatest net increase from 1976/77 to 1980/81 and then dropped markedly in 1981/82. Tractors of less than 45 hp show a wide fluctuation of net increase over time, though the net increase substantially dropped in 1981/82. The case of big tractors (over 45 hp) is quite remarkable. The net gain from 1980/81 to 1981/82 was from 3,892 to 12,867 vehicles. The slowdown of domestic production in recent years has been caused by a decrease in demand which in turn has been affected by the decline in major farm product prices.

As regards other types of farm machinery, rice threshers provide an interesting case as the increase from 1975/76 to 1981/82 was about five times. After a steady increase until 1979/80, a big jump occurred in 1980/81, when the net increase was about 19 times (from 667 to 12,170 units). The net gain then dropped drastically to 2,207 units in 1981/82. This slowdown could be attributed to the same factor(s) as that in the case of two-wheel tractors.

Water pumps have been widely used by farmers all over the country for many years. The number has increased substantially over time. From 1975/76 to 1981/82, the number has more than doubled. Net increase shows some wide fluctuations, much greater in 1981/82 than in 1980/81.

Other machines such as water wheels and winnowers show generally steady net increase over the same period (except in 1978/79 for water wheels).

The extent of farm mechanization may also be demonstrated by the data in Table 3. The number of tractors in use per 1000 hectares of cultivated land varies among regions. For the whole kingdom, over the period 1975/76, 1979/80 and 1981/82 there was an increase in the numbers of all types of tractors. This is particularly true for power tillers whose number increased from 5.01 to 12.25 and 14.65 per hectare. In later periods, the number of large tractors seems to be somewhat greater than that of smaller tractors. The number of tractors has been increasing over time in all regions. In all cases, except that of large tractors in the North, the number of such vehicles especially the number of power tillers, is greatest in the Central Plain.

Estimates of horsepower per hectare in 1979/80 for selected machines are presented in Table 4. The average for all types of tractors for the whole Kingdom is 0.24.[2] The horsepower per hectare is about the same for two-wheel and large four-wheel tractors. The average horsepower per hectare for water pumps is quite low (i.e., 0.089). As expected, the average horsepower per hectare varies among regions and follows the same pattern as the average number of tractors per 1,000 hectares. The high level of mechanical power available in the Central Plain and in the North reflects the widespread use of power tillers and large tractors and hence relatively intensive land utilization.

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[2]This is considerably greater than the FAO estimate in 1967-68 which was 0.05 for Thailand (cited in Merrill, 1975).

THE AGRICULTURAL MACHINERY INDUSTRY[3]

The government, through the Division of Agricultural Engineering, began to produce farm machines in 1950s, and commercial production took place in the mid-1960s. Local production capacity expanded rapidly and then started to level off in late 1970s and early 1980s. In 1982, 143 factories producing farm machinery and implements in Thailand were reported. Almost 50 percent of these factories are located in the Central Plain, especially in the five provinces of Bangkok, Chachoengsao, Lobburi, Saraburi and Ayudhya. Factories located in other regions are small (with less than 10 employees). In fact, for the whole country, about 50 percent of the factories are small and labour intensive. Large firms (having over 30 employees) constitute only about 20 percent of the total number of firms.

Production capacity does not appear to have been fully utilized. Large firms produce more than half of the total, while medium and small size firms produce 25 and 19 percent, respectively.

It is generally known that almost all factories obtain their machine designs through copying and modifying machines that are available in the market. In the early stage of the industry, many modifications of power tillers were made to suit local physical conditions and tastes. The design and the technology of power tillers are now well accepted by farmers. Any change or modification usually means more cost to the manufacturers. With regard to design and technical knowledge, it should be noted that many factories have benefited from the Agricultural Engineering Division (AED), The International Rice Research Institute (IRRI), and the Industrial Service Division (ISD). However, the assitance from these agencies has been limited mainly to supplying information.

The problems of the farm machinery industry include: high risk, low purchasing power and technical skills or users, small farm size, limited market size coupled with easy entry, and dispersed and small-scale factories. These problems appear to be inherent in the agricultural sector and in the agricultural machinery industry as well, contributing negatively to the growth of the industry. There are also problems or factors external to the industry such as lack of sound and explicit government policy and problems of tax structure. The problems of local manufacturers involve financing, marketing, and production. Details of all these may be found in Nit Sammapan et al. (1982). An understanding of these problems will be useful for policy formulation and planning for the promotion of the farm machinery industry.

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[3]For detailed discussions, see Loohawenchit and Pathnopas (1981), Loohawenchit (1980), Nit Sammapan, et al., (1982), Pintong (1974), Taenkam (1980) Chakkaphak, (1978).

FARM MACHINERY UTILIZATION

1) Extent of Farm Mechanization

The extent and pace of farm mechanization in Thailand varies among the regions. The Central Plain, which is the most progressive farming region with the highest percentage of irrigated area in the country, has had the highest level of farm mechanization. Although largest in land area and population, the Northeast has a small share of the farm machinery, compared with the North and the Central Plain. The case of the two-wheel tractor is an obvious example. The Central Plain has about 58 percent of the total number of tractors while the North, South, and Northeast have 26, 9, and 7 percent, respectively. The case of small farm tractors is quite similar, while big farm tractors (over 45 hp) appear to be distributed relatively more evenly among the Central Plain, North and Northeast regions (Table 5).

About 55 percent of all water pumps are in the Central Plain compared with 23, 19, and 4 percent in the North, Northeast and South. Other types of machinery are not shown in the Table. However, data from elsewhere shows that rice threshers and water wheels are used mainly in the Central Plain (over 90 percent of the total number). Corn threshers are found mostly in the North (66 percent of the total). Sprayers are used in the Central Plain (41 percent), North (40 percent) and Northeast (24 percent) (Sukharomana, 1983 Table 4).

From the data presented, it is quite clear that tractorization has been most dominant in the Central Plain. The use of large tractors is quite significant in the North and in the Northeast only slightly so. This is due to the fact that most upland areas in the Northeast require large tractors for land preparation, especially during the dry season or early rainy season when the soil is too hard to be ploughed by animals.

2) Factors Affecting the Utilization of Farm Machinery

Experiences in other relatively advanced countries like Japan, Taiwan, and South Korea seem to indicate that the level of farm mechanization increases with the level of farm commercialization. As farming becomes more and more commercialized, the demand for farm machinery will continue to increase. If this is the case, there must be a number of factors which will affect the utilization of farm machinery. These factors have been identified by Loohawenchit and Renu Pathnopas (1981) and Loohawenchit (1983). They include:

1. Irrigation and double cropping
2. Adoption of HYV's of seeds
3. Profitability of machine use
4. Increased purchasing power of farmers

5. Contractor service
6. Natural environment
7. Demonstration effect and the learning process
8. Other non-economic factors
9. The ability of local farm machinery industry to adjust to the needs of local farmers.

These factors are quite familiar to those interested in Thai agriculture. For example, over the past three decades, the Thai government has invested a tremendous amount of money in irrigation projects. Irrigated areas comprise about 20 percent of the total area, and are increasing over time. Cropping intensity has also been increased. New rice and corn varieties have increasingly been adopted by farmers, especially in the Central Plain, North and Northeast. The use of both farm tractors and rice threshers has proved quite profitable (Pinthong, 1974, Taenkam 1980, Pathnopas, 1980). The income of Thai farmers, though relatively low, has increased over time, especially in the Central Plain, and this has resulted in an increase in the purchasing power of the farmers. Contract services have been very common and in fact have helped speed up farm mechanization in the initial stage. Big tractors, which are very expensive, are nonetheless used by farmers even in the poor region of the Northeast and are easily accessible through contract services (Wattanachariya, 1983, Pak-uthai, 1981, and Chancellor, 1980). The need for tractors also arises from the natural environment especially when the soil is too hard for animals to work. Non-economic factors also have an effect on the demand for tractors. Finally, the ability of local farm machinery industries to adjust to local needs is well documented. The machines are usually modified to make them more operational under local conditions. Provision for after-sale services has also been very good. The factories usually get feed-back from the farmers which results in improvement of the machines.

In addition to these factors there are others, such as agricultural policies of the government, which will directly or indirectly affect the use of farm machines. These include subsidized credit, infrastructural investments, subsidized fertilizer, and price support programs. Some of these policies will be discussed later.

IMPACT OF FARM MECHANIZATION

Among the most controversial issues with regard to farm mechanization in a developing country like Thailand is the potential impact on production, employment, income and income distribution. Farm mechanization may be regarded as a major indicator of development and therefore, an essential part of agricultural development. It is then arguable that mechanization will increase agricultural production and employment by bringing more land into production, increasing multiple cropping, and improving cultivation practices. However, it

may also be argued that, if introduced too early in the development process, in a country where labour force increases at a high rate, farm mechanization may create unemployment, causing even more unequal distribution of income within the farm sector.

These important issues of farm mechanization have been of great interest to various agencies in many parts of the world, especially in the developing countries of South and Southeast Asia. A comprehensive review on this has been done by W.C. Merrill (1975). Merrill's review covers a wide range of countries including those in Latin America and Asia (though Asian experiences appear to get more attention). Hans P. Binswanger has also taken a careful look at the economics of tractors in South Asia (Binswanger, 1978). Another recent publication of findings of a farm mechanization study in Asia has just been released by IRRI (1983). The IRRI sponsored project on the consequences of small rice farm mechanization in Thailand has recently been completed. The interesting results of this study have been reported in a seminar in Bangkok, November 10-11, 1983.

Though all these major works deal with the impact of farm mechanization, the findings are still inconclusive. A careful study of the conclusions of Merrill's 1975 report compared with the IRRI's 1983 findings (for Asia and Thailand) will show that the two had remarkably similar results. This, if anything, indicates that systematic research on the problem is still required. The research methodology may have to be modified to obtain results which will give more concrete conclusions on the immediate and long-term impact of farm mechanization in the process of agricultural development in a country like Thailand.

This section will attempt to summarize findings on the impact of farm mechanization indicated by available research. A more detailed discussion on this may be found in the studies mentioned above.

1) Farm Mechanization and Output

Farm mechanization is usually said to affect output in four ways. (1) it can increase yields. (2) It can increase cropping intensity. (3) It can expand cultivated area. (4) It can reduce losses and improve quality in post harvest operations (Adulavidhaya and Duff, 1983). However, available findings of research studies in Asia (including Thailand) do not indicate a clear relationship between mechanization and crop yields, cropping intensity, and growth in the cultivated area. These studies suggest that farm mechanization contributes little, if anything, to farm output.[4]

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[4] A number of studies report a positive yield and output effect (see for example, Inukai, 1971 and Pongsrikul, 1983). However, they are too few and too area specific. Most findings are inconclusive.

Merrill states that "In its early stages, farm mechanization, usually has very little, if any, effect on crop yields ...., it appears unlikely that deep plowing, better weed control, or improved gain harvesting resulting from mechanization will increase yields by more than 10 percent" (Merrill, 1975, p.1). He gives several reasons for this. One is that the introduction of tractors, when other technological inputs are unchanged, merely substitutes one power source (tractors) for another (usually are animal). Furthermore, during the early stages, it is only a partial mechanization, i.e. for land preparation. A more complete mechanization, e.g., weeding, fertilizing and harvesting, would have a greater effect on yields. Clearly, mechanization alone without additional inputs such as fertilizer, irrigation, new varieties of seeds, and pesticides, would not have a significant effect on yields and output.

2) Farm Mechanization and Employment

The impact of mechanization on employment is of particular interest to policy makers. Unemployment problems are receiving great attention at present. Unless policy makers are convinced that mechanization will not worsen the current and future unemployment problem, mechanization will not be justified. Supporters of farm mechanization point out that more on-farm employment can be generated through increased cropping intesity. Additionally, off-farm employment can also be increased. For example, labour inputs are required to build and maintain the machines. These inputs may more than offset the reduction in farm employment. Furthermore, if labour is saved on the farm, it may be employed outside the farm (in construction work, for example, or for other non-farm activities in villages, towns, and cities). However, this can only occur if off-farm employment is available.

Again, available data are not adequate to provide a clear conclusion on this issue. In fact, it is difficult to separate the employment impact of mechanization from that of other technological or institutional changes that may occur simultaneously with mechanization. Moreover, the reliability of data on employment (or labour utilization) is always subject to question.[5]

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[5] To collect data on farm employment over a one-year period is more difficult and more costly than other types of farm data since it may require several interviews to capture seasonal variations.

At the current state of art, it may be said that mechanization which replaces animal power usually results in a reduction in labour inputs. According to Merrill, during the early stages of mechanization of grain production, labour requirements may be reduced by as much as 30 to 40 percent. Non-farm employment engaged in the manufacture distribution and maintenance of farm equipment replaces only a small part of the on-farm employment displacement (Merrill, 1975, p.2). Displacement of on-farm employment by mechanization is also found in IRRI studies (Adulavidhaya and Duff, Dermot Shields, and Pongsrikul).

The employment impact of mechanization cannot be considered independently. Account must be taken of the overall employment situation in both rural and urban areas. off-farm employment may indeed be very significant in rural development which has the dual objective of growth with equity. It must be promoted, especially in the provinces. If this policy is successful, farmers, especially the tenants and the landless, may be able to find more attractive jobs elsewhere. This issue, however, is a rather complex one and requires careful consideration.

FARM MECHANIZATION AND INCOME DISTRIBUTION

Related to employment is distribution of income. If mechanization does in fact displace labour, those who will most likely be affected are landless farmers who depend largely on farm work. There is evidence that mechanization (e.g., mechanical threshing) reduces total labour requirements of which a substantial portion is hired (Adulavidhaya and Duff, 1983, Table 15). The net effect is a reduction in earnings by hired labour. The result may be a more unequal distribution of income. This is somewhat confirmed by the findings of Saitan (1983) and Pongsrikul (1983). Saitan finds that farm income distribution as measured by Gini ratios is more unequal among those farms that hire tractors than among those farms that own tractors. The results also indicate that when off-farm income is added to farm income, income distribution improves among all classes of farms. The contribution of off-farm income to a more equitable income distribution among rural household is also found in other studies (see, for example, Onchan, 1979).

AGRICULTURAL MECHANIZATION POLICY

Until now the government has had no explicit or declared policy on farm mechanization. However, the formulation of such a policy is

in process.[6] It can be expected that Thailand will finally have farm mechanization in the very near future. The government policy or view on farm mechanization is now clearer than before. In a document prepared by the Ministry of Agriculture and Cooperatives, "Views of the Government on Certain Aspects of Farm Mechanization in Thailand and the UNDP/FAO Agricultural Machinery Project", a quotation is taken from the inaugural address by the Deputy Minister of Agricultural and Cooperatives. It states:

"I wish to clearly state that it is the Government policy to give high priority to the development, production and use of agricultural machinery appropriate for different areas. Farmers in the poverty-striken areas should have improved tools with human beings or animals as the source of power. Machinery with mechanical power should at the same time be further developed. These small machinery are not meant to replace labour but will help facilitate and better the work ..... It is therefore a government policy to promote appropriate agricultural machinery...." (p.2).

There is no doubt that this statement clearly spells out the current thinking of the government on this important issue. Emphasis will be on improved tools and on the development of appropriate small machinery for poor areas. This is clearly quite different from the past and current state of farm mechanization.

According to the above statement, agricultural machinery is considered a part of agricultural engineering. This includes development, production and use of tools, equipment and machinery used in the process of farming soil preparation, planting, watering, weeding, plant protection, harvesting, threshing, transport, and storage and processing of agricultural produces. Such equipment has three sources of driving power-human, animal and mechanical or other substitute power (MOAC Document, pp. 2-3). Hence, there is a need for a balanced development of appropriate farm mechanization, something which is generally not adequately covered in most farm mechanization studies. In too many cases, farm mechanization is treated as tractorization, a very narrow vies of mechanization. Unfortunately, this present paper is not much of an exception.

There are several policies that may directly or indirectly affect the extent and the pace of farm mechanization in the country. Some of the most relevant will be discussed here. They include: taxes and tariffs, credit policy, industrialization policy, research and development and/or training and agricultural development.

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[6]The National Committee for Agricultural Mechanization was set up in 1979, among other things, to formulate policy and implementation plan for farm mechanization.

1) Taxes and Tariffs[7]

Prior to 1982, the local farm machinery industry had to pay more taxes than those who imported farm machinery. This put local manufacturers in a disadvantageous position. Tractor import was at a high level of 15,480 vehicles in 1981. The policy of the government appears to have worked against the development of the local small-scale industry, an effect conflicting with the industrial development policy.

The local machinery producers, through the Association for Thai Industries, were successful in pressing the government for increased protection in the form of higher tariff rates for imported machinery and imported engines amounting to 33% of the C.I.F. value in both cases (compared to the previous 5% of the import price). In addition, an import quota was set for farm machines in order to control the quantity imported. For example the quota was 5,337 for two wheel power tillers, which is much less than the quantity imported in 1981, 15,480 vehicles.

In order to study this issue carefully, Loohawenchit made a calculation of the tax burden before and after adjustment in 1982. He found that local manufacturers did indeed pay a higher percentage of taxes before the adjustment (24.14% of the cost of production compared to 20.32% of the C.I.F. price). However, after the adjustment in 1982, machine importers had to pay higher taxes than those for locally produced machines, i.e. 52.4% of the C.I.F. price as compared to 35.6% of the production cost. Clearly, local manufacturing firms are now well protected. This has been interpreted as a government action for the promotion of the local, small-scale, and labour intensive industry, which is in accordance with the current industrial development policy. But Loohawenchit is of the opinion that this policy of protectionism will retard the growth of the industry since local producers will be less inclined to innovate and cut production costs in order to compete with imported machines. As a result, he stated, farmers will end up paying higher prices for the machines. This is the common case of government protecting the local industry at the expense of poor farmers. This type of policy has been controversial for a long time. If not carefully designed and implemented, it may indeed be detrimental to rural development.

2) Credit policy

Credit policy affects both farmers, who are the users, and producers, who are the manufacturers, of farm machinery. It is

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[7]This section is drawn largely from Loohawenchit (1983).

quite possible that the new farm credit policy[8] which has resulted in a dramatic increase in commercial bank credit since 1975, has contributed to the increasing demand for farm machinery. All banks have provided funds to farmers for the purchase of farm machines, including tractors. In this regard the credit operation of the Bank of Agriculture and Agricultural Cooperatives (BAAC) is of particular interest. Since 1980, the BAAC has been extending credit in kind to its clients. Credit for the purchase of farm machines is now being given in kind instead of in cash as previously done. Manufacturers of farm machinery will have to register with the BAAC. Once the machine brands have been approved by the BAAC, the farmer client can get the machine, which will be delivered by the manufacturer or the dealer. In the first year of operation, a great deal of criticism came from tractor dealers or manufacturers who did not participate in the programme. The BAAC was accused of playing the role of middleman and it was charged that the selection of machine brands was not really fair. However, this "farm mechanization credit" has been quite successful, and the farmers do appear to be getting machines of good quality at relatively low prices.

The extension of credit for farm machinery by BAAC and other commercial banks must have been increasing over the past 10 years, although the total amount of credit for this purpose has not been separately reported. Nevertheless, the BAAC reports that this credit in kind project has been very successful. The number of borrowers and the total credit for farm equipment and supplies has increased four times in 2 years (BAAC, 1982).

The fact that commercial banks and the BAAC have been providing credit for the purchase of farm machinery at an increasing amount over time may indicate the profitability of farm mechanization from the farmer's point of view. Therefore, if the demand for farm machinery increases in the future, and if it proves to be profitable, credit institutions are likely to provide the financial services required. However, it must be noted that there is evidence that the increased credit from institutions has been extended primarily to the relatively large rich farmers. Credit distribution has been very unequal among different groups of farmers and among the regions. If small farmers cannot get an equal share of subsidized credit, the problem of income distribution may worsen. This is a major policy issue of interest to the current government.

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[8]Starting in 1975, in an attempt to increase institutional credit to farmers, all commercial banks were requested to give loans directly to the farmers (or through deposits with BAAC). The required credit quota was set as a proportion of total deposit, now 13%. As a result, credit from commercial banks increased markedly from a few hundred million baht in the 1960s to over 25,000 million baht in 1982 (For discussion on this policy, see Onchan, 1982).

Credit for manufacturers is a different story. As pointed out before, finances is one of the major problems of the manufacturing industry. Generally, small firms suffer more in this regard than do the larger ones. Commercial banks are usually the most important credit institutions for these manufacturers. Credit from informal sources has also been quite significant. The Small Industry Finance Office (SIFO) under the Ministry of Industry has thus far not given much support to the industry. Only a few firms have received loans from this Office (Sammapan, 1982). The Industrial Finance Corporation of Thailand (IFCT) has been providing funds to some large firms, but the amount extended to this type of industry is still relatively small.

If farm mechanization policy is going to be given a high priority, as policy makers have stated, it is clear that the IFCT and the SIFO will have to play a greater role in financing the industry.

3) Research, Development, Extension and Training

This is the area where the government could be most effective, playing an important role in supporting the growing farm machinery industry and promoting farm mechanization in the country.

Farm mechanization has been characterized by limited types of machinery which concentrated mostly on land preparation (i.e. tractors). In recent years, however, farm machines of different types have been introduced and used. Small four-wheel tractors have been manufactured in Thailand. Rice threshers have become increasing popular in certain areas. Water pumps have been widely used and rice reapers are found to be used by a limited but increasing number of farmers. The development of farm mechanization in Thailand has therefore paralleled that of Japan, Taiwan and Korea (Adulavidhaya and Duff, 1983, p. 9). In fact, Mechanization strategy should be aimed at mobilizing resources to help ensure that farmers have a wide range of implements and tools from which to choose and that farmers know how to use and manage machinery input effectively and efficiently (Gifford, 1981).

This points directly to the role of research, development, extension and training in which much remains to be done. The public sector alone cannot possibly undertake all these functions. Cooperation from the private sector is therefore necessary.

With respect to the manufacturing industry, much mention has been made of its dynamism as indicated by the frequent modifications of machines and the necessary responsiveness to changing situations and farmers' needs. However, most small firms do not have technical expertise in agricultural engineering. Government agencies such as the The Agricultural Engineering Division (AED), Department of Agriculture (DOA) and the Department of Industrial Promotion (DIP),

can serve to upgrade and help standardise farm machines. In fact, AED has been quite active in this regard over the years. However, with limited capability, the AED is not able to provide adequate services. Increasing the capability of AED is requisite to the promotion of farm mechanization.

Research in agriculture has generally ignored rainfed and upland areas. If rainfed areas are to get priority in terms of development, research in farm machinery for these areas and for upland crop farming will have to be done. At present, research capabilities in this area are extremely limited. Besides strengthening research capability, there is also a need for research reorientation in farm mechanization so that new concepts will be learned and accepted by the researchers who are more familiar with irrigated mechanization. This issue is strongly emphasized by Chinsuwan (1983).

Extension work which involves mainly the users or farmers is also important and the Department of Agricultural Extension (DOAE) has begun to work in this area. Again, its limited capability in terms of personnel and knowledge will not allow a wide coverage. There is also a need to draw up an extension for farm mechanization.

As for training and education, the need extended to all levels, farmers, government officials, and college and university students. Three universities, namely Kasetsart, Khon Khaen, and Chiang Mai have been particularly active. The training of farmers may be done effectively by DOAE and AED. This is also true for the case of government (extension officers, and officers of MOA). However, in addition to AED, MOAE, trainers may also come from the universities. Finally, providing training to the staff of private fims (manufacturing and distributing) is also essential to mechanization development. In this regard, the public and private sectors may work together.

4) Industrial Development Policy

Increased industrialization usually enhances farm mechanization. As for Thailand, over the past twenty years, industrial growth has been particularly rapid. The share of manufacturing has increased from 13.1 percent of GDP in 1960 to 21.0 percent in 1982 compared with the agricultural share of 24.8 percent of GDP in 1981. It is estimated that at the end of the Fifth Plan period, the value of manufacturing output will roughly equal that of the agricultural sector. Furthermore, by that time, it is expected that the Thai economy will have been transformed into a semi-industrialized one. If this is the case, farm mechanization can be substantially increased (NESDV, Fifth Plan, p. 59).

The past performance of the industrial sector has caused great concern to the government. There are several reasons for this concern. First, the industrial structure is still very import dependent. Second, the export industry is not efficiently developed. Third, the technology used is still not labour intensive. And, fourth, development of basic industry has not occurred. Another issue which is of particular interest is the concentration of industries in and around Bangkok and their failure to disperse to provincial areas. Measures to reach planned targets have been many. One of these has been the promotion of small-scale industry in provincial areas.

In Thailand, most industries are small. Small firms tend to be very labour intensive. Therefore, to generate more employment, these industries should be promoted. As mentioned earlier, about 50 percent of farm machinery establishments have less than 10 employees. These establishments are also located mainly in and around Bangkok. If small scale industry is to be promoted, it is quite logical that farm machinery industry should bet a high priority. This is because small farm machinery factories are labour intensive (Loohawenchit, 1983). Furthermore this type of industry is closely linked with the farm sector. As commercialization of agriculture increases in the future, farm inputs from this type of industry will become more and more necessary. Besides, mechanical technology cannot be readily transferred or imported. It must be experimented with and modified to suit the local environment. This process will take some time. R & D activities must be done continuously. This can be jointly or cooperatively undertaken by both public and private sectors.

Development of farm machinery is actually an integral part of the rural industrialization which has been one of the major policy objectives of the current Plan. Promotion of the farm machinery industry, even if it must be done gradually and carefully, can take place in many ways. For example, a credit extension system and related institutions for industries in outlying regions can be developed. There should be improvement of research work and the development of production. Improvement of management techniques is also desirable as well as the promotion of subcontracting systems between small and large scale industries (NESDB, Fifth Plan, pp. 63-64). Major public institutions that may be involved in these effort include SIFO, IFCT, Department of Industrial Promotion (DIP).

5) Agricultural Development Policy

The extent and pace of farm mechanization will depend mainly on the development of agriculture. Since agriculture in Thailand is in a transition period, the next strategy must be to increase the productivity of land and labour. To implement this policy, new technology is called for, i.e. improved cropping or farming system, new seeds, fertilizer, insecticide, irrigation water, and farm machinery.

The adoption of new technology can occur only if production incentives are provided. Product prices must be raised and stabilized, land tenure security improved, and credit provided at reasonable interest rates. Past performance of productivity improvement has been very unsatisfactory, especially in rainfed areas where farming is of a subsistence nature. In these areas, yields of some crops have even shown a declining trend. Improvement of yields in this type of farming will be very difficult as the natural environment is not favourable and new technology usually unavailable. Farm mechanization must take a different form in these areas, for example, improved hand tools, animal-drawn machines, and so forth.

In more progressive areas where infrastructural facilities are more available, the potential for yield improvement and increased output is considerable. Irrigation systems must be improved, especially in terms of management, and cropping intensity must be increased. Agricultural development in this area appears to be a relatively easier task as new technologies (seeds, fertilizer, farm machines & implements, insecticide, etc.) are usually available. This is also an area in which farm mechanization (tractors, sprayers, threshers, water pumps, reapers, etc.) can be easily promoted.

SUMMARY AND CONCLUSIONS

Though farm mechanization in Thailand has, over the past 10 years, increased greatly, the level of farm mechanization is still very low. This is indicated by the very low horsepower per hectare (0.25 hp) and the low machine density per 1000 hectare ratios. Thai farm mechanization has been characterized by: (1) the dominance of hand-tool technology, (2) the use of locally manufactured or assembled major types of farm machinery, (3) the use of limited types of tractor attachments, (4) Mechanization, mainly in progressive farm areas, and (5) private contractor services, especially for large tractors. The farm machinery industry started to grow rapidly in the early 1970s and then slowed down considerably in the late 1970s and early 1980s. Over 50 percent of farm machinery producers are small and mostly located in and around Bangkok. The copying of farm machinery design has been common. Modifications on farm machinery were frequently made during the early stages of manufacturing. Standardization of farm machinery has not yet occurred, though there are some exceptions.

Utilization of farm machinery has been increasing at a high rate over the past 15 years. Power tillers appear to be the most popular machines, while small tractors have gained increasing popularity in recent years. Other farm machines of importance include large tractors, water pumps, sprayers, and threshers. The introduction and adoption of rice threshers has been particularly spectacular. Another machine which is relatively new is the rice reaper. It is being used only by a limited number of farms, but may be more widely accepted in

the future, especially in the progressive rice growing areas of the Central Plain and upper North.

The impact of farm mechanization on production, employment, and income distribution, based on available data in Thailand, remains unclear and findings from research are still inconclusive. In fact, available data does not show a significant yield and/or cropping intensity effect. Data on employment is even more unsatisfactory. Nevertheless, the data we have tends to indicate a negative effect on employment as may types of machines help save human and/or animal labour. If cropping intensity is not increased by increased mechanization, labour will be reduced. However, off-farm employment may help offset this effect. Finally, the effect on income distribution is also inconclusive. What can be said is that the effect has been very little, though there is some evidence of income inequality between farmers who own tractors and those who hire tractors. The data is still inadequate for the analysis of income distribution.

At present, the government has no declared policy on farm mechanization. However, a policy on this is being formulated by a national committee on farm mechanization. It can be expected that the government will promote farm mechanization through a number of measures which will soon be known.

Several policies and programs which have directly or indirectly affected farm mechanization include import taxes and tariffs, credit policy, industrial development policy, research and development, training and extension, and agricultural development. Taxes and tariffs affect both farm machinery producers and farmers. Since 1982, the government has decided to provide both tariff and non-tariff protection for the local manufacturing industry. Farm credit policy has resulted in a tremendous increase in credit supply from the commercial banks and the BAAC. This also has had much effect on the extent of farm mechanization in Thailand. Current industrial development policy is quite consistent with the promotion of the farm machinery industry. Research, development, and extension and training programs have been intensified in recent years. Much, however, remains to be done. Agricultural development, which has always received the highest priority in every national economic plan, will emphasize improvement in productivity through increased use of new technology, including mechanical power.

If farm mechanization is to be promoted as is now proposed, it must be done with caution in view of the possible adverse effects on employment and income distribution. A few approaches have been suggested by Merrill (1983, pp. 31-32). They appear very applicable to Thailand. One approach is to promote <u>selective mechanization</u> by mechanizing only those operations which will reduce costs, have the least effect on employment, and have the greatest effect on output.

The second approach is referred to as fractional mechanization which focuses almost exclusively on the small farmer. Under this approach, a two-wheel tractor can be adopted as it will replace animals rather than people. The last approach is appropriate mechanical technology. For example, technology should be profitable to the large proportion of farmers, be produced locally, and enable farmers to have more effective and timely farm operations which will raise yields and output. In practice, a combination of the three approaches may be desirable. However, a great deal of consideration will be necessary before an appropriate farm mechanization strategy can be prepared and executed.

Since subsidy policy (low-cost credit, special exchange rate) is often used in the promotion program for farm mechanization, it should be mentioned that such policy usually benefits large farmers. Tax and tariff policy and other types of import controls to protect local industry may do more harm both to producers and farmers. In most cases, farmers suffer more from such a policy than do the manufacturers. If these policies must, for certain reasons, be implemented, the government should make sure that ill effects are eliminated or at least minimized.

It is suggested that policy to support hand-tools, implements and small machines in rainfed areas should receive a higher priority than before. R & D activities must therefore be increased and strengthened.

Finally, farm mechanization must be viewed as part of the development process. Other new forms of inputs must also be available and used to raise output, generate on-farm employment, and improve income distribution. If these can be done, farm mechanization will be able to fulfill its essential role in the development of agriculture in Thailand.

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Table 1. Imports and domestic production of agricultural machinery in Thailand, 1951-1981.

Year	Imports		Domestic production		
	Tractors[a]	Water pumps[a]	Two-wheel power tillers	Four-wheel power tillers	Tractors
1951	-	2,598			
1955	262	11,294			
1960	855	11,166			
1961	1,487	12,059			
1965	3,047	39,099			
1970	1,763 (688)	136,686			
1971	2,414 (1,367)	105,109			
1974	3,318 (1,112)	168,524	24,808	2,324	n.a.
1975	6,877 (4,231)	212,319	27,860	2,582	2,426
1976	n.a. (5,257)	291,189	31,766	2,914	2,332
1977	n.a. (6,161)	303.026	35,568	3,808	2,158
1978	n.a. (4,298)	320,933	39,568	3,808	2,158
1979	(3,348)	359,508	38,756	4,142	-
1980	(3,892)	380,495	50,075	6,853	-
1981	(15,840)	491,052	60,000	7,000	-

n.a. = not available.

[a] Imports relate to all tractors, including those for industrial units and consists mainly of 4-wheel tractors. Source: Jongsuwat, 1980, assembled from the Customs Department's "Annual Statement of Foreign Trade Statistics". Figures in brackets relate to farm tractors as reported by Loohawenchit, 1980, Table 7. In later years, data are from Ministry of Agriculture and Cooperatives.

Source: World Bank, Nonfarm Employment Study, April 1982, Ministry of Agriculture and Cooperatives, Bank of Thailand and Department of Customs.

Table 2. Stock and increase of farm machines in Thailand, 1975/76 - 1981/82.

(unit)

Type of machine	Crop year						
	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82
Tractor (45 hp)							
stock in use	13,338	17,569	22,826	28,987	33,285	37,177	50,044
net increase	-	4,231	5,257	6,161	4,298	3,892	12,867
Tractor (45 hp)							
stock in use	14,575	16,427	23,942	26,984	31,158	36,158	39,158
net increase	-	1,852	7,515	3,042	4,174	5,000	3,000
Two-wheel tractor							
stock in use	90,001	113,286	151,504	192,004	230,591	280,591	284,351
net increase	-	23,285	38,218	40,500	38,687	50,000	3,760
Water pump							
stock in use	251,288	277,084	317,328	359,308	473,975	517,975	603,548
net increase	-	25,796	40,244	41,980	114,667	44,000	85,573
Water wheel							
stock in use	56,891	68,219	81,923	87,775	107,730	125,811	146,927
net increase	-	11,328	13,704	7,852	17,955	18,081	21,116
Rice thresher							
stock in use	3,955	4,430	4,962	5,557	6,224	18,934	20,601
net increase	-	475	532	595	667	12,170	2,207
Winnower							
stock in use	42,342	47,432	53,114	59,488	66,806	74,782	83,801
net increase	-	5,081	5,691	6,374	7,318	7,976	9,019

Source: Loohawenchit (1983). Data are from Division of Agricultural Economic Research, Office of Agricultural Statistics, Ministry of Agriculture and Cooperatives.

Table 3. NUmber of tractors per 1000 hectares of cultivated land by region, 1975/76, 1979/80, and 1981/82.

Year	Whole Kingdom			North			Northeast			Central Plain			South		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1975-76	0.74	0.94	5.01	1.21	1.09	2.94	0.40	0.17	0.40	1.16	2.36	15.50	0.28	0.07	0.52
1979-80	1.77	1.65	12.25	2.50	1.28	11.61	0.82	3.56	1.70	2.37	4.14	24.51	0.60	0.41	7.83
1981-82*	2.58	2.02	14.65	-	-	-	-	-	-	-	-	-	-	-	-

Note: [1] 2-axle tractors over 45 h.p.

[2] 2-axle tractors under 45 h.p.

[3] Single-axle tractor (power tillers)

* Data by region are not available.

Source: Office of Agricultural Economics, Ministry of Agricultural and Co-operatives, Bangkok, Thailand. No. 84(6), 1982 and No. 84(3), 1978.

Table 4. Horspower available of selected farm machines by region, 1979/80.

Unit = hp/ha

Region	Type of machines				
	2-T	T-TS	4-TL	Total	Water pump
Northeast	0.019	0.003	0.135	0.057	0.038
North	0.136	0.018	0.192	0.346	0.1
Central Plain	0.256	0.906	0.176	0.491	0.194
South	0.094	0.006	0.045	0.14	0.029
Overall Average	0.111	0.02	0.116	0.247	0.089

Source: Supachat Sukharomana (1983), Table 5. Data from Office of Agricultural Economics (1981).

2-T = Two wheel tractor

4-TS = Small four wheel tractor

4-TL = Large four wheel tractor.

Table 5. Distribution of major farm machines by region, 1979/80.

Categories	Northeast	North	Central Plain	South	Whole Kingdom
Farm tractor (>45 H.P.)	7,912 (23.77)	11,170 (33.56)	12,719 (38.21)	1,483 (4.45)	33,284 (100)
Two wheel Walking tractor	16,789 (7.28)	58,788 (25.48)	133,551 (57.89)	21,563 (9.35)	230,691 (100)
Farm tractor (<45 H.P.)	1,828 (5.86)	5,888 (18.89)	22,452 (72.06)	990 (3.17)	31,158 (100)
Water pump	87,502 (18.46)	109,572 (23.12)	259,203 (54.68)	17,698 (3.73)	473,975 (100)

( ) = percent

Sources: Office of Agricultural Economics Ministry of Agricultural and Co-operatives, Bangkok, Thailand. No. 84(6), 1982.