IMPACT ASSESSMENT OF MECHANIZATION ON SOCIO-ECONOMIC STATUS OF PADDY FARMERS IN PYINMANA AND ZEYYARTHIRI TOWNSHIPS

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DEDICATED TO MY BELOVED PARENTS,
U MG MG AND DAW YI YI NWE

DECLARATION OF ORIGINALITY

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This thesis represents the original work of the author, except where otherwise stated. It has not been submitted previously for a degree at any other University.

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ABSTRACT

The objectives of the study were to investigate the socio-economic conditions of sampled farmers, to examine the economic profitability and influencing factors on yield of rice production before and after buying power tillers, and to assess the financial profitability and sensitivity analysis of power tiller ownership according to vintage groups. The survey was conducted during February and March, 2011. Purposively random sampling procedure was used to select 109 respondents in Pyinmana and Zeyyarthiri Townships.

In this study, the sampled farm households were categorized into three groups: last 11-15 year (1995-99), last 6-10 year (2000-2004) and last 5 year (2005-2010) vintage groups. Shelter condition, luxury and productive asset, yield of rice, and cropping intensity in all vintage groups were improved after buying power tiller. Utilization of human labour per hectare decreased drastically in monsoon and summer paddy after buying power tillers. In paddy production, the highest benefit-cost ratio (BCR) was 1.56 in monsoon paddy of last 11-15 year vintage group. In monsoon paddy production, land preparation mechanization was the major determinant for achieving high yield. In summer paddy production, land preparation mechanization, fertilizer amount and pre-harvest labour were major influencing factors in the sampled households. Therefore, the benefits associated with tractor ownership were the potential for timely planting, followed by more cropping intensity and reduced hired labour requirements.

To assess the financial profitability and sensitivity analysis of power tiller ownership, respondents were delineated as three groups: 2005 vintage group, 2006 vintage group, and the average of the entire power tiller group that applied 2011 prices. Based on sensitivity analysis, the profit of sampled farmers can be increased by means of increased capacity utilization and contract rate. Increments in initial power tiller price and interest rate affected negatively on the BCR and NPV. Moreover, the availability of capital at low interest rates constitutes a strong incentive for mechanization and has been a major inducement to invest in power tillers. In the study area, the interest rate (1.42% per month) was very low compared to 7% to 15% per month from other lending groups. Power tillers are likely to generate a positive return on investment at prevailing prices. Therefore, mechanization of farm should be promoted to generate economic development opportunities for the rural areas.

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LIST OF ABBREVIATIONS

AMD	Agricultural Mechanization Department
ARDC	Agricultural and Rural Development Corporation
BCR	Benefit-Cost Ratio
FAO	Food and Agriculture Organization
ha	Hectare
HYV	High Yielding Varieties
Kg	Kilogram
Ks	Kyats
MAS	Myanmar Agriculture Service
mil	Million
MOAI	Ministry of Agriculture and Irrigation
NCAER	National Council of Applied Economic Research
SLRD	Settlement and Land Records Department
UNIDO	United Nations Industrial Development Organization
USAID	United States Agency for International Development

LIST OF CONVERSION FACTORS

1 Basket of Paddy	=	20.66 kilogram
1 Basket of Black Gram	=	72 pounds
1 Basket of Black Gram	=	32.73 kilogram
1 Hectare	=	2.471 acres

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CHAPTER 1
INTRODUCTION

Myanmar has continuously stood as an agriculture nation due to her water, soil and climate conditions and natural resources. The agricultural production sector has relations with the social and economic sectors of the nation. Efforts are being made for national economic progress based on agriculture.

The State has laid down twelve national objectives in order to create the peaceful and modern developed nation, of which one factor from the four economic objectives, the development of agriculture as the base and all-round development of other sectors of the economy as well, we are implementing the development of agriculture and also keeping-up the momentum of industrial productivities. Emphasis must be based on agricultural sector which is gaining momentum.

Due to the adoption of the market oriented economy as the first priority, the private sector has many opportunities to expand its fields of work. The private trading enterprises, foreign firms, joint-ventures companies with the government and other trading organizations are emerging in the country.

It is impossible to build an industrialized nation overnight by leaps and bounds. Extensive application of mechanized farming system, extension of establishment of new factories, boosting production by operating the existing factories at full capacity, effective and speedy development of industrial zones and establishment of new industrial zones and development of industry in private sectors are policies laid down for building of agro-based industrialized nation. (Min Khant, 2001)

1.1 Distribution of Farm Machineries in Myanmar (1995-2010)

The State has organized the establishment of eighteen industrial zones to settle the scattered private industrial enterprises in the country. For industrial development, it is necessary for national industrialists to apply technology and investment from home and abroad. As the government gave impetus for full operation at workshops, new factories were established. Agricultural mechanization department has six farm machinery factories;

1. No (1) Myanmar Farm Machinery Factory – (9) mile, Yangon
2. No (2) Myanmar Farm Machinery Factory – Innkone, Kyaukse

3. No (3) Myanmar Farm Machinery Factory – Kyaikkalo, Mingalardon
4. No (4) Myanmar Farm Machinery Factory – Kyaikkalo, Mingalardon
5. No (5) Myanmar Farm Machinery Factory – Ywarthargyi, Yangon
6. Myanmar Farm Machinery Factory – Innkone, Kyaukse

According to the distribution of farm machineries in Myanmar, 63,789 power tillers have been distributed from 1995 to 2010 and 2,236 threshers as well as 1,277 seeders were produced from 1995 to 2000 but there has been no distribution of threshers and seeders since 2001 (AMD, 2010).

Table1.1 Yearly distribution of farm machineries in Myanmar (1995-2010)

Sr. no.	**Types**	**Number of Distribution**		
		1995-2000	**2001-2005**	**2006-2010**
1.	Power tiller	18,989	23,313	21,487
2.	Seeder	1,277	-	-
3.	Inter-cultivator	17,103	-	-
4.	Harvester	500	-	1 24
5.	Thresher	2,236	-	-
6.	Seed dryer	940	-	-

Source: AMD, 2009

1.2 Utilization of Farm Machineries in Myanmar

Under the market economic system, in addition to the State sector, private sector participation is increasing in utilization of the farm machineries and equipments for various activities of agricultural production. Some local entrepreneurs have even started small scale factories and are producing machines and tools for farmers' requirement. Besides, most agricultural machinery sale centers, for example, Good brothers co. ltd, Shwe Myanmar, Malar Myine, etc, import the machineries from China. Utilization of farm machineries are steadily increasing as shown in Table 1.2.

Table1.2 Agricultural implements utilized in Myanmar (1995-2010)

(000' number)

Sr. no.	Particulars	1995/96	2000/01	2005/06	2007/08	2008/09	2009/10
1.	Tractor	9	11	11	11	11	11
2.	Power tiller	17	57	97	118	138	148
3.	Water pump	72	142	179	194	198	203
4.	Inter-cultivator	132	156	179	180	181	192
5.	Harvester	4	3	3	3	3	2
6.	Combined harvester	1	1	0.1	0.1	0.14	0.16
7.	Thresher	6	19	29	34	37	40

Source: MOAI, 2011

Utilization of farm machineries has been accelerated since the summer rice was introduced on a large scale in 1992-1993. In her march towards agricultural development, land preparation with machines has been done to develop the production of crops as shown in Table 1.3. The total machine operated area was 7,178,970 hectares and it was 31.26% of total sown area of Myanmar (22,961,000 ha) in 2008-2009. The total land preparation area operated by government machine was 4.95% (355,510 ha) of total machine operated area. The largest government machine operated area was 43% (151,691 ha) in monsoon paddy and the second largest area was 14% (51.291 ha) in pulses. About 95.05% (6,823,460 ha) of total machine operated area were prepared by peasant-owned machine. The major area operated by peasant-owned machine was about 70.30% (4.8 million ha) in monsoon paddy. There were 12.43% (843,383 ha) of total peasant-owned machine operated farm in pulses (AMD, 2009).

Table1.3 Land preparation area of different crops with farm machineries (2008-2009)

Sr. no.	Crop	Hectare by government machine	Hectare by peasant-owned machine	Total machine-operated hectare
1.	Jute	16,611 (4.67)	11,791 (0.17)	28,402
2.	Cotton	12,290 (3.46)	35,000 (0.51)	47,290
3.	Sugarcane	29,831 (8.39)	483,900 (7.09)	513,731
4.	Pulses	51,291 (14.43)	848,383 (12.43)	899,675
5.	Monsoon Paddy	151,691 (42.67)	4,800,000 (70.35)	4,951,691
6.	Summer Paddy	34,538 (9.72)	178,660 (2.62)	213,198
7.	Groundnut	4,535 (1.28)	37,313 (0.55)	41,848
8.	Sesame	36,953 (10.39)	353,913 (5.19)	390,866
9.	Sunflower	1,500 (0.42)	5,000 (0.07)	6,500
10.	Wheat & Maize	7,973 (2.24)	7,000 (0.10)	14,973
11.	Jetropha	400 (0.11)	2,500 (0.04)	2,900
12.	Others	7,896 (2.22)	60,000 (0.88)	67,896
	Total	355,510	6,823,460	7,178,970

Source: AMD, 2009

Note: Values in brackets indicate percentages

1.3 Effect of Mechanization in Myanmar

Agricultural mechanization can be defined as the economic application of engineering technology to enhance the effectiveness and productivity of human labour. Agricultural mechanization aims at reducing human drudgery, increasing yields through better timeliness of operations because of the availability of more power, bringing more land under cultivation, providing agriculture-led industrialization and markets for rural economic growth, and ultimately improving the standard of living of farmers (FAO and UNIDO, 2008). Proper use of mechanized inputs into agriculture has a direct and significant effect on achievable levels of land productivity, labour productivity, the profitability of farming, the sustainability, the environment and, on the quality of life of people engaged in agriculture.

Farm mechanization involves a major role to help in bringing about a significant improvement of agricultural productivity.

Mechanization of agricultural operations needs many factors. Because of mechanization, optimal yield from different crops can be obtained during the timeliness of operations. Secondly, the quality and precision of the operations are equally significant for realizing higher yields. As the agricultural activities like seeding, transplanting, harvesting have to be carried out under time constraint imposed by weather conditions, machines are a great help. Multiple cropping systems require timely cultivation. It has not been feasible in the peak season of land preparation, since the ratio of area under crops to animal population remains disproportionate in many Divisions and States. In 2009-2010, the net sown area of Myanmar was about 13.64 million hectare but there were only about 1.03 million draught cattle and buffalo (SLRD, 2010).It is now imperative either increase the manpower and drought cattle as quickly as possible or bring in farm mechanization. Latter seems easier to accomplish.

To determine the cropping intensity, the time taken to perform sequence of operations is an important factor. Agricultural mechanization has helped in increasing area under cultivation and increase cropping intensity. Cropping intensity has increased 21.42% from 1995-96 to 2009-10, and the highest cropping intensity (171.2%) was found in 2009-10.

Table1.4 Net sown area, total sown area and cropping intensity (1995-2010)

Year	Net sown area (mil ha)	Total sown area (mil ha)	Cropping intensity (%)
1995-1996	9.17	12.88	141
2000-2001	10.25	15.04	147.9
2004-2005	11.41	17.43	152.7
2009-2010	13.64	23.36	171.2

Source: MOAI, 2011

However, if farm operations are mechanized, there are good chances to reduce the cost of production as it saves labour, both human and bullock. In the absence of mechanization, the ever-increasing wage rate of human labour, and cost of upkeep of drought animals could have increased the cost of production much higher. The use of farm machineries enlarges the employment opportunities both on farms and in non-farm sectors through increase in area under plough, multiple cropping, development of agro-industries and related services. On the other hand, displacement of human labour does take place and demand for semi-skilled labour in place of unskilled labour is reduced and unhygienic operations such as handling of farm yard manure can be done with farm machineries (S.R. Verma, 2008).

Although the utilization of farm machineries is continuously increased, Myanmar utilizes the lowest amount of farm machineries among the South-East Asian countries. In order to be effective in resource utilization in Myanmar, priority is being given to introducing the agricultural mechanization system with a view to fulfilling the first requirement, sufficiency in food and clothing; based on agricultural mechanization.

1.4 Historical Background of the Farm Mechanization in Myanmar

After the second world-war, the country encountered a shortage of draught cattle, a need for reclamation of lands that were under cultivation before the war, and the shortage of farm lands. In 1948 the Agriculture Department experimentally ploughed about 465 hectares (1150 acres) of land for rice cultivation with the crawler tractor, which was turned out to be quite successful. Plowing by mechanical means was found to be feasible, fruitful and cost effective in time and labor. As a result, the Government formed a pilot project in 1949, directly under the Ministry of Agriculture and Forests for further investigation measures.

In 1951, the pilot project was reorganized as an Agricultural Engineering Branch and was placed under the Department of Agriculture. In addition to plowing and reclamation of lands, wheeled tractors were also procured and utilized to prepare lands for cultivation of rice and other crops. Mechanized agriculture was further expended and with the provision of tractor hired services to private farmers by establishing 12 tractors stations in selected townships. At the same time, temporary 5 Tractor Driving Training Schools were also established in five selective townships.

With a view to meet increasing demands for hired services; and also assist in industrial crops expansion, and promotion of double cropping, the Government, in 1962, decided to annually procure 1000 wheeled tractors each, for the Government sector and cooperative sector, respectively. Further the Agricultural Engineering Branch, under the Department of Agriculture was recognized as the Agricultural Mechanization Project, and transferred to the Agricultural and Rural Development Corporation (ARDC), in the same year.

The project became the main agency for furthering mechanized agriculture, and 20 numbers of Agricultural Tractor Station each with 50 tractors were established under the new organization scheme. To enhance and promote increasing mechanization, the project started selling agricultural machineries, such as wheeled tractors with implements, power tillers, water pumps for irrigation purposes, and rice threshers, to village co-operatives and farmers as well in the 1968-69 fiscal years.

And with the new administration act of 1972, the Agricultural Mechanization Project and the Rural Water Supply under the ARDC, were merged to become the separate Agricultural Mechanization Department. The Department was once again reorganized in fiscal year 1984-85, to meet growing responsibilities and services. The Myanmar Industrial Development Committee was formed in 1995 to transform traditional methods of agricultural production into mechanized farming by promoting the use of farm industrial villages were formed to facilitate the process of mechanized farming. Agricultural Mechanization Department and Myanmar Heavy Industries were the principal state organizations manufacturing farm machinery and implements locally. Between 1995-96 and 1998-99, the number of power tillers, tractors, and threshers registered a large increase (Figure 1.1).

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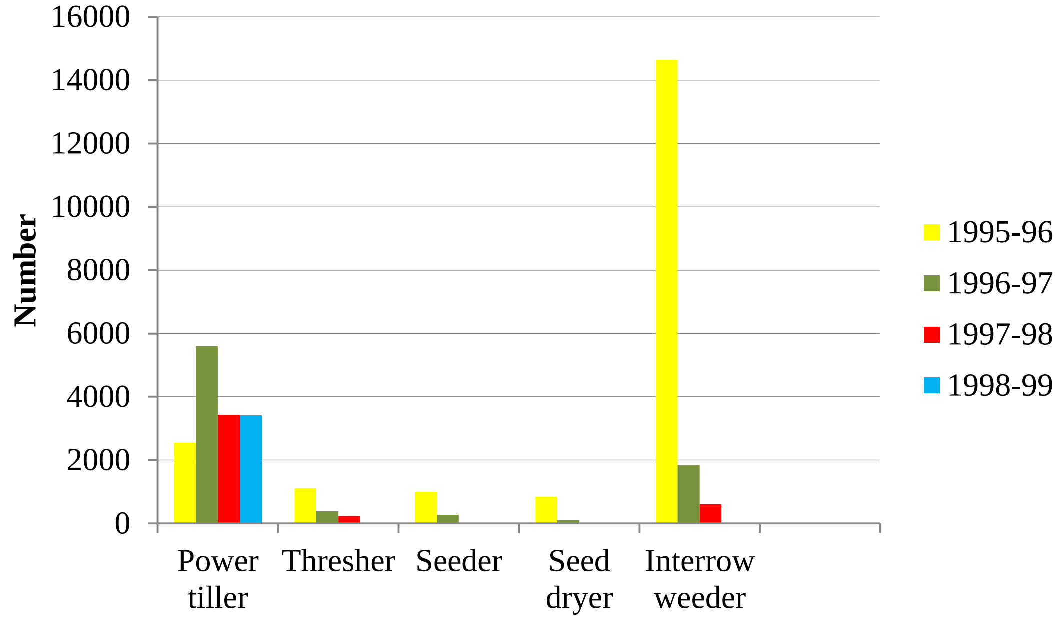

Figure 1.1 Distributions of Farm Machineries in Myanmar (1995-1999)

Source: AMD, 2010

. Farm mechanization through time-saving has proven to be an essential component of increased cropping intensity. Since the early 1990s, local and foreign investment have been welcomed to develop new agricultural land through the utilization of cultivable, fallow and waste land for plantation, orchard, and seasonal crops. However, there was only one FDI project in the agricultural sector proper. So, in 1998 the government launched a massive campaign encouraging national private investors with new incentives to reclaim virgin, fallow, vacant and waste land all over the country. It was a bold attempt to introduce modernized large-scale into traditional small-scale farming. As described earlier, however, so far only 84,720 hectares (0.2 million acres) had been reclaimed out of the total of 434,359 hectares (1.1 million acres) granted to private investors. The main functions of the Agricultural Mechanization Department are:

1. To provide tractors hired services to farmers
2. To reclaim lands for cultivation
3. To produce small farm machineries and equipment
4. To import power tillers and farm implements for resale to farmers

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5. To research, develop and utilize small farm machineries applicable to the prevailing general conditions of the agricultural sector of the country
6. To propagate the use and technical know-how of small farm machineries among the farmers. (AMD, 2010)

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Leyar Rice Transplanter – 8 rows

Harvester – 4GL-120 A

Power Tiller – EMEI 190 N

Power Tiller – DF 20

Thresher – FMF 2

Thresher – TH 60

Figure 1.2 Farm Machineries Distributed by Agricultural Mechanization Department

Source: AMD, 2010

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1.5 Problem Statement

Traditional agriculture is being transformed to modernized agriculture by various methods including new crop varieties, irrigation and farm mechanization. Some farmers believe that traditional land preparation is natural and best. Some are not tradition-bound but responsive to higher prices of farm machines. Traditional farming is good for environment, available farmyard manure and fertile in farm land. At present, as a result of increased population growth and urbanization in the study area, to increase production becomes a pressure on the agricultural sector in Nay Pyi Taw.

For improvement in productivity, the introduction of hybrid rice varieties is a major concern and causes a concurrent requirement for improvement in cultural practices. Because of the shorter growing season and availability of sufficient irrigated water, it makes possible double or multiple cropping systems. Utilization of farm machineries is efficient and time saving, so, it makes land preparation faster and land use more efficient. Mechanization of land preparation is an attempt to redress apparent shortages of man and animal power. However, there appear too few rigorous studies about farm mechanization effect on household level in Myanmar. Among the eight townships of Nay Pyi Taw, Pyinmana and Zeyyarthiri Townships were selected as study sites. The study villages were Ahlyinlo and Nutthaye villages in Pyinmana as well as Seinsarpin and Aisaut villages in Zeyyarthiri Township.

According to survey data, the ratio of power tiller to land holder was very low in Nutthaye village (10.77%), in Aisaut village (23.78%), and in Seinsarpin village (28.44%). In Ahlyinlo village, 41.46% of power tiller to land holder was higher than other villages in the study area. The ratio of thresher to land holder is lower than the ratio of power tiller to land holder. Although the ownership and utilization of farm machineries provides the economic aspects to farm machinery owners, the ratio of farm machineries to land holder is still low in the study area (Table 1.5).

Therefore, it is necessary to appear the urgent studies about farm mechanization effect on household level. This paper reviews the impact of farm mechanization on agricultural production and productivity, cropping intensity, human labor employment on the farm, as well as gross farm income. Moreover, this study attempts to analyze the economic aspects of power tiller ownership and utilization.

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Table1.5 Number and percentage of agricultural machineries in the study area

(number)

Village	Land Holder	Power tiller	Thresher	Seeder	Hand sprayer	Inter-cultivator	Pump
Aisaut	185	44 (23.78)	12 (6.49)	-	100 (54.05)	-	24 (12.97)
Seinsarpin	109	31 (28.44)	10 (9.17)	-	90 (82.57)	32 (29.36)	5 (4.59)
Ahlyinlo	123	51 (41.46)	17 (13.82)	27 (21.95)	105 (85.37)	-	3 (2.44)
Nutthaye	325	35 (10.77)	15 (4.62)	-	120 (36.92)	-	20 (6.15)

Source: Field survey, 2011

Note: Values in parentheses indicate percentages

1.6 Objectives of the Study

1. To investigate the socio-economic conditions of sampled farmers before and after buying of power tiller owners in the study area;
2. To examine the economic profitability and influencing factors on yield of rice production before and after buying power tillers of the sampled farm households; and
3. To assess the financial profitability and sensitivity analysis of power tiller ownership according to vintage groups.

CHAPTER 2
LITERATURE REVIEW

2.1 Influencing Factors of Farm Mechanization

2.1.1 Impact of mechanization on agricultural production and productivity

NCAER (1973) compared the values of annual farm output per hectare of net sown area under different levels of mechanization. The output per hectare was found to increase as the level of mechanization increased from irrigated non-mechanized farms to tubewell, tractor-thresher farms.

Singh and Chancellor (1974) found that though, tractor and tubewell farms had significantly higher yields than bullock farms in case of wheat, much of the difference was accounted for by difference in other factors such as level of irrigation. Pathak et al. (1978) reported that the use of tractors enhanced agricultural productivity due to better seed-bed preparation, timeliness of operations and precision in distribution and placement of seed and fertilizer owing to the use of the seed-cum-fertilizer drills.

Aggarwal (1983) revealed that the use of tractors instead of bullocks for ploughing and sowing did not add to the yield of high yielding varieties of wheat. Rao (1978) conducted a study to investigate the effect of the use of tractors on yield, employment of labour and cropping pattern. The methodology employed was on recall basis i.e. data obtained before and after tractor acquisition. As many as 4000 tractor-owning farmers were contacted through a mailed questionnaire but only 1500 responded. As evident, of all the crops raised on different sizes of farms, tractor owning farms obtained higher yields per acre and the increase was more for the larger sizes of tractor owning farms.

Binswanger (1978) adopted value of crop production per ha per year as a proxy to determine any cropping effects attributable to tractorization. Production value was considered as a function of cropping intensity, yields, cropping patterns, and a residual interactive effect. Since tractorization had increased the first two only slightly, it was reasonable to suppose that increase in production value was attributable to a tractor-based cropping pattern or to factors such as irrigation, credit, and/ or managerial capacity.

2.1.2 Impact of mechanization on cropping intensity

Agricultural mechanization has made significant contribution in enhancing cropping intensity. The growth in irrigated areas and tractor density has had direct bearing on the cropping intensity. Findings of the studies conducted in the past are briefly presented to highlight the contribution of mechanization in enhancing the cropping intensity. Chopra (1974) reported that the cropping intensity was higher after the introduction of tractors.

NCAER (1974) revealed that tractor-owning farms had a higher cropping intensity of 137.5 per cent as compared to 131.8 per cent in the case of those without a tractor. Cropping intensity was found to be generally higher on small farms. NCEAR (1980) reported that the cropping intensity of tractor-owning and tractor-using households in all the States of New Delhi was higher than that of bullock farms. An average tractor owner had a cropping intensity of 12 per cent higher than that of the bullock farms.

Nandal and Rai (1986) concluded that the cropping intensity showed consistently positive relationship with tractorization. Within the given size groups, tractor-owning farms had higher cropping intensity as compared to tractor-using or animal operated farms.

Binswanger (1978) has shown that farm mechanization allows for more efficient farm operations which, in turn, positively affects yields as well as allows for greater intensity of land use. The before and after study in Pakistan shows an intensity increase of only 7 per cent. For reasons connected with the phenomenal size growth of these farms this is probably an overstatement of the true intensity gain. Since the proportion of sample farms owning tubewells increased from 45 to 60 per cent during the same period, the modest increase in intensity cannot exclusively be linked with the tractorization process. The largest intensity increase occurred in the smallest farm-size group and there is a decrease in intensity in 48.6 – 72.8 ha farm-size group. The only before and after study in the Indian Punjab is by Chopra, who reports an intensity increase of 16 per cent. This intensity increase is associated with a 20.5 per cent increase in net irrigated area on these farms, which makes it unlikely that tractors played a major role in enabling the intensification to occur. Therefore, it can be concluded that tractors have not been a significant factor in intensification on tractor farms in Haryana and the Indian and Pakistan Punjab.

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2.1.3. **Impact of mechanization on displacement of human labour**

GIPE, Poona (1967) concluded that tractorization generated greater demand for labour by facilitating more intensive cultivation. Thus, there was no significant displacement of human labour after tractorization. Billing and Singh (1970) studied the changes in the demand for labour. The study, however, failed to estimate the possible increase in human labour employment arising out of the increase in cropping intensity followed by mechanized cultivation.

Bhagwati Committee on Unemployment (1970) concluded that mechanization of agricultural operations, by and large, displaced bullock labour and not human labour. In another study, Johl (1970) reported that increased use of tractors was associated with marked rise in employment due to their effect on cropping intensity. AERC, Delhi (1970-71) concluded that the use of tractors had, in most cases, displaced only one pair of bullocks. The overall human labour input for crop production per cultivated hectare was practically the same for both types of farms.

USAID, New Delhi (1972) concluded that the large scale adoption of high yielding varieties accompanied by higher use of chemical fertilizers and enhanced cropping intensity led to higher demand for farm labour. Singh and Singh (1972) observed that mechanization did not displace labour significantly. The average humen labour employment per hectare on mechanized farms was 169 man-days as compared to 180 man-days on non-mechanized farms, which was only 6.1 per cent less. It was concluded that displacement of human labour was significant only on mechanized farms in the size group of 15-20 ha and above. Singh and Singh (1975) in their study on "Impact of Farm Mechanization on Human and Bullock Labour use" in two regions of U.P. reported that an additional hour of tractor would replace 1.04, 0.76 and 0.13 human and bullock labour days on small, medium and large farms respectively. Thus, the rate of labour displacement through tractorisation was higher on relatively small farms of Jaunpur District than large farms of Meerut District of U.P.

Barker and Cordova 1978 have indicated that mechanization of certain farm operations has resulted in the replacement and displacement of labour, particularly in countries where manual power is abundant and farming operations are labour intensive. Sison, J.F. and P.B. Moran (1981) concluded that the substitution of farm machinery for manual power in certain operations such as land preparation and post production has resulted in the reduction in total labour requirement for all operations. As a result of higher production and greater intensity of land cultivation, proponents of farm mechanization argue that the increase in the labour requirements of certain farming activities, i.e., harvesting, has an offsetting effect on the amount of labour displaced from other farm operations, such as land preparation. This implies that farm mechanization may alleviate the food problem that is common in most developing countries, like the Philippines, without necessarily displacing labour in the rural areas.

2.2 **Review of the Studies on Analysis of Farm Mechanization**

Important reasons for utilization of farm mechanization were high rate of agriculture labour, farm size, high cropping intensity, higher percentage of irrigated area and more adoption of high yielding technology. As cultivable land resources are limited, increased agricultural production can only be attained in most countries of the world through increased yields per hectare of land and improved preservation of already produced commodities. Technological inputs must be applied wisely and economically to bring about the desired increased outputs of production. Mechanization is one of the critical inputs of production followed by preservation of food crops. Mechanization can increase yields through the improvement of water control, better soil preparation for planting, more efficient weed and insect control and the proper harvesting, handling, drying, storing and processing of food, feed and fiber crops. So that, agricultural mechanization is the art and scientific application of mechanical aids for increased production and preservation of food and fiber crops with less drudgery and increased efficiency.

One of the interesting studies is by Ray. A. KC (1993), who analyzed the status of agricultural mechanization in Indian agriculture. The main conclusions drawn from this study are the following. The use of traditional implements is much more popular as compared to the improved implements and machineries. A small farm size, low adoption of HYV seed, percentage of areas under irrigation, poor cropping intensity, higher wage rates and poor holding size are some of the constraints for non-adoption of agricultural implements and machinery in most of the states, in both the periods under study.

Binswanger H.P. (1978) has analyzed the economics of tractors in south Asia, by considering different studies in recent years. The main effort of this work is to review the studies, and present their findings in a way which makes them comparable across agro-climatic zones. The researcher has apparently two contradictory views regarding the benefits of tractors. The first is the substitution view in which the switch from animal power to tractor power is primarily guided by factor prices or factor scarcities. The second is the net contributor view of tractors, which in a more extreme forms, argues that power is a primary constraint to agricultural production almost, regardless of factor prices. The power of tractors allows more through or deeper tillage than with bullocks. Tractor machinery such as seeders, levelers, and interculture equipment also achieve higher level of precision. Both factors would lead to higher yields. Furthermore, tractors may be able to reclaim land which cannot be operated by bullocks at all. Finally, the high power and speed tractors would allow more timely operation, thus contributing both to higher yields; and to a more extensive practice of double cropping. Higher yields and double cropping would lead to higher levels of output, requiring more labour in operation, not performed by the tractor. The tractor could therefore contribute to increased production without necessarily displacing labour. Tractorization would be consistent with employment objectives, even in low wage countries.

Cezer G.Salas (1987) has done pioneering study on mechanized rice production in Philippines agriculture. The mechanized farm operations done were of the nature of field and seed bed preparation, transplanting, weed control, pest control, harvesting and threshing.

The main conclusions are, that the farm mechanization should be practiced by farmers especially in seed bed and field preparation because of the shorter time involved at the same cost. Adequate irrigation throughout the year will give the farmers all the chances to plant rice three times a year, thus, there is a greater possibility of increasing yearly income of the farmers. Mechanized method of transplanting and field care, on the other hand, is greater in tost than the non-mechanized. But in terms of labour requirement non-mechanized transplanting and field care is twice greater than the mechanized. By taking the option of mechanized transplanting and field care it will give the farmer ample time for other farm activities to be done.

Balishter, et.al (1991) did analytical work on impact of farm mechanization on employment and farm productivity in Mathur district. The main conclusions that emerge from this study are the average value of farm assets in mechanized farms and about 8 times more than that in non-mechanized farms and about 4 times more than that in partially mechanized farms. The average cropping intensity is the highest in mechanized farms (206.4%) followed by partially mechanized farms (176.6%) and the non-mechanized farms (143.8%). The mechanized farms allocate more area under high income crops as compared to partially mechanized and non-mechanized farms. In comparison to non-mechanized farm, the per hectare yield was high by about 10 to 27 per cent in mechanized farms and by about 2 to 16 per cent high in partially mechanized farms in all the major crops grown in these farms. The net returns per hectare in mechanized farms is about 49 per cent higher than in the partially mechanized farms and about 29 per cent higher than in non-mechanized farms. The labour use per hectare of cultivated area is about 197 man days in non-mechanized farms, 208 man days in partially mechanized farms and 212 man days in mechanized farms.

Another interesting study by Howard F. McColly (1973) examined the factors influencing agricultural mechanization in different Asian countries. The main conclusion of this study indicates that the rural sector of the less developed countries is difficult and continues but possible slowly. Unfavourable land tenure patterns have sustained the poor traditional social and economic conditions in many of the Asian countries. Mechanization, if planned and timed properly with other technological inputs can play important role in increasing productivity of land and man. Mechanization must enhance multi-cropping and diversification of crops.

Bina Agarwal (1983) traced out the cropping intensity effects of tractors and tube wells in the Punjab. The researcher identified some of the limitations existed in earlier studies. Firstly many of them do not take into account the tractors as a source of irrigation, the level of irrigation, farm size and agro-climatic zones, which could also significantly affect cropping intensity. Secondly, most studies, use the ownership of a tractor as a proxy for usage: farms where tractors are hired in are counted as bullock-farms. Thirdly, in all the noted studies cropping intensity is defined conventionally as the ratio (expressed as a percentage) of gross cropped area to net sown area. While this index is straightforward to interpret, it suffers from one major weakness: it takes no account of the differences between farmers in their ability to intensify cultivation. The main conclusions are, that tractors (in particular owned tractor) and tube wells were associated with high cropping intensity, as measured by each of the incices, in comparison with bullocks and canals respectively. However, the advantage of tube wells over canals was much greater than that of tractors over bullocks. That irrigation, in particular, tube well irrigation, is a more important factor in increasing cropping intensity, than the use of tractors in lieu of bullocks, which has been emphasized in other studies as well. On individual farms, tractors need not lead to a diversion of land under fodder to other crops, and at the micro level, say, for Punjab as a whole, whether or not, tractorisation significantly reduces the area under fodder would depend on how substantial a reduction in bullock requirements and hence in the bullock population that helps to bring about. On the whole, the cropping intensity advantages of tractorisation in the Punjab appear to have been overstated.

Verma, S.R (2008) conducted on the impacts of mechanization on production, productivity, cropping intensity, income generation and employment of labour in Punjab. These studies indicated that agricultural mechanization led to increase in inputs due to higher average cropping intensity, larger area and increased the productivity of farm labour. Furthermore, arm mechanization increased agricultural productivity and profitability on account of timeliness of operations, better quality of work and more efficient utilization of crop inputs. Undoubtedly, farm mechanization displaced animal power from 60 to 100% but resulted in less time for farm work. Also mechanization led to increase in the human labour employment for the on-farm and off-farm activities as a result of manufacture, repair, servicing and sales of tractors and improved farm equipment.

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CHAPTER 3
RESEARCH METHODOLOGY

3.1 Study Area

3.1.1 Location and choice of the study area

Nay Pyi Taw is located between the Bago Yoma and Shan Yoma mountain ranges. It is more centrally and strategically located than the old capital, Yangon. It is also a transportation hub located adjacent to the Shan, Kayah and Kayin states. It is situated within 19˚ 44' 42" N latitude and 96 7' 47" E longitudes, and it covers a total area of 7,054.37 square km and 320 feets above sea level (Figure 3.1).

The Nay Pyi Taw Union Territory consists of the city proper (downtown) and eight surrounding townships. Downtown is further divided into four wards. Pyinmana, Lewe, and Tetkone townships were all formerly part of Yamethin District. Oatharathiri, Dekkinathiri, Popphathiri, Zaputhiri, and Zeyarthiri are all new townships currently under construction. For surveying, Aisaut and Seinsarpin, two villages from Zeyarthiri as well as Ahlyinlo and Nutthaye, two villages from Pyinmana townships, were selected as a study area. In Aisaut village, there are 370 households, 185 land holders and 995 farm labours. The total population of the Aisaut village is about 1336. There are 474 households, 109 land holders, 1200 farm labour, and 1837 population in Senisarpin village. The total population of Ahlyinlo village is about 1684, household number 790, land holder 123 and farm labour is about 1223. In Nutthaye village, there are 436 households, 325 land holders, 1350 farm labour, and the total population is about 2107 (Table 3.1).

Nay Pyi Taw was chosen as a sample area for the impact of agricultural mechanization on production, productivity, cropping intensity, income and employment of labor. Aisaut, Seinsarpin, Ahlyinlo and Nutthaye are the most tractor using villages in Nay Pyi Taw. (MAS, 2010) These four villages are irrigated areas and grow monsoon rice-summer rice-black gram.

At least 25 construction companies, including Asia World and Htoo Ltd, were making new buildings in Nay Pyi Taw. Many farm labours are working in construction sites instead of farm works. Construction works pay more wage rates than farm works. Therefore, many landless labours would like to work in construction sites more than in farming activities.

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Farm labour force is now decreasing and labour wage rates are increasing year by year. Farmers are facing labour scarcity in peak season such as land preparation, growing, harvesting. Agricultural machines, seeder, power tillers, tractors, inter-cultivator, and combine harvester, can be used in land preparation, growing, weeding and harvesting as a replacement for human workers and cattle/buffalo.

Factors leading to the choice of these villages were: 1) power tillers have been used here for several years. 2) The villages are predominantly rice areas, with good irrigation and wide adoption of HYV of rice and other crops. Based on the concentration of power tillers, 109 power tiller owners were selected as sample. This study emphasized only on before and after buying power tiller effects among the various kinds of agricultural machines.

Table 3.1 General Description of the Study Area (2010-2011)

Village Tract	**Village**	**Household no.**	**18 years<**		**18 years>**		**Population**	
			Male	**Female**	**Male**	**Female**	**Male**	**Female**
1 Kyaukchet	Aisaut	370	216	246	422	452	638	698
2 Mautaw	Seinsarpin	474	293	328	576	640	869	968
3 Ahlyinlo	Ahlyinlo	790	238	232	553	661	791	893
4 Nutthaye	Nutthaye	436	372	405	625	707	997	1,110

1.2 Agriculture and Land Utilization of Pyinmana Townships

Although new five townships were constituted in 2006, there were no specific data for each township until 2011. The agricultural data of Lewe and Tatkon townships have also been separately until 2011. The data that dealt with the agricultural production were all constituted in Pyinmana agricultural production data.

Rice is the most important crop in Pyinmana area. The total monsoon and summer rice production area is 23948.18 ha in 2008-2009 growing season. Among these area, 6051.42 ha (25% of total sown area) are under irrigation. The rainfed lowland area is 17896.76 ha (75% of total). The dams in the study area are Chaungmagyi, Ngalaik and Yezin dams. Chaungmagyi Dam is located on the north of Nay Pyi Taw, Ngalaik Dam is on the south, and Yezin Dam is on the northeast.

Cropping patterns grown in irrigated area of Pyinmana Township were monsoon paddy- summer paddy and monsoon paddy- food legume- summer paddy during 2009-2010 growing season.

As of Figure 3.2, the highest irrigated and rainfed areas were 7,170.04 ha in 2000-2001 and 19,471.26 ha in 2002-2003 respectively. About 0.40% irrigated area and 8.01% rainfed area of Pyinmana Township has slightly been decreasing from 2000 to 2009. Because the cultivated area has changed to urban area that is fulfilled with infrastructure like shopping mall, zoological garden, hotel zone, etc.

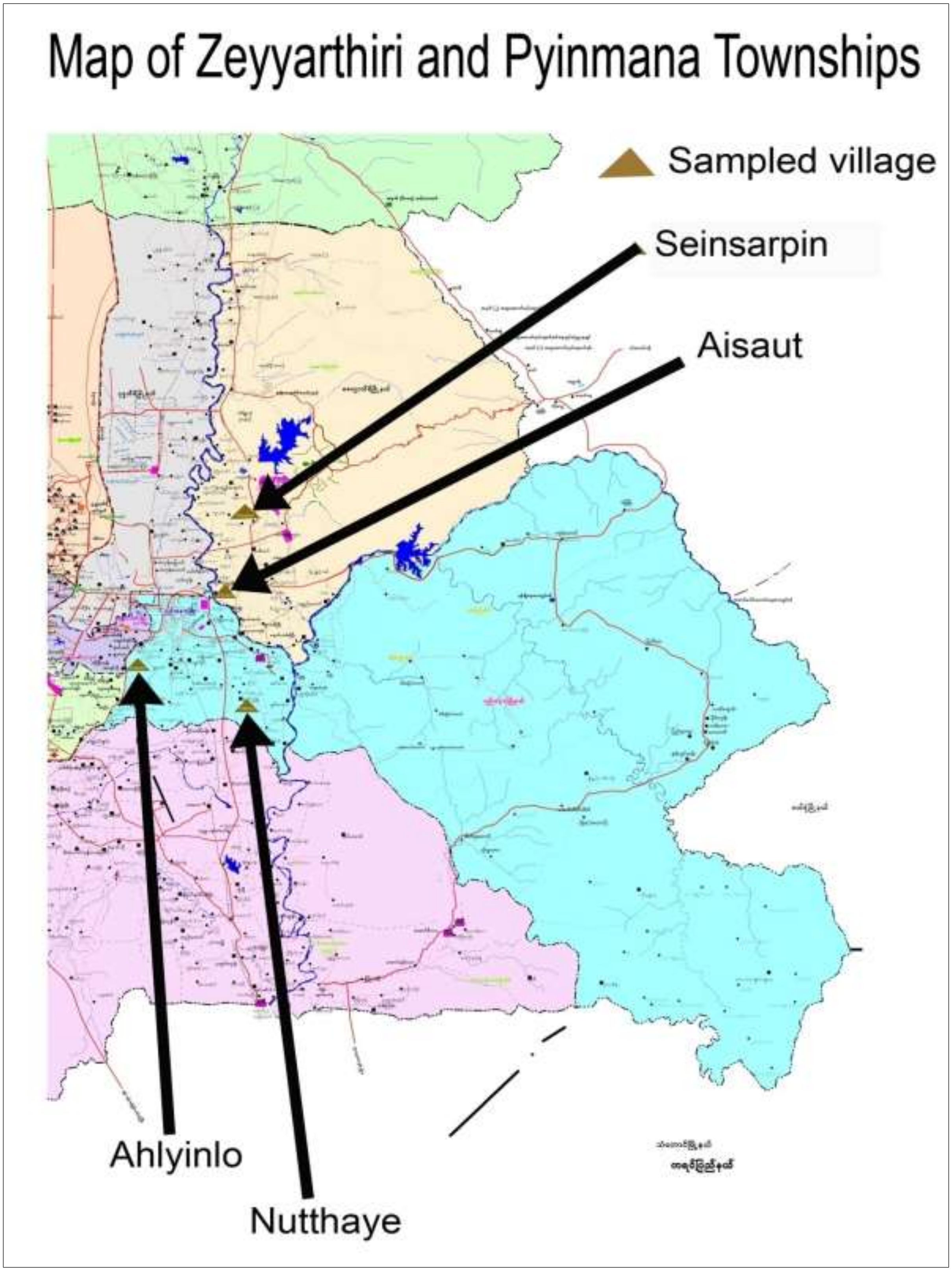

Figure 3.1 Map of Zeyyarthiri and PyinmanaTownships

Source: SLRD, Pyinmana (2010)

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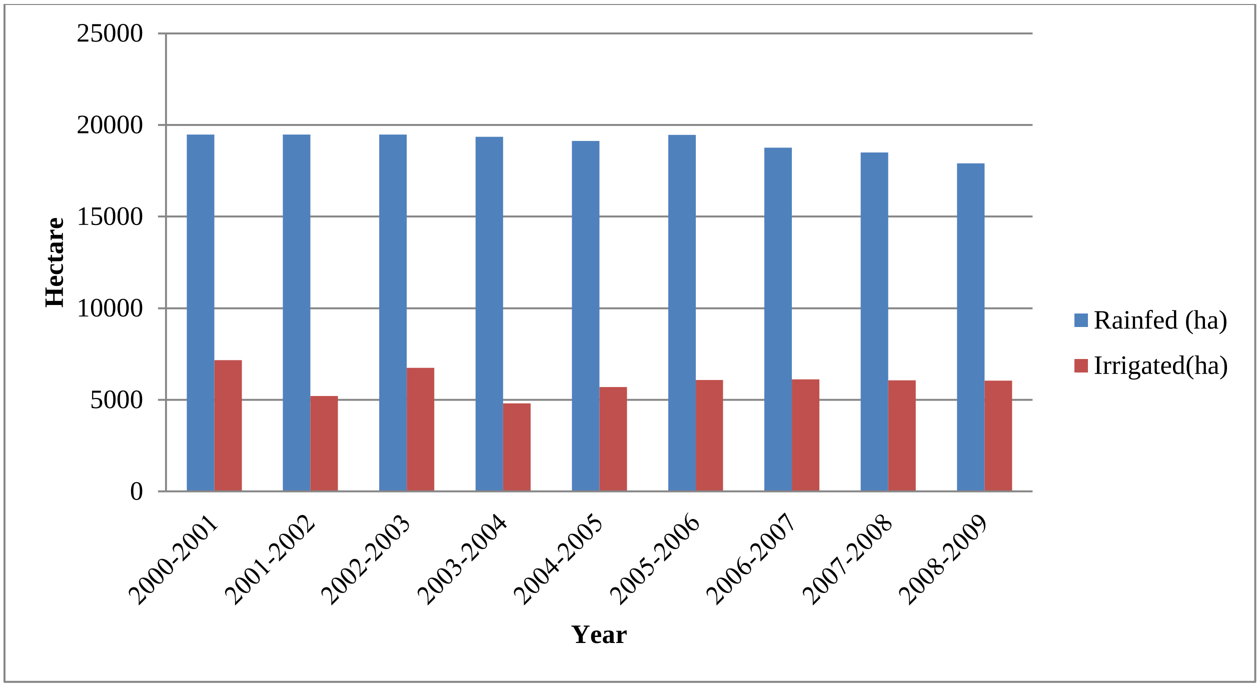

Figure 3.2 Irrigated and rainfed area (hectare) of Pyinmana Township
Source: MAS, Pyinmana (2010)

The 2000-2001 harvested area of monsoon paddy was 18,957.9 ha and the highest during these nine years. The harvested area of monsoon paddy was 17,868.4 ha and the lowest in the year of 2008-2009. The highest yield and the lowest yields of monsoon paddy were 5,221.2 kilogram per hectare in 2006-2007 and 18,013.40 kilogram per hectare in 2003-2004 (Table 3.3).

In summer rice, the highest harvested area of 7,170 ha was in 2000-2001 and the lowest 4,814 ha was in 2003-2004. The harvested area of black gram was increasing annually until 2006. Black gram is a major cash crop for farmers in Pyinmana. The harvested area of black gram decreased from 7,522 ha to 7368 ha in 2007-2008 but about 868.8 kilogram per hectare of black gram yield reached a peak in 2009 (Table 3.3).

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Table 3.3 Production of Three Major Crops in Pyinmana Township (2001-2009)

Year	Monsoon Paddy			Summer Paddy			Black Gram		
	Area (ha)	Yield (Kg/ha)	Production (Kg/ha)	Area (ha)	Yield (Kg/ha)	Production (Kg/ha)	Area (ha)	Yield (Kg/ha)	Production (Kg/ha)
2001-02	18,957.9	3,606.5	68,372,047	7,170	4,431.8	31,775,990	3,939	704.4	2,774,801
2001-02	18,665.2	3,666.2	68,429,761	5,217	4,521	23,584,189	5,550	739.7	4,104,998
2002-03	18,172.1	3,596.7	65,358,844	6,738	4,673.5	31,488,328	5,349	684.2	3,659,592
2003-04	18,013.4	3,541.7	63,797,623	4,814	4,656.4	22,414,671	3,915	702.8	2,751,883
2004-05	18,955.1	3,565	67,575,267	5,704	4,646.5	26,505,826	3,841	719.4	2,763,570
2005-06	19,454.7	3,593	69,901,258	6,076	4,773.6	29,002,978	6,841	724.1	4,953,818
2006-07	18,700.8	5,221.2	97,641,307	6,115	5,786.6	35,387,390	7,522	752.6	5,661,207
2007-08	18,496.4	5,055.3	93,503,709	6,057	6,081.8	36,835,260	7,368	806.6	5,942,883
2008-09	17,868.4	5,200	92,915,209	6,051	5,958.8	36,059,339	7,187	868.8	6,244,266

Source: MAS, Pyinmana (2010)

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3.1.5 Distribution of Powertillers from Agricultural Mechanization Department of Nay Pyi Taw Division

Following the agricultural policies, agricultural mechanization department aided farmers to develop agricultural sector and stabilized productivity. In Table (3.4), the data pointed out that the selling amount of power tillers in Nay Pyi Taw agricultural mechanization department from 2006 to 2012. The types of agricultural machineries distributed from this department were Leyar-16, Leyar-22, Dong-phan, Thai-buffalo and AMR 994. Lewae Township bought the largest amount and there were 36.04% of Leyar-16, 59.24 % of Leyar-22 and 80.34% of Dong-Phan power tillers from agricultural mechanization department during six years. Pyinmana was the second largest buyers of Dong-Phan and Leyar-16 and had the percentage of 13.48 and 34.74 respectively in buying power tillers from the department. Tet-Kone was the lowest buyers of Dong-Phan and Leyar-16. There were 6.18 % in Dong-Phan and 29.22 % in Leyar-16 power tillers in buying from Nay Pyi Taw agricultural mechanization department. Besides Nay Pyi Taw agricultural mechanization department, there are companies and sale centers that sell agricultural machines in Nay Pyi Taw. They are Good brothers' company limited, Sein Yadanar, Pann Nu Yaung, Myin Than (U), Malar Myaing, etc (myanmarbusiness-directory.com).

Table 3.4 Distribution of Power Tillers from Agricultural Mechanization Department of Nay Pyi Taw (2006-2011)

(number)

No	**Year**	**Leyar-16**			**Leyar-22**			**Dong-Phan**			**Thai-buffalo**			**AMR994**		
		P	**T**	**L**	**P**	**T**	**L**	**P**	**T**	**L**	**P**	**T**	**L**	**P**	**T**	**L**
1	2006- 07	57	39	79	-	-	-	-	-	-	-	-	-	-	-	-
2	2007-08	23	9	32	12	24	-	-	-	-	-	-	-	21	1	-
3	2008-09	-	-	-	2	1	43	-	-	-	-	-	-	-	-	-
4	2009-10	27	38	-	4	30	56	-	-	-	-	-	-	-	-	-
5	2010-11	-	4	-	4	9	26	5	5	-	1	2	-	-	-	-
6	2011-12	-	-	-	-	-	-	19	6	143	7	2	-	-	-	-
Total (Township)		107	90	111	22	64	125	24	11	143	8	4	-	21	1	-
Total (NPT)		308			211			178			12			23		

Source: AMD, 2012

Note: P – Pyinmana, T – Tetkone, L – Lewae, NPT – Nay Pyi Taw

3.2 Data Collection

Data were collected from 109 respondents from four villages of Pyinmana and Zeyyarthiri townships in Nay Pyi Taw Division during the period of February 2011 and March 2011. From Pyinmana Township, Ahlyinlo and Nutthaye villages were selected as sample villages. 31 farm households from Ahlyinlo village and 25 farm households from Nutthaye village were collected as samples. From Zeyyarthiri Township, 28 farm households were sampled from Aisaut village and 25 farm households from Seinsarpin village. In the study area, power tiller owners were selected because there is not enough other machinery–owners to analyze the impact of farm mechanization. Therefore, the purposively random sampling method was used to collect the data, and about 109 power tiller owned farmers were randomly selected.

The selected farmers were asked on their demographic and socio-economic characteristics such as farmer's age, education, experience in farming, family size, shelter condition, luxury ownership, productive assets, monsoon paddy production, summer paddy production, black gram production. For profitability of power tiller ownership, land preparation served area by power tiller, custom rate, fuel price, repair and maintenance cost of power tiller, and interest rate were collected. The secondary data were also collected from the village head office, township manager of Myanmar Agricultural Service, Pyinmana, Agricultural Mechanization Department and Settlement and Land Record Department.

3.3 Data Analysis Method

(a) Descriptive analysis was applied to compare the socio-economic characteristics of sampled power tiller owners.

(b) Economic analysis was applied to compare the financial profitability of before and after buying power tiller.

(c) To estimate the influencing factors of production of monsoon paddy and summer paddy, the Cobb-Douglas production function, which was transformed into linear form by using the natural logarithm, was applied.

The Cobb-Douglas production function is a standard production function which is applied to describe much output to inputs into a production process make. It is used commonly in both macro and micro examples. Log-linearization simplifies the function, meaning just that taking logs of both sides of a Cobb-Douglas function gives one better separation of the components. In the Cobb-Douglas function, the elasticity of substitution between capital and labour is 1 for all values of capital and labour (http://economics.about.com/cs/economicsglossary).

The Cobb-Douglas production function was applied to estimate the influencing factors of production of monsoon paddy and summer paddy in this study. Therefore, the following model was used:

$$Ln\ Yi = ß_0 + ß_i\ Ln\ X_{1i} + ß_i\ Ln\ X_{2i} + ß_i\ Ln\ X_{3i} + \ldots + \mu_i$$

Where,

Y_i = yield per hectare of crop in kilograms

Ln = natural logarithm

X_{1i} = total amount of fertilizer used per hectare (Kg)

X_{2i} = total amount of pesticide used per hectare (L)

X_{3i} = pre-harvest labor input per hectare (hour)

X_{4i} = total amount of machine/animal services used in land preparation measured in man-machine hours per hectare (hour)

X_{5i} = household head’s experience(yr)

X_{6i} = farm size(yr)

μ_i = disturbance or error term

(d) To evaluate tractor profitability, the benefit cost ratios (BCR), net present value (NPV) and break even points (BEP) were calculated for each group.

BCR is defined as the ration of the value of benefits to the value of cost, and is usually expressed as a discounted present value using the following formula:

$$BCR = \frac{\sum_{t=0}^{n}\frac{B_t}{(1+r)^t}}{\sum_{t=0}^{n}\frac{C_t}{(1+r)^t}} \lesseqgtr 1$$

where:

B_t - the benefits incurred in year t. These include annual benefits of own and off-farm area cultivated and the salvage value in kyats.

C_t - the costs incurred in year t. These include initial tractor cost and variable costs (for fuel, operator/drivers and repairs and maintenance).

t - index of the t th year

n - the tractor life (year)

r - the interest (discount) rate

NPV is defined as the net present value of cash inflows and outflows. A project is economically justified if the present value of inflow minus outflow is greater or equal to zero and unjustified otherwise. The NPV formula is:

$$\text{NPV} = \sum_{t=0}^{n}\frac{B_t}{(1+r)^t} - \sum_{t=0}^{n}\frac{C_t}{(1+r)^t} \lesseqgtr 1$$

where:

B_t, C_t, t, n and r are as well as previously defined.

BEP analysis indicates that the level at which an investment neither incurs a loss not produces a profit. For mechanization, it is defined as the use level at which the machine must be operated (hectares of land cultivated) to cover total annual costs. The BEP formula is:

$$\text{BEP (ha/yr)} = \frac{AFC}{X} + \text{AVC} \quad \text{or}$$

$$\text{CR (X)} = \text{AFC} + \text{AVC(X)}$$

Hence,

$$X = \frac{AFC}{(CR - AVC)}$$

where:

CR _ the average custom rate (Kyats/ha)

X _ the hectare area served to cover total annual cost at breakeven

AFC _ average fixed cost (Kyats/ha) as the total sum of depreciation and interest on capital investment

AVC _ variable costs (Kyats/ha) as the total sum of operation costs as previously defined

The assumptions of the analysis are as follows: 1) the expected economic life of the tractor is 5-years, 2) the final salvage value is placed at 10% of initial capital investment after 5-years and, 3) the capital discount rate on tractor investments is 17% per annum.

(e) To measure the relative magnitude of changes in one or more variables that will reverse a decision among alternatives, sensitivity analysis was used. The variables of interest in the present analysis include: a) capacity utilization (ha/yr), b) purchase price (Kyats), c) contract rate (Kyats/ha) and d) economic life (years).

a) Sensitivity to capacity utilization. As annual use varies, the costs and revenue may also vary. The variables listed under group R_1 and C_2 to C_4 would vary in direct proportion to capacity utilization.

b) Sensitivity to initial purchase price. With the assumption that tractors cultivate a certain number of hectares each year, revenues (R_2) and fixed costs (C_1) will vary as the tractor price is varied. Other variables remain constant.

c) Sensitivity to the contract rate. The variables R_1, C_3 and C_4 will change as the contract rates changes.

d) Sensitivity to economic life, will affect the revenue (TR) and total cost (TC) (Appendix 4).

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Background Information on Sample Farm Households

The farm survey was conducted in Nay Pyi Taw Division from February to March, 2011 in two townships, i.e, Pyinmana and Zeyyarthiri, each having two sample villages. In Pyinmana Township, the following villages were included: Aisaut and Seinsarpin. In Zeyyarthiri Township are Nutthaye and Ahlyinlo villages (Table 4.1). The number of total households in the sample villages of Aisaut, Seinsarpin, Nutthaye and Ahlyinlo were 474, 436, 790, and 370 households, respectively. Among the total households, total farm households in the sample villages were 109, 125, 123 and 185 households respectively. Sampled farm households represented 5.27% of total households and 20.11% of total farm households.

4.2 Classification of Farm Households According to Buying Years

In the study area, farm-family-households can never in actual fact be considered a homogenous group. To evaluate activities of farm-family-household, the approach usually taken is to group the households in relatively homogenous clusters. The sample power tiller owners were classified into three groups: (1) last 11-15 year vintage group who bought power tiller from 1995-99; (2) last 6-10 year vintage group who bought power tiller from 2000-2004; and (3) last 5 year vintage group who bought power tiller from 2005-2010.

As shown in Table 4.2 , 26.61% of the total sample households can be classified as ‘last 11-15 year vintage group’, 26.61% of sample households as ‘last 6-10 year vintage group’, and 46.78% of sample households as ‘last 5 year vintage group’ based on buying year of power tiller. According to size of operational land holding, about 55.17% of last 11-15 year vintage group were large farmers who owned farm size of above 4.05 ha. About 48.28% of last 6-10 year vintage group and 56.86% of last 5 year vintage group were medium farmers who owned farm size of 2.03 ha to 4.05 ha. A few power tiller owners, 17.24% of last 11-15 year vintage group, 13.79% of last 6-10 year vintage group and 25.49% of last 5 year vintage group were small farmers (Table 4.3).

Table 4.1 Percentage of Sample Farm Households in the Study Area

Village name	Total households (no.)	Total farm households (no.)	Sampled farm households (no.)
Aisaut	474	109 (22.99%)	28 (25.69%)
Seinsarpin	436	125 (28.67%)	25 (20.00%)
Nutthaye	790	123 (15.57%)	25 (20.33%)
Ahlyinlo	370	185 (50.00%)	31 (16.76%)
Total	**2,070**	**542 (26.28%)**	**109 (20.11%)**

Source: Field survey, 2011

Note: Values in parentheses indicate percentages

Table 4.2 Power Tiller Owners of the Sample Farm Households According to the Buying Years

Buying years	Sampled farm households (no.)
(a) Last 11-15 years (1995-99)	29 26.61%)
(b) Last 6-10 years (2000-04)	29 26.61%)
(c) Last 5 years (2005-10)	51 (46.78%)
Total	109 (100%)

Source: Field survey, 2011

Note: Values in parentheses indicate percentages

Table 4.3 Distribution of Sample Power Tiller Owners According to Size of Operational Holding

Size of Operational Holdings (ha)	Power Tiller Owners			
	Last 11-15 years	Last 6-10 years	Last 5 years	Total
<5ac (<2.02 ha)	5 (17.24)	4 (13.79)	13 (25.49)	22 (20.18)
6-10ac (2.03 - 4.05 ha)	8 (27.59)	14 (48.28)	29 (56.86)	51 (46.79)
>10 (> 4.05 ha)	16 (55.17)	11 (37.93)	9 (17.64)	36 (33.03)
Total	**29 (100)**	**29 (100)**	**51 (100)**	**109 (100)**

Source: Field survey, 2011

Note: Values in parentheses indicate percentages

4.3 Changes in Demographic and Social Characteristics of Sample Farm Households

4.3.1 Demographic characteristics of sample farm households

In terms of demographic characteristics (Table 4.4), the eldest of sample farmers was 53.90 years in age and was found in last 11-15 year vintage group. The average age of last 6-10 year vintage group was 51.90 years and it was the youngest group among the sample farmers. Last 5 year vintage group had 53.43 years in age. There were not so much differences in the average age of the sample farmers in the study areas. Last 11-15 year vintage group had 31.79 years farm experience in average. Over 29 years' farming experience was found in last 5 year vintage group while last 6-10 year vintage group had less experience in farming as 28.29 years in average. The average schooling years of the household head were 4.41 years in last 11-15 year vintage group, and 4.45 years in last 6-10 year vintage group. In last 5 year vintage group, the average schooling years of the household head were 6.14 years. Therefore, last 5 year vintage group was more educated than the other two groups. The average family members were 4.90 members in last 11-15 year vintage group, 4.86 members in last 6-10 year vintage group and 3.29 members in last 5 year vintage group. The family labours were around 3 members on average in three groups. There were no significant difference in age, experience, schooling year, family size and family labour among three groups.

4.3.2 Productive asset ownership of sample farm households

In table 4.5, of the total 109 farmers, 62.07% of last 11-15 year vintage group, 55.17% of last 6-10 year vintage group and 23.53% of last 5 year vintage group possessed pump well. Thresher was owned by 68.97% of last 11-15 year vintage group, 62.07% of last 6-10 year vintage group and 21.57% of last 5 year vintage group. Only 6.89% in last 11-15 year vintage group, 3.45% in last 6-10 year vintage group and 7.84% in last 5 year vintage group possessed machine sprayer.

Table 4.4 Demographic Characteristics of Sample Farm Households

Items	Power tiller owners		
	Last 10-15 years (1995-99)	Last 5-10 years (2000-04)	Last 5 years (2005-10)
Average head's age (year)	53.9	51.9	53.43
F-test	F= 0.230 ^{ns}, p= 0.795, df= 2		
Average head's schooling year (year)	4.41	4.45	6.14
F-test	F= 2.181 ^{ns}, p= 0.118, df= 2		
Average family size (no.)	4.90	4.86	4.88
F-test	F= 0.003 ^{ns}, p=0.997, df= 2		
Average family labour (no.)	3.69	3.03	3.29
F-test	F= 1.347 ^{ns}, p= 0.264, df= 2		
Average head's experience (year)	31.79	28.29	29.54
F-test	F= 0.639 ^{ns}, p=0.530, df= 2		

Source; Field survey, 2011

Note: ***, **, * significant at 1%, 5% and 10% level and ^{ns} = not significant

Table 4.5 Productive Asset Ownership of Sample Farm Households

Power Tiller Owners	Farmers having pump well	Farmers having thresher	Farmers having machine sprayer
Last 11-15 years (N=29)	18 (62.07)	20 (68.97)	2 (6.89)
Last (10-5) years (N=29)	16 (55.17)	18 (62.07)	1 (3.45)
Last 5 years (N=51)	12 (23.53)	11 (21.57)	4 (7.84)

Source: Field survey, 2011

Note: Values in parentheses indicate percentages

4.3.3 Changes in housing conditions of sample farm households

As shown in Table 4.6, about 41.38% and 37.93% of sample farmers stayed in the house of thatch roof and bamboo wall house type in last 11-15 year vintage group and last 6-10 year vintage group respectively before buying power tiller. After buying power tiller, there was no sample farmer who lived in thatch roof and bamboo wall house type in last 11-15 year vintage group and last 6-10 year vintage group. In last 5 year vintage group, about 31.37% of sample farmers possessed the house type of thatch roof and bamboo wall in before buying power tiller. However, after buying power tiller, there is only on sample farmers who lived in the house type of thatch roof and bamboo wall. Among the three groups, the sample farmers who stayed in the house type of corrugated iron sheet roof and wooden wall did not change significantly before and after buying power tiller.

The share of sample farmers living in the house type of corrugated iron sheet roof and brick wall increased from 6.89% to 48.28 % in last 11-15 year vintage group, from 3.45% to 51.72% in last 6-10 year vintage group and from 0% to 37.25% in last 5 year vintage group after buying power tiller.

4.3.4 Changes of livestock ownership of sample farm households

The sample farmers breed less number of draught cattle after buying power tiller than before buying power tiller and t-test indicated there was significantly different in number of own cattle before and after buying power tiller at 1% level. For land preparation, instead of the utilization of draught cattle/buffalo alone, sample farmers in the study area were using power tiller or power tiller and draught cattle/buffalo combinations. Difference in ownership of dairy cattle, buffalo, poultry and pig was not significant before and after buying power tiller (Table 4.7).

Table 4.6 Changes in Housing Conditions of Sample Farm Households

Items	Last 11-15 years (N=29)		Last 6-10 years (N=29)		Last 5 years (N=51)	
	Before	After	Before	After	Before	After
1. BW & TR	12 (41.38)	0	11 (37.93)	0	16 (31.37)	1 (1.96)
2. W & CI	15 (51.73)	15 (51.72)	17 (58.62)	14 (48.28)	35 (68.63)	31 (60.78)
3. B & CI	2 (6.89)	14 (48.28)	1 (3.45)	15 (51.72)	0	19 (37.25)

Source: Field survey, 2011

Note: BW & TR = Bamboo wall and Thatch roof

W & CI = Wooden and Corrugated iron sheet

B & CI = Brick and Corrugated iron sheet

Values in parentheses indicate percentages

Table 4.7 Changes of Livestock Ownership of Sample Farm Households

Livestock (Number)	Last 11-15 years (N=29)		t-test	Last 6-10 years (N=29)		t-test	Last 5 years (N=29)		t-test
	Before	After		Before	After		Before	After	
1.Draught cattle	2.07	0.90	4.31***	2	0.93	3.75**	1.47	0.78	3.85***
2.Dairy cattle	0	0		0	0		0.22	0.14	1 ns
3.Draught buffalo	1.0	0.83	0.87 ns	0.17	0.17		0.55	0.45	0.48 ns
4.Hen	14	25.69	0.65 ns	12.93	4.79	0.77 ns	7.45	7.43	0.03 ns
5.Pig	0.38	0.66	1.68 ns	0.38	0.41	0.27 ns	0.78	0.76	0.11 ns

Source: Field survey, 2011

Note: ***, **, * significant at 1%, 5% and 10% level and ns = not significant

4.3.5 Changes of farm and home assets of sample farm households

As shown in Table 4.8, farm and home asset ownership of last 11-15 year vintage group and last 6-10 year vintage group changed significantly in generator, motorcycle, television, video compact disc player and pump well at 1% level of significance. However, there was no significant increase in bicycle, radio, well, sewing machine and refrigerator of last 11-15 year vintage group and last 6-10 year vintage group. Ownership of bicycle, motorcycle, radio, television and video compact disc player was increased significantly at 1% level in last 5 year vintage group. Although ownership of generator, well, pump well and sewing machine in last 5 year vintage group was increased after buying power tiller, the paired sample t-test demonstrated that the changes of these asset ownership were not significantly different. One can say that the living standard of the farmers as regards possession of farm and home assets has improvement after buying power tiller.

4.4 Utilization of Human Labour per Hectare in Crop Production of Sample Farm Households

Labour employment is a basic source of livelihood for the rural poor. A comparison of labour utilization before and after buying power tiller was shown in Table 4.9. The average human labour employment per hectare before buying power tiller was 127.95 man-days as compared to 87.99 man-days per hectare after buying power tiller, which was 31.23% less in monsoon paddy production of last 11-15 year vintage group. In summer paddy production, average human labour employment decreased from 117.69 man-days to 80.43 man-days after buying power tiller. It was concluded that displacement of human labour was significant after buying power tiller at 1% level of significance in last 11-15 year vintage group.

In last 6-10 year vintage group, the average reduction in labour use after buying power tiller was 33.64% in monsoon paddy production and 33.12% in summer paddy production as compared to the labour use before buying power tiller. Paired sample t-test indicated that there was significant displacement of labour after buying power tiller at 1% level of significance.

In last 5 year vintage group, the average reduction in labour input after buying power tiller was 25.34% in monsoon paddy and 34.73% in summer paddy in comparison to the labour use before buying power tiller. It was concluded that displacement of human labour was significant after buying power tiller at 1% level of significance.

In all sample groups of black gram production, utilization of human labour per hectare increased from 37.74 man-days before buying power tillers to 69.57 man-days after buying power tiller in last 11-15 year vintage group, from 55.05 man-days to 74.79 man-days in last 6-10 year vintage group and from 50.71 man-days to 72.43 man-days in last 5 year vintage group. Paired sample t-test indicated that there was significant increase of labour use at 10% level in last 11-15 year vintage group and last 5 year vintage group. At present, farmers are using more pesticide and nutrients in black gram production for better quality and prevention of pests and insects. Therefore, labours employed in pesticide and nutrient application for black gram had been increased significantly in the study area (Table 4.9).

4.5 Percentage Change of Local and Hybrid Rice Varieties of Sample Farm Households

Gaut, Shwe War Htun, Inn Ma Yebaw, E` Ma Hta and Shwe Ta Sote are the local varieties of rice that were sown in the study area. The modern varieties of rice were Thu Kha Yin, Manaw Thu Kha, Shwe Thwe Yin, Sin Thwe Lat, Yar Kyaw and Thi Htet Yin. In the monsoon rice, the percentage of growing high yielding varieties were 83% and that of growing local varieties were 17% of the sample farmers before buying power tiller. But, after buying power tiller, 99% of the monsoon rice growing farmers used high yielding varieties and only 1% used local variety. In summer rice production, high yield varieties of rice were sown by 90% of sample farmers and local varieties by 10% of them before buying power tiller. However, after buying power tillers, high yielding varieties were sown by all sample farmers. These were described in Table 4.10. Therefore, the introduction of high yielding varieties brings concurrent requirements for improvement in cultural practices with the effective use of farm machinery.

Table 4.8 Changes of Farm and Home Assets of Sample Farm Households

Assets (Number)	Last 11-15 years (N=29)		t-test	Last 6-10 years (N=29)		t-test	Last 5 years (N=51)		t-test
	Before	**After**		**Before**	**After**		**Before**	**After**	
Generator	0.07	0.48	4.45***	0.14	0.79	3.09***	0.06	0.14	2.06*
Bicycle	1.48	1.38	0.39ns	0.9	1.07	0.66ns	0.71	1.18	4.16***
Motorcycle	0.14	1.24	6.33***	0.03	1.17	7.76***	0.08	0.84	7.69***
Radio	0.52	0.72	2.07*	0.28	0.48	2.268*	0.16	0.49	4.29***
TV	0.21	0.86	7.29***	0.03	0.86	11.59***	0.12	0.67	7.82***
VCD	0.10	0.86	9.38***	0.00	0.93	10.96***	0.04	0.67	9.18***
Well	0.69	0.83	2.12*	0.66	0.83	1.983ns	0.59	0.73	2.45*
Pump well	0.00	0.62	6.77***	0.00	0.55	5.870***	0.04	0.24	2.64*
Sewing machine	0.34	0.41	0.70ns	0.31	0.45	1.68ns	0.06	0.16	1.69ns
Refrigerator	0.03	0.10	1.44ns	0.00	0.03	1ns	0.02	0.02	

Source: Field survey, 2011

Note: ***, **, * significant at1%, 5% and 10% level and ns = not significant

Table 4.9 Utilization of Human Labour per Hectare in Monsoon Paddy, Summer Paddy and Black Gram Production of Sample Farm Households

Crop	Last 11-15 years (N=29)		t-test	Last 6-10 years (N=29)		t-test	Last 5 years (N=51)		t-test
	Before	After		Before	After		Before	After	
Monsoon Rice	127.95	87.99	6.88***	118.59	78.70	8.12***	112.47	83.97	9.27***
Summer Rice	117.69	80.43	5.92***	118.10	78.99	4.79***	111.33	72.67	9.25***
Black gram	37.74	69.57	2.69*	55.05	74.79	1.49ns	50.71	72.43	2.66*

Source: Field survey, 2011

Note: ***, **, * significant at1%, 5% and 10% level and ns = not significant

Table 4.10 Percentage Change of Local and Hybrid Rice Varieties of Sample Farm Households

Variety	Monsoon Paddy		Summer Paddy	
	Before (%)	After (%)	Before (%)	After (%)
High Yielding Variety (N=109)	83	99	90	100
Local Variety (N=109)	17	1	10	0

Source: Field survey, 2011

4.6 Changes in Crop Sown Area, Cropping Intensity, Yield, Value of Production and Inputs Used

4.6.1 Changes in crop sown area and cropping intensity of sample farm households

Table 4.11 represented the changes in crop sown area and cropping intensity of sample farmers. After buying power tiller, the sown area of monsoon paddy and summer paddy increased significantly at 10% level in last 11-15 year vintage group. In last 6-10 year vintage group, the sown area of monsoon paddy, summer paddy and black gram increased significantly after buying power tiller at 5% and 1% level respectively. Also in last 5 year vintage group, after buying power tiller there was a significant increase in the sown area of monsoon paddy, summer paddy and black gram.

Findings of this study presented to highlight the contribution of mechanization in enhancing the cropping intensity. The sample farmers after buying power tiller had a higher cropping intensity as compared to those before buying power tiller and the paired sample t-test showed that there were significant increase in the cropping intensity of last 6-10 year and last 5 year vintage groups at 1% level and of last 11-15 year vintage group at 5% level. Therefore, the cropping intensity was found to be higher after the introduction of power tiller.

4.6.2 Changes in yield of monsoon paddy, summer paddy and black gram of sample farm households

Based on the survey data in Table 4.12, the yield of monsoon paddy, summer paddy and black gram increased significantly at 1% and 5% level respectively. After buying power tiller, last 6-10 year vintage group obtained higher yield of monsoon paddy, summer paddy and black gram at 5%, and 10% level of significance. In last 5 year vintage group, yield of summer paddy and black gram increased significantly at 1% level. Although the yield of monsoon paddy increased from 4673.40 kilogram per hectare to 4697.10 kilogram per hectare, no statistically significant yield effect was found in last 5 year vintage group. This study revealed that the use of power tillers instead of draught cattle/buffalo for ploughing and sowing added to the yield of crops because of the advantage of timeliness of operation of a power tiller.

Table 4.11 Changes in Sown Area of Monsoon Paddy, Summer Paddy, Black Gram and Cropping Intensity of Sample Farm Households

(hectare)

Name	Last 11-15 years (N=29)		t-test	Last 6-10 years (N=29)		t-test	Last 5 years (N=51)		t-test
	Before	After		Before	After		Before	After	
Monsoon paddy	3.99	5.05	2.08*	2.81	4.08	2.93**	2.44	2.97	2.74**
Summer paddy	3.78	5.20	2.31*	2.62	3.89	2.99**	2.29	2.97	3.64**
Black gram	3.04	4.35	2.14*	2.85	3.77	2.81*	2.27	2.89	2.29*
Cropping intensity (%)	215.23	265.35	3.31**	216.35	282.64	5.37***	233.67	284.13	6.34***

Source: Field survey, 2011

Note: ***, **, * significant at1%, 5% and 10% level and ns = not significant

Table 4.12 Changes in Yield of Monsoon Paddy, Summer Paddy and Black Gram of Sample Farm Households

Crop	Last 11-15 years (N=29)		t-test	Last 6-10 years (N=29)		t-test	Last 5 years (N=51)		t-test
	Before	After		Before	After		Before	After	
Monsoon paddy	4453.70	4942.60	4.96***	4668.30	5115.50	3.08**	4673.40	4697.10	0.20ns
Summer paddy	4631.30	5187.00	4.01***	4760.90	5133.30	2.21*	4699.40	5176.10	4.67***
Black gram	1536.00	1977.70	4.33**	1650.50	2043.30	2.03*	1345.20	1765.50	4.91***

Source: Field survey, 2011

Note: ***, **, * significant at1%, 5% and 10% level and ns = not significant

4.7 Gross Margin Analysis of Crop Production of Sample Farm Households

A gross margin is simply an estimate or a budget of the income and costs associated with a specific crop or activity in a farming business. Gross margin analysis is used to determine which crops are more profitable than others. Gross margins are useful for decision-making. They are a logical and systematic way of assessing each activity including input costs such as machinery costs, fertilizer and labour and yields or market prices. Gross margin is used to calculate the profitability of crop production and is obtained by calculating the gross output by multiplying the output volume by the farm gate price received for the crop, and deducting the variable costs in producing the volume of output. Assessment of the benefits associated with power tiller-buying was done by using gross margin analysis in this study.

4.7.1 Gross margin analysis of monsoon paddy production of sample farm households

According to Table 4.13, the study revealed that the average gross benefit of monsoon paddy was found higher for 'after buying power tiller' compared to 'before buying power tiller' for all sample farm households in the study area. In last 11-15 year vintage group, gross benefit of monsoon paddy production increased from 44,450 kyats per hectare before buying power tiller to 1,011,513 kyats per hectare after buying power tiller and total production cost rose from 41183 kyats per hectare to 648,590 kyats per hectare during last 11-15 years.

Last 6-10 year vintage group obtained higher gross benefit after buying power tiller than before buying power tiller and ranged from 188,973 kyats per hectare before buying power tiller to 1,063,402 kyats per hectare in the case of monsoon paddy production. The total production cost of monsoon paddy production was higher by about 794,374 kyats per hectare after buying power tiller as compared to 168,936 kyats per hectare before buying power tiller in last 6-10 year vintage group.

Sample farmers after buying power tiller had a higher gross benefit of 995,764 kyats per hectare as compared to 584,125 kyats per hectare in the case of those before buying power tiller in last 5 year vintage group. The total production cost of last 5 year vintage group after buying power tiller was higher than that of before buying power tiller.

An average total production cost before buying power tiller was 449,878 kyats per hectare and that of after buying power tiller was 769,602 kyats per hectare.

Average benefit-cost ratio for monsoon paddy production was increased from 1.08 before buying power tiller to 1.56 after buying power tiller in last 11-15 year vintage group and from 1.12 to 1.34 in last 6-10 year vintage group. There is no change of benefit-cost ratio for monsoon paddy in last 5 year vintage group.

4.7.2 Gross margin analysis of summer paddy production of sample farm households

Last 11-15 year vintage group had achieved higher gross benefit of 1,089,270 kyats per hectare after buying power tiller than that of 50,941 kyats per hectare before buying power tiller. Sample farmers in last 11-15 year vintage group expensed higher total production cost of 669,157 kyats per hectare than that of 40,480 kyats per hectare before buying power tiller.

The gross benefit per hectare was 1,098,462 kyats per hectare after buying power tiller as compared to 199,920 kyats per hectare before buying power tiller in last 6-10 year vintage group. The total production cost was found to be higher after buying power tiller compared to before buying power tiller during last 6-10 years. The total production cost applied in summer paddy production was 150,630 kyats per hectare before buying power tiller and 807,971 kyats per hectare after buying power tiller.

In last 5 year vintage group, the total gross benefit received before buying power tiller was 601,472 kyats per hectare and that received after buying power tiller was 1,123,192 kyats per hectare. The total production cost incurred for production process before buying power tiller was 423,396 kyats per hectare and that incurred after buying power tiller was 773,177 kyats per hectare.

In summer paddy production, there was an increase in benefit-cost ratio of last 11-15 year vintage group from 1.21 before buying power tiller to 1.63 after buying power tiller, that of last 6-10 year vintage group from 1.32 to 1.36 and that of last 5 year vintage group from 1.42 to 1.45 (Table 4.14).

4.7.3 Gross margin analysis of black gram production of sample farm households

According to Table 4.15, the average gross benefit of black gram was found higher for 'after buying power tiller' compared to 'before buying power tiller' for all sample farm households in the study area. In last 11-15 year vintage group, gross benefit of black gram production increased from 93,936 kyats per hectare before buying power tiller to 1,519,104 kyats per hectare after buying power tiller and total production cost rose from 51,567 kyats per hectare to 503,114 kyats per hectare during last 11-15 years.

Last 6-10 year vintage group obtained higher gross benefit after buying power tiller than before buying power tiller and ranged from 172,800 kyats per hectare before buying power tiller to 1,599,669 kyats per hectare after buying power tiller in the case of black gram production. The total production cost of black gram was higher by about 591,760 kyats per hectare after buying power tiller to 85,578 kyats per hectare before buying power tiller to in last 6-10 year vintage group.

The sample farmers after buying power tiller had a higher gross benefit of 569,538 kyats per hectare in black gram production as compared to 1,269,048 kyats per hectare in the case of those before buying power tiller in last 5 year vintage group. The total production cost of black gram in last 5 year vintage group after buying power tiller was higher than that of before buying power tiller. An average total production cost before buying power tiller was 279,937 kyats per hectare and that of after buying power tiller was 476,827 kyats per hectare.

Average benefit-cost ratio for black gram production was increased from 2.47 before buying power tiller to 3.02 after buying power tiller in last 10-15 year vintage group, from 2.02 to 2.70 in last 5-10 year vintage group and from 2.03 to 2.66 in last 5 year vintage group.

Table 4.13 Changes in Production Cost, Net Benefit and Benefit-Cost Ratio of Monsoon Paddy Before and After Buying Power Tiller

Items	Last 11-15 years (N=29)		Last 6-10 years (N=29)		Last 5 years (N=51)	
	Before	**After**	**Before**	**After**	**Before**	**After**
Yield (Kg/ha)	4,454	4,889	4,668	5,115	4,673	4,697
Price (Ks/ha)	10	207	40	208	125	212
Gross benefit (Ks/ha)	**44,540**	**1,011,513**	**188,973**	**1,063,402**	**584,125**	**995,764**
(A) Material Cost (Ks/ha)	17,746	346,809	82,099	483,959	218,014	445,344
Seed	1,723	38,275	7,623	37,661	23,418	37,360
Fertilizer	9,027	200,679	45,575	260,773	135,165	243,574
Pesticide and Herbicide	4,883	62,867	18,516	93,731	39,303	78,615
FYM	1,944	24,824	9,792	67,483	17,997	60,513
Fuel		14,940		19,680		18,752
Food cost	169	5,226	593	4,631	2,131	6,530
(B) Family Labour Cost (Ks/ha)	3,044	43,660	14,359	49,504	47,116	53,531
Driver		2,224		1,912		2,186
Land preparation	781	6,175	2,965	4,746	12,882	9,069
Cleaning the Field Margin	144	2,471	654	2,345	1,970	2,765
Seeding	136	2,253	548	2,516	1,489	2,148
Fertilizer application	127	1,961	557	2,150	1,810	2,958
Pesticide and Herbicide application	108	1,641	550	1,813	1,587	1,908
FYM Application	123	2,115	733	2,451	2,055	2,955
Manual weeding	206	2,436	1,900	6,656	5,290	3,351
Threshing and winnowing	252	2,593	1,237	2,004	3,782	3,431
Drying	292	4,599	736	1,745	2,473	3,728
Transportation	875	15,191	4,478	21,167	13,778	19,032
(C) Hired Labour Cost (Ks/ha)	14,037	157,299	46,716	136,766	117,621	151,232
Driver		2,414		2,433		1,963
Land preparation	816	8,968	4,326	4,296	15,790	7,232
Cleaning the Field Margin	163	2,868	628	2,741	2,342	2,256
Seeding	1,429	34,782	1,728	13,372	11,698	21,356
Fertilizer application	147	2,391	624	2,417	1,786	2,353
Pesticide and Herbicide application	108	1,865	550	1,967	1,914	2,138
Cowdung Application	150	2,030	670	2,054	2,466	2,118
Manual weeding	1,401	9,013	7,384	12,451	11,618	6,341
Harvesting	2,793	45,020	11,560	50,789	30,650	44,201
Threshing and winnowing	5,651	18,965	13,997	34,714	21,864	35,476
Drying	401	3,765	1,491	877	3,796	4,146
Transportation	978	25,218	3,756	8,655	13,697	21,652
(D) Interest on Cash Cost (Ks/ha)	6,356	100,822	25,763	124,145	67,127	119,495
Material cost	3,549	69,362	16,420	96,792	43,603	89,249
Hired labour cost	2,807	31,460	9,343	27,353	23,524	30,246
Total Production Cost	**41,183**	**648,590**	**168,936**	**794,374**	**449,878**	**769,602**
Net Benefit	**3,357**	**362,924**	**20,036**	**269,028**	**134,247**	**226,162**
BCR	**1.08**	**1.56**	**1.12**	**1.34**	**1.30**	**1.29**

Table 4.14 Changes in Production Cost, Net Benefit and Benefit-Cost Ratio of Summer Paddy Before and After Buying Power Tiller

Items	Last 11-15 years (N=29)		Last 6-10 years (N=29)		Last 5 years (N=51)	
	Before	After	Before	After	Before	After
Yield (Kg/ha)	4,631	5,187	4,760	5,133	4,699	5,176
Price (Ks/ha)	11	210	42	214	128	217
Gross benefit (Ks/ha)	**50,941**	**1089,270**	**199,920**	**1,098,462**	**601,472**	**1,123,192**
(A) Material Cost (Ks/ha)	18,996	382,215	69,889	495,372	205,093	463,322
Seed	1,722	33,612	6,700	39,543	22,983	37,675
Fertilizer	11,920	243,367	48,358	298,865	128,828	246,696
Pesticide and herbicide	3,249	55,850	5,910	64,081	29,556	91,778
FYM	1,931	29,262	8,357	69,666	21,799	61,478
Fuel		14,974		18,780		19,170
Food cost	174	5,150	564	4,437	1,927	6,525
(B) Family Labour Cost (Ks/ha)	2,839	45,232	14,343	46,353	49,471	51,117
Driver		1,103		1,819		2,524
Land preparation	761	5,452	2,912	5,508	14,226	4,488
Cleaning the Field Margin	154	2,627	658	2,359	1,787	2,997
Seeding	134	2,184	537	2,138	1,494	2,123
Fertilizer application	149	2,340	607	2,357	1,637	3,261
Pesticide and Herbicide application	73	1,497	535	2,515	1,989	1,972
FYM Application	129	2,136	635	2,221	1,833	3,420
Manual weeding	195	2,232	1,578	3,335	4,344	3,800
Threshing and winnowing	180	2,913	957	3,447	2,663	3,664
Drying	283	6,020	987	5,768	2,988	5,443
Transportation	781	16,728	4,937	14,886	16,510	17,425
(C) Hired Labour Cost (Ks/ha)	12,672	137,723	43,683	139,310	106,512	138,395
Driver		1,190		2,244		2,269
Land preparation	982	6,535	4,386	4,296	16,810	5,573
Cleaning the Field Margin	148	3,000	558	2,790	2,041	2,260
Seeding	770	22,002	801	12,190	2,085	3,733
Fertilizer application	147	2,358	558	2,307	1,565	2,411
Pesticide and Herbicide application	317	2,078	535	1,715	1,617	2,069
Cowdung Application	144	1,946	659	1,764	1,716	2,401
Manual weeding	1,324	8,550	7,342	8,889	15,164	10,017
Harvesting	2,759	45,351	11,341	44,207	30,776	42,965
Threshing and winnowing	5,012	18,798	13,029	28,611	19,850	39,080
Drying	647	9,057	2,225	8,688	7,326	6,147
Transportation	422	16,858	2,249	21,609	7,562	19,470
(D) Interest on Cash Cost (Ks/ha)	6,333	103,987	22,715	126,936	62,320	120,343
Material cost	3,799	76,443	13,978	99,074	41,018	92,664
Hired labour cost	2,534	27,544	8,737	27,862	21,302	27,679
Total Production Cost	**40,840**	**669,157**	**150,630**	**807,971**	**423,396**	**773,177**
Net Benefit	**10,101**	**420,113**	**49,290**	**290,491**	**178,076**	**350,015**
BCR	**1,.25**	**1.63**	**1.33**	**1.36**	**1.42**	**1.45**

Table 4.15 Changes in Production Cost, Net Benefit and Benefit-Cost Ratio of Black Gram Before and After Buying Power Tiller

Items	Last 11-15 years (N=29)		Last 6-10 years (N=29)		Last 5 years (N=51)	
	Before	**After**	**Before**	**After**	**Before**	**After**
Yield (Kg/ha)	1,132	1,978	1,280	2,043	1,791	1,748
Price (Ks/ha)	83	768	135	783	318	726
Gross benefit (Ks/ha)	**93,936**	**1,519,104**	**172,800**	**1,599,669**	**569,538**	**1,269,048**
(A) Material Cost (Ks/ha)	29,537	279,496	38,816	335,968	124,149	243,284
Seed	8,680	65,541	10,522	68,749	31,420	69,407
Nutrient and pesticide	14,980	171,140	17,945	224,762	77,797	130,408
Fuel		15,480		15,840		15,824
Food cost	5,877	27,335	10,349	26,,617	14,932	27,645
(B) Family Labour Cost (Ks/ha)	2,090	31,351	6,598	39,213	26,226	41,407
Driver		1,188		1,553		1,634
Land preparation	741	4,278	1,288	3,005	5,741	4,418
Cleaning the Field Margin	91	2,085	215	2,123	739	2,137
Seeding		1,683		1,870		1,902
Nutrient and pesticide application	175	5,733	722	6,401	3,677	6,131
Manual weeding	98		615	3,774	2,489	2,933
Threshing and winnowing	88	2,927	215	4,574	1,411	3,655
Drying	81	4,046	260	3,672	1,249	3,723
Transportation	816	9,411	3,283	12,241	10,920	14,874
(C) Hired Labour Cost (Ks/ha)	11,694	113,640	27,001	124,488	87,277	119,566
Driver		1,533		1,654		1,368
Land preparation	557	3,243	2,576	3,780	6,490	2,921
Cleaning the Field Margin	68	2,085	185	1,995	1,227	2,087
Seeding	140	1,683	181	1,870	1,151	1,902
Nutrient and pesticide application	170	5,985	556	5,821	6,506	6,895
Manual weeding	896	3,510	2,423	4,199	7,879	4,467
Harvesting	1,757	35,069	4,679	38,272	31,098	39,856
Threshing and winnowing	7,505	43,514	13,749	46,276	22,488	43,608
Drying	170	4,731	491	3,931	1,678	3,196
Transportation	431	12,287	2,161	16,690	8,760	13,266
(D) Interest on Cash Cost (Ks/ha)	8,246	78,627	13,163	92,091	42,285	72,570
Material cost	5,907	55,899	7,763	67,194	24,830	48,657
Hired labour cost	2,339	22,728	5,400	24,897	17,455	23,913
Total Production Cost	**51,567**	**503,114**	**85,578**	**591,760**	**279,937**	**476,827**
Net Benefit	**42,369**	**1,015,990**	**87,222**	**1,007,909**	**289,601**	**792,221**
BCR	**1.82**	**3.02**	**2.02**	**2.70**	**2.03**	**2.66**

4.8 Factors Influencing the Monsoon and Summer Paddy Productivity of Sample Farm Households

The productivity of monsoon and summer paddy was estimated by using independent variables such as fertilizer amount, pesticide amount, land preparation labour, pre-harvest labour, head's experience and farm size. Cobb-Douglas production was used to estimate the yield of crop production. In decomposing the structural differences of the production functions for 'before and after buying power tiller,' the variable of land preparation labour must be made comparable for both sample farmers before and after buying power tiller. In the case of 'after buying power tiller,' land preparation hour by power tiller is in terms of man-machine hours, while in the case of before buying power tiller, land preparation hour is in terms of man-animal hours. To make them comparable, man-machine hours were converted to equivalent man-animal hours by multiplying a proportion which measured the speed of power tiller over drought cattle/buffalo in preparing a hectare of land. This was done by comparing the average amount of machine hours needed to plow, harrow and level a hectare of land to the average amount of animal power. In the case of power tiller versus draught cattle/buffalo, the ratio of the speed of the power tiller over draught cattle/buffalo in preparing a hectare of land is 3.29. This value was therefore used to standardize land preparation power and hence made them comparable.

Table 4.14 revealed that while fertilizer amount and farm size were important in explaining the variation in monsoon paddy productivity among the explanatory variables in the production function, land preparation labour was the most important variable in explaining this variation before buying power tiller. The land preparation labour coefficient indicated a 1% increase in land preparation hour would, in the average, had led to a 0.128% increase in productivity of monsoon paddy before buying power tiller in the study area. Yield of monsoon paddy have also been increased before buying power tiller by increasing the use of fertilizer amount and expanding farm size. The increase in yield of monsoon paddy would, on the average, have been 0.026% for each 1% increase in fertilizer amount and 0.03% for each 1% increase in farm size. The variation in monsoon paddy productivity explained by the variation in the independent variables included in model can be considered satisfactory because the value of adjusted R^2 was about 73.8%.

According to Table 4.15, land preparation mechanization is the most important variable explaining the variation in yield of monsoon paddy after buying power tiller. The power tiller owners, on the average, could have increased their monsoon paddy production 0.19% by increasing the land preparation mechanization by 1%. Fertilizer amount, pesticide amount, pre-harvest labour, head's experience and farm size did not influence to increase monsoon paddy productivity after buying power tiller. The variation in the yield of monsoon paddy explained by the variation in the independent variables included in the model can be considered satisfactory because the value of adjusted R^2 was about 68.4%.

Based on the results of regression analysis before buying power tiller in Table 4.16, the fertilizer amount, land preparation labour, pre-harvest labour and head's experience explained a large proportion of the variation in summer paddy productivity. A 1% increase in land preparation hour increased the yield of summer paddy by 0.078% before buying power tiller. Increasing the amount of fertilizer, pre-harvest labour and experience of head by 1% increased the productivity of summer paddy by 0.128%, 0.019% and 0.017% respectively. Adjusted R^2 was equal to 0.901, indicating that 90.1% of the variability in the response was explained by the explanatory variables.

In Table 4.17 after buying power tiller a significant proportion of the variation in summer paddy productivity was explained by fertilizer amount, land preparation mechanization and pre-harvest labour. A 1% increase in fertilizer amount, land preparation hour by mechanization and pre-harvest labour would have been expected to result in 0.188%, 0.022% and 0.109% increases respectively in the yield of summer paddy after buying power tiller. Adjusted R^2 was equal to 0.873, indicating that 87.3% of the variability in the response is explained by the explanatory variables.

Therefore, absolute agricultural production could be increased significantly if effective utilization of power tiller in land preparation was enhanced.

Table 4.16 Influencing Factors on Yield of Monsoon Paddy Farmers (Land Preparation with Draught Animal)

Explanatory Variables	Unstandardized Coefficients		Standardized Coefficients	t-value	Sig.
	B	Standard error	ß		
Constant	3.307	0.405		73.75	0.000***
Fertilizer amount (Kg/ha)	0.026	0.012	0.128	2.233	0.028*
Pesticide amount (L/ha)	-0.003	0.015	-0.011	-0.021	0.837ns
Land preparation labour (animal-hour)	0.128	0.021	0.610	6.01	0.000***
Preharvest labour (man-hour)	0.007	0.007	0.056	0.99	0.321ns
Head's experience (year)	-0.002	0.009	-0.01	-0.22	0.820ns
Farm size (hectare)	0.03	0.01	0.25	2.31	0.023*
R^2	0.754				
Adjusted R^2	0.738				
N	109				
$F_{6,92}$ = 47.07, sig = 0.000***					

Dependent variable: Yield of Monsoon Paddy
Note: ***, **, * significant at1%, 5% and 10% level and ns = not significant

Table 4.17 Influencing Factors on Yield of Monsoon Paddy Farmers (Land Preparation with Power Tiller)

Explanatory Variables	Unstandardized Coefficient		Standardized Coefficient	t-value	Sig.
	B	Standard error	ß		
Constant	3.26	0.07		50.17	0.000^{***}
Fertilizer amount (Kg/ha)	0.02	0.02	0.07	1.16	0.249^{ns}
Pesticide amount (L/ha)	-0.01	0.01	-0.08	-1.39	0.17^{ns}
Land preparation labour (mechanization)	0.19	0.06	0.73	3.20	0.002^{**}
Pre-harvest labour (man-hour)	0.03	0.05	0.21	0.69	0.491^{ns}
Head's experience (year)	-0.02	0.04	-0.09	-0.43	0.665^{ns}
Farm size (hectare)	-0.004	0.06	-0.02	-0.07	0.947^{ns}
R^2	0.71				
Adjusted R^2	0.684				
N	32.79				
	$F_{6,82}$ = 32.79, sig = 0.000^{***}				

Dependent variable: Yield of Monsoon Paddy

Note: ***, **, * significant at1%, 5% and 10% level and ^{ns} = not significant

Table 4.18 Influencing Factors on Yield of Summer Paddy Farmers (Land Preparation with Animal)

Explanatory Variables	Unstandardized Coefficient		Standardized Coefficient	t-value	Sig.
	B	Standard error	ß		
Constant	3.16	0.03		113.34	0.000***
Fertilizer amount (Kg/ha)	0.13	0.01	0.60	9.58	0.000***
Pesticide amount (L/ha)	0.00	0.01	-0.00	-0.05	0.961ns
Land preparation labour (mechanization)	0.08	0.01	0.46	7.41	0.000***
Pre-harvest labour (man-hour)	0.02	0.01	0.19	3.90	0.000***
Head’s experience (year)	0.02	0.01	0.12	2.23	0.032*
Farm size (hectare)	-0.01	0.01	-0.05	-1.06	0.296ns
R^2	0.914				
Adjusted R^2	0.901				
N	109				
$F_{6,40}$ = 70.91, sig = 0.000***					

Dependent variable: Yield of Summer Paddy

Note: ***, **, * significant at1%, 5% and 10% level and ns = not significant

Table 4.19 Influencing Factors on Yield of Summer Paddy Farmers (Land Preparation with Power Tiller)

Explanatory Variables	Unstandardized Coefficient		Standardized Coefficient	t-value	Sig.
	B	Standard error	ß		
Constant	3.07	0.07		43.49	0.000^{***}
Fertilizer amount (Kg/ha)	0.19	0.05	0.61	4.17	0.000^{***}
Pesticide amount (L/ha)	0.01	0.01	0.04	1.06	0.293^{ns}
Land preparation labour (mechanization)	0.02	0.01	0.11	2.73	0.008^{**}
Pre-harvest labour (man-hour)	0.11	0.02	0.54	4.52	0.000^{***}
Head's experience (year)	0.02	0.01	0.07	1.49	0.140^{ns}
Farm size (hectare)	-0.05	0.04	-0.21	-1.19	0.237^{ns}
R^2	0.881				
Adjusted R^2	0.873				
N	109				
$F_{6,87} = 107.13$, sig = 0.000^{***}					

Dependent variable: Yield of Summer Paddy

Note: ***, **, * significant at1%, 5% and 10% level and ^{ns} = not significant

4.9 Financial Profitability of Power Tiller Ownership

For financial profitability of power tiller ownership, the sample power tiller owners were grouped according to the year the power tiller was purchased. Five stratification or vintage groups were randomly chosen, based on the year of purchase and operation from 2005-06 to 2009-10. From the five vintage groups, three groups were further delineated for analysis. They were 2005 vintage group, 2006 vintage group and the average of the entire fifty-one power tiller group that applied 2011 prices to the entire tractor group.

According to size of operational holding among these three groups, there were three small farmers, five medium farmers and three large farmers in 2005 vintage group. In 2006 vintage group, there were one small farmer, eight medium farmers and one large farmer. In the average entire group, thirteen power tiller owners were small farmers, twenty-nine power tiller owners were medium farmers and nine power tiller owners were large farmers (Table 4.17).

As shown in Figure 4.1, only small power tiller owners of 2005 and 2006 vintage groups were not profitable, as indicated by BCRs less than one. A positive profit was found in medium and large power tiller owners of 2005 and 2006 vintage groups as well as the average entire group as mentioned by BCRs greater than one.

According to net present value (NPV) in Figure 4.2, medium and large power tiller owners of 2005 and 2006 vintage groups and an average entire group that applied 2011 price were profitable, as indicated by a positive NPV more than the opportunity cost of capital. Small power tiller owners of 2005 and 2006 vintage groups had achieved the negative profit for buying power tiller as mentioned by a negative NPV less than the opportunity cost of capital.

In Figure 4.3, comparative utilization by power tiller vintage group and location of activity was described. In the study area, average 17.49 hectares of own farm and 32.66 hectares for custom work were operated by the sample power tiller owners in the average entire group. In all vintage groups, own farm area worked is smaller than the area of custom work.

Breakeven served area and custom rate of power tiller was shown according to vintage group in Figure 4.4 and 4.5 respectively. At existing custom rates and capacity utilization, the minimum breakeven points of served area and custom rate were achieved in all vintage groups. Among the groups, the minimum breakeven served area was 18.02 hectares and the maximum area was 40.67 hectares. The minimum breakeven custom rate was 23,839.45 kyats per hectare and the maximum custom rate was 35,487.25 kyats per hectare among the groups.

According to sensitivity analysis, 10% increase in capacity utilization affected mostly on medium group. 1% increase in capacity utilization made 0.62% increase in BCR. In all vintage groups, increase in capacity utilization and contract rate had a positive impact on BCR and NPV. An increment in initial power tiller price and interest rate had a very adverse effect on the BCR and NPV. A 150% increase in interest rate decreased the BCR and NPV (Table 4.18).

Table 4.20 Distribution of Sample Power Tiller Owners According to Size of Operational Holding and Vintage Year

Vintage Year	Small farmers	Medium farmers	Large farmers
2005	3	5	3
2006	1	8	1
2007	-	4	2
2008	4	5	3
2009	4	4	-
2010	1	3	-
Total	13	29	9

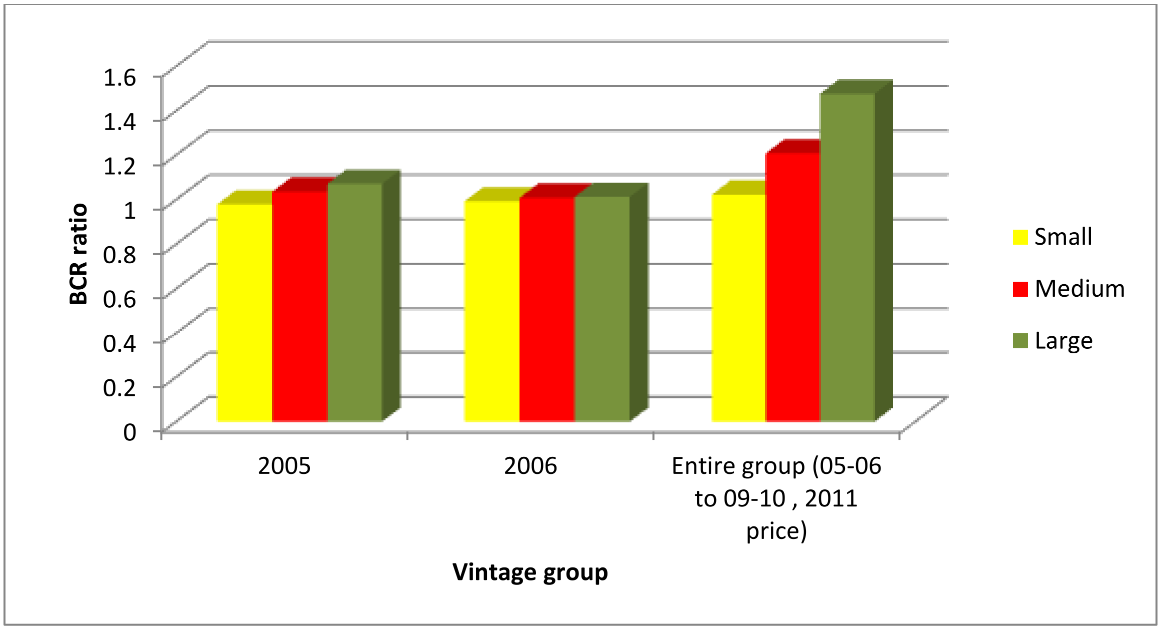

Figure 4.1 Benefit Cost Ratio of Power Tiller According to Vintage Group

Power tiller price (2005)	- 1610000 Kyats/unit
Power tiller price (2006)	- 1765000 Kyats/unit
Power tiller price (entire group-2011)	- 1860000 Kyats/unit

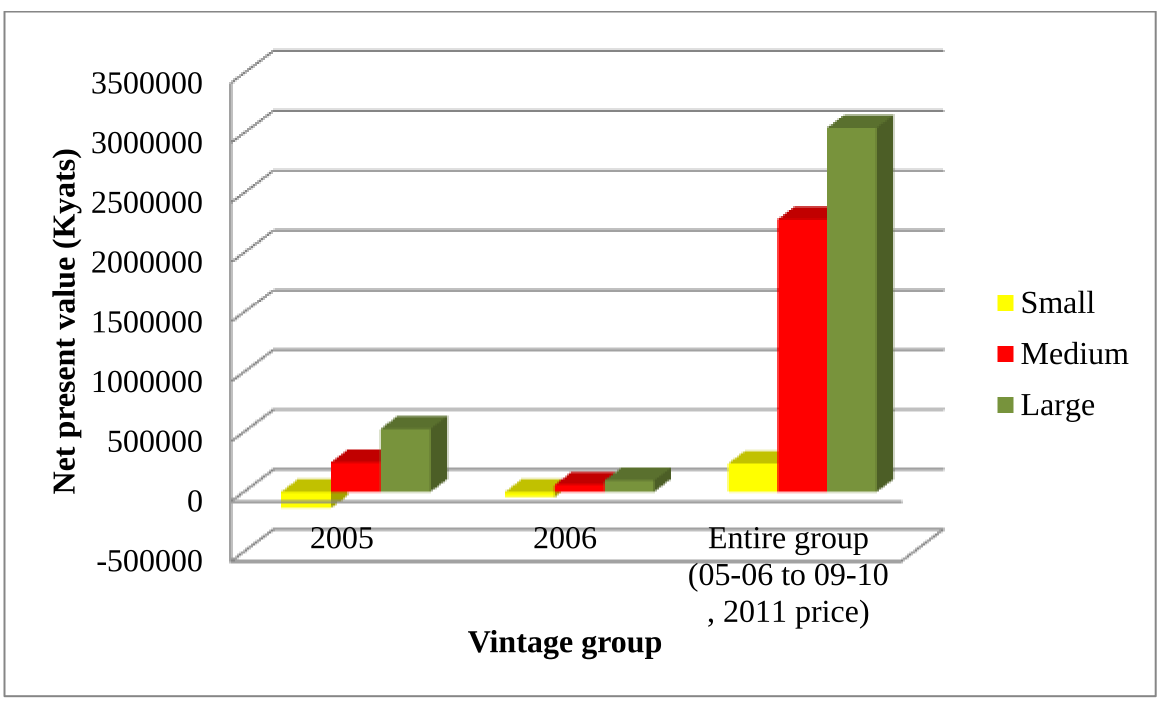

Figure 4.2 Net Present Value of Power Tiller According to Vintage Group

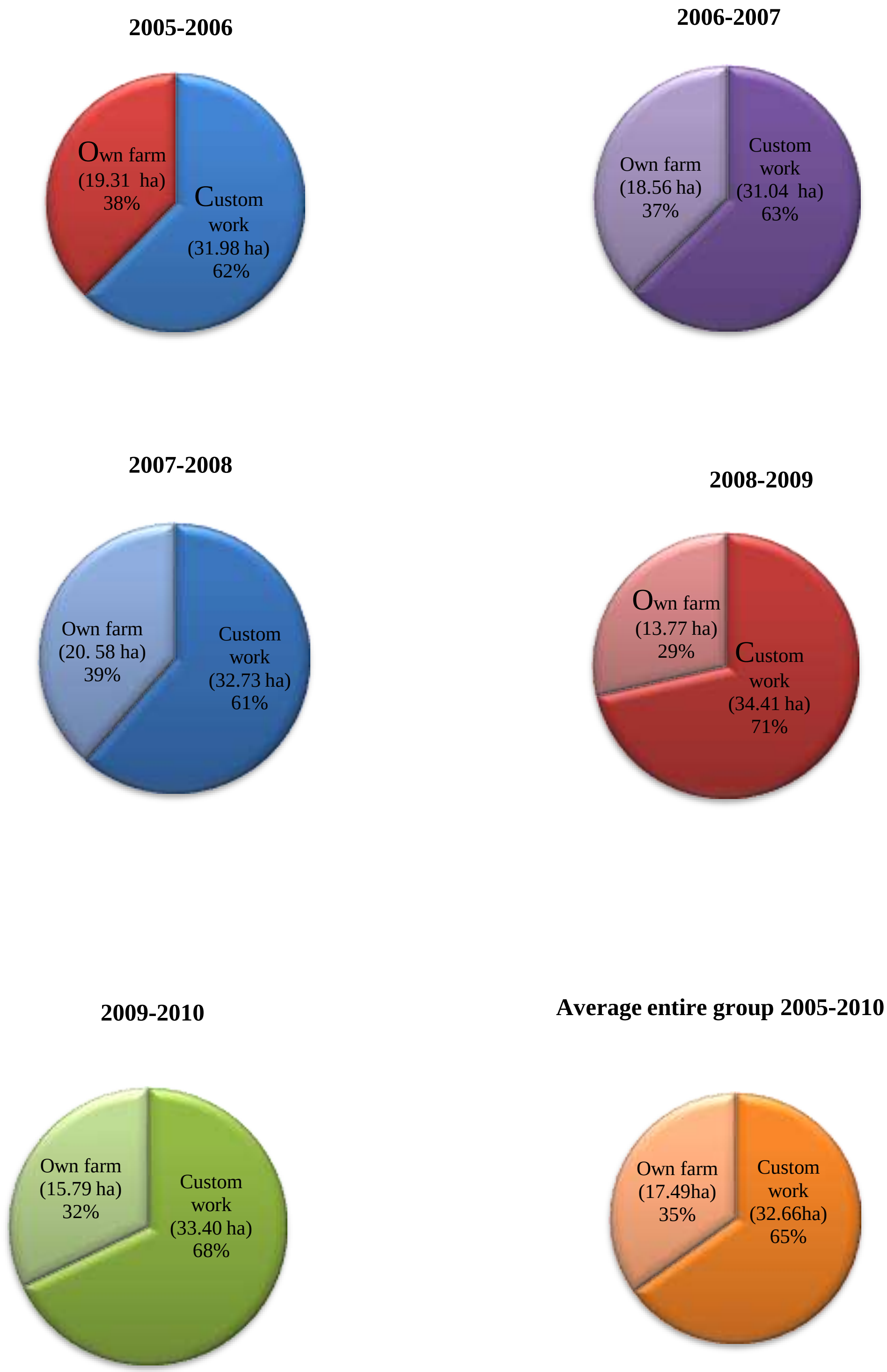

Figure 4.5 Comparative Utilization by Power Tiller Vintage Group and Location of Activity, 2005-2010

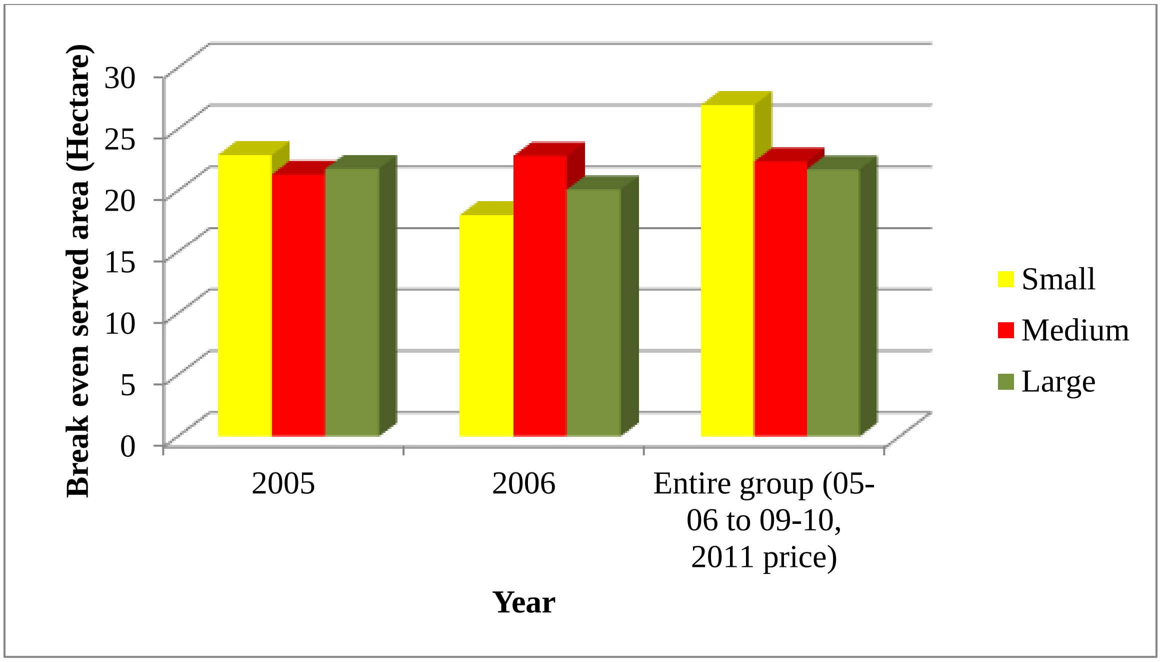

Figure 4.4 Breakeven Served Area of Power Tiller According to Vintage Group

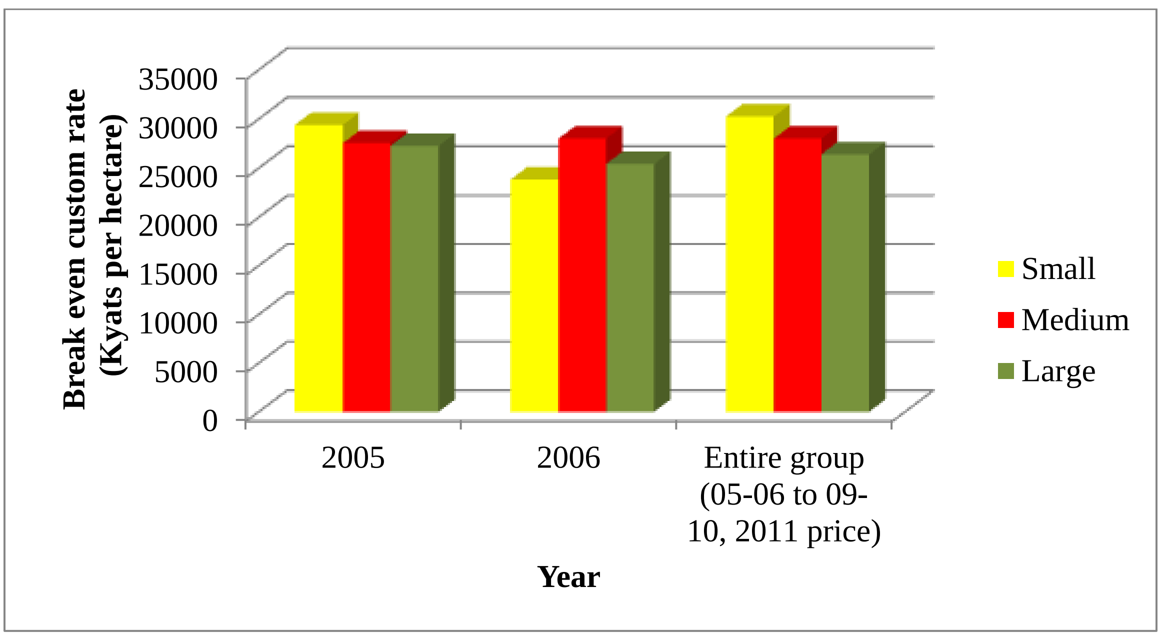

Figure 4.5 Breakeven Custom Rate of Power Tiller According to Vintage Group

Table 4.21 Sensitivity Analysis: Elasticities of BCR and NPV with Respect to Stated Parameters Using 2011 Prices for Average of Entire Group

Parameter	Small (N=13)		Medium (N=29)		Large (N=9)	
	BCR[a]	NPV[a]	BCR[a]	NPV[a]	BCR[a]	NPV[a]
1. Ordinary	1.02	235850	1.21	2279056	1.48	3044057
1. Capacity utilization	0.51	1.61	0.62	1.48	0.54	2.22
2. Initial power tiller price	-0.65	0.97	-0.39	-1.05	-0.36	-1.69
3. Contract rate[b]	0.80	0.91	0.80	2.03	0.77	3.16
	(-0.17)	(-1.98)	(-0.16)	(-0.18)	(-0.17)	(-0.81)
4. Interest rate[c]	-0.11	-0.45	-0.24	-0.66	-0.14	-0.89
5. Economic life	0.23	1.21	0.24	-0.62	0.22	0.54
6. Economic life and capital util.	0.46	0.95	0.47	3.81	0.38	1.90
7. Economic life and price	-0.55	-2.50	-0.51	0.80	-0.49	-1.92
8. Economic life and contract rate	0.64	0.95	0.68	4.40	0.62	2.46

- Assume a 10% increase in parameters 1,2,3 and one year of economic life in 5,6,7,8
- [a]Discount rate at 17%
- bA 20% custom rate reduction in parentheses
- cA 150% increase in interest rate from 17% to 42.5%
- The elasticities are defined as dY/dX and indicate the % change of the Y coefficient to a 10% change (increase) in the relevant parameter X

CHAPTER 5

CONCLUSION AND POLICY IMPLICATION

5.1 Conclusion of the study

Most of farmers included in last 11-15 year vintage group were large farmers who owned more than 4.05 ha. In last 6-10 year and last 5 year vintage groups, most farmers were medium farmers who owned farm between 2.43 ha and 4.05 ha. Across vintage groups, the households were not significantly different in terms of the average age, education and experience of sample farm households as well as the average total number of members per household. Among the groups of power tiller owner, last 11-15 year vintage group possessed more pump well and thresher than other two groups. Only a few percentage of sample farm households owned machine sprayer.

Nowadays, arising numbers of house type with bamboo or brick wall and corrugated iron sheet roof have been built in the studied villages. Improvement in shelter condition was significantly found after buying power tiller in all groups. Livestock rearing, especially cattle rearing, decreased significantly after buying power tiller in all groups. Farm and home asset ownership increased significantly in all groups after buying power tiller especially in generator, motorcycle, radio, television, video compact disc player and pump well. Therefore, one can say that the living standard of the farmers as regards possession of farm and home assets has improvement after buying power tiller.

It was found that the labour employed had significantly decreased after buying power tiller in monsoon and summer paddy production at 1% level, except in black gram production. About 41.28% and 42.45% of the selected power tiller owners changed from local to hybrid rice varieties in monsoon and summer paddy production respectively. Therefore, the introduction of high yielding varieties brings concurrent requirements for improvement in cultural practices with the effective use of farm machinery. After buying power tiller, a significant increase was found in the sown area of monsoon, summer paddy and black gram in all vintage groups. There was a significant increase in the cropping intensity of last 11-15 year, last 6-10 year and last 5 year vintage groups. Therefore, the cropping intensity was found to be higher after the introduction of power tiller.

The yield of monsoon paddy, summer paddy and black gram increased significantly in all vintage groups after buying power tiller. This study revealed that the use of power tillers instead of draught cattle/buffalo for ploughing and sowing added to the yield of crops because of the advantage of timeliness of operation of a power tiller. Average benefit cost ratio for monsoon paddy production was increased from 1.08 before buying power tiller to 1.56 after buying power tiller in last 11-15 year vintage group and from 1.12 to 1.34 in last 6-10 year vintage group. There is no change of benefit cost ratio for monsoon paddy in last 5 year vintage group. In summer paddy production, after buying power tiller the benefit cost ration of last 11-15 year vintage group increased from 1.21 to 1.63, last 6-10 year vintage group from 1.32 to 1.36 and last 5 year vintage group from 1.42 to 1.45. According to BCR of paddy production, it can be concluded that financial return of after buying power tiller in last 11-15 year vintage group was more attractive than before buying power tiller. However, BCRs of after buying power tiller in last 6-10 year and last 5 year vintage groups were not financially attractive than before buying power tiller. In BCRs of black gram production among the vintage groups, sample farmers after buying power tiller gained higher financial return than those farmers before buying power tiller.

In regression analysis before buying power tiller, fertilizer amount, land preparation labour, and farm size influenced positively and significantly on the yield of monsoon paddy. After buying power tiller, only land preparation mechanization influenced positively and significantly on the yield of monsoon paddy. In summer paddy production, fertilizer amount, land preparation labour, pre-harvest labour and head’s experience had a positive and significant influence on yield of summer paddy before buying power tiller. After buying power tiller, fertilizer amount, land preparation mechanization and pre-harvest labour had a positive and significant influence on yield of summer paddy after buying power tiller. Therefore, absolute agricultural production could be increased significantly if effective utilization of power tiller in land preparation were enhanced.

According to profitability and sensitivity analysis, average break even hectare per year was 23.69 ha at existing custom rates and capacity utilization in the study area. The average breakeven custom rate of 28212.59 kyats per hectare was charged to be efficient in buying power tiller. Small power tiller owners of 2005 and 2006 vintage groups were not profitable, as indicated by BCRs less than one, a negative NPV less than the opportunity cost of capital. Medium and large power tiller owners of 2005 and 2006 vintage groups and an average entire group that applied 2011 price were profitable as mentioned by BCRs greater than one, and a positive NPV more than the opportunity cost of capital.

Based on sensitivity analysis, increase in capacity utilization and contract rate at 5 year economic life had a positive impact on the BCR and NPV. An increment in initial power tiller price and interest had a very adverse effect on the BCR and NPV. 10% increase in capacity utilization and contract as well as one year increase in economic life impacted on the BCR and NPV positively. At 6 year economic life, an increment in initial power tiller price impacted adversely on the BCR and NPV. A sensitivity analysis showed that changes in the contract rates resulted in large changes in the BCR and NPV. A 10% increase in the contract rate increased the BCR and NPV. A reduction in the contract rate has a very adverse effect on the BCR and NPV. The NPV in particular was highly sensitive to capacity utilization and/or economic life. As a result of the BCR and NPV in the study area, large and medium sampled farmers were profitable after buying power tiller 5 year later.

It has been shown in the study that at prevailing prices, power tillers are likely to generate a positive return on investment with the exception of the small power tiller owners of 2005 and 2006 vintage group.

5.2 Policy Implication

In Myanmar, national food policy aims to increase food production through use of improved technologies, including new crop varieties, irrigation and farm mechanization. There is no separate National Policy on Agricultural Mechanization. However, this aspect is covered under the agriculture policy of the National government which promotes agricultural mechanization with the following goals in mind:

- Agricultural mechanization should lead to a sustainable increase in yields and cropping intensity with the objective of meeting the planned growth rate in agricultural production and maintaining it.
- The income of agricultural workers should rise at a satisfactory rate so that the disparity between urban and rural incomes is contained and they get opportunity to lead a dignified life.
- The benefits of agricultural mechanization should apply to all types of farmers including small and marginal ones in different regions of the country, particularly rainfed areas.
- Agricultural mechanization should create a worker friendly environment especially for women workers by lessening hard labour, health hazards and improve safety in production operations.
- Agricultural mechanization should lead to a reduced cost of production agricultural thereby increase the income of farmers and impart a price advantage while competing for export contracts in the international market.

Mechanization in agriculture is the need of time but adoption of farm machinery in the small farms of Myanmar will have differential impacts on family labour. In-depth analysis must be made not only in terms of how many man-machine hours have been substituted for man-animal hours but also in terms of which of the family household members have been relieved from farm work.

- In the light of high fuel cost, more local research must be done to develop appropriate mechanical technology which improves crop production efficiency without necessarily substituting for labour and is not dependent on petroleum base energy fuel for operation.

- The distribution of power tiller from area to area should be normalized. To solve this problem of mechanization, cooperative management of farm machinery and cooperative management of farm machinery and financing of second hand power tiller for small farmers may be effective.

According to regression analysis in this study, land preparation by power tiller (mechanization) is an important factor influencing on the yield of paddy. Therefore, agricultural mechanization is a very important element to increase agricultural productivity and production with dwindling percentage of the population engaged in agriculture. That farm mechanization led to increase in inputs on account of higher average cropping intensity and productivity of farm labour. It increased agricultural production and profitability on account of timeliness of operation, better quality of work done and more efficient utilization of inputs.

According to research findings in the study area, it was found that farm and home asset ownership, productive assets, and shelter condition improved the living standard of sample farmers after mechanization. In profitability and sensitivity analyses, the availability of capital at low interest rate constitutes a strong incentive for mechanization and has been a major inducement to invest in power tillers. The interest rate 1.42% per month was very low compared to 7%-15% per month from other lending groups. Power tillers are likely to generate a positive return on investment at prevailing prices. Therefore, mechanization of farm should be promoted to generate economic development opportunities for the rural area.

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APPENDICES

Appendix 1 Benefit-Cost Ratio of Power Tiller, Nay Pyi Taw 2005-2010 According to Vintage Group

Farm size group	2005 Vintage group	2006 Vintage group	Entire group (05-06 to 09-10, 2011 prices)
Small	0.979	0.993	1.023
Medium	1.036	1.009	1.208
Large	1.071	1.013	1.477

Source: Field survey, 2011

Appendix 2 Net Present Value of Power Tiller, Nay Pyi Taw 2005-2010 According to Vintage Group

Farm size group	2005 Vintage group	2006 Vintage group	Entire group (05-06 to 09-10, 2011 prices)
Small	-134543.47	-44457.51	235850
Medium	246740.89	59951.98	2279056
Large	526619.43	94897.84	3044057

Source: Field survey, 2011

Appendix 3 Breakeven Points of Area Served and Custom Rate of Power Tiller, 2005-2010 (2011 prices)

Year	Break even Area Served (ha)			Break even Custom rate (Kyats)		
	Small	Medium	Large	Small	Medium	Large
2005	22.92	21.34	21.79	29,405.27	27,544.8	27,263.55
2006	18.02	22.84	20.11	23,839.45	28,023.69	25,426.94
2007	-	22.06	20.89	-	28,432.75	25,897.08
2008	25.25	22.35	24.14	30,366.03	28,333.47	26,999.06
2009	28.05	23.75	-	32,078.3	28,491.19	-
2010	40.67	21.89	-	35,487.25	27,209.29	-
Average	26.98	22.37	21.73	30235.26	28005.87	26396.66

Source: Field survey, 2011

Appendix 4 Revenues, Costs and Profits of Power Tiller

No.	Item	
1.a.	Revenue = area served (ha) x custom rate (Kyats/ha)	= R1
b.	Salvage value = 10 percent of initial cost	= R2
		TR
2.	Expenses	
a.	Fixed cost (initial cost)	= C1
b.	Variable cost	
	Fuel = gallon/ha price (Kyats/gal) x area served (ha/yr)	= C2
	Driver = Ave.wage (Kyats/ha) x area served (ha/yr)	= C3
	Repair and maintenance = ave. cost (Kyats/yr) x area served (ha/yr)	= C4
		TC
3.	Profit (net benefit) л = TR - TC	

Appendix 5 Local and Hybrid Rice Varieties Sown in the Study Area

Local Rice Varieties	Hybrid Rice Varieties
Gaut	Thu-kha-yin
Shwe-war-htun	Ma-naw-thu-kha
Inn-ma	Shwe-thwe-yin
E`-ma-hta	Sin-thwe-lat
Shw-ta-sote	Yar-kyaw
	Thi-htet-yin

Source: Field survey, 2011

Appendix 6 Regression Results of Productivity of Monsoon Paddy Farmers (Land Preparation with Animal)

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	LG.BE.MR.LPlabour, LG.BE.MR.labour, LG.BE.MR.Pestamount, LG.BE.MR.fertilizer, LG.BE.MR.Exp, LG.BE.MR.Farmsize[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: LG.BE.MR.yield

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.868[a]	.754	.738	.02040	1.869

a. Predictors: (Constant), LG.BE.MR.LPlabour, LG.BE.MR.labour, LG.BE.MR.Pestamount, LG.BE.MR.fertilizer, LG.BE.MR.Exp, LG.BE.MR.Farmsize

b. Dependent Variable: LG.BE.MR.yield

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.118	6	.020	47.067	.000[a]
	Residual	.038	92	.000		
	Total	.156	98			

a. Predictors: (Constant), LG.BE.MR.LPlabour, LG.BE.MR.labour, LG.BE.MR.Pestamount, LG.BE.MR.fertilizer, LG.BE.MR.Exp, LG.BE.MR.Farmsize

b. Dependent Variable: LG.BE.MR.yield

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.307	.045		73.747	.000
	LG.BE.MR.fertilizer	.026	.012	.128	2.233	.028
	LG.BE.MR.labour	.007	.007	.056	.998	.321
	LG.BE.MR.Exp	-.002	.009	-.012	-.223	.824
	LG.BE.MR.Pestamount	-.003	.015	-.011	-.206	.837
	LG.BE.MR.Farmsize	.033	.014	.249	2.305	.023
	LG.BE.MR.LPlabour	.128	.021	.608	6.006	.000

a. Dependent Variable: LG.BE.MR.yield

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	3.5317	3.7284	3.6557	.03463	99
Residual	-.05161	.06682	.00000	.01977	99
Std. Predicted Value	-3.581	2.097	.000	1.000	99
Std. Residual	-2.529	3.275	.000	.969	99

a. Dependent Variable: LG.BE.MR.yield

Appendix 7 Regression Results of Productivity of Monsoon Paddy Farmers (Land Preparation with Power Tiller)

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	LG.Af.MR.Farmsize, LG.Af.MR.Fer, LG.Af.MR.Pestamount, LG.Af.MR.Exp, LG.Af.MR.LPLabour, LG.Af.MR.PreHLabour[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: LG.Af.MR.Yield

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.840[a]	.706	.684	.02978	1.634

a. Predictors: (Constant), LG.Af.MR.Farmsize, LG.Af.MR.Fer, LG.Af.MR.Pestamount, LG.Af.MR.Exp, LG.Af.MR.LPLabour, LG.Af.MR.PreHLabour

b. Dependent Variable: LG.Af.MR.Yield

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.174	6	.029	32.789	.000[a]
	Residual	.073	82	.001		
	Total	.247	88			

a. Predictors: (Constant), LG.Af.MR.Farmsize, LG.Af.MR.Fer, LG.Af.MR.Pestamount, LG.Af.MR.Exp, LG.Af.MR.LPLabour, LG.Af.MR.PreHLabour

b. Dependent Variable: LG.Af.MR.Yield

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.255	.065		50.170	.000
	LG.Af.MR.Fer	.022	.019	.070	1.162	.249
	LG.Af.MR.PreHLabour	.031	.045	.209	.691	.491
	LG.Af.MR.LPLabour	.194	.060	.733	3.203	.002
	LG.Af.MR.Pestamount	-.012	.009	-.084	-1.385	.170
	LG.Af.MR.Exp	-.019	.044	-.088	-.434	.665
	LG.Af.MR.Farmsize	-.004	.060	-.019	-.067	.947

a. Dependent Variable: LG.Af.MR.Yield

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	3.5368	3.8039	3.6868	.04453	89
Residual	-.12159	.08444	.00000	.02875	89
Std. Predicted Value	-3.368	2.630	.000	1.000	89
Std. Residual	-4.083	2.835	.000	.965	89

a. Dependent Variable: LG.Af.MR.Yield

Appendix 8 Regression Results of Productivity of Summer Paddy Farmers (Land Preparation with Animal)

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	LG.BE.SR.farmsize, LG.BE.SR.fer, LG.BE.SR.preHLabout, LG.BE.SR.pestamount, LG.BE.SR.exp, LG.BE.SR.LPLabout[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: LG.BE.SR.yield

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.956[a]	.914	.901	.01056	2.181

a. Predictors: (Constant), LG.BE.SR.farmsize, LG.BE.SR.fer, LG.BE.SR.preHLabout, LG.BE.SR.pestamount, LG.BE.SR.exp, LG.BE.SR.LPLabout

b. Dependent Variable: LG.BE.SR.yield

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.047	6	.008	70.911	.000[a]
	Residual	.004	40	.000		
	Total	.052	46			

a. Predictors: (Constant), LG.BE.SR.farmsize, LG.BE.SR.fer, LG.BE.SR.preHLabout, LG.BE.SR.pestamount, LG.BE.SR.exp, LG.BE.SR.LPLabout

b. Dependent Variable: LG.BE.SR.yield

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.164	.028		113.338	.000
	LG.BE.SR.fer	.128	.013	.596	9.854	.000
	LG.BE.SR.preHLabout	.019	.005	.190	3.896	.000
	LG.BE.SR.LPLabout	.078	.011	.456	7.406	.000
	LG.BE.SR.pestamount	.000	.006	-.002	-.049	.961
	LG.BE.SR.exp	.017	.008	.121	2.225	.032
	LG.BE.SR.farmsize	-.008	.007	-.054	-1.058	.296

a. Dependent Variable: LG.BE.SR.yield

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	3.5664	3.7231	3.6564	.03211	47
Residual	-.03443	.01877	.00000	.00985	47
Std. Predicted Value	-2.804	2.076	.000	1.000	47
Std. Residual	-3.260	1.777	.000	.933	47

a. Dependent Variable: LG.BE.SR.yield

Appendix 9 Regression Results of Productivity of Summer Paddy Farmers (Land Preparation with Power Tiller)

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	LG.Af.SR.Farmsize, LG.Af.SR.LPLabour, LG.Af.SR.pestamount, LG.Af.SR.HHExp, LG.Af.SR.PreHLabour, LG.Af.SR.fer[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: LG.Af.SR.yield

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.939[a]	.881	.873	.02189	1.482

a. Predictors: (Constant), LG.Af.SR.Farmsize, LG.Af.SR.LPLabour, LG.Af.SR.pestamount, LG.Af.SR.HHExp, LG.Af.SR.PreHLabour, LG.Af.SR.fer

b. Dependent Variable: LG.Af.SR.yield

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.308	6	.051	107.132	.000[a]
	Residual	.042	87	.000		
	Total	.350	93			

a. Predictors: (Constant), LG.Af.SR.Farmsize, LG.Af.SR.LPLabour, LG.Af.SR.pestamount, LG.Af.SR.HHExp, LG.Af.SR.PreHLabour, LG.Af.SR.fer

b. Dependent Variable: LG.Af.SR.yield

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.074	.071		43.487	.000
	LG.Af.SR.fer	.188	.045	.609	4.165	.000
	LG.Af.SR.pestamount	.007	.007	.040	1.058	.293
	LG.Af.SR.LPLabour	.022	.008	.108	2.728	.008
	LG.Af.SR.PreHLabour	.109	.024	.541	4.516	.000
	LG.Af.SR.HHExp	.017	.011	.065	1.491	.140
	LG.Af.SR.Farmsize	-.052	.044	-.210	-1.189	.237

a. Dependent Variable: LG.Af.SR.yield

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	3.5611	3.8339	3.7066	.05755	94
Residual	-.06806	.04924	.00000	.02117	94
Std. Predicted Value	-2.528	2.212	.000	1.000	94
Std. Residual	-3.109	2.250	.000	.967	94

a. Dependent Variable: LG.Af.SR.yield