PN-AAO-932
ISN 36451

THE CONSEQUENCES OF SMALL RICE FARM MECHANIZATION PROJECT

Working Paper No. 75

THE FARM POWER STRATEGY OF THAILAND

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1983

931-1026.01
The Consequences of Small Rice Farm Mechanization Project is supported by the United States Agency for International Development under Contract tac-1466 and Grant No. ~~931-12026.01~~ and is being implemented by the International Rice Research Institute and the Agricultural Development Council, Inc.

The Farm Power Strategy of Thailand*

by

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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]

Thailand's attempts at farm mechanization began in early 1891 when the government imported steam-powered tractors and rotary hoes (Howards) that were found to be unsuitable to paddy conditions and also quite expensive.

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*An earlier version of this paper was presented at an International Seminar on Farm Power on October 25-29, 1982 sponsored by Reading University and the Agrarian Research and Training Institute, Colombo, Sri Lanka

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In the 1950's, the government rice experiment station acquired several 4-wheel tractors, devising a scheme to promote their use by selling tractor services at 15-58 baht per rai (about 93.75-112.50 baht per ha). The project however, was later abandoned.

Until 1967, Thai farmers relied heavily on animal, wind and water power. A decade of low-cost farm machinery experimentation began in 1957 and resulted in the successful development of the Debaridhi pump, a lowlift irrigation water pump, and a simplified 2-wheel tractor. In 1975, a modified version of the IRRI-designed thresher proved to be another success among 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 with farmers. In 1961, the same Division released a simplified 4-wheel tractor design called the Iron Buffalo powered by a 25 hp engine. The machine, which took about 3 years to develop was suitable to paddy operation but, priced at 30,000 baht per unit, couldn't compete with a cheaper imported model. Its production was eventually discontinued.

During this period, several manufacturers had been simplifying the Japanese 2-wheel tractor. A successful model with a modified

gear box, was definitely cheaper, more versatile and readily available than its Japanese predecessor. Demand for this tractor was so phenomenal 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 firmly established.

Within the next 12 years, we saw the invention of a simple gear system that made commercial production of 3 different 4-wheel tractors possible. Somewhat later, we saw another farm machine, the axial flow rice thresher, transform Thai rice farming. In early 1975, IRRI sent its blueprint for an axial rice thresher to the Department of Agricultural Engineering Division of the Ministry of Agriculture in Bangkok which promptly produced a prototype. When released to a selected firm in Chachoengsao for commercial production, 10 units were immediately sold at 12,000 baht each. These particular models were subsequently eturned to the manufacturer because existing threshing machine seemed to do a better job. The IRRI design went back to the drawing board and, together, IRRI and DAE refined it and later in 1975, a new blueprint for an axial flow thresher was ready. Three selected firms executed the blueprint, modifying the design as necessary. When the threshers were released, they were enthusiastically received by farmers.

IRRI was to send later (1977) another blueprint for a portable rice thresher that was both cheap and easy to operate. One firm

produced and sold 9 units, each priced at 8,500 baht. But, because these machines had a lower capacity then the earlier and post-sale services were not available, they were eventually returned to the manufacturer.

Presently the design and production of a reaper-harvester has generated much interest. A modified transplanter was also introduced into the market in 1978 but did not sell.

2. Government Intervention

The investment climate created by a combination of fiscal measures is an indicator of the government's contribution to the national farm mechanization program. Policies such as price disincentives, i.e., taxes applied to locally produced machines, government subsidies on imported machines and protective tariffs to benefit the local fledging diesel engine industry, non-price incentives, e.g., cheap credit, free irrigation water supplies, a good transportation network that reduces marketing costs, funds for research and development, training and extension services -- all are programs which 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 industry.

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 that go into production of locally built farm machinery. An imported CKD machine is subject to only 5 percent ad volorem tariff, and 8.76 percent corporate business and municipal taxes.[3] In contrasts, consider a locally manufactured machine whose individu l imported components are taxed separately and at different rates. Tariff charges and business and municipal taxes on a small imported diesel engine sum to 19.2 percent of the c.i.f. value. This implies that about 9.6 to 12.5 percent is added to domestic cost because of charges on the engine, not including taxes levied on the machine body and accessories. Actual taxes can be higher than 12.5 percent because of double taxation.[4] As a result, the cost of engines for a locally produced 2-wheel and 4-wheel tractors, and rice threshers represents about 65, 51 and 51 percent of the wholesale price, respectively.

Compounding the manufacturer's tax difficulties is the threat of an increase in the market share commanded by imported used tractors and Chinese-made small tractors, both sold at very low prices.[5] The government has not taken any action on this problem but is aware of it. Pongpojkasem (1979) estimated both the nominal effective rates and effective rate of protection, claiming 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. It is known that the low cost of fertilizer induces farmers to use more fertilizer, resulting in increased yield. Cheap credit to eligible farmers can provide working capital enabling them to continue or expand operations, or perhaps, acquire a farm machine. Free irrigation water reduces production costs while making doublecropping possible. A good transportation network reduces marketing costs and ensures timely arrival of fresh produce at the market place. Some problems are evident. Irrigation water supplies 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 a trickle. 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, research and development on the design, application and maintenance of farm machines and implements has helped rationalize farm mechanization goals and objectives. Although several government institutes 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 Extension, and the Departments of Agricultural Engineering at Kasetsart, Chiengmai and Khon Khaen Universities. The Division of Agricultural Engineering is quite involved in all three activities. The Department of Agricultural Extension should be more involved in training and extension work than it is at present. Although training of production engineers at the graduate level is a principal activity of the agricultural engineering department in universities, it seems their inadequate research facilities limit further gains in this area.

To test new ideas to improve farming conditions requires meaningful research and development. In 1981, there were 5 research projects attached to 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 (1975-1985), (2) the Regional Network for Agricultural Machinery - RNAM, of the Economic and Social Commission for Asia and the Pacific - ESCAP (1979-1982), (3) the Asian-Australian Post-harvest Technology Project (1978/79 - present), (4) The International Development Research Centre - IDRC Canada (1979-1981), and (5) The Agricultural Machinery Production Project of the UNDP/FAO (1981-present).

Of these, the joint project between the Department of Agriculture, Division of Agricultural Engineering and IRRI has been the most promising and productive to data. The IRRI-designed axial flow thresher is an outstanding product of this joint endeavor. Four other joint projects commenced in 1978/79, all focused at strengthening the capability of Division of Agricultural Engineering, as well as rationalizing the farm mechanization program in Thailand at both the farm and the manufacturing 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 the dissemination of farm engineering technologies at both the fabrication and farm levels are both extremely important, for at this point 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

A comprehensive survey of the farm machinery industry by the Bank of Thailand (BOT) in 1979 showed 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 competiton pressure on local manufacturers to simplify. In the end however, it is the larger firms who, with more resources (capitalization and cash flow) generally achieve greater market share and a higher level of profitability.

Most 2 and 4-wheel tractors, rice threshers, corn shellers, and axial flow pumps are now produced locally. Large tractors are imported CKD (completely-knocked-down) complete with all components and accessories for domestic assembly.

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

An effort has been made to assess the design simplification and innovation efforts which have taken place. Over many years the design of the locally made 2-wheel tractor has evolved and may not require further design improvements without increasing its cost. It

could use further quality upgrading. The rice thresher has been found to be only satisfactory design, its most distinctive innovative feature being that the current Thai model has a much greater capacity and is self-propelled, allowing it to be conveniently driven to its destination. The machine's capacity was doubled from one to more than two tons per hour. Additional modifications are also underway to reduce power requirements and increase threshing efficiency. Competition is the driving force inducing those innovations.

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

Imported machines have a special place in the industry. Much of the agricultural machinery industry's impressive development is the result of borrowed and modified technology. The 2 and small 4-wheel tractors and the Chinese reaper are cases in point. In contrast, importation of used tractors is creating much anxiety among local manufacturers because these machines are much cheaper than locally made ones, selling even at prices significantly lower than those of local manufacturers. Local manufacturers suggest that importation and use of foreign those made of machines should be regulated for two good reasons: to save foreign exchange and, to relieve the farmer of the high maintenance cost of used machines.

5. Equipment Inventories

The stock of farm tractors in Thailand has been increasing rapidly since 1967. In 1979 the 2-wheel tractor stock was 230,591 units, with 31,158 small 4-wheel and 33,280 small 4-wheel large tractors, respectively. A similar trend was observed with other types of farm equipment. This increase in the stock of farm machines over the years seems to indicate there is a 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 of these four regions namely: Northern, Northeastern, Central, and Southern. The Northeastern region is designated as zones 1-5, Northern region, as zones 6-10 (except zone 7), Central region, as zone 7 and zones 11-16, and the Southern region as zones 17-19 (Appendix 1).

The greatest numbers of farm machines, (with the exception of the corn sheller) are 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 region than in the Northeastern region (Table 4). Because the geographic size of each region differs, the ratio of hp (horsepower) per hectare of land 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 figures for average hp per hectare of farm land shows that the Central region has the highest level of tractorization, followed by the Northern, Southern and Northeastern regions. Average hp per hectare of these regions are 0.49, 0.34, 0.14 and 0.057, respectively. 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. In zones 11 and 14 where rice is the main crop, tractors have the highest utilization level per hectare (Table 5).

Notice that more 2-wheel and small 4-wheel tractors were used by farmers in the Central region. Small tractors were much more widely used in zones 11 and 14, but in zones adjacent to zones 11 and 14, both large and small tractors were used in similar proportions. Small tractors were thinly distributed in the remaining regions.

A cross section analysis by Jongsuwat (1980) implies the widespread use of small 2-wheel tractors in the Central plain area was due to the relatively high agricultural wage rate structure compared with other locations. In addition, farmers in this region have a higher income compared to those in other parts of the country. Farmers in the Central region enjoy the advantages of abundant irrigation water, very fertile soil, and a higher return from investments in farm machinery. This region high productivity offsets the low average farm output of other regions. Favorable

crop prices over the last decade raised farm income in the Central region. As a consequence it has been easy to induce farmers in this region to adopt tractors to their farming requirements.

A preference for small tractors is largely a consequence of its suitability for paddy field operations. This makes 2 and small 4-wheel tractors superior to the large tractor. Small tractors can also be used for a greater variety of farm jobs, such as pumping water, threshing, transporting farm supplies and produce. The smaller price tag of a small tractor makes it an attractive, and reasonable investment for a small farm owner.[7]

In contrast, large tractors have greater utility for covering large farm areas quickly especially before the rainy season commences. Large tractors are mainly used for plowing paddies in the Central region before the monsoon season, but as mentioned earlier, they can only efficiently be used on farms with relatively few field dikes.

Notice that 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. Likewise, in the Northeastern region where rice and cassava are raised on a more extensive scale, large tractors tend to be utilized more 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. In zones 11 and 14 where tractorization is highest, use of water pumps is also higher than other zones. Notice that the Central region has not only the highest concentration of tractors but 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 total corn shellers in 1975 (5,721 units) 2,146, 559 and 398 units were reported in zones 6, 8 and 5, respectively, where corn is extensively grown.

The average hp per hectare for rice threshers and corn shellers is not readily 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 indicates 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 is usually accomplished with human and animal labor using simple implements.

7. Accessibility to Farm Machinery

Accessibility to farm machinery depends much on the type and condition of the machine, availability of credit facilities, farmers' purchasing power and local farming conditions. Thus, accessibility to machine services of a farmer who owns a machine will varies with one who simply wants to hire the machine's services.

In 1979, a 2-wheel tractor was priced at US$1540, large tractor at US$10000, and a water pump at US$119.80. A rice thresher sold for US$1072 in 1978.

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 to purchase a small tractor. Interest charges on the balance range from 12-48 percent, but the usual rate is 24 percent with 6 months to pay (Taenkam, 1980).

Farmers who can not afford the initial investment, particularly for larger tractors may hire machine services through

the contract market. Farmers have similar access to rice threshers and corn shellers.

The contract rate for land preparation using a large tractor varies according to crop. In 1980, the rate for land preparation for field crops was about US$10.47-11.82 per ha for rice. The rate for a rice thresher is on a per ton basis (threshed rice) at about US$4.37.

A farmer who wants to hire a small tractor can usually go to farmers in neighboring areas. The rate for land preparation (includes 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 financing institutions however, have been few (9.34 percent of farm households) and only members of farmer's organizations are eligible for credit.

Private financial institutions are more willing to give loans to farmers whose farms are suitably located. Funds for the purchase of farm machines, however, appear to have been primarily generated 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 contracting machine services, which helped defray some of the machine's initial investment cost.

8. Farm Tractor and Rice Thresher Use

While use of small tractors accounts for 95 percent of total hours in farm activities, a large tractor can account for only 16 percent[8] of total activities on farm jobs.

By type of activity performed, both small and large tractors are mainly utilized for land preparation. Water pumping is the second 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 relatively minor importance.

Several kinds of machine implements can be attached to a tractor which make the machine more versatile e.g., 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 readily available in the local market.

A rice thresher is a specialized machine, with little versatility like the tractor, but similar to the tractor, much of its use is off-farm 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.

Mechanization allows the farm operator to prepare the field which otherwise would be too difficult using only animal power, thereby increasing his effective area under cultivation. Machines are often introduced in conjunction with use of fertilizer 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 is made possible with the application of both extensive and intensive farming methods, involving expansion in cultivated areas using existing technology and use of improved technology. Extensive farming accounts for greater output because the land area has been increased, while intensive farming occuring in irrigated areas demonstrates a very high productivity because of doublecropping.

As the shortage of suitable agricultural land becomes more acute, we increasingly look to frontier lands. Opening up frontier lands requires a high degree of machine power and mechanization can make a significant contribution, especially in Thailand where land area is increasing at a rate of 7.5 percent per annum (Tables 8 & 9). Comparing field crop output with of rice shows that the growth rate of output from field crops is 11-24 percent while rice is 3.2 percent. Notice that expansion of rice land is growing at a rate of 1.93 percent (Table 10). Much of this expansion is a result of increases in irrigated area, while increased output appears to be the result of greater production efficiency.

A modern technology package which includes mechanization has made double cropping of rice possible in well-irrigated farms. Mechanization enables the farmer to achieve precision scheduling of his land preparation activity in relation to transplanting and broadcasting, and in applying water to his paddy field. With the help of the rice thresher, the farmer is released from a lengthy post harvest activity permiting him to prepare land for a second crop. In addition, a 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 rice threshers are seldom found (Pathnopas, 1980). In a few non-irrigated areas intensive farming may possible to realize a second crop but a farmer must be quick to harvest his wet season crop and prepare the land for the next crop while residual soil moisture assures germination and seedling growth. This is a very risky practice and is done only sporadically.

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 for analysis. The results indicate 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 which classified into two categories: direct effect at 28.83 percent, and indirect effect at 34.02 percent.

Effects of farm mechanization on yield, as investigated by Inukai (1970) using regresion analysis showed that mechanization could increase rice yield. His study, however, did not take into account the effect of chemical inputs such as fertilizers and pesticides on yield, and the statistical test of the coefficients for the mechanization index and yield were not presented. Inukai (1970) volunteers that another machine that may increase crop yield is the water pump. Control of water supply at pollination and maturing periods is critical to crop yield, but there is not a single study that can shows conclusively 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 and its net impact on agricultural employment.

Labor savings are expressed as labor saved per unit of land per season or per unit of output or the reduction in labor required to care for draft animals. Data used relate only to rice farming.

Information from NEDECO (1968) shows that mechanized rice farms using broadcasting techniques required less labor than those using transplanting technique at -37 percent and -25 percent, respectively (Table 11). Meanwhile, the Consequences Project survey in 1979 shows that irrigated rice farms using 2-wheel tractors required 33 percent less labor than farms using buffalo power. Among farms using tractors, those with small 4-wheel tractors used 49 percent less labor than farms employing all buffalo power (Tables 12 & 13).

Labor reduction occurs in land and seedbed preparation, planting and crop maintenance. Just how much labor there was in the threshing activity is not clear because all rice was threshed by (hired) mechanical threshers.

Labor saved using 2-wheel and 4-wheel tractors in land preparation was estimated to be 63 percent and 74 percent or 15.75 mandays and 18.37 mandays per season less than animal power respectively.

Threshing may be done either by hand beating, foot treading, animal treading, tractor treading or machine threshng. Kittikul (1980) reports that the threshing machine required the least labor manhours among all methods at an average of 5 manhours/ton.

Pathnopas' study (1980) indicates that tractor treading required 17.76 manhours per ton and buffalo treading 38.8 hours per ton. In comparison, a threshing machine required only 10.27

manhours per ton (including machine operator and other labor), reducing labor requirements by 72.93 percent if using a 2-wheel tractor and 377.80 percent if using an animal. Expressed in man-days, we can assume that there is a savings of one man-day per ton of rice. Given 3 tons of yield per hectare, the labor saved would be at least 3 man-days per hectare. Altogether, total man-days saved by combined use of the small tractor and the thresher for all farm activities is between 18.75 - 21.37 mandays per ha per season. This helps explain why it is possible for farmers to achieve a high level of double cropping.

One note which is often overlooked, is the labor saved by elimination of draft animal management when a farmer switches from animal to machine power. Although this activity is normally a child's task, we have assigned the cost of adult labor because draft animal management is not optional.

Does mechanization create unemployment? Evidence fails to support such a view. Earlier in this paper we described farming zones that were extensively mechanized and had a higher wage structure than less mechanized areas. This high wage could mean a scarcity of labor supply. Sometimes there is occasional excess labor supply but this 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 distinctive for their high cropping intensity index as well as high average machine hp per hectare (Table 14).

The effects of mechanization on labor productivity are undoubtedly positive when 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: buffalo power is 3:41 kg: (875 manhours), 2-wheel tractor is 4:11 kg: (613 manhours), and small 4-wheel tractor is 6.38 kg (482 manhours).

Indirect Benefits of Farm Mechanization on Employment

Besides rationalizing agricultural employment, mechanization also generates employment in the farm machinery and parts industry, in the marketing section, and of course, in the repair and maintenance service sector. 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 for such machines were 20, 16 and 20 percent, respectively.

Employment in small tractor manufacturing alone was 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 as demand for these machines has been increasing steadily at an annual growth rate of 9-10 percent since its introduction in late 1975. As of 1979/80 there were an estimated 6,224 units of rice threshers in the market.

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

The transport cost of imported power engines which are 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 since the engines need to be brought to the 59 manufacturers' shops for installation (Taenkam, 1980).

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 from whom he purchased the machine, or 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 pronounced, but much more evident is the gap between the rich and the poor within the rural sector. The new rice technology requires a package that includes high yielding rice varieties, chemical fertilizers,

pesticides, and mechanization which usually only rich farmers can afford. For reasons described earlier, farm machines in Thailand seem to be accessible only to certain kinds of farmers, especially those in the Central region and surrounding provinces. Ownership of large tractors is also associated with large farm ownership in contrast to farmers with smaller holdings who usually hire tractor services.

Because a correct technology package can result in a greater net farm income derived from increased productivity of both land and labor, mechanized farming is becoming increasingly attractive. It is difficult though to isolate the contribution of a farm machine to the net farm income. Nevertheless it is safe to say that at least mechanization does contribute to the farmers' income equal to the net cost savings generated by mechanization. We may safely say, too that mechanization increases income per unit of labor.

Contracting a large 4-wheel tractors for custom plowing can bring in much off farm income, the average net being US$400 per year (Pak-uthai, 1981). In 1979 contracting a rice thresher's services could bring a net income of about US$640 - 1,013 per unit or 86 percent of the total income derived from the use of thresher (Pathnopas, 1980).

Using the average hp of each agro-economic zone and the data on the 1979 income and expenditures of farm households from the Office of Agricultural Statistics, Ministry of Agriculture and

Cooperatives, indicates that the gross income of farm households located in a dense zone is higher than the income of farm households in a low density zone. The lower hp per hectare is much more pronounced in the Northeastern and Southern regions. The percentage of farm households that are least mechanized was 40, while it was less, at 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 - 869. The income of farmers in the Northeastern region where there is a low level of tractorization averaged only US$449 (Table 15). In 1979 the average income of farm households in the Central region came close to the average income of the urban area.

The average farm size of 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. For some farms it would seem more practical to hire contract tractor services than 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 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 When Acquiring or Hiring Farm Machine

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

Owning a tractor usually means a cost savings in time and buffalo care, and more effective land preparation than when using animal power. It might appear the return on investment is low if only the on farm activities of the machine are taken into account, but since services can be contracted outside during the peak season, additional income is generated which reduce average fixed costs.

A partial equilibrium analysis shows the rate of return on investment for a large tractor is around 13-15 percent. This analysis uses restrictive assumptions, indicative of a highly competitive market for custom services which makes the rate of return nearly as large as the rate of interest[11].

A rice thresher demonstrated the highest rate of return on investment over all other farm machines at 40-45 percent[12].

Because the thresher is new and is in limited quantity in Thailand, farmers can recoup their investment faster through contractor services, because of a low level of competition.

Non-cash considerations for mechanization are: "to save manhours," "timely planting," and "ease and reduction of farm drudgery" (Table 17).

13. Contribution to Thailand's Economy

At this point, we might conclude that mechanization does raise 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 i.e. social costs and benefits attributable to mechanization. It is hoped mechanization will provide the attractions that will encourage rural Thais to remain in the countryside. Linkage industries, as a result of mechanization, i.e. processing and distribution, also generate income and employment as well as provide excellent training opportunities.

14. Future of the Farm Machinery Industry

Thai farmers, especially those in the Central Region are innovative. They have demonstrated a willingness to try most types of farm machines in the market: water pumps, large tractors, small tractors, rice threshers, sprayers and locally fabricated trucks. In the future we will see other new machines such as the

transplanter, reaper and combine-harvester introduced in the Thai market. All three machines are still under field trial, and among these, the reaper seems to generate the most positive response from farmers.

Among field crop machines, the corn sheller, sorghum threshing machine, soybean and peanut threshing machine are well received by farmers. These machines are not yet widely used and may require redesign and further development, may being quite unsuitable to local topographical conditions and extremely expensive to operate. Corn harvesters and sugarcane cutting machines, both imported, are hired on either per hectare or per hour basis.

In less fertile regions, mechanization is still unaffordable to most farmers. Better hand tools and implements to complement animal power seem to be more practical there, and would be most desirable if farmers can be taught proper handling by extension specialists. Improvement in the efficiency of these farm tools and implements will help the farmer increase animal and manpower productivity. However, such improvement may require changes in farm practices. For instance, the substitution of the iron for the wooden plow, and modification in its shape, redesign of the seed and fertilizer spreader and hand corn sheller are a few examples.

The iron plow has been in use for the last 15 years and there have been several attempts to redesign the traditional model to suit farmers' requirements and idiosyncracies. Farmers demand that the

iron plow should have the same shape and weight as the wooden version and its price should not be much higher.

The modified plow blade developed by the Division of Agricultural Engineering developed was not efficient, that farmers rejected it, because its ploughing efficiency rose by about 30 percent. Perhaps, when hardwood (raw material for wooden plough) becomes scarce, farmers will eventually turn to iron plows. Or, perhaps, farmers need to be educated on its use to make it attractive. Perhaps, too, if a seed and fertilizer spreader and hand corn sheller were modified to suit regional conditions, and these were accepted by farmers, we would see a rise in farm productivity in these regions.

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 availability of a good technology package.

Significantly, 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).

To conclude, we might say 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 motivate or de-motivate

farmers to utilize farm machinery; (3) excellent credit facilities and (4) 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 handicaps. 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 initial importation of small tractors from which local manufacturers borrowed its present technology. Having successfully borrowed, their industry has flourished with little government support - despite prevailing hostile fiscal policies and the government's indifference to industry needs. Such indifference is evident in the inequitable distribution of irrigation facilities, the farmer's inaccessibility to cheap credit, and lack of extension services. As if these weren't enough, inventors face the dreadful prospect of being victims of design piracy, all because the government does not have a patent rights protection policy.

Another weak link in the strategy is the lack of cohesiveness of institutional efforts on research and development and training and extension.

That the farm strategy of Thailand works is a tribute to the innovativeness, the ingenuity and resiliency of the Thais.

FOOTNOTES

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

2. In 1963 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.

13. Division of Agricultural Engineering, Ministry of Agriculture and Cooperatives, "Development of Traditional Animal Ploughing," 1979, (mimeographed).

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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, Agricultur-l 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	9.30	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	203.81	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 (8,413.12)*	3,661.43 (410.08)*	146.47 (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 - Transplanting 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) Renu 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	-,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 work	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 (6,877)*	159.41 (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	0.177	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)*	Gro. 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	859.74	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).