ASSESSMENT OF FARMERS' RICE PRODUCTION PROFICIENCY AS AFFECTED BY PUBLIC AND PRIVATE SERVICES IN PYAY TOWNSHIP, BAGO REGION

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A Thesis Submitted to the Post-Graduate Committee of the Yezin Agricultural University in Partial Fulfillment of the Requirements for the Degree of Master of Agricultural Science (Agricultural Economics)

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The thesis attached hereto, entitled "**Assessment of Farmers' Rice Production Proficiency as Affected by Public and Private Services in Pyay**

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DECLARATION OF ORIGINALITY

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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Date ------------------------------

DEDICATED TO MY BELOVED PARENTS,

U MAUNG KO AND DAW OHN NGWE

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LIST OF ABBREVIATIONS

AED	Agricultural Extension Department
Amd	Animal man day
ASEAN	Association of South East Asian Nations
BCR	Benefit Cost Ratios
CBM	Central Bank of Myanmar
CSO	Central Statistical Organization
DAP	Department of Agricultural Planning
DOA	Department of Agriculture
FAO	Food and Agriculture Organization
GAD	General Administration Department
GDP	Gross Domestic Product
ha	Hectare
Kg	Kilogram
KHRSC	Khittayar Hinthar Rice Specialization Company
Ks	Kyats
M Ha	Million hectare
M MT	Million metric ton
MADB	Myanma Agriculture Development Bank
md	Man-day
MFF	Myanmar Fisheries Federation
MIC	Myanmar Investment Commission
M ks	Million kyats
MOAI	Ministry of Agriculture and Irrigation
MOC	Ministry of Commerce
MRIA	Myanmar Rice Industry Association
MRSCs	Myanmar Rice Specialized Companies
MT	Metric ton
NB	Net Benefit
NGOs	Non government organizations
RAVC	Return above variable cost
RAVCC	Return above variable cash cost
RSCs	Rice Specialized Companies
SLRD	Settlement and Land Records Department

TC	Total costs
TCC	Total cash cost
TVC	Total variable cost
TVCC	Total variable cash cost
UMFCCI	Union of Myanmar Federation for Chamber of Commerce and Industry

LIST OF CONVERSION FACTORS

1 Basket of Paddy	= 20.9 Kilogram
1 Hectare	= 2.47 Acres
1 Ton	= 1000 Kilogram

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CHAPTER I

INTRODUCTION

Agriculture sector occupies a dominant position in the development of economy of Myanmar. It contributes 32 percent of GDP, and 17.5 percent of total export earnings. In Myanmar, seventy percent of population reside in rural areas and are employed in agriculture, livestock and fishery sector for their livelihood (MOAI 2011).

The importance attached to agriculture in the national development policy priority is reflected in the first of the four national economic objectives, which states "Building of modern industrialized nation through the agricultural development, and all-round development of other sectors of the economy". Agriculture, including crop, livestock, fisheries and forestry, is indeed critically important for Myanmar economy in a multiple ways. Agriculture is also the main source of raw materials and other inputs for the local agro-processing industries; and the sector is an important market for domestic manufactures (Tin Maung Shwe 2011).

Rice production accounts for (69.14) percent of the gross value of agricultural products and influences all social aspects of rural life. The rice crop occupies the largest share of the multiple crop-sown areas followed by pulses and oil crops. The successive government have always attempted to rice economy for producing sufficient amount of rice to consumer at a low price. It is essential to increase rice production through appropriate production technology, minimizing cost and increasing marketing potential. Table 1.1 indicates the trend of harvested area, yield, production of rice and export from 2000-01 to 2009-10 in the country (MOAI 2011).

The area expansion was increased from 6.3 million hectares in 2000 to 8.06 million hectares in 2009-10. Mean while, yield, productivity and export of rice have been increasing. In addition, agricultural efficiency is growing attention in the light of agricultural market liberalization and Myanmar currency appreciation. The experience of agricultural market reforms since the early year of 1990s shows how particularly importance of farm household efficiency is to country’s rural economy. The fundamental role of such reforms was to enable private markets to perform better by replacing the dominant public sector, encouraging the development of private sector (Nay Myo Aung 2012).

According to market reforms, the reduction or removal of subsidies on agricultural inputs such as fertilizer or various other inputs tends to increase the cost of these inputs to farmers and reduce their profits. The agricultural outputs and profit of farmers can be increased by encouraging using good agricultural technology through extension service.

1.1 Public Agricultural Extension Service

The public extension services, unfortunately have been weaken in dissemination of information and technologies needed to ensure farm income and food security. When provision of information, training and technology are insufficient, farmers have to rely on other sources (private extension service or private companies who sell seed, fertilizer, pesticides, etc.) in gaining knowledge on technology (Dolly Kyaw 2007). Therefore, considerable research for technical efficiency for agriculture by assisting effective extension services in the country is urgently needed.

The role of public-supported agricultural extension services has traditionally been to provide the important link between agricultural research and farmers and the farming community, especially in technology transfer for supporting agricultural rural development. Agricultural extension is a mechanism by which information on new technologies, more effective management options, and better farming practices can be transmitted to farmers (Owens *et al*. 2003). Extension agents interact with farmers, providing information and aiding in developing their managerial skills. In addition, extension agents disseminate information on crop and livestock practices, optimal input use, and consult directly with farmers on specific production problems, thus facilitating a shift to more efficient methods of production (Birkhaeuser *et al*. 1991).

Public extension is sometimes used as a channel to introduce – and sometimes enforce – agricultural policies. Extension also functions informally as farmers transfer their best practices to each other. In addition, extension activities are carried out by a wide range of organizations in the private business and non-profit sectors (Lafourcade 1988; Hayward 1989; Moris 1991).

Table 1.1 Rice productions in Myanmar (2000/01-2009/10)

Year	Sown Area (M Ha)	Harvested Area (M Ha)	Yield (MT/Ha)	Production (M MT)	Export (M MT)
2000/01	6.36	6.30	3.38	21.32	0.25
2005/06	7.39	7.34	3.75	27.68	0.18
2006/07	8.13	8.07	3.83	30.92	0.15
2007/08	8.09	8.01	3.93	31.45	0.36
2008/09	8.09	8.08	4.03	32.57	0.67
2009/10	8.07	8.06	4.06	32.68	0.82
2010/11	8.04	8.01	4.07	32.59	0.54

Source: MOAI 2011

1.1.1 Public agricultural extension service in Myanmar

Department of agriculture (DOA) is one of the institutions of the Ministry of Agricultire and Irrigation (MOAI) which is composed of 9 sub divisions so as to successfully and systematically develop the sector. The Agricultural Extension Department (AED) absorbs a large portion of the total strength of DOA. The agricultural extension service in Myanmar was started in 1927 by the Department of Agriculture (Lwin Lwin Aung 2005).

The government is trying to develop the agricultural and rural sectors by shouldering all responsibilities of agricultural extension services and changing the new strategies to achieve the importance of the agricultural sector. The major task of Agricultural Extension Division (AED) is to enable farmers to use effectively the advanced agricultural technology to promote the productivity of all kinds of crops. Another duty is to collect information on field problems encountered by farmers and to find out the solutions in collaboration with research division. Myanmar Agricultural extension service has practised continuously the traditional extension approach, particularly more on individual contact. In 1976, Training and Visit System (T&V) was introduced in Ayeyarwady division and it was implemented on a nation wide scale. The Selected Concentrative Strategy (SCS) was laid down in the selected special high yielding rice production area in 1978. After 1980, the country adopted market oriented economic system in place of the centralized economic system. SCS was not systematically carried out as the planned economic system. Since 1993, Participatory Extension Approach (PEA) was implemented by the United Nations organizations, and NGOs in Myanmar. The public extension services was formed at different level of administrative structures such as National level, State and Regional level, District level, Township level and the Village level. In the country, the national level extension office (i.e public extension staff) has been managed and controlled extension program activities and resources at the state/region, district, township and village level (Tin Hlaing 2004).

1.1.2 Accessibility of external inputs

The government has been distributing chemical fertilizers to farmers through Myanmar Agriculture Service (MAS) especially for rice production. Among the crops, rice has a dominant share so far as the receipt of fertilizer is concerned and over 80 percent of the total volume of fertilizer made available for rice cultivation after 1990s. The chemical fertilizer (urea, potash and TSP) application rate reached 75 kg per hectare in the peak year (1985-1986) and reduced to about 30 kg per hectare in the early 2000s. The government official price of fertilizer was kept low for 15 years until 1987-1988 (FADINAP 1987). It rapidly increased to level close to the international price after 1990s. Since the government was grateful to a withdraw subsidies, the official price was increased in accordance with rises in market prices. Because of government budget deficit, the government distribution of fertilizer shrank considerably in 2005. As was pointed out earlier, the rice price also increased very steeply after the mid 1980s. The fertilizer prices increased at faster rate than rice prices resulting deterioration in the price ratio of rice and fertilizer. Therefore, nowadays the usage of fertilizer and chemical in rice production depends largely on the provision of rice price incentive or reduction in price gap between domestic and international price. Changes in diesel oil supply have also influenced on paddy cultivation. As is the case with fertilizer, most of Myanmar's diesel oil is imported and the domestic price has risen quite rapidly. Although increased irrigation facilities are beneficial to rice yield, the farmers' low level of access to the external inputs has attributed largely to the low land productivity. The average yield was about 3.2 and 3.62 ton per hectare in 1994-95 and 2004-05, respectively (CSO 2006 and DAP 2006**).**

1.1.3 Credit programme in Myanmar

Myanmar Agriculture Development Bank (MADB) have borrowed increasing amount of loans to farmers year by year. The amount of loan borrowed by agricultural producers from MADB was about nearly seventy thousand million kyats in 2009. Among the total amount of loan borrowed to farmers, nearly 84% was borrowed by paddy farmers. It was about sixty thousand million kyats in amount (Figure 1.1). We can see that how government put rice production sector intensively. Each farmer can borrow twenty thousand kyats per acre with two percent interest rate per month. In 2011, the amount of loan increased to Ks 40000 per acre with the same interest rate. Total area of rice sown area was 20 million acres in 2009. Therefore, nearly 15% of total paddy land only are getting loan from MADB. The rest, 85%, are still inaccessible to the MADB loan. But there are many informal lenders in every place with higher interest rate. This informal financial market makes farmers increased cost of production. Many farmers cannot escape from debt because of the lack of money which is needed during crop season. They have no other way to choose to get loan even if they do not want to borrow loan with higher interest rate. Government is also trying to establish small and large local entrepreneurs or cooperative groups who can borrow money to agricultural producers. Because of this effort, many small cooperative groups and rice specialization companies have emerged to borrow loan and other various inputs for farmers. A considerable number of local groups are formed in the light of present policies, the question on whether it is an ad hoc basis or not remains to be answered. According to MAS and CSO data, government subsidized inputs such as fertilizers and pesticides are becoming fewer by year. The previous government, however, imposed a fertilizer law in 2002 to encourage private sector involvement in large potential domestic market. The imposition of the law made many business tycoons appear in the country' fertilizer market. They expanded their markets in every township and every village. Though the fertilizers produced domestically are experimentally tested by Plant Protection Division of MAS, it is heard that there are still many inefficient and unregistered fertilizers in the market. This money affect to the yield and production of farmers. On the other hand, because of the emergence of such fertilizer producing and importing companies, farmers have many choices to use in their production (Nay Myo Aung 2012).

Most farmers have only land as their main asset, their inability to use land as collateral for bank loans has made it difficult for them to access formal credit with lower interest rate for large-scale investment in agriculture. Myanma Agricultural Development Bank (MADB), established in 1953 as a State Agricultural Bank (SAB), is the only source of institutional credit for crop cultivation. The Bank has now 16 regional offices and 205 branches in 325 townships. The total seasonal loans disbursed by the MADB in 2009 reached 9.35 billion kyats, nearly 10-fold increase compared to the 1995 level (Tin Maung Shwe 2011).

The rice farmers have been given top priority and about 80 percent of total loans are given to the rice farmers alone, while the remaining 20 percent had to be divided among farmers growing oilseeds, pulses, cotton and culinary crops. No private banks have yet undertaken the money lending function to the farmers, but there are a few NGOs giving the microfinance to the rural people. However, their scope and scale of operation in terms of coverage of the number of rural people and of areas is still very limited.

The MADB loans are mostly seasonal and the amount is also as small as about Kyat 10,000 to 20,000 per acre, compared to the estimated production cost of around Kyat 100,000 to 190,000 per acre. The MADB is virtually the only major source of institutional credit for small scale farmers in terms of relative coverage and accessibility for investment in agriculture. The scale and impact of MADB loans to farmers are limited in comparison with the funding requirement which is inadequate and ineffective for the purpose of productive investment. The loan of MADB covers just around 10 percent of production cost (MOAI 2010). Comparison of cost of cultivation and the rate of seasonal loan of MADB for some crops in 2010 are shown in Table 1.2.

In 2011, the MADB has extended loans of up to 40,000 kyat per acre to farmers. The MADB currently faces with problem of insufficiency of funds to meet the growing demand for agricultural credit. It does not have the system and procedure for disbursing loans to landless and poorest segments of the rural society. With insufficient amount of credit from MADB, most farmers borrow money at high interest rate from private money lenders and the said vicious circle has sunk them into debt spiral.

Nowadays, private players called Myanmar Rice Specialized Companies (MRSCs) emerge to help the farmers by providing farm credit and such inputs as seeds and fertilizers. Although their coverage is rather small to fulfill the needs of the whole country, it is a good initiative of private public- partnership (PPP). Farmers and MRSCs should have a more cohesive legal arrangement towards the progress and sustainable of the system. There are altogether 32 companies established in Ayeyarwady Region, Bago Region and Rakhine State, as of 2009. Since the area of coverage of MRSC's loan is minimal, majority of farmers have still to rely on informal money lenders. It highlights the need of supervised micro-financing for agriculture industry. The emergence of MRSCs is the positive move in the development of agricultural sector. The majority of farmers in Myanmar have little or no recourse to agricultural credit for either seasonal or term loans. This is a major constraint to growth in crop production, diversification and to innovative farm business development. Institutional credit in rural area is provided by Agricultural

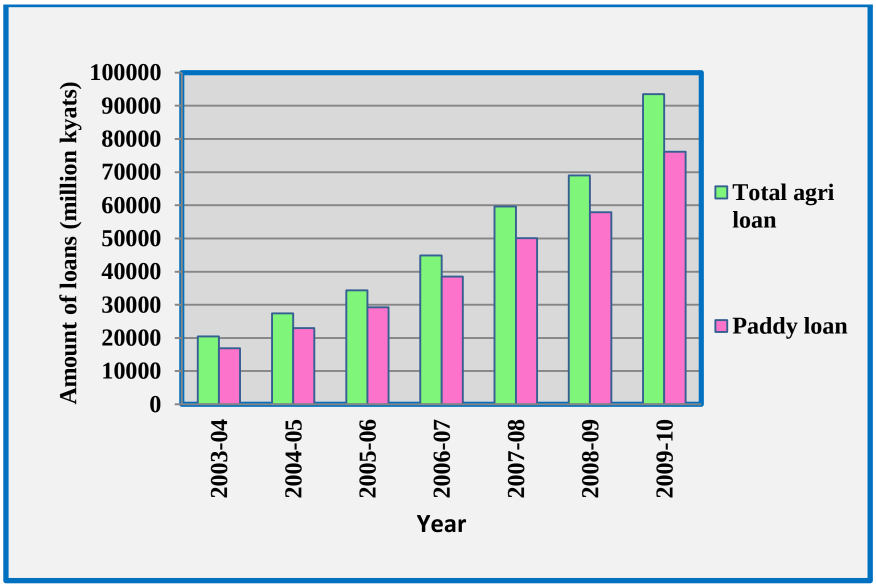


Figure 1.1 The MADB loan to agricultural products

Source: CSO, 2010

Table 1.2 Comparison of cost of cultivation and rate of annual loan for crops in 2010

Crop	Cost of cultivation (Ks/ac)	Rate of seasonal loan (K/ac)	Loan coverage to cultivation cost (%)
Monsoon Paddy	198,400	20,000	10.1
Maize	142,500	10,000	7.0
Groundnut	238,250	10,000	4.2
Sesamum	147,710	10,000	6.8
Green gram	123,950	10,000	8.1
Black gram	85,300	10,000	11,7
Sugarcane	384,900	10,000	2.6
Jute	124,575	10,000	8.0
Long Staple Cotton	205,400	10,000	4.9

Source: MOAI (2010)

Table 1.3 Supporting finance for monsoon rice production in Pyay by MADB (2006-07 to 2010-11)

Year	Village Tract	Provided Area (Ha)	Farmers	Finance for Production (M ks)	Pay back (M ks)
2006-07	53	18,709	8,246	323.48	323.48
2007-08	53	18,709	8,240	369.69	369.69
2008-09	53	18,713	8,221	462.20	462.20
2009-10	53	18,806	8,320	929.00	929.00
010-11	53	20,449	8,869	2,017.24	2,017.24

Source: MADB, Pyay (2012)

Development Bank (MADB) for the farmers. MADB is administration target-oriented credit programme at subsidized interest rate with 1.5 percent per month of crop production (Tin Maung Shwe 2011).

In the study area, the finance provided areas increased from 18709 to 20449 hectares during last five years. And the finance for production was also increased from 323.48 million kyats in 2006-07 to 2017.24 million kyats in 2010-11 (Table 1.3).

1.2 Private Agricultural Extension

Private extension tends to be more prevalent under circumstances of relatively, technically and commercially advanced agriculture. In most countries, private sector companies contribute to technology transfer and advancement of agricultural development through mainly contract arrangement with farmers (Cary and Wilkinson 1992). The characteristic of "privatized" extension systems is a focus on commercial farms. Regarding decision on private and public of extension, when extension is delivered privately, it represents a commercial decision. When extension is delivered publicly, it is a political or bureaucratic decision. It is important to determine whether an extension program is designed to help commercial enterprises or small-scale farming and rural development (Rivera and Cary 1997).

1.2.1 Private extension service in Myanmar

During the 1990's, the government encouraged the private sector involving in local production, importation and marketing of small scale agricultural machineries. The rice farmers use the hand tractors for land preparation and transportation of their produce. The provision of agricultural loan for rice increased from 8750 million kyats in 1999-2000 to 22986 million kyats in 2004-2005. Small-scale irrigation pumps are widely used for summer rice production. In major rice producing areas, threshing is practiced by small-scale machineries. The reason is that the threshing floor is not required for paddy threshing and farmers can manage to cultivate the next crop before the loss of soil residual moisture. Use of small-scale agricultural machineries highly relates to the amount of working capital and provided loan (Dolly Kyaw 2007).

The private sector increasingly participates in the sale of seed, agrochemical products and agricultural machineries and then enters into kind of business that transfers knowledge on the use of their products which is becoming similar a private extension service. The private companies such as agro-chemical companies organize the group meeting as a primary method for dissemination of plant protection technology. They are the market-oriented commercial input suppliers.

1.2.2 Private agricultural service in Myanmar rice sector

Myanmar Rice Industry Association (MRIA) is private association dealing with recommending which companies are eligible to export. The expected role of MRIA is to increase the productivity and to reestablish the country as a major rice exporter in the world market while considering the strategic plans and addressing the challenges and risks of the industry. Myanmar Rice Specialized Companies (MRSCs) engage in a cooperation with the farmers in identified areas by supporting inputs and credit to produce the quality rice. Since government seed production program is insufficient to cover all areas of paddy cultivation, the MRSCs provide the certified seeds to produce required quality for export. About 40 percent of the paddy production cost is also provided by the companies through contract arrangements. Seeds, credit with 2 percent interest per month without collateral and other inputs are provided to the farmers through contract farming arrangement, settling mutual benefit between farmers and traders. However, the area under this arrangement is limited and covers few farm households in designated township. This type of arrangement may last as long as keeping trust between farmers and investors, since there is no legal instrument if it has some breaches on agreement by either side. In order to implement the activities of the association, Myanmar Rice Industry Associations have been formed in township level and down to village tract level in target areas to implement the activities such as distribution of farm inputs, advance payment for cultivation and collection of the payback in kind. Without legal association or group of farmers from demand side, crop specialized companies are dealing with local farmers' group for their business based on trust and mutual benefits which is not the legal binding and is difficult for sustainable arrangement. Rice Specialization Companies (RSCs) were recently formed in main rice growing areas consisting of exporter, traders, millers and some farmers who have comprehensive knowledge about the industry. The intention of RSC formation was to upgrade the small scale farmers into more commercialized one and finally aims to transform as public companies. The RSC is giving seasonal loans, credit in kind such as seeds and other necessary inputs, extension services, farm mechanization services, providing recommended agronomic practices and contract farming. It also aims to purchase paddy at just price in the harvesting time. RSC leads to develop contract farming system for mutual (joint or share) benefit between businessmen and farmers (Tin Maung Shwe 2011).

During 2009 to 2011, the second largest amount of seasonal loans was 3,139.18 million kyats which was found in Bago Region (Table 1.4)

Table 1.4 Capital and finance provided to farmers by RSCs in Myanmar

Sr.	Region/State	Organization	Capital (M ks)	Support to Farmers (million kyat)		
				(2009-10)	(2010-11)	Total
1	Ayeyarwaddy	23	65835.20	9155.01	17512.43	26667.44
2	Bago	10	14302.25	748.50	2390.68	3139.18
3	Saging	4	13500.00	83.56	109.45	193.01
4	Rakhine	2	1500.00	17.48	35.02	52.50
	Total	39	95137.45	10004.55	20047.58	30052.13

Source: Nay Sun (2011)

1.2.3 Activities of Khittayar Hinthar Rice Specialization Co, Ltd. in the study area

Khittayar Hinthar RSC was formed and implemented in June 2009. It was divided into two zones. Zone (1) consists of Pyay, Padaung and Theikhone Townships. Assistant Manager has controlled the activities of the company with the field workers in Zone (1). Zone (2) includes Shwedaung, Paungtai and Paukkhoung Townships. Assistant Manager and Deputy Supervisor have managed the functions of the company with their staffs in zone (2). Sufficient working capital is required for small-scale farmers in order to gain maximizing yield and better quality. As for now, KHRSC supports not only finance (seasonal loans) for production but also quality seeds, agro-chemicals such as Urea, TSP and Potash are absolutely necessary to increase productivity and output quality. Farmers need to pay just 2% interest for their loans. In addition, small-scale machineries are required in every stage of rice production and it therefore sells small scale farm machines (KHRSC 2009).

The KHRSC has been continuously implementing agricultural extension services such as land preparation, use of chemical fertilizers, organic bio-fertilizers, pesticides, selecting the suitable quality seeds raised bed sowing methods, etc in many villages by coordination and supervision of Company's Agronomist, Monitoring Committee Member, Associated Directors and farmers. It was also highlighted that the importance of quality seed in present farming practices and on-time and in-time use of fertilizers are very important to assure high productivity and better quality. It has also been distributing pamphlets (GAP system) to farmers in order to broaden their agri-related knowledge and proficiency. One of the rice specialization companies (KHRSC) was purposively selected in this study which was located in Pyay Township, Bago Region.

Table 1.5 described that KHRSC provided seasonal loans and credit-in-kind from 12.5 million ks in 2009-10 to 5342 million ks in 2011-12. Number of credit received farmers increased from 73 farmers in 2009-10 to 2,190 farmers in 2011-12 (KHRSC, 2012). But the loan amount of KHRSC was too small for rice farmers in the study area.

Table 1.5 Dissemination of seasonal loans and credits-in-kind (seeds & inputs) by Khittayar Hinthar Rice Specialization Co, Ltd (2009-10 to 2011-12)

Year	Crops	Village Tract	Farmers	Provided Area (Ha)	Seasonal Loan (M ks)	Credit-in-kind					Total Value (M ks)
						Seed		Fertilizer			
						Amount (bag)	Value (M ks)	Urea (bag)	Compound (bag)	Value (M ks)	
2009-10	Monsoon rice	2	73	101.21	8.65	300	1.35	125	_	2.5	12.5
	Summer rice	4	80	121.45	15.15	300	2.55	150	300	4.8	22.5
2010-11	Monsoon rice	16	912	1364.37	134.8	8424	28.6	1685	1685	55.6	219.1
	Summer rice	18	1406	2123.07	152.08	_	_	5244	_	57.7	209.8
2011-12	Monsoon rice	36	2190	4332.79	398.01	_	_	5359	1450	136.2	534.2

Source: KHRSC, Pyay Township (2012)

1.3 Review of Extension Services

Extension has been recently defined as systems that facilitate the access of farmers, their organizations and other market actors to knowledge, information and technologies; facilitate their interaction with partners in research, education, agribusiness, and other relevant institutions; and assist them to develop their own technical, organizational and management skills and practices (Christoplos 2003). In addition, extension activities are carried out by a wide range of organizations in the private business and non-profit sectors (Lafourcade 1988; Hayward 1989; Moris 1991). Public extension staff may be paid by farmers for special services or they may routinely exchange their services for food, money and other goods. Private sector extension services generally focus on cash crops, or on sale of inputs such as seeds, chemicals, fertilizers, and machinery (Lisa A Schwartz 1994). Agricultural cooperatives, in general, are multipurpose. Through their services they enable the farmers to produce agricultural products. A cooperative is an autonomous institution the aim of which is to support production activities of their members. Agricultural cooperatives perform a variety of services. Their principal services are Guidance, Credit, Supply and Marketing (Daman 2005).

According to Tin Hlaing (2004) the extension system practiced in Myanmar was primarily the transfer of technology. The ministry understood the slow transfer of technology to farmers, and reorganized the extension services of the country. For the effective and efficient transfer of improved technology, new extension approaches were introduced. Training and visit system (T&V) introduced in 1975s as a pilot program in the World Bank assisted land reclamation project. However it was stopped after the completion of the project. Special High Yielding program (SHY) (former name was Selective Concentrative Strategy) was started for the whole township rice production in 1977. The concept and implementation of SHY program was based in the T&V system. Market oriented economic system has been substituted for the former central form of economy and drastic changes were instituted in the production, manufacturing and trading polices with a view to maximize private sector participation and foreign investment. Myo Min Tun (2006) indicated that Myanmar Extension Services should be served for the benefit of farming community with the parallel extension service of agrochemical companies. Since companies are the market-oriented commercial input suppliers, in the long term, it is anticipated for guiding companies to be a private extension system that is responsive to farmers' need and environmentally sustainable agriculture development.

The role of public-supported agricultural extension services has traditionally been to provide the important link between agricultural research and farmers and the farming community, especially in technology transfer for supporting agriculture and rural development. Although this role is still played by public extension services, the demands for support, as well as the targets, mechanisms, processes and strategies would require more comprehensive attention regarding specific for producers. After World War II, Myanmar established formal agricultural extension services not only to support educational trainings but also to supply inputs and credit especially for rice. The public extension services, unfortunately, have been weaken in dissemination of information and technologies needed to ensure farm income and food security. The public extension services emphasize only for reaching the target of planned crops production (Dolly Kyaw 2007).

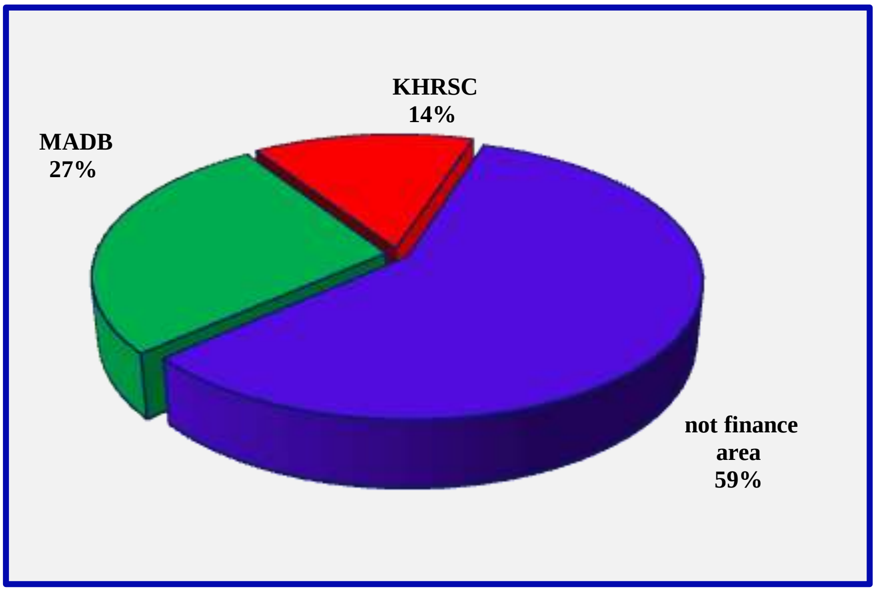
Currently, there are many RSCs like KHRSC, Green Land Myanmar, etc provide farmers a package of plant production with their supporting finance has recently become the leading contract farming in Bago Region. In this contact, the RSCs are doing the private extension services in this area. When information, training and technology provided by the public extension services are insufficient, farmers thus have to rely on other sources (private extension services or private companies who provide seasonal loans, credit-in-kinds such as quality seed, chemical fertilizes etc) in gaining knowledge and getting supply of inputs. The role of public extension services are increasingly replaced by the private extension services. Therefore, strength and weakness of the activities provided by these two agencies should be studied and the study will be emphasized on the extension services instead of focusing on the extension methods.

1.4 Rationale of the Study

In Myanmar, rice productivity is below to compare with neighboring countries. Myanmar has to be significant priority for rice farming development due to the large remaining uncultivated areas. Two major bottleneck constraints are limited market access and underdeveloped agricultural infrastructure. Smallholder farmers are especially important to market access of national economy. Contract farming is an institutional arrangement in the private sector that may eventually help to overcome the constraints. Myanmar government can help ease these constraints through extension services and public investment, limited extension staff and experts created a big problem. Currently an extension agent has to take the charge of 1,788 hectare/person in monsoon rice production (AED 2011). Moreover, contract farming activities of RSCs could implement only 5-8 % of the sown area in the specialized township (Ye Min Aung 2011). Although the government has continuously expended supporting not only production credit but also good agricultural practices, the private and public agricultural extension service capacities are still too weak.

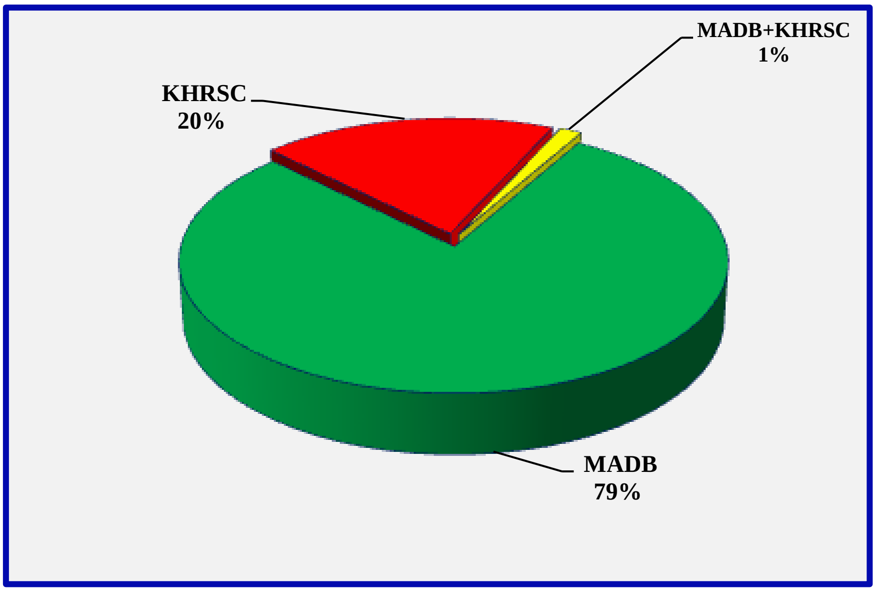
In the study area, only 14% of finance provided area was supported by KHRSC, 27% of finance provided area was obtained by MADB and not finance provided area was about 59% (Figure 1.2). In Figure 1.3, KHRSC supported production credit for 20% of farm household, 79% of farm household was obtained their production credit by MADB and 1% of farm household was assisted by private and public organization (KHRSC and MADB 2011-12).

Whether or not farms using both public and private extension service at higher degree of technical efficiency or efficient and a better profit than those of using either public or private extension service to farmers are needed to study for the rice improvement of farmers' profitability and technical efficiency in Pyay Township.



Source: MADB and KHRSC in Pyay Township (2011-12)

Fig1.2. Percentage of finance provided area in Pyay Township



Source: MADB and KHRSC in Pyay Township (2011-12)

Fig 1.3 Percentage of finance obtained households in Pyay Township

1.5 Objectives

The objectives of the study are:

(1) To investigate the socio-economic characteristics of sampled farmers regarding the public and public services in the study area;

(2) To compare the profitability of rice production of sampled farmers by the public and private services in the selected area;

(3) To examine the production efficiency for the existing technology of rice production of the sampled farmers in the study area.

1.6. Hypothesis of the Study

Farms using both public and private extension services will achieve a higher degree of technical efficiency and better profit than those of using either public or private extension service alone.

CHAPTER II

LITERATURE REVIEW

2.1. Concept of Agricultural Extension

In a FAO publication, “Agricultural extension means a service or system which assists farm people, through educational procedures, in improving farming methods and techniques, increasing production efficiency and income, bettering their levels of living and lifting the social and educational standards of rural life” (Swanson 1984).

Van den Ban and Hawkins (1988) synthesized the term agricultural extensions as diverse perspectives into five goals – transforming knowledge from researchers to farmers; advising farmers in their decision-making; educating farmers to be able to make similar decisions in future; enabling farmers to clarify their own goals and possibilities and to realize them; and stimulating desirable agricultural development (rural guidance). Providing a range of options from which farmers can choose is therefore central to the learning process.

Maalouf *et al* (1991) stated "The possibility needs to be explored of complementing government funded extension by involvement of cooperatives, farmers' and other community-based organisations, non-governmental voluntary organisations and private/commercial firms in doing extension work".

Extension is a political and organizational instrument utilized to facilitate development. Its purposes may differ, from technology transfer by companies organized around specific, usually mono-cropping farm systems to problem-solving educational approaches to participatory program aimed at alleviating poverty and advancing community involvement in the process of development (Diouf and Wolfensohn 2001).

Investment in agricultural research and extension is thus a crucial input of agricultural growth (Anderson and Feder 2003). However, "agricultural extension services in developing countries are currently grossly under-funded to undertake the activities required for achieving food security while protecting the productive resource base in order to keep up with population and economic growth" (Gallagher 2002).

Agricultural extension plays an important role in agricultural and rural development. It serves as a tool for the education of farming community about technologies and improved crop production techniques along with judicious use of natural resources. Side by side this important task, agricultural extension works as two-way information exchange junction between farmers and research stations. It means that agricultural extension reports the field problems of farming community to research stations and outcome of research is disseminated back to farming community (Bajwa 2004).

Agricultural extension is a sharing of experiences. It is a Two-Way process. Directions from the top or scientists are not enough. It is a highly participatory exercise and must be handled systematically. There has to be an active and continuous interaction between the scientists and the farmers. The extension agent is the media, which promotes such an interaction. The benefits of agricultural extension to the farmers are many. Advisory services given result into: transfer of technology to the farmers; increase in their income from farming operations, and increase in the productivity. By making use of extension services not only the national production of foodgrains and horticulture products can go up, but also create additional wealth for the farmers. Higher agricultural income can bring about prosperity to the nation (Daman 2005)

Agricultural extension, or agricultural advisory services, comprises the entire set of organizations that support people engaged in agricultural production and facilitate their efforts to solve problems; link to markets and other players in the agricultural value chain; and obtain information, skills, and technologies to improve their livelihoods (Birner *et al.* 2009; Davis 2009).

In many countries, extension is currently called as rural advisory services. The Global Forum for Rural Advisory Services defines extension also called rural advisory services, as consisting of all the different activities that provide the information and services needed and demanded by farmers and other actors in rural settings to assist them in developing their own technical, organizational and management skills and practices so as to improve their livelihoods and well-being (GFRAS 2010).

2.1.1 Agricultural extension reform strategies

Diouf and Wolfrnsohn (2001) said that Public sector agricultural extensions were confronted by high competitive interests from the private sector. Input suppliers and output buyers became increasing active in instructing farmers in the processes and standards desired by particular market. Often enough, these information providers created demonstration plot and field trials, similar to public sector extension techniques but with a view to vertical technology transfer. In some cases, “contract farmers” turned into workers for the contracting companies.

SAR (1987) reported that as agriculture develops and becomes more highly commercialized, farmers require specialized information and are more able to pay for it. For example, in Mexico in the mid-1980s, "private services focus[ed] mainly on advanced technology packages in plant production and marketing of perishable commodities. They provided support mainly to higher income farmers and groups of farmers and generally did not directly compete with the public sector for clients". Although there were some private extension activities with smaller farmers even in the mid 1980s, the range of private extension activities in Mexico have expanded since that time. Many industrialized nations have decentralized extension systems with a strong private element. Some countries have experienced a shift from primarily public extension to a mixed system accompanied by some amount of public sector extension cost recovery through fees for service (e.g. Ireland and the UK). However, extension has been completely privatized in some countries (e.g. New Zealand). Generally, industrialized countries have experienced faster growth in the number of private agricultural consultants than that of public sector staff. For example in the UK, "private sector advisors are more numerous than ADAS [public] advisers, and provide a great deal of the on-farm advice given to farmers".

Arnon (1989) stated that different types of commercial firms engage in extension activities as a part of their business. In addition, public extension has an increasingly difficult time competing with specialized farm consultants. A lack of funding for public extension often exacerbates this problem. Several factors characterize an increasingly commercialized agricultural sector which affects the incidence of private extension: increased use and availability of purchased inputs (including machinery); increased opportunities for high-value agricultural production and processing. As private input suppliers expand operations, they naturally increase their involvement in extension as part of their marketing activities. On the production side, more high-value production (as well as limitations on direct government intervention in the production and marketing of cash crops) is often accompanied by private specialized extension as a part of vertically integrated contract farming schemes.

"Agricultural extension services in developing countries are currently grossly under-funded to undertake the activities required for achieving food security while protecting the productive resource base in order to keep up with population and economic growth" (Gallagher 2002).

William (2003) said that extension is multidisciplinary. It combines educational methodologies, communication and group techniques in promoting agricultural and rural development. It includes technology transfer, facilitation, and advisory services as well as information services and adult education. It is dependent for success on other agricultural development processes such as marketing and credit services, not to mention economic policy and physical infrastructure.

2.1.2 Emergence of private sector Service

Chea (2011) studied the public versus private provision of irrigated water management on rural economic development. He reported that people were satisfied with FWUC (Farmer Water User Community) in terms of irrigated water management in this area, mainly due to much lower water fee. The level of farmer contribution to O&M (Operation and Maintenance) was revealed moderate acknowledgment while it was difficult to address if farmers have adequate knowledge to participate in the decision making level toward sustainable irrigation management in this area. This could be a limited capacity of farmers in terms of contributing at a high level of participation and/or the unclear structure of either FWUC or private sector in order to inform to the communities for gaining their participation. Although both of these sectors had different functions and ways of management, still they had the same vision of irrigation system development. Thus, public private partnership with the participation from the farmer water user group under the method payment of ISF (Irrigated Service Fee) based on farm size was a useful combination strategy to apply in this area in order to better farmers' livelihood as well as socio-economic development. .

Anuradha and Zala (2010) studied the technical efficiency in rice production in the central Gujarat and the effect of farm-specific factors on this technical efficiency. They found that the farm-specific technical efficiency range from 71.39 percent to 99.82 percent, with the mean of 72.78 percent, which indicates that on average, the realized output can be raised by 27 percent in the region with the available technology and recourses without additional resources. They also reported that factors like operational area, experience, education and distance of field from canal structure are the most influential determinants of technical efficiency, while the variable, number of working family members, had shown significant but negative relationship with technical efficiency.

Belen and Manuel (1997) examined the technical efficiency in the Spanish agrofood industry. They indicated that the Spanish agrofood industry had a level of efficiency between 68% and 93%; which means that it was potentially capable of increasing production without increasing its consumption of inputs. This efficiency level was positively related to factor productivity and unitary labor costs.

2.1.3 Public-Private Partnership (PPP)

In several developing countries, public-private extension coordination is already established. Alternative patterns indicate a fostering of private corporate initiative, encouraging cooperative ventures by farmers, coordinating public-private extension services and privatizing the public system (Wilson 1991).

World Bank (2002) reported that public-private partnerships were increasingly popular in development policy and practice as a means of addressing global issues as diverse as health, environment, finance, governance, and agriculture. The pubic-private partnership inculcated and produced results in diversified fields of life like health, environment, finance, governance, and agriculture (World Bank 2002; Buse and Walt 2000b).

World Bank (2003) found significant support for increased public-private collaboration among Consultative Group on International Agricultural Research (CGIAR) center director generals, donors, representatives of national agricultural research systems, and members of the private sector. Moreover, efforts had been made in several forums to promote public-private partnership in agricultural research.

Public-private partnerships are defined as any collaborative effort between the public and private sectors in which each sector contributes to the planning, resources, and activities needed to accomplish a mutual objective. These partnerships are a constructive means of enhancing the production of goods, services and technologies that would not otherwise be produced by either sector acting alone (Morse, 1996; Ojha and Morin, 2000; and Government of Pakistan 2006).

Partnerships have been defined as "two or more organizations with complementary areas of expertise committing resources and working together to achieve a mutually beneficial outcome that would have been difficult for each to reach alone" (Gormley 2001). It means that publicly funded institutions look on partnerships as a means to attract funding rather than as a way to bring about some mutually beneficial goal (Bajramovic *et al.* 2007).

According to European Commission in 2003, a partnership is an arrangement and agreement between two or more parties to work cooperatively toward sharing compatible objectives, share authorities and responsibilities, join resources for investment, share liability or risk-taking, and share mutual benefit if the plan ideally implemented. Public-Private Partnership (PPP) is the relationship involving the power sharing, work, support and/or information between the public and the private enterprise for the achievement of joint goals and/or mutual benefit (Kernaghan 1993).

New South Wale Treasury (2009) reported that public private partnership has been used since 1970s in the United State which initially focused on economic infrastructure development, and then on building, health center, energy, water, and waste treatment as well as has applied successfully in European countries. It refers to change of government management system – turning from state own only to the combination joint venture between the public and private in order to faster the economic growth in the countries.

According to Deloitte (2006), the PPP has been optimistically defined as the good concept to apply in each nation in order to achieve the economic development and reduce responsibilities of the governments. There are numbers of types of Public-Private Partnerships, The agreement between the private sector and the government has to be made service contract and/or management contract. Service contract refers to the private partner takes the task of providing service which government used to perform previously. Management contract is the private which is responsible for operation and maintenance.

Public-Private Partnership (PPP) is considered as an important strategy for agricultural development in India and research and extension organizations are currently mandated to initiate specific activities under PPP. Public-Private Partnership (PPP) is going to be very crucial in the area of agri-processing and marketing and the same can be meaningfully extended to extension services as well (Pandey 2010).

2.2. Impact of Agricultural Extension on the Performance of Farm

Dinar *et al*. (2007) studied that the impact of agricultural extension on farms' performance in Crete, Greece. They pointed out that the proposed formulation instead of either the production- or the efficiency-based formulations as extension was found to have a statistically significant effect on closing both the technology and management gaps. Public and private extension services were found to be competitive in the production function and complementary in the technical inefficiency effect function. In addition, farms using both public and private extension services achieved a higher degree of technical efficiency than those using either public or private extension services, and farms with no extension services were found to be the least efficient.

Patrick and Kehrberg 1973; Huffman 1977; Moock 1981; Pudasaini 1983; Owens et al. 2003 studied the estimation of a production function in which extension was considered as a separate input. This production-based approach assumed that farms were operating at full technical efficient levels and thus do not purposely waste resources. However, if they did waste resources but were ignorant of doing so, this was only due to lack of knowledge. Within this approach the impact of extension on farms performance was evaluated through its marginal product and, in a sense, captures its direct effect on output. On the other hand, the analysis of agricultural extension took a quite different direction in the context of frontier models.

Kalirajan 1981b; Kalirajan and Shand 1985; Bravo-Ureta and Evenson 1994; Seyoum *et al.* 1998; Young and Deng 1999 stated that extension had been included along with other socioeconomic and variables in the inefficiency effect function as a factor influencing technical efficiency. The impact of extension on farm production was indirect and may be evaluated through the potential output gain due to elimination of technical inefficiency. Although each approach is informative by itself, each may be criticized as incomplete since it is intuitively more appealing to evaluate simultaneously the direct and indirect effects of extension on the performance of farms. The main objective of this paper was to integrate both the production- and the efficiency-based approaches into one single framework, wherein two distinct roles are assigned to extension: one as an input in the production function and another as a factor narrowing the technology gap in the inefficiency effect function.

Dinar and Keynan (2001) pointed that discriminating between private and public extension enables the identification of potential benefits that may arise from different sources of extension provision on the performance of farms. It may be useful from a policy point of view to obtain comparative results regarding the impact that public and private extension services may have in closing the technology and management gaps. Specifically, the technical interdependence (complementary or competitive) between public and private extension is empirically investigated in terms of both the direct and the indirect effects. Such potential distinction between possible roles for private and public extension services could be very useful in the emerging debate in the literature on the role of public extension, especially for small-scale family farms or in developing countries. The empirical analysis was based on a sample of 265 farms from Crete, Greece.

Myo Min Htun (2006) reported that companies participated in present agricultural extension services as a complementary extension system for MAS. Contact farmers perceived that private companies were more effective than MAS with respect to their activities and extension contact methods conducted in this study area. Overall, neither system appeared to be working for the benefit of the wider farming community. The implication from this study was a clear indication of Myanmar Extension Services to be served for the benefit of farming community with the parallel extension service of agrochemical companies. Since companies are the market-oriented commercial input suppliers, in long term, it is anticipated for guiding companies to be a private extension system that is responsive to farmers' needs and environmentally sustainable agricultural development.

Albrecht *et al*. (1989) provided that all extension approaches can be classified as either production technology approaches or problem-solving approaches. Production technology approaches tend to emphasize the production targets more than the clientele; technologies used in these approaches are more concerned with addressing production issues than clientele-related problems (for example, commodity-focused approach and technology-centered). In problem solving approaches, the clientele participate in defining their problem. These approaches used socioeconomic information and the development of more appropriate content. The training & visit community development-cum-extension, and animation rural approaches fall into this category.

Ogunsumi (2008) studied extension activities on farmers' productivity in South West Nigeria. The study revealed that there were significant positive correlations between age and adoption pattern (r = 0.16), age and soybean adoption level (r = 0.15), age and cassava adoption level (r= 0.14), organizational membership and extension contact (r = 0.21), factors affecting sustained use of maize and cassava technologies (r = 0.09) while a negative significant correlation exists between factors affecting sustained use of maize technology and extension contact (r = - 0.15). There were also significant positive correlations between attitude of farmers towards improved technologies and factors affecting the sustained use of maize technologies (r = 0.44). About 84% of variation in the sustained use of technology was explained by the independent variables included into the Probit model. Agricultural technologies developed and disseminated should meet farmers' socio-cultural, economic and environmental changing situations; Government should fund research and extension to enhance sustainable agriculture.

Ajieh *et al. (*2008) examined the perception of constraints to privatization and commercialization (P and C) of agricultural extension services by extension professionals and farmers. They reported that the constraints (i.e. fear of job insecurity among extension staff, farmers' poor economic background, difficulty in attaching monetary value to extension services, political instability, unequal access to farm resources and poor linkages between research and extension) identified by this study are serious issues to P and C and should therefore be given adequate consideration by policy makers, stakeholders in extension service delivery and the government of Delta State, Nigeria before final decision is taken on whether or not to privatize and commercialize agricultural extension services in the State.

Junning *et al*. (2008) reported that farmers with larger family sizes, younger and more educated household heads, less asset value, and those with farm locations closer to the highway were more likely to join the contract. The results provided evidence that contract farming of non-certified organic rice had a positive impact on farmers' profitability. They also suggested that progressive farmers living near the highway tended to join the contract first, but left contract farming early, while farmers in more remote areas remain under contract. It appeared that the sample former-contract farmers' profitability did not decline after leaving contract farming as they further intensified their farming systems to produce for the less chemical conscious market. Contract farming may be involved in the process of helping subsistence farmers develop into independent commercial farmers. This study provided empirical evidence that contract farming of safe food in remote areas where land was less contaminated could be an effective private-sector led poverty reduction strategy.

However, since contract farming in this case was not inclusive of the poorest farmers, public sector support was required to lower the transaction costs of working with them.

Songsak and Aree (2008) studied overview of Contract Farming in Thailand. They evaluated the effectiveness of contract farming as a means to stabilize farmers' income and strategize agricultural development. The findings showed that while the poorest farmers were not excluded from contract farming, special measures may be needed to encourage their full participation. In the long run, small farmers were able to accumulate production and management skills, thus improving their bargaining position. Together with improved infrastructure and a more competitive market due to farmers' innovation, the farmers' best choice may include non-contract production. Contract farming could be promising for agro-industry development. The quality of farm produce can be rapidly improved through contract farming to meet global market standards. This will require thorough effort from local agencies. It is also important to control exploitation of farmers by private firms. Contract farming was a means to assist small growers in gaining market access and reducing price risk, and as such it has attracted attention from development agencies and governments in developing countries.

2.3 Allocative and Technical Efficiency

Stefan and Michael (2005) examined economic efficiency (EE) of crop production of Russian corporate farms for 1993–1998. EE declined over the period, due to declines in both technical and allocative efficiency. Technical efficiency (TE) results indicated that output levels could have been maintained while reducing overall input use by an average of 29–31% in 1998, depending on the method used, while the allocative efficiency (AE) results show that costs could have been reduced about 30%. The EE scores showed that Russian corporate farms could have increased efficiency by reducing the use of all inputs, particularly fertilizer and fuel. Russian agriculture inherited machinery-intensive technology from the Soviet era, which may be inappropriate given the relative abundance of labor in the post-reform environment. Investment constraints have prevented the replacement of old machinery-intensive technology with smaller scale machines that allow for a more labor-using technology.

David *et al*. (2005) examined efficiency effects of agricultural economics research in the United States was examined. Farm management and marketing research variables are used to explain variations in estimates of allocative and technical efficiency using a Bayesian approach that incorporates stylized facts concerning lagged research impacts in a way that is less restrictive than popular polynomial distributed lags. Results are reported in terms of means and standard deviations of estimated probability distributions of parameters and long-run total multipliers. Extension is estimated to have a greater impact on both allocative and technical efficiency than either R&D or social science research.

Michael (2006) studied that delivery of Agricultural Extension Services to Farmers in Developing Countries. The agriculture sector is a key contributor to the economy and remains an important source of rural employment. The sector accounted for 33.8% of GDP in 2010 and is a vitally important source of employment (72% in 2010), enterprise formation, and poverty reduction. While agriculture has grown by around 5% annually (although at a lower rate than the industry and services sectors), the total nominal value of production increased by 73% from 2006 to 2010. Rice accounted for about half of the total crop value in 2007, while other crops such as maize, soybeans, and cassava production have been increasing due to cross-border contract farming. Fisheries contribute significantly to national food security and accounted for 7.3% in 2010. Livestock accounted for 4.5% of GDP in 2010, but domestic production is projected to grow due to increasing regional demand.

Nay Myo Aung (2011) studied the households' profit efficiency and the relationship between farm and household attributes and profit inefficiency using a Cobb-Douglas production frontier function. He reported that the frequency distribution reveals that the mean technical inefficiency is 0.1627 with a minimum of 3 percent and maximum 73 percent which indicate that, on average, about 16% of potential maximum output is lost owing to technical inefficiency in Hmawbi and Waw Townships. While 85% of sample farms exhibit profit inefficiency of 20% or less, about 40% of sample farms is found to exhibit technical inefficiency of 20% or less, indicating that among the sample farms technical inefficiency is much lower than profit inefficiency.

CHAPTER III
RESEARCH METHODOLOGY

3.1 Description of the Study Area

The study area, Pyay Township, 185 miles away from the Bago, is located between 18˚ 44' N latitude & 19˚ 16' N latitude and 95˚ 15' E longitude & 95˚ 29' E longitude. It is at an elevation of around 180 feet or 54.95 meters. It is bounded by Paukkhaung township in the east, river of Ayeyarwady and Pandaung townships in the west, Aunglan in the north Theakhone in the south. The people in Pyay can go easily to the surrounding townships by car. The township also has access to railway as it is situated on Yangoon-Mandalay railway route.

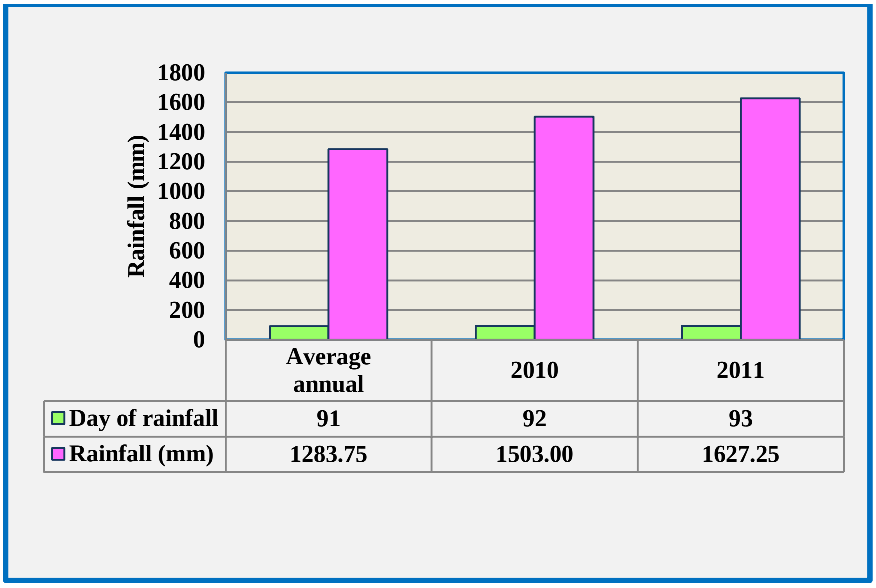
In general, the average annual precipitation was 51.35 inches (1238.75 mm) and the day of rainfall within year was 91 days in the study area. The minimum average monthly temperature was 13 ˚C and the maximum average monthly temperature was 42 ˚C in the summer and the former was 12 ˚C and the latter was 30 ˚C in the winter. Figure 3.1 described that a maximum rainfall precipitation was 1627.25 mm was found in 2011.

3.1.1 Area and population of study area

The land area of Pyay Township was about 304.41 square miles (481,205 hectares) with the population of 212,636 in the year 2011. There were 65 village tracts and 260 villages in the study area. There were 10 wards in urban area with total 23,197 households in 2010-11. The other 25,903 of households were in rural areas. Study areas were Khyakhat village, Kyotyatha village and Letpantaw village in Pyay Township (Figure 3.2).

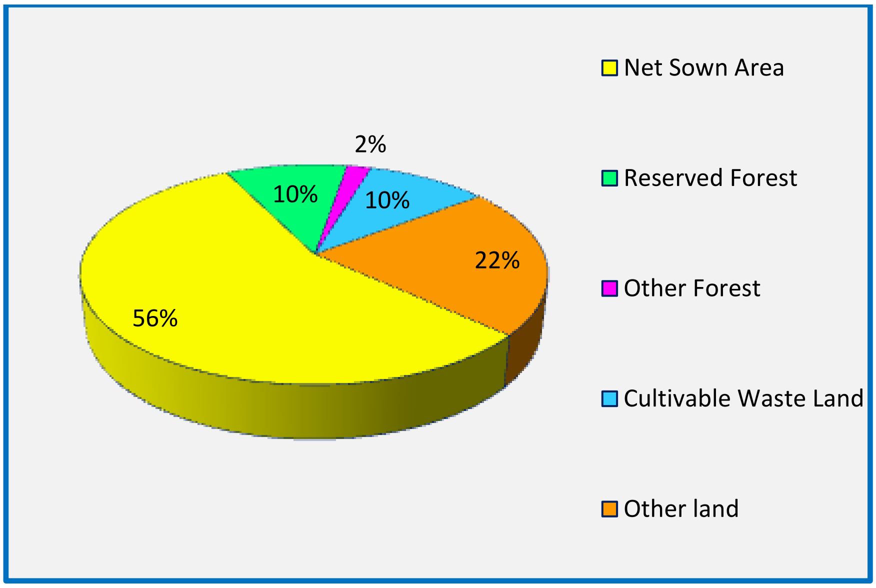
3.1.2 Land use pattern

Net sown area was 56.48 % of total land including lowland (Le), and upland (Yar) (Figure 3.3). In agricultural land, lowland (Le) occupied about 39.02% (30773.68 ha) of the net sown area while upland (Yar) was about 12.43 % (9,807.29 ha). Therefore, in the study area, lowland cultivation was the major cropping system. About 10 % and 2 % of land use were classified as reserved and other forest area respectively which was about 7771.66 and 1573.68 hectares. Cultivable waste land occupied 10 % and other land (residential area, river and streams area, etc.) was about 22 % in the study area.



Source: DOA Pyay Township (2011-12)

Figure 3.1 Comparison of precipitation (mm) among average annual, 2010 and 2011 in Pyay Township



Source: DOA Pyay (2011-12)

Figure 3.3 Land use pattern in Pyay Township (2010-11)

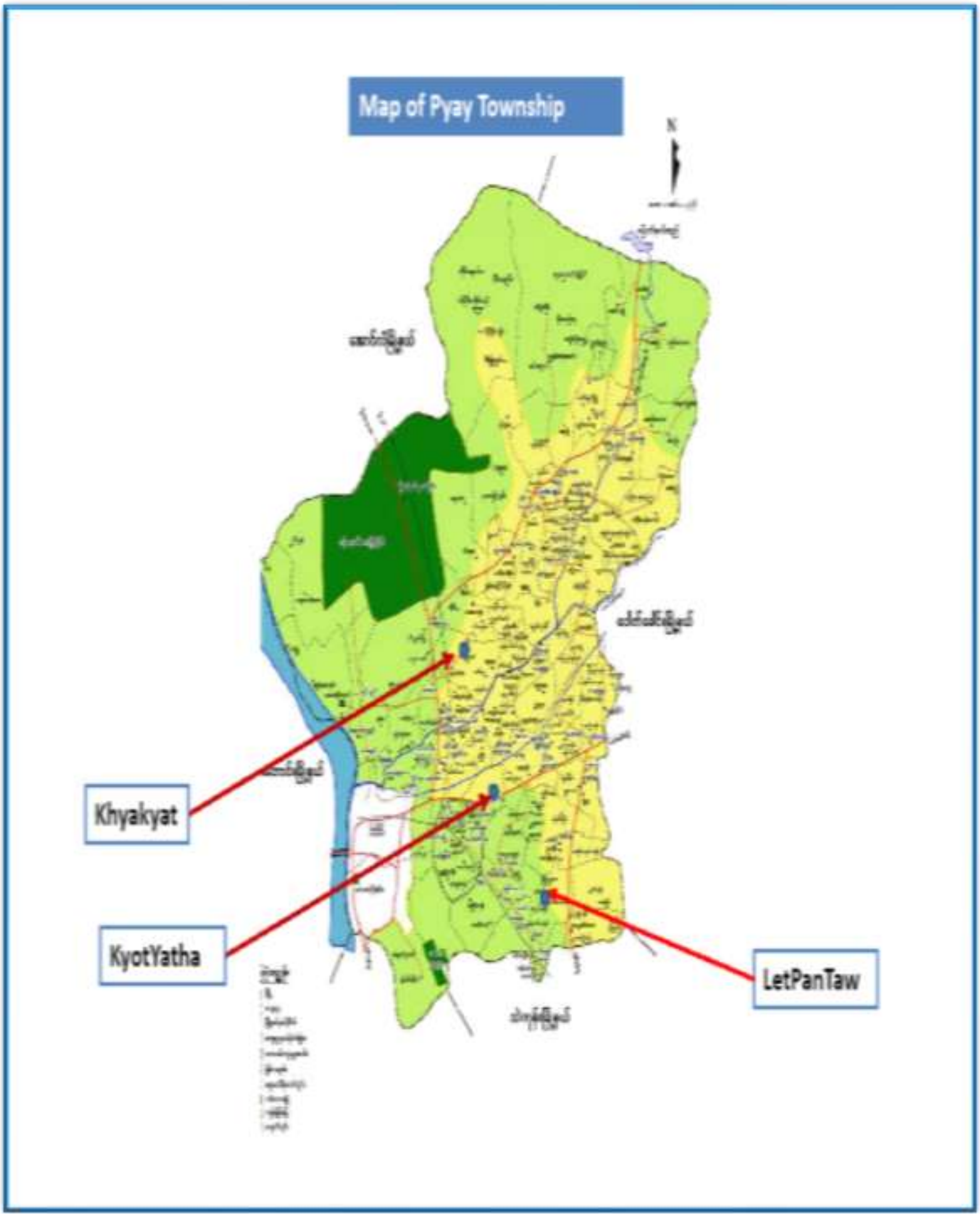


Figure 3.2 Study sites in Pyay Township, Bago Region

3.1.3 Cropping patterns, sown acreage and production of rice

Manawthukha, Sinthwelatt, Kyawzayya, Inmayebaw, IR747 and other rice varieties were sown in this township. Common cropping pattern in the survey areas were monsoon paddy-summer paddy, monsoon paddy-blackgram and summer paddy-black gram-monsoon paddy. Vegetables, chili and onion are also grown in this area.

Total paddy productions in Pyay Township (2006-07 to 2011-12) were mentioned by the following Table 3.1 and 3.2.

Table 3.1 Paddy production in Pyay Township for monsoon rice (2006-07) to 2011-12)

Year	Sown Area ('000 Ha)	Harvested Area ('000 Ha)	Yield (T/Ha)	Production ('000T)
2006-07	35.05	35.05	3.39	118.96
2007-08	34.83	34.83	3.63	126.44
2008-09	34.92	34.92	3.81	133.13
2009-10	35.42	35.42	3.82	135.20
2010-11	35.46	35.46	3.82	135.40
2011-12	30.34	30.22	3.68	111.20

Source: Official record, DOA Pyay Township, 2011-12

Table 3.2 Paddy production in Pyay Township for summer rice (2006-07 to 2011-12)

Year	Sown Area ('000 Ha)	Harvested Area ('000 Ha)	Yield (T/Ha)	Production ('000T)
2006-07	7.28	7.28	3.98	28.98
2007-08	8.18	8.18	4.12	33.71
2008-09	8.10	8.10	4.00	32.43
2009-10	8.27	8.27	4.12	34.02
2010-11	5.32	5.32	3.98	21.19

Source: Official record, DOA Pyay Township, 2011-12

3.2 Data Collection, Data Source and Household Level Survey

3.2.1 Data collection

Data were collected by using structured questionnaires in which demographic information, socio-economic characteristics, production and income information, crop production, consumption, marketing information and constraints information.

Both primary and secondary data were collected. Primary data was included that all sorts of technical and socio-economic data such as age, education, family size, farm size, area planted, crop yield, farm experiences, cropping pattern, labor used in crop production, fertilizer application, input-output prices, state of agricultural extension access (access to credits by public, access to credits by private and access to credits by public and private. Secondary data were collected from MOAI (Ministry of Agriculture and Irrigation), MADB (Pyay), KHRSC (Pyay), CSO and other publications.

3.2 .2 Data source and household level survey

Pyay Township, Bago Region was selected one of the most developed rice areas in the country. Bago Region is larger rice surplus areas in Myanmar. Pyay Township was purposively selected due to the larger rice surplus areas in Myanmar and the development of private agricultural extension services in rice production. Khittayar Hinthar Rice Specialization Company (KHRSC) has carried out extension services such as payment of seasonal loans and credit in kind (in terms of seeds and inputs) and farm mechanization services for rice farmers.

Farmers were considered as sampling unit. The survey was carried out during December 2011 to January 2012. Firstly, three villages were selected randomly from Pyay Township. Thirty rice farmers in each village were divided into traditional group (contact with DOA), contract farming group (contact with KHRSC) and both contact group (contact with DOA & KHRSC). Distribution of sampled extension contact households was described in Table 3.3. Ninety respondents from three villages in Pyay Township, Bago region were interviewed to fulfill the objective of the study.

Table 3.3 Distribution of sampled households based on public and private services in the study area

Items	Khyakhat	Kyoutyathar	Letpantaw
PU	10	10	10
PR	10	10	10
PU+PR	10	10	10
Total	30	30	30

Note: PU = farmers who conduct with Department of Agriculture

PR = farmers who carry out Khittayar Hinthar Rice Specialization Company

PU+PR = farmers who perform with Department of Agriculture and Khittayar Hinthar Rice Specialization Company

3.3 Methods of Analysis

After collecting the primary and secondary data, they were analyzed with Microsoft Excel program. The Statistical Packages for Social Science (SPSS) software was employed for descriptive analysis of actual farm data. Mean and standard deviation of social characters, amount of resources used, production cost, and other required data were calculated. Using SPSS 16, descriptive analysis and the production frontier 4.1 of actual farm data were calculated. Descriptive analysis was applied to describe and compare the socio-economic profile of farmers' social characteristics and exit farming technology, yield, input use, existing farming practices, and income of the sampled rice farmers in Pyay Township.

3.3.1 Descriptive analysis

The analytical tools included in this study were descriptive analysis (i.e mean, frequency and percentage). Farmer's characteristics, farm production and household access, credit access, farm production (revenue, cost and benefit, labor cost, material and operating cost in monsoon rice and summer rice for each farm type of the study area were explored by using descriptive analysis.

3.3.2 Economic analysis

In this study, benefit and cost analysis of monsoon paddy and summer paddy were taken up for three different types of household groups. Both cash and non cash items were included in the estimation of material cost and labor cost. Non-cash items for material costs were owned seeds, family labor, cattle and farm yard manure. Hired labor costs were valued by market wage rates and man days used in all farming practices. Return of paddy production included return from sale with effective field price of rice. In order to estimate gross return for respective crops, average yield and average price were used. Benefit cost ratio was used as profitability measures for each crop enterprise computing total gross margin or return above variable cost and return above cash cost.

The interest was normally charged on cash expensed for early in the growing season. The counted interest rate was 2 % (by PR), 1.5 % (by PU) and 1.75 % (by PU+PR) per month for cropping period of four months.

In this study, the profitable procedure was used as follow;

RAVC = TGR – TVC

RACC = TGR – TCC

BCR = TGR/ TC

Where;

RAVC = Return above variable cost

RACC = Return above cash cost

BCR = Benefit cost ratios

TGR = Total gross return

TC = Total cost

TVC = Total variable cost (cash and non-cash items)

TCC = Total cash cost (only cash items)

3.3.3 Analytical measurement in technical efficiency

To address the third objective, stochastic frontier production function for technical efficiency of rice production was estimated. The factors affecting technical inefficiency in rice production were identified for growers in Pyay Township, Bago Region. The stochastic production frontier was used to estimate technical efficiency using maximum-likelihood methods. At the same time, frontier production function was expressed technical inefficiency in rice production at the farm level using survey data.

Determination of production function included information of input utilization such as seed rate per hectare, amount of T-super application and compound fertilizer application. In addition, it was also included the information of socio-economic aspects of the farmer such as farm experience, number of extension visit during rice growing season, education level, credit access, sown area and variety.

In this study, the effects of technical efficiency in the stochastic frontier production function specified by using the flexible trans-log specification. The specified model is assumed to be the appropriate model for analysis of the data.

The model to be estimated is defined by:

$$Ln\, Y_i = \beta_0 + \Sigma_j \beta_j\, Ln\, X_{ji} + ½\, \Sigma_j \Sigma_k \beta_{jk}\, Ln\, X_{1i}\, Ln_{ki} + \nu_i - \mu_i \qquad (1)$$

Where,

i indicate an observation for the i-th farmer in the survey, i=1,2,3,…..,90

ln = natural logarithms,

β_0 = parameters to be estimated production function,

Y_i = rice yield (kg/ha)

X_{ji} = all *j* input variables per ha,

X_{1i} = seed rate used in rice production (kg/ha)

X_{2i} = amount of T-super application (kg/ha)

X_{3i} = amount of compound fertilizer application (kg/ha)

The error term is defined as

$\varepsilon_i = \nu_i - \mu_i$

Where,

I = 1,2,…..,n farms,

ν_i = an error term, independent and identically distributed (with N (O, δ_v^2);

μ_i = a non-negative term, accounting for inefficiency, with (O, δ_v^2), truncated half normal

For the inefficiency terms, variation in efficiency was estimated at the firm level due to farmer-specific characteristics. The inefficiency model was estimated base on the equation given below;

$$\boldsymbol{\mu_i = \delta_0 + \Sigma\, \delta_m\, Z_i} \quad \textbf{(2)}$$

Where,

δ_m = unknown parameters to be estimated

Z_{i1} = the vector of observation explanatory variables

In this study, the inefficiency equation is as follows;

$$\boldsymbol{\mu_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i} + e_i} \quad \textbf{(3)}$$

Where,

δ_0 = constant

$\delta_1 Z_{1i}$ = years in farm experience of the household head (years)

$\delta_2 Z_{2i}$ = number of extension visits during the rice growing season

$\delta_3 Z_{3i}$ = years in school of the household head

$\delta_4 Z_{4i}$ = dummy variable for credit access. If the farmer has access to credit by private (KHRSC), the value was 1 if he has access to credit by public (MADB), the value was 0

$\delta_5 Z_{5i}$ = sown area (hectare)

$\delta_6 Z_{6i}$ = dummy variable for rice variety. If the farmer grows Sinthwelatt , the value was 1 if he grows Manawthukha , the value was 0

The production function defined by equation (1) has the explanatory variables; use of seed rate, use of T-super and application of compound fertilizer involved in rice farming. These variables were assumed to explain the output of rice at Pyay Township in Bago Region.

The technical inefficiency effect outlined by equation (3) indicated that these effects in stochastic frontier (1) are expressed in terms of various explanatory variables which include the year of farm experience, number of extension visit during rice growing season, the education of farmer, credit access described by dummy, sown area and rice variety as dummy.

Coelli and Batteese (1998) stated that the technical efficiency of production of i^{th} farmer was estimated as

$TE_i = \exp (X_i \beta + \nu_i - \mu_i) / \exp (X_i \beta + \nu_i)$

$TE_i = \exp (- \mu_i)$

If $\mu_i = 0$, the farms were 100% efficient

Therefore,

$TE_i = e*p (-U_i)$

The technical efficiency of a farmer is between zero and one and is inversely related to the level of the technical inefficiency.

The technical efficiency was obtained from equation (1) and (3) using the method of maximum likelihood estimation to estimate the production frontier jointly with the inefficiency equation by using the computer program FRONTIER Version 4.1.

FRONTIER Version 4.1 is the most commonly used package for predicting for stochastic production frontier. The estimation process consists of three main steps in estimating the maximum-likelihood estimate (MLE) of the parameters of a stochastic frontier production function. At the first step, the model is applied to estimate the parameter of the production function with Ordinary least-square (OLS) method. This provides unbiased estimators for the β's with the exception of the intercept, β_0. The OLS estimators are used at the beginning of estimating values to the final MLE model. At the second step, the values for the likelihood function is estimated for different value of ϒ between 0 and 1 given the values for β's are derived in the OLS. Finally, an interactive algorithm calculates the final maximum-likelihood estimate, using the values of the β's from the OLS and the value of ϒ from the intermediate step as starting values in an iterative procedure (Coelli 1996).

CHAPTER IV
RESULTS AND DISCUSSION

4.1. Description of Sample Rice Farmers

4.1.1. Socio-economic characteristic of sample farmers

The classification of households was done based on the types of extension services contact observed in the study area. To evaluate of different services on rice production proficiency, the approach usually taken is to group the households in relatively homogeneous clusters. The sample households were classified into three groups: (1) public services contact farmers (PU) who conduct with the Department of Agriculture (DOA), (2) private services contact farmers (PR) who carry out with the Khittayar Hinthar Rice specialization Company (KHRSC); and (3) public and private services contact farmers (PU+PR) who perform with DOA and KHRSC.

4.1.2 Distribution of sampled extension contact households based on farm size

The sample extension contact farmers are classified into three groups according to size of operational land holding. There are 11.1% of PU, 66.75% of PR and 22.2% of PU+PR sample households in small farm household groups. In PR groups, there are six small households, seventeen medium households and seven large households. In the PU+PR farm households; there are two small households, twelve medium households and sixteen large households (Table 4.1). The differences are statistically significant at 10% level among these farm size groups.

4.1.3 Farm characteristic

A. Family size and farms size

On average, PU farmers have larger families and own more land. The average family size for PU farmers is 4.67 persons (4.43 adults) per household, greater than PR farmers' 4.07 persons (3.60 adults) and PU+PR farmers' 3.90 persons (3.50 adults). On average, a PU household controls 4.06 hectare of land (4.02 hectare of sown area), greater than PR farmers' 3.05 hectares (3.05 hectares of sown area) and PU+PR farmers' 3.86 hectares (3.86 hectares of sown area). And the differences are statistically significant at 10% level. On average, the three types of farmer significantly different at 10% level in their rice production with respect to the ratio of female family in total family members (Table 4.2).

B. Household head characteristics

On average, age of PU farmers' household heads is 52.63 years, which is older than age of PR and PU+PR farmers'47.30 and 46.17 years. There are statistically significant at 10% level. PU+PR farmers' household heads are younger and more educated usually have better access to first hand information and hence are in a better position to make decisions.

Table 4.1 Distribution of sampled households based on farm size

Farmer Groups	number and percentage of farmers Small farm household (n=9)	Medium farm household (n=45)	Large farm household (n=36)
PU	1 (11.1%)	16 (35.6 %)	13 (36.1%)
PR	6 (66.75%)	17(37.8%)	7 (19.4%)
PU+PR	2 (22.2%)	12 (26.7%)	16 (44.4%)
Total	9 (10%)	45 (50%)	36 (40%)
Chi-Square		**P=0.059***	

Note: * significant at 10% level

Table 4.2 Farmers' characteristics of selected farmers in the study area

Variables	PU (n=30)	PR (n=30)	PU+PR (n=30)	F Value	Total (n=90)
No. of family members (No.)	4.67	4.07	3.90	2.02^{ns}	4.21
No. of family members older than 14 (No.)	4.43	3.60	3.50	2.85^{*}	3.84
Percentage of female family members (%)	47.30	56.9	48.93	2.74^{*}	51.04
Total Land (Ha)	4.06	3.05	3.86	2.82^{*}	3.66
Sown Area (Ha)	4.02	3.05	3.86	2.59^{*}	3.64
Percentage of land for rice (%)	99.00	100.00	100.00	0.25^{ns}	99.04
Age of household head (year)	52.63	47.30	46.17	2.82^{*}	48.70
Education of household head (year)	5.47	4.83	5.97	1.43^{ns}	5.42
Experience of household head (year)	24.37	25.13	25.2	0.03^{ns}	24.9

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

4.1.4 Farm production and household head Access

On average, PR farmers exist in relatively poor economic conditions. They own less land, and fewer TVs, plows, radios, motorcycles, telephones, threshers and livestock than PU and PU+PR farmers (Table 4.3). Poor economic conditions may be a factor encouraging farmers joining the private company (KHRSC) because they need to produce more rice for earning. On average, PR farmers own 0.73 bullock carts, lower than PUC farmers'0.93 bullock carts and PU+PR farmers'0.96 bullock carts and there is a significant difference at 10% level.

4.1.5 Credit access and income

Credit as an external capital source plays an important role in providing liquid resources in times of need. Much of this credit is taken for filling the gap between cash payments receipts for produce, and cash payments for working capital inputs for the farm. Institutional credit in the study areas is provided by Myanma Agricultural Department Bank (MADB) for the farmers. The MADB is administrating target-oriented credit programme at subsidised 40,000 kyats per acre (98,800 kyats per hectare) with 1.5 percent interest rate per month for crop production. Other source for credit in the study area was KHRSC run by the Ayeyar Hinthar Co.Ltd group. It supports not only finance for production but also quality seed and agro chemicals such as urea and compound fertilizer NPK (15:5:5) as advanced in kind. And farmers need to pay just 2 percent interest rate per month for 45,000 kyats per acre (111,150 kyats per hectare) mainly for rice production. The three types of farmers differ significantly in their total credit at 1% level. Both contact farmers have taken out a loan of about 0.229 million kyats. PU and PR farmers borrowed the money of 0.082 million kyats and 0.147 million kyats respectively. PU+PR farmers have more potential to invest in their farms (Table 4.4).

A. Family income

Family income constitutes the summation of farm and off-farm income. This represents the income generating power of the family-owned resources and reflects the decision-making capabilities of the family. Family income is used to defray family living expenses, increase owned capital, and to repay interest if necessary.

B. Farm income, off-farm income and non-farm income

Farm income is the economic ability of a farm to provide in one year economic surplus to be used by the farming family. This measure is calculated as a residual after deducting all expenses from all revenues which are not directly related to family resources and is the income from the use of the family owned resources. Farm income comprises of family labour income, capital income, and management income (Doppler 2004).

On average, PR farmers have less income from on-farm income (2.44 million kyats per year) than PU farmers (2.89 million kyats per year) and PU+PR farmers (2.83 million kyats per year). Three types of farmers have similar compositions of off-farm incomes. This mainly reflects PR farmers relatively lower off-farm income compared with the other two types of farmers (Table 4.4). The PU farmers on average have more income than other two types of farmers. These income patterns indicate that PU farmers are more agriculture-oriented than PR and PU+PR farmers. Non-farm income in this study was concerned with any income other than agriculture such as income of salary and from company, shop keeping, and transportation and so on.

Table 4.3 Farm production and household access in the study area

Variables	PU (n=30)	PR (n=30)	PU+PR (n=30)	F Value	Total (n=90)
No. of plough	1.23	1.03	1.26	1.20^{ns}	1.14
No. of harrow	1.23	0.96	1.23	1.95^{ns}	1.14
No. of thresher	0.16	0.06	0.06	1.10^{ns}	0.10
No. of water pump	0.53	0.36	0.50	0.84^{ns}	0.46
No. of bullock cart	0.93	0.73	0.96	2.82^{*}	0.87
No. of cattle	2.63	1.93	2.10	0.96^{ns}	2.22
No. of Television	0.76	0.76	0.86	0.39^{ns}	0.80
No. of Radio	0.50	0.40	0.66	2.02^{ns}	0.52
No. of Motorcycle	0.80	0.50	0.70	2.12^{ns}	0.66
No. of Telephone	0.10	0.03	0.06	0.52^{ns}	0.06
No. of Sewing Machine	0.16	0.16	0.10	0.35^{ns}	0.14
No. of Generator	0.06	0.06	0.03	0.21^{ns}	0.55

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

Table 4.4 Credit access and income of selected farmers in the study area

Variables	PU (n=30)	PR (n=30)	PU+PR (n=30)	F Value	Total (n=90)
Average credit amount per year ('00,000 Ks)	0.82	1.47	2.29	22.36^{***}	1.53
Family Income ('00,000 Ks)	33.79	29.38	32.06	0.40^{ns}	31.73
On-farm Income ('00,000 Ks)	28.98	24.98	28.36	0.47^{ns}	27.44
Off-farm Income ('00,000 Ks)	0.92	0.89	1.70	0.77^{ns}	1.17
Non-farm Income ('00,000 Ks)	3.88	3.51	1.93	1.11^{ns}	3.10

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

4.2 Farming characteristic of monsoon rice and summer rice in the study area

4.2.1 Farming characteristic in monsoon rice

In the following, the three types of farmers' production characteristics in their monsoon rice production were described in Table 4.5.

A. Rice field

On average PR farmer controls 3.05 hectares of land and uses 3.05 hectares (100%) of the land for rice operation. An average, PU farmer has larger rice field and controls 4.06 hectares of land and uses 4.02 hectares (99%) of the land for rice farming. On average PU+PR farmers controls 3.86 hectare of land and uses 3.86 hectares (100%) of the land for rice production.

B. Rice price

On average, PRC and PU+PR farmers can sell their rice at 164.28 kyats per kg and 166.50 kyats per kg, higher than PU farmers' 154.84 kyats per kg (Table 4.5). High rice price is a major factor attracting farmers to join the KHRSC, which not only subjects them to strict quality stands but also constrains their freedom in farming activities such as the use of seeds and chemicals.

C. Revenue/Total gross return (Kyats per hectare)

As PR and PU+PR farmers can sell their rice at higher prices, one may expect that would have higher revenue. On average, PR and PU+PR farmers' revenue (per hectare) from rice production are 0.727 million kyats and 0.752 million kyats respectively, which are higher than PUC farmers' 0.674 million kyats and significantly at 5 % level.

D. Yield (Tons per hectare of land)

PR and PU+PR farmers' average yield are 4.41 tons and 4.51 tons per hectare respectively, which are higher than PU farmers' 4.35 tons per hectare but not significantly different. This may indicate that the rice farming practice recommended by DOA for PU farmers did not lead to lower yield. The yield differences among the three groups of farmers indicate that inflexibility in farming practices may be a factor motivating farmers to abandon the KHRSC.

E. Cost (Kyats per hectare or kyats per kg of rice production)

On average, PR farmers spend 0.446 million kyats on one hectare of rice production, which appears higher than PU farmers' 0.443 million kyats and PU+PR farmers' 0.438 million kyats. However, the differences are not statistically significant (Table 4.4). For rice operation, the average ratio of PR farmers' cash costs to their total cost is 82.38 %, which is not significantly different from PU farmers' 83.81 % and PU+PR farmers' 83.95%, but lower than PU and PU+PR farmers (Table 4.5). For rice production, the average ratio of PR farmers' labor cost to their total cost is 44.54 %, which is significantly different at 10 % level from PU farmers' 42.84 % and PU+PR farmers' 43.32 % and higher than PU and PU+PR farmers (Table 4.5).

F. Profitability (Kyats per hectare)

The average profit (cash and non-cash inputs included) for PR and PU+PR farmers in rice production are 0.275 and 0.309 million kyats per hectare respectively, which appears higher than PU farmers' 0.229 million kyats. The differences are statistically significant at 1 % level (Table 4.2). Three types of farmers' average total profit are positive. Their average cash profit (only cash cost) for PR and PU+PR t farmers in rice operation are 0.326 and 0.351 million kyats per hectare respectively, which appears higher than PU farmers' 0.279 million kyats.

Table 4.5 Farm production of monsoon rice: Revenue, cost and profit in the study area

Variables	PU (n=30)	PR (n=30)	PU+PR (n=30)	F Value	Total (n=90)
Sown Area (Hectare)	4.02	3.05	3.86	2.68^{ns}	3.63
Revenue (’00,000 ks/ha)	6.74	7.27	7.52	6.47**	7..18
Rice Price (ks/kg)	154.84	164.28	166.50	8.24***	161.87
Yield (Ton/ha)	4.35	4.41	4.51	1.96^{ns}	4.42
Production Cost ('00,000 ks/ha)	4.43	4.46	4.38	0.74^{ns}	4.42
Production Cost (ks/kg of rice production)	92.62	89.64	87.11	4.98**	89.79
Ratio of Cash in Cost (%)	83.83	82.38	83.95	0.99^{ns}	83.38
Ratio of Labor Cost in Total Cost	42.84	44.54	43.32	3.47*	43.58
Profit per Area of Land ('00,000 ks/ha)	2.29	2.75	3.09	11.31***	3.21
Cash Profit per Area of Land ('00,000 ks/ha)	2.79	3.26	3.51	11.48***	3.18

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

4.2.2 Farming characteristic in summer rice

In the following, the three types of farmers' production characteristics in their summer rice production were indicated in Table 4.6.

A. Rice field

On average, PR farmers have smaller rice field and control 1.84 hectares of rice sown area. PU and PU+PR farmers have larger rice field and control 2.465and 2.59 hectares of rice sown area. The differences are not significant by the three types of farmers.

B. Rice price

On average, PR and PU+PR farmers can sell their rice at 166.94 kyats per kg and 174.23 kyats per kg, higher than PU farmers' 149.02 kyats per kg (Table 4.6). High rice price is a major factor attracting farmers to join the KHRSC, which not only subjects them to strict quality stands but also constraints their freedom in farming activities such as the use of seeds and chemicals. Thus, the differences are statistically significant at 1% level by the three groups of farmers.

C. Revenue/Total gross return (Kyats per hectare)

As PR and PU+PR contact farmers can sell their rice at higher prices, one may expect that would have higher revenue. On average, PR and PU+PR farmers' revenue (per hectare) from rice production are 0.821 million kyats and 0.871 million kyats respectively, which are higher than PU farmers' 0.718 million kyats and significantly at 1 % level.

D. Yield (Tons per hectare of land)

PR and PU+PR farmers' average yield are 4.91 tons and 5.0 tons per hectare respectively, which are higher than PU farmers' 4.81 tons per hectare and significantly different at 1% level. This may indicate that the rice farming practice recommended by KHRSC for PR and PU+PR farmers did lead to higher yield for rice production. Theyield differences among the three groups of farmers indicated that inflexibility in farming practices may be a factor motivating farmers to abandon the KH RSC.

E. Cost (Kyats per hectare or kyats per kg of rice production)

On average, PR farmers spend 0.439 million kyats on one hectare of rice production, which appears similar with PU farmers' 0.432 million kyats but lower than PU+PR farmers' 0.451 million kyats. Thus, the differences are statistically significant at 1%level (Table 4.6). For rice operation, the average ratio of PR farmers' cash costs to their total cost is 88.95% and PU+PR farmers' 89.01%, which are significantly different at 10% level from PU farmers' 86.63 % (Table 4.6). For rice production, the average ratio of PR farmers' labor cost to their total cost is 53.34 %, which is significantly different at 1 % level from PU farmers' 43.34 % and PU+PR farmers' 45.57 % and higher than PU and PU+PR farmers (Table 4.6).

F. Profitability (Kyats per hectare)

The average profit (cash and non-cash inputs included) for PR and PU+PR farmers in rice production are 0.381 and 0.417 million kyats per hectare respectively, which appears higher than PU farmers' 0.285 million kyats. And the differences are statistically significant at 1 % level (Table 4.6). Three types of farmers' average total profit are positive. Their average cash profit (only cash cost) for PR and PU+PR farmers in rice operation are 0.430 and 0.462 million kyats per hectare respectively, which appears higher than PU farmers' 0.337 million kyats.

Table 4.6 Farm production of summer rice: Revenue, cost and profit in the study area

Variables	**PU (n=17)**	**PR (n=17)**	**PU+PR (n=17)**	**F Value**	**Total (n=51)**
Sown Area (Hectare)	2.46	1.84	2.59	1.30^{ns}	2.30
Revenue ('00,000 ks/ha)	7.18	8.21	8.71	12.14***	8.03
Rice Price (ks/kg)	149.02	166.94	174.23	10.65***	163.40
Yield (Ton/ha)	4.81	4.91	5.00	3.52*	4.81
Production Cost ('00,000 ks/ha)	4.32	4.39	4.51	13.53***	4.40
Production Cost (ks/kg of rice production)	82.29	91.93	80.67	10.56***	84.96
Ratio of Cash in Cost	86.63	88.95	89.01	3.24*	88.20
Ratio of Labor Cost in Total Cost	43.34	53.34	45.57	22.29***	47.42
Profit per Area of Land ('00,000 ks/ha)	2.85	3.81	4.17	10.53***	3.61
Cash Profit per Area of Land ('00,000 ks/ha)	3.37	4.30	4.62	9.31***	3.97

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

4.2.3 Labor structure of monsoon rice and summer rice

A. Labor cost for monsoon rice

On average, PR farmers spend 0.175 million kyats (40 kyats per kg of rice production) on one hectare of rice operation, higher than PU farmers' 0.172 million kyats (39.78 kyats per kg of rice production) and PU+PR farmers' 0.17 million kyats (37.77 kyats per kg of rice production), but the differences are not statistically significant (Table 4.7). On average, the three types of farmer significantly different in their rice production with the respect to the ratio of family labor in total labor and the ratio of hired labor in total labor. However, PR farmers use relatively higher percentage of females in total labor in their rice production (Table 4.7).

B. Labor cost for summer rice

On average, PR farmers spend 0.241 million kyats (49.19 kyats per kg of rice production) on one hectare of rice operation, higher than PU farmers' 0.173 million kyats (36.12 kyats per kg of rice production) and PU+PR farmers' 0.183 million kyats (36.77 kyats per kg of rice production), and the differences are statistically significant at 1% level (Table 4.8). On average, the three types of farmer significantly different in their rice production with respect to the ratio of family labor and hired labor in total labor. However, PR farmers use relatively higher percentage of females in total labor in their rice production but not significantly different among the three types of farmers (Table 4.8).

Table 4.7 Labor cost of monsoon rice by the selected sample farmers

Variables	PU (n=30)	PR (n=30)	PU+PR (n=30)	F Value	Total (n=90)
Labor Cost ('00,000 ks/ha)	1.72	1.75	1.70	0.66^{ns}	1.70
Labor Cost (ks/kg of rice production)	39.78	40.00	37.77	2.39^{ns}	37.77
Cash Labor Cost ('00,000 ks/ha)	1.23	1.25	1.23	0.21^{ns}	1.23
Cash Labor Cost (ks/kg of rice production)	28.35	28.58	27.23	0.98^{ns}	27.23
Ratio of Family Labor in Total Labor (%)	30.61	29.05	28.59	0.47^{ns}	28.59
Ratio of Hired Labor in Total Labor (%)	69.39	70.95	71.41	0.47^{ns}	71.41
Ratio of Female Labor in Total Labor (%)	61.35	64.27	56.33	7.14***	56.33

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

Table 4.8 Labor cost of summer rice by the selected sample farmers

Variables	PU (n=17)	PR (n=17)	PU+PR (n=17)	F Value	Total (n=51)
Labor Cost ('00,000 ks/ha)	1.73	2.41	1.83	25.38***	1.99
Labor Cost (ks/kg of rice production)	36.12	49.19	36.77	22.75***	40.69
Cash Labor Cost ('00,000 ks/ha)	1.21	1.91	1.39	24.53***	1.51
Cash Labor Cost (ks/kg of rice production)	25.38	39.03	27.88	21.95***	30.76
Ratio of Family Labor in Total Labor (%)	37.75	27.80	23.85	3.40*	29.8
Ratio of Hired Labor in Total Labor (%)	62.24	72.19	76.14	3.40*	70.19
Ratio of Female Labor in Total Labor (%)	53.75	60.11	56.75	2.29^{ns}	56.87

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

4.2.4 Material and operating cost structure of monsoon rice and summer rice

A. Material and operating cost structure of monsoon rice

(1) Material cost

On average, PR farmers spend 0.218 million kyats on material cost (including rental machine cost) per hectare of rice field, lower than PU farmers' 0.23 million kyats and PU+PR farmers' 0.22 million kyats, but the differences were not statistically significant (Table 4.4). On average, PR and PU+PR farmers use 44.64 kyats and 49.33 kyats of material cost to produce one kg of rice which were lower than PU farmers' 52.99 kyats and the differences are statistically significant at 1 % level (Table 4.9).

(2) Chemical fertilizer

With respect to rice production, the average chemical fertilizer costs per hectare for PR farmers and PU+PR farmers (0.869 million kyats and 0.862 million kyats respectively) are significantly higher than that of PU farmers' 0.63 million kyats (Table 4.9). On average, PR and PU+PR farmers spend 19.56 kyats and 18.97 kyats in producing one kg of rice respectively which are higher than PU farmers' 14.64 kyats. Significant differences were found at 1 % level in the cost of chemical fertilizer encountered by the three types of farmers (Table 4.9).

(3) Farmyard manure (FYM)

On average, PR farmers use 22,000 kyats of FYM on one hectare of rice field, which is similar to PU+PR farmers' 24,000 kyats but lower than PU farmers' 26,000 kyats (Table 4.9). The use of FYM was significant difference at 5% level by the three types of farmers.

(4) Pesticide

All three types of farmer didn't use pesticide for rice production in the study area. They didn't have pesticide cost for one hectare of rice production.

(5) Transportation

PR farmers' average transportation cost (kyats per kg of rice production) was 3.55 kyats which was higher than PU farmers' average 3.40 kyats (not statistically significant) and PU+PR farmers' average 3.38 kyats.

Table 4.9 Material cost and operating cost structure of monsoon rice in the study area

Variables	PU (n=30)	PR (n=30)	PU+PR (n=30)	F Value	Total (n=90)
Material Cost ('00,000 ks/ha)	2.30	2.18	2.22	2.78^{ns}	2.23
Material Cost (ks/kg of rice production)	52.99	49.64	49.33	8.90^{***}	50.65
Chemical Fertilizer Cost ('00,000 ks/ha)	0.63	0.86	0.86	21.53^{***}	0.78
Chemical Fertilizer Cost (ks/kg of rice production)	14.64	19.56	18.97	25.24^{***}	17.72
Compost Cost ('00,000 ks/ha)	0.26	0.22	0.24	6.99^{**}	0.24
Compost Cost (ks/kg of rice production)	6.10	4.94	5.34	9.09^{***}	5.46
Transportation Cost (ks/kg of rice production)	3.40	3.55	3.38	0.54^{ns}	3.44

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

B. Material and operating cost structure of summer rice

(1) Material cost

On average, PR farmers spend 0.21 million kyats on material cost (including rental machine cost) per hectare of rice field, lower than PU farmers' 0.221 million kyats and PU+PR farmers' 0.217 million kyats, but the differences are not statistically significant (Table 4.10). On average, PR and PU+PR farmers use 42.74 kyats and 43.89 kyats of material cost to produce one kg of rice which were lower than PU farmers' 46.16 kyats and the differences were statistically significant at 1 % level (Table 4.9).

(2) Chemical fertilizer

With respect to rice production, the average chemical fertilizer costs per hectare for PR farmers and PU+PR farmers (0.94 million kyats and 0.96 million kyats respectively) were significantly higher than for PU farmers' 0.66 million kyats (Table 4.10). On average, PR and PU+PR farmers spend 19.16 kyats and 19.27 kyats in producing one kg of rice respectively which were higher than PUC farmers' 13.75 kyats. The cost of chemical fertilizer encountered by the three types of farmers was significant differences at 1% level (Table 4.10).

(3) Farmyard manure (FYM)

On average, PR and PU+PR farmers used 50,000 kyats and 90,000 kyats of FYM on one hectare of rice field respectively, but higher than PU farmers' 15,000 kyats (Table 4.10). There was significant difference in the use of FYM at 1% level by the three types of farmers.

(4) Pesticide

Since the three types of farmer did not use pesticide for rice production in the study area, they have no pesticide cost for one hectare of rice production.

(5) Transportation

The PR farmers' average transportation cost (kyats per kg of rice production) was 1.95 kyats, lower than PU farmers' average 3.45 kyats (statistically significant) and PU+PR farmers' average 2.22 kyats.

Table 4.10 Material and operating cost structure of summer rice in the study area

Variables	PU (n=17)	PR (n=17)	PU+PR (n=17)	F Value	Total (n=51)
Material Cost ('00,000 ks/ha)	2.21	2.10	2.19	2.72^{ns}	2.17
Material Cost (ks/kg of rice production)	46.16	42.74	43.89	4.23**	44.26
Chemical Fertilizer Cost ('00,000 ks/ha)	0.66	0.94	0.96	22.22***	0.85
Chemical Fertilizer Cost (ks/kg of rice production)	13.75	19.16	19.27	18.79***	17.39
Compost Cost ('00,000 ks/ha)	0.15	0.05	0.09	12.17***	0.10
Compost Cost (ks/kg of rice production)	3.31	1.24	1.87	13.28***	2.14
Transportation Cost (ks/kg of rice production)	3.45	1.95	2.22	11.33***	2.54

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

4.3 Cost and Return of Monsoon Rice and Summer Rice in the Study Area

Cost and return analysis can be applied to compare the profitability among three types of farmers (PU, PR and PU+PR farmers). The economic return from PU, PR and PU+PR farmers were discussed in this section.

4.3.1 Enterprise budget of monsoon rice in the selected sample farmers

Cost and return of the monsoon rice production were computed for 90 households in case of PU, PR and PU+PR farmers. The enterprise budget of each type of farmer is shown in tables (Appendix 1, 2 and 3).

The total gross benefit of the rice production is the multiply of total rice yield and the actual market price of the rice. The variable cost includes the total material cost, total machinery cost, total family labor cost, total hired labor cost and interest rate of the total material cost and total hired labor cost. Considering the opportunity cost of the family labor, it is valued at market price in this analysis.

In Tale 4.11 the total gross benefit of PU farmers is 0.67 million kyats per hectare. The yields of PU farmers is 4.35 t/ha and the price of rice is 154.84 kyats per kg. The total material cost employed in rice production is 0.106 million kyats per hectare. The machinery cost applied in this production is 0.12 million kyats per hectare. The total labor and cattle cost in rice production is 0.209 million kyats per hectare and the interest on material and hired labor cost is 0.04 million kyats per hectare.

The total gross benefit of PR farmers is 0.72 million kyats per hectare. The yields of PR farmers is 4.41 t/ha and the price of rice is 164.28 kyats per kg. The total material cost employed in rice production is 0.12 million kyats per hectare. The machinery cost applied in this production is 0.098 million kyats per hectare. The total labor and cattle cost in rice production is 0.21million kyats per hectare and the interest on material and hired labor cost is 0.05 million kyats per hectare.

The total gross benefit of PU+PR farmers is 0.75 million kyats per hectare. The yields of PU+PR farmers is 4.51 t/ha and the price of rice is 166.50 kyats per kg. The total material cost employed in rice production is 0.123 million kyats per hectare. The machinery cost applied in this production is 0.098 million kyats per hectare. The total labor and cattle cost in rice production is 0.208 million kyats per hectare and the interest on material and hired labor cost is 0.046 million kyats per hectare.

The gross revenues among these three types of farmers are statistically significant at 1% level. The total variable cost is not significant. The material and machinery cost are statistically significant at 5% level among these three groups. The labor and cattle cost are not significant. The interest rate and net benefits is highly significant at 1% level among these farmers. On average, cost and benefit ratio of PU+PR farmers is 1.70, higher than the cost and benefit ratio of PU farmers' 1.52 and the cost and benefit ratio of PR farmers' 1.61 and the differences are statistically significant at 1% level.

4.3.2 Enterprise budget of summer rice in the selected sample farmers

Cost and return of the summer rice production were computed for 51 households in case of PU, PR and PU+PR farmers. The enterprise budget of each type of farmer is shown in tables (Appendix 4, 5 and 6).

The total gross benefit of the rice production is the multiply of total rice yield and the actual market price of the rice. The variable cost includes the total material cost, total machinery cost, total family labor cost, total hired labor cost and interest rate of the total material cost and total hired labor cost. Considering the opportunity cost of the family labor, it is valued at market price in this analysis.

In Tale 4.12, the total gross benefit of PU farmers is 0.718 million kyats per hectare. The yields of PU farmers are 4.81ton per hectare and the price of rice is 149.02 kyats per kg. The total material cost employed in rice production is 0.98 million kyats per hectare. The machinery cost applied in this production is 0.123 million kyats per hectare. The total labor and cattle cost in rice production is 0.173 million kyats per hectare and the interest on material and hired labor cost is 0.0412 million kyats per hectare.

The total gross benefit of PR farmers is 0.8.21 million kyats per hectare. The yields of PR farmers is 4.91 ton/ha and the price of rice is 166.94 kyats per kg. The total material cost employed in rice production is 0.11 million kyats per hectare. The machinery cost applied in this production is 0.098 million kyats per hectare. The total labor and cattle cost in rice production is 0.24 million kyats per hectare and the interest on material and hired labor cost is 0.49 million kyats per hectare.

The total gross benefit of PU+PR farmers is 0.87 million kyats per hectare. The yields of PU+PR farmers is 5.00 t/ha and the price of rice is 174.23 kyats per kg. The total material cost employed in rice production is 0.12 million kyats per hectare.

The machinery cost applied in this production is 0.098 million kyats per hectare. The total labor and cattle cost in rice production is 0.18 million kyats per hectare and the interest on material and hired labor cost is 0.044 million kyats per hectare.

The gross revenues among these three types of farmers are statistically significant at 1% level. The total variable cost and variable cash cost are not significant. The returns above material and machinery cost are statistically significant at 1% level among these three groups. The returns above labor and cattle cost are not significant. The interest rate and the net benefits are highly significant at 1% level among these farmers. On average, cost and benefit ratio of PU+PR farmers is 1.92, higher than the cost and benefit ratio of PU farmers' 1.66 and the cost and benefit ratio of PR farmers' 1.87 and the differences are statistically significant at 1% level.

Table 4.13 indicates that Sinthwelatt variety was grown by the majority of the sample farmers in the study area.

Table 4.11 Comparison of net benefits and BCR of monsoon rice in sample farmers (PU, PR and PU+PR**)**

Item	**PU (n=30)**	**PR (n=30)**	**PU+PR (n=30)**	**F Value**	**Total (n=90)**
Yield (ton/ha)	4.35	4.41	4.51	1.96^{ns}	4.42
Price (ks/kg)	154.84	164.28	166.50	8.24^{***}	161.87
Gross benefit (ks/ha)	674789.18	727172.10	752979.50	6.49^{***}	718313.59
Interest on cash cost(ks/ha)	404776.97	52002.52	46249.59	51.39^{***}	46243.03
Net benefit (ks/ha)	231614.92	280639.80	314214.00	10.41^{***}	275489.56
BCR ratio	1.52	1.61	1.70	11.86^{***}	1.61

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

Table 4.12 Comparison in net benefits and BCR of summer rice in sample farmers (PU, PR and PU+PR**)**

Item	**PU (n=17)**	**PR (n=17)**	**PU+PR (n=17)**	**F Value**	**Total (ns=51)**
Yield (ton/ha)	4.81	4.91	5.00	3.52^{*}	4.91
Price (ks/kg)	149.02	166.94	174.23	10.61^{***}	163.40
Gross benefit (ks/ha)	718682.82	821347.60	871546.8	12.14^{***}	803859.07
Interest on cash cost (ks/ha)	41241.79	48213.20	43037.28	12.92^{***}	44164.09
Net benefit (ks/ha)	288384.06	347050.00	425361.90	11.99^{***}	353598.65
BCR ratio	1.66	1.87	1.92	8.84^{***}	1.82

Note: ***, * significant at 1% and 10% level,

Table 4.13 Percentage of sampled farm groups growing major variety of rice

Variety	**PU (n=30)**	**PR (n=30)**	**PU+PR (n=30)**	**Total (n=90)**
Sinthwelatt	20 (66.7%)	23 (76.7%)	23 (76.7%)	66 (73.3%)
Manawthukha	10 (33.3%)	7 (23.3%)	7 (23.3%)	24 (26.7%)
Pearson Chi-square		**$p=0.60^{ns}$**		

Note: ns = not significant

4.4 Input Use of Rice Production in the Sample Farm Households

In Table 4.14, the use of seed rate and FYM of PU farmers were the highest and the lowest in PR. The PU+PR farmers used the highest amount of urea and T-super. The PR farmers used the highest amount of compound fertilizer and family labor.

4.5 Summary Statistics of the Variables of the Sample Rice Farm Households in Pyay Township

Table 4.15 describes the summary statistic of the variables used in estimation of the stochastic production function of the sample farm households. The average rice yield of Pyay is 4.42 ton per hectare with a range of about 3.7 to 5.03 ton per hectare. The average amount of seed rate applied in rice production is 72.56 kilograms per hectare with a range of about 51.87 to 103.74 kilogram per hectare. The average amount of T-super used in rice production is 44.29 kilograms per hectare with arrange of 25.94 to 61.78 kilogram per hectare. The average amount of compound fertilizer applied in rice production is 73.33 kilograms per hectare with a range of about 43.23 to 123.5 kilogram per hectare.

For variables used in technical inefficiency equation, the average years of farm experience in Pyay is 24.9 year with arrange of 3 to 53 year. The average number of extension visit in the rice growing season is 16.27 with a range of about 13 to 19. The schooling years of households head is about 5 years. The land is measured in hectare, on which rice is grown in the year of survey. The average area produced by rice in Pyay is 3.63 hectare with arrange of 1.12 to 10.12 hectares. The credit access and variety of sample farmers are computed in dummy variables. The credit access obtained from private (KHRSC) is one, the credit access gained from public (MADB) is zero and Sinthwelatt variety used in rice production is one, otherwise is zero.

Table 4.14 Input use of rice production in the sample farms households

Item	PU (n=30)	PR (n=30)	PU+PR (n=30)	F Value	Total (n=90)
Seed rate (kg/ha)	85.58	60.34	71.75	18.80***	72.56
FYM (ton/ha)	5.31	4.36	4.82	6.95**	4.83
Urea (kg/ha)	56.65	84.4	90.58	17.26**	77.26
T-super (kg/ha)	29.97	50.43	52.48	31.72***	44.20
Compound (kg/ha)	58.54	86.32	75.13	22.76***	73.33
Family labor (man-day/ha)	23.54	23.49	21.35	0.77ns	22.80
Hired-labor (man-day/ha)	52.52	57.22	53.3	2.78*	54.35

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

Table 4.15 Statistic summary of the variables used in analysis of sample rice farmers in Pyay Township

Variables	All sample farmers (n=90)			
	mean	std	min	Max
Production function				
Yield (Ton/ha)	4.42	0.30	3.70	5.03
Seed rate (Kg/ha)	72.56	18.89	51.87	103.74
T-Super (Kg/ha)	44.29	15.73	25.94	61.75
Compound (Kg/ha)	73.33	19.58	43.23	123.5
Technical Inefficiency effect				
Farm experience (Years)	24.90	13.90	3.00	53.00
Extension visit (times/growing season)	16.27	2.44	13.00	19.00
Household head education (schooling year)	5.48	2.63	1.00	10.00
Credit access (dummy)	0.67	0.47	0.00	1.00
Sown area (Ha)	3.63	1.79	1.12	10.12
Variety (dummy)	0.73	0.44	0.00	1.00

4.6 Results of Maximum-likelihood Estimate of Stochastic Frontier Cobb-Douglas Rice Production Function

The maximum likelihood estimation of stochastic frontier model is presented in Table 4.17 using the program FRONTIER 4.1. At this step, the Cobb-Douglas production function is expected to have a significant influence on output.

Table 4.17 indicates that explanatory variables of rice farms in the model contribute significantly to the explanation of yield of rice within the selected study area of Pyay Township. It shows that the joint effects of these variables on technical efficiency are statistically significant using maximum likelihood estimation of technical efficiency. OLS estimates of coefficients were taken as the starting values for maximum likelihood (ML) estimation of the frontier function. Two out of nine variables are significant (credit access, sown area and also the intercept) and explain 97% of the variation in the total production of rice.

A high value of Υ (0.97) in all selected farms indicates the presence of significant in efficiencies in the production of rice crop. It shows about 97 percent of differences between the observed and maximum production frontier outputs were due to the factors which were under farmers control. The stochastic frontier analysis has further shown 97 percent of observed inefficiency was due to farmers' inefficiency in decision-making and only 3 percent of it was due to random factors outside their control in the case of all selected farms.

The average of technical efficiency has been estimated as 0.89 percent for farms as a whole, implying that on an average the sample farmers tend to realise around 89 percent of their technical abilities. Hence, on an average, approximately 11 percent of the technical potentials are not realized. Therefore, it is possible to improve the yield by 11 percent by following efficient crop management practices without increasing level of inputs application.

In the estimation of Cobb-Douglas production function with technical efficiency effects; all coefficients of the resources in the rice production are positive. However there are not significant.

For technical inefficiency model, the access to credit is negative and significant at 1% level, indicating that farmers who had more access (from KHRSC) to credit proved to be more efficient in utilization of resources than who had less access (from MADB). Therefore program on rural credit can improve the technical efficiency of rice production. Some progress in accessibility of credit has been made by MADB and KHRSC in recent year in rural area of Pyay but there are still in insufficient of rice production. The sown area is negative and statistically significant at 1 percent level. This finding indicates that household head with larger sown area have more efficient in using scarce resources than ones with the smaller sown area. The number of extension visits in rice growing season is negative but not significant. A negative relationship between the numbers of extension visit implies that extension services are still weak in the study area and training should be improved to develop the farmers' analytical skill, critical thinking and creativity to make better decision. A training program should be able to improve the knowledge and skill of farmers in rice production. The education and variety variables are positive and not significant.

Table 4.16 Maximum likelihood estimate of the production frontier model for all sampled farmers in Pyay Township

Variables		**OLS**		**MLE**	
Stochastic production function	**parameter**	**coefficient**	**SE**	**coefficient**	**SE**
constant	β_0	3.717***	0.243	4.240***	0.141
Ln seed rate	β_1	-0.002	0.035	0.019	0.023
Ln T-super	β_2	0.147***	0.027	0.028	0.021
Ln compound fertilizer	β_3	0.035	0.037	0.022	0.024
Inefficiency model					
constant	δ_0			0.563	0.336
Ln Farm experience	δ_1			0.034	0.028
Ln extension visit	δ_2			-0.157	0.131
Ln Household head education	δ_3			0.018	0.030
Ln Credit access	δ_4			-0.189***	0.063
Ln sown acre	δ_5			-0.124***	0.024
Ln Variety	δ_6			0.046	0.045
Variance Parameter					
$\delta^2 = \delta_v - \delta_u$	δ^2			0.013***	0.004
$\Upsilon = \delta_v / \delta_u$	Υ			**0.972***	0.021
Log Likelihood				113.36	
LR ratio test				23.27	
Mean efficiency				**0.89**	
No of observation				90	

Source: Analyzed by FRONTIER 4.1 *** significant at 1% level

4.7 Technical Efficiency of Rice Producer in Pyay Township

As described in chapter III, technical efficiency of the firms is calculated and measured the deviation of current output from its possible maximum. Technical efficiency is calculated using the conditional expectation of following equation, conditioned on the composed error ($\varepsilon_i = v_i - \mu_i$). Thus,

TE $_{output} \leq 1$ with TE =1 capturing zero inefficiency,

TE = exp ($-\mu_i$) * 100

(TE is converted into a percent by multiplying this equation by 100)

In the study area, the technical efficiencies of sample farms in a cropping season can be predicted using conditional expectation of TE = exp ($-\mu_i$) using computer program FRONTIER 4.1. These technical predication are between zero, reflecting the existence of technical inefficiency, and the index takes the value one, with fully technical efficient for farms in the production frontier.

The predicted technical efficiencies groups of different farms households in the study area are presented in Table 4.17. The technical efficiency ratings arranged into a frequency distribution where class interval is 10 (see Table 4.17). The groups are classified as technical efficiency levels between 0.70-0.79 as low, 0.80-0.89 as medium and above 0.90 as high, which represents the distribution of technical efficiency levels. It is also observed that a majority of the large farm households (57.4%) operated at technical efficiency level above 90 percent. The majority of the medium farm households (67.9%) operated at technical efficiency level between 80 to 90 percent. The majority of the small farm households (17.9%) operated at technical efficiency level between 80 to 90 percent. About 33.3% of large farm households and 66.7% of medium farm households lie below 80% of technical efficiency level. Further, the analysis revealed that about 57.4% of large farm households, 34.0% of medium farm households and 8.5% of small farm households are operating close to the frontier with the technical efficiency of more than 90 percent.

In Table 4.18 (Figure 4.1), over 40% of PU+PR and PR farmers gained above 0.90 technical efficiency levels. About 39% of PU+PR and 32% of PR farmers obtained between 0.80 to 0.89 technical efficiency levels. About 87% of PU farmers gained between 0.70 to 0.79 technical efficiency levels. Therefore PU+PR and PR farmers are more efficient than PU farmers in rice farming.

4.8 Main Constraints of Sample Farmers for Agriculture Development

Main constraints for PR farmers in the study area are poor soil (20%), irrigated water (45%), high price fertilizer (33%), unavailability of machine (10%), high yield seed (40%), technology (57%) and limited money (43%) in their rice production. Main constraints for PU farmers in the study area are poor soil (13%), irrigated water (50%), high price fertilizer (73%), unavailability of machine (30%), high yield seed (63%), technology (67%) and limited money (97%) in their rice production. Main constraints for PU+PR contact farmers in the study area are poor soil (10%), irrigated water (40%), high price fertilizer (73%), unavailability of machine (13%), high yield seed (60%), technology (83%) and limited money (83%) in their rice production (Table 4.19). Therefore, capital requirement, technology and fertilizer requirement were the main needs for sample farm households in the study area.

Table 4.17 Technical efficiency group of household head according to farm size

Number and percentage of farmer

Mean Efficiency Group	**Small Farm Household**	**Medium Farm Household**	**Large Farm Household**
0.70-0.79	0 (0%)	10 (66.7%)	5 (33.3%)
0.80-0.89	5 (17.9)	19 (67.9%)	4 (14.3%)
Above 0.90	4 (8.5%)	16 (34.0%)	27 (57.4%)
Total	9 (10%)	45 (50%)	36 (40%)
Chi- Square		**p=0.002*****	
Average	0.76	0.86	0.95
Max	0.78	0.89	0.99
Min	0.72	0.8	0.9
Observation	9	45	36
F-test		**F=614.97*****	

Note: *** significant at 1% level

Table 4.18 Technical efficiency group of different farmer groups

Number and percentage of farmer

Farmer groups	**Mean Efficiency Group**		
	0.70-0.79	**0.80-0.89**	**Above 0.90**
PU	13 (87%)	8 (29%)	9(19%)
PR	2 (13%)	9 (32%)	19 (40.5%)
PU+PR	0 (0%)	11 (39%)	19 (40.5%)
Total	15 (17%)	28 (31%)	47 (52%)
Chi-Square		**p=0.000*****	
F-test		**F=12.89*****	

Note: *** significant at 1% level

Table 4.19 Percentage main constraints for rice farming in sample farm households

Farmer Groups	Poor Soil	Machine	Water Supply	High Yield Seed	Fertilizer	Technology	Capital
PU	13	30	50	63	73	67	97
PR	20	10	45	40	33	57	43
PU+PR	10	13	40	60	73	83	83
Total	14	18	45	54	60	69	74

CHAPTER V

SUMMARY, CONCLUSION AND POLICY IMPLICATION

5.1 Summary and Conclusion of the Study

Majority of Myanmar people depend on agriculture for their food and livelihoods. Developing agriculture means developing the economy of rural people. Major tasks of agriculture sector are to fulfill food security, to increase foreign exchange through exporting agricultural products and providing assistance to rural development. The main objective of Ministry of Agriculture and Irrigation (MOAI) is "promotion of productivity in Agriculture through providing farmer support service" and give high priority to rice and other exportable pulses. In order to improve the rice productivity of farm households in rice surplus area (delta region), it is needed to promote the rice production proficiency. Some of the most important results in this study will provide policy implications for our country.

Based on the survey data provided by rice farmers in Pyay Township, comparison of socio-economic characteristic among the three service types-PU, PR and PU+PR of sampled farm households are described. In addition, profitability of rice production and production proficiency of the sampled farmers in the study are examined.

5.1.1 Descriptive Analysis of Case Study

In the study area, the comparison means test (by SPSS V16.0) used to compare farms' characteristics. The results showed that the PR farmers had smaller family size (adult member and female) and sown area (farm size). They were poor farmers with less access like plows, radios, motorcycles, telephones, TV, threshers and livestock. PR farmers received seasonal loans including credit-in-kinds (compound fertilizer, NPK) primarily from KHRSC. PU farmers gained their credits mainly from MADB and PU+PR farmers obtained their credits largely from KHRSC and MADB. Much of this credit is taken for filling the gap between cash payment receipts for produce, cash payments for working capital inputs for rice production. Three service types of farmers had similar compositions of off-farm incomes. This mainly reflects PR farmers relatively lower off-farm income compared with the other two types of farmers.

Overall, the results showed that PR and PU+PR farmers received higher average profits as well as cash profits than PU farmers because they gained more rice price and more credit access with less rental machine cost provided by KHRSC in their rice farming.

Among three types of farmer groups, PU+PR farmers are younger age than that of other two groups but showed the highest average education level and average farm experience, gained largest in average credit total amount per year, and the highest in average revenue, average price and average profit in monsoon and summer rice production.

5.1.2 Cost and Benefit Analysis of the Study

PU+PR farmers obtained the higher gross benefit and the highest yield than that of PR and PU farmers but PU farmers showed the lowest in yield. In addition, PU+PR farmers received the higher value of net benefit than other two groups.

The benefit-cost ratio (1.72, MR and 1.95, SR) of PU+PR farmers was higher than that of other two groups. The cost and benefit analysis clearly showed that PU+PR farmers are more beneficial than PR and PU farmers as their gross revenue and net benefits are higher than the other twos. Thus, it was suggested that rice farmers should involve in their farming collaborated with public and private partnership.

5.1.3 Technical Efficiency of Rice Production in the Study Area

In accordance with the basic analysis of obtained data, the variables in the rice production were seed rates (kg/ha), amount of T-super fertilizer (kg/ha) and amount of compound fertilizer (kg/ha). The variables in the technical inefficiency equation consisted of number of years in farm experience, number of extension visits in rice growing season, number of years in school of household heads, rice sown area (ha) and dummy variables for access to credit and rice variety used.

The stochastic frontier production was based on Cobb-Douglas model. The Maximum Likelihood Estimation (MLE) was used to estimate the stochastic production frontier in Pyay Township. The results showed that all variables were positively related to the yield level but not significant.

In technical inefficiency model, the number of extension visit during rice growing season was negatively related to technical inefficiency but not significant. The variable of credit access was negatively related to technical inefficiency with 1 percent significant level indicating that the farm household heads who received more credit provide to be more efficient in utilization of resources than who received less. The coefficient of sown area also showed negatively significant at 1 percent level. This finding indicated that the farmers with larger sown area have more efficient in rice production than ones with smaller sown area. A high value of Υ (0.97) in all sample farms indicated the presence of significant inefficiencies in the production of rice crop. The mean technical efficiency had been found 89 percent among the all sample farmers, which indicated that on an average, the realized output could be raised by 11 percent without any additional resources in the study area. By proper management and proper allocation of the existing resources and technology, sufficient potential exists for improving the productivity of rice. The variables of farm experience, education and variety are positively related to technical efficiency but not significant. This observed that efficiency of all sample farmers tended to realize 89 percent of their technical abilities in rice production.

In conclusion, farmers who differ in efficient use of resources achieved differences in technical efficiency. The technical efficiency found different in each farm household as 72% in small, 80% in medium and 90% in large farm households. Consequently, it could be proposed that promoting of technical efficiency is required in place of existing technology for further improvement of rice production; this will lead to lessen the existing gap and increase the productivity as well. Briefly, farmers collaborating with public and private services achieved higher degree of technical efficiency than conducting with public or private service only.

5.2 Recommendation and Policy Implication

Based on the result of survey data from this study, it was obvious that PU+PR farmers were more willingly to accept the provision of public and private services as they were younger and more educated than other two groups. Thus, PU+PR farmers obtained more credits and more profits, thus they were able to pay back for their loan money in time. In this way, they have more opportunity to practice the modern technology in their farming. Because most of PU farmers were older and possessed medium farm size, they were reluctant to get the loan from the MADB as the result of lower debts was found in PU farmers. However, PR farmers possessed small farm size and less farm access so that they liked to receive much more money from private service. Due to above mentioned results, PU+PR farmers obtained the accomplishment of their farm households' needs. Therefore, it is recommended that the combination of private and public services creates more efficient for crop production.

According to the results of frontier production function, the number of extension visit was not significant but negative impact resulted in inefficiency model. This could be observed that current extension agents are not sufficient when compare with the ratio of number of agent and their accountable area. Thus, the Government ought to emphasize in appointing of more extension agents and conducting trainings to produce the skilful agricultural technicians in the frontage areas. Extension agents also should intensify farmers' awareness on adoption of advanced technologies. Consequently, strengthened extension services will result in more valuable technical efficiency for farmers and crop production.

As the estimated coefficient of credit access and sown area showed negative and statistically significant, it could be suggested that farmer access to land and capital should be enhanced together with the assistant of public and private services. In terms of finding of relationship between inefficiency and access to credit, it is proposed that production efficiency will be advanced by enhancing farmers' access to formal credit. In particular, credit priority program should be highlighted for poorer farmers with small holding size. Furthermore, streamlining the acquisition of credit among farmers will help improve efficiency.

Therefore, the government should arrange in various schemes such as increasing agricultural loans and credits, encouraging private and public services as PPP and establishing small cooperative for farmers for the successful implementation of crop production as well as for nation's economy.

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Appendix 1. Enterprise Budget for Monsoon Rice (PU) in Pyay

No	Items	Unit	Level		Benefits
1	**Gross Benefit**				
	Crop Yield	Kg/ha	4357.08		
	Effective Price	Ks/Kg	154.84		
	Total Gross Benefit (Ks/ha)				**674655.80**
		Unit	**Level**	**Effective cost/unit**	**Total Cost**
2	**Variable Costs**				
	a. Non Labor Cost				
	Seed	Kg/ha	85.59	190.48	16302.00
	FYM	Ton/ha	5.31	5000.00	26552.50
	Fertilizer (Urea)	Kg/ha	56.60	480.00	27170.00
	(T-super)	Kg/ha	29.97	440.00	13186.51
	(Compound)	Kg/ha	58.54	400.00	23415.60
	Subtotal (a) Cash Cost				**106626.61**
	b. Labor-input (Family)				
	Land Preparation	Amd/ha	3.21	3673.33	11795.07
		Md/ha	4.86	1500.00	7286.50
	Seeding/Transplanting	Md/ha	4.78	2000.00	9550.67
	Fertilizer application	Md/ha	2.55	1000.00	2552.33
	Manual Weeding	Md/ha	3.62	1500.00	5434.00
	Harvesting	Md/ha	2.47	2000.00	4940.00
	Transportation	Md/ha	5.43	1500.00	8151.00
	Subtotal (b) Opportunity Cost				**49709.57**
	c. Labor-input (Hired)				
	Land Preparation	Amd/ha	6.83	3673.33	25102.34
		Md/ha	1.40	1500.00	2099.50
	Seeding/Transplanting	Md/ha	38.04	2000.00	76076.00
	Fertilizer application	Md/ha	0.25	1000.00	247.00
	Manual Weeding	Md/ha	8.56	1500.00	12844.00
	Transportation	Md/ha	4.45	1500.00	6669.00
	Subtotal (c) Cash Cost				**123037.84**
	d. Machinery Cost	Ks/ha			
	Land Preparation				74100.00
	Harvesting & Threshing				49400.00
	Subtotal (d) Cash Cost				**123500.00**
	e. Interest on Cash Cost				
	Interest on subtotal (a)		0.12	106626.61	12795.19
	Interest on subtotal (c)		0.12	123037.84	14764.54
	Interest on subtotal (d)		0.12	123500.00	14820.00
	Total Interest on Cash Cost				**42379.73**
	TVC				445253.75
	TVCC				395544.18
	(RAVCC)				279111.62
	NB (RAVC)				229402.05
	BC Ratio				**1.52**

Appendix 2. Enterprise Budget for Monsoon Rice (PR) in Pyay

No	Items	Unit	Level		Benefits
1	**Gross Benefit**				
	Crop Yield	Kg/ha	4415.00		
	Effective Price	Ks/Kg	164.29		
	Total Gross Benefit (Ks/ha)				**725321.68**
		Unit	**Level**	**Effective cost/unit**	**Total Cost**
2	**Variable Costs**				
	a.Non Labor Cost				
	Seed	Kg/ha	60.34	190.48	11493.73
	FYM	Ton/ha	4.36	5000.00	21818.33
	Fertilizer (Urea)	Kg/ha	84.39	420.00	35444.50
	(T-super)	Kg/ha	50.43	400.00	20171.67
	(Compound)	Kg/ha	86.33	360.00	31077.54
	Subtotal (a) Cash Cost				**120005.77**
	b. Labor-input (Family)				
	Land Preparation	Amd/ha	3.38	3933.33	13277.62
		Md/ha	4.20	1500.00	6298.50
	Seeding/Transplanting	Md/ha	4.20	1966.67	8258.03
	Fertilizer application	Md/ha	3.05	1000.00	3046.33
	Manual Weeding	Md/ha	3.87	1500.00	5804.50
	Harvesting	Md/ha	2.47	2000.00	4940.00
	Transportation	Md/ha	5.68	1500.00	8521.50
	Subtotal (b) Opportunity Cost				**50146.49**
	c. Labor-input (Hired)				
	Land Preparation	Amd/ha	5.43	3933.33	21373.73
		Md/ha	1.65	1500.00	2470.00
	Seeding/Transplanting	Md/ha	39.44	1966.67	77560.74
	Fertilizer application	Md/ha	0.49	1000.00	494.00
	Manual Weeding	Md/ha	10.95	1500.00	16425.50
	Transportation	Md/ha	4.69	1500.00	7039.50
	Subtotal (c) Cash Cost				**125363.48**
	d. Machinery Cost	Ks/ha			
	Land Preparation				61750.00
	Harvesting & Threshing				37050.00
	Subtotal (d) Cash Cost				**98800.00**
	e. Interest on Cash Cost				
	Interest on subtotal (a)		0.16	120005.77	19200.92
	Interest on subtotal (c)		0.16	125363.48	20058.16
	Interest on subtotal (d)		0.16	98800.00	15808.00
	Total Interest on Cash Cost				**55067.08**
	TVC				449382.82
	TVCC				399236.33
	(RAVCC)				326085.34
	NB (RAVC)				275938.85
	BC Ratio				**1.61**

Appendix 3. Enterprise Budget for Monsoon Rice (PU+PR) in Pyay

No	Items	Unit	Level		Benefits
1	**Gross Benefit**				
	Crop Yield	Kg/ha	4510.96		
	Effective Price	Ks/Kg	166.51		
	Total Gross Benefit (Ks/ha)				**751110.81**
		Unit	**Level**	**Effective cost/unit**	**Total Cost**
2	**Variable Costs**				
	a. Non Labor Cost				
	Seed	Kg/ha	71.75	190.48	13667.33
	FYM	Ton/ha	4.69	5000.00	23465.00
	Fertilizer (Urea)	Kg/ha	90.57	420.00	38038.00
	(T-super)	Kg/ha	52.49	400.00	20995.00
	(Compound)	Kg/ha	75.13	360.00	27046.50
	Subtotal (a) Cash Cost				**123211.83**
	b. Labor-input (Family)				
	Land Preparation	Amd/ha	3.29	3993.33	13151.38
		Md/ha	4.53	1500.00	6792.50
	Seeding/Transplanting	Md/ha	4.45	2000.00	8892.00
	Fertilizer application	Md/ha	2.31	1000.00	2305.33
	Manual Weeding	Md/ha	3.29	1500.00	4940.00
	Harvesting	Md/ha	2.47	2000.00	4940.00
	Transportation	Md/ha	4.45	1500.00	6669.00
	Subtotal (b) Opportunity Cost				**47690.21**
	c. Labor-input (Hired)				
	Land Preparation	Amd/ha	6.42	3993.33	25645.19
		Md/ha	0.74	1500.00	1111.50
	Seeding/Transplanting	Md/ha	35.98	2000.00	71959.33
	Fertilizer application	Md/ha	0.66	1000.00	658.67
	Manual Weeding	Md/ha	10.13	1500.00	15190.50
	Transportation	Md/ha	5.76	1500.00	8645.00
	Subtotal (c) Cash Cost				**123210.19**
	d. Machinery Cost	Ks/ha			
	Land Preparation				61750.00
	Harvesting & Threshing				37050.00
	Subtotal (d) Cash Cost				**98800.00**
	e. Interest on Cash Cost				
	Interest on subtotal (a)		0.14	123211.83	17249.66
	Interest on subtotal (c)		0.14	123210.19	17249.43
	Interest on subtotal (d)		0.14	98800.00	13832.00
	Total Interest on Cash Cost				**48331.08**
	TVC				441243.31
	TVCC				393553.10
	(RAVCC)				357557.70
	NB (RAVC)				309867.49
	BC Ratio				**1.70**

Appendix 4. Enterprise Budget for Summer Rice (PU) in Pyay

No	Items	Unit	Level		Benefits
1	**Gross Benefit**				
	Crop Yield	Kg/ha	4817.81		
	Effectiv0e Price	Ks/Kg	149.02		
	Total Gross Benefit (Ks/ha)				**717947.81**
		Unit	**Level**	**Effective cost/unit**	**Total Cost**
2	**Variable Costs**				
	a.Non Labor Cost				
	Seed	Kg/ha	85.43	190.48	16272.94
	FYM	Ton/ha	2.83	5529.41	15666.12
	Fertilizer (Urea)	Kg/ha	65.38	480.00	31383.53
	(T-super)	Kg/ha	32.76	414.12	13568.08
	(Compound)	Kg/ha	58.12	305.88	17777.16
	Subtotal (a) Cash Cost				**94667.84**
	b. Labor-input (Family)				
	Land Preparation	Amd/ha	3.63	3958.82	14379.84
		Md/ha	3.63	2000.00	7264.71
	Seeding/Transplanting	Md/ha	4.07	2500.00	10170.59
	Fertilizer application	Md/ha	2.76	1000.00	2760.59
	Manual Weeding	Md/ha	3.20	1500.00	4794.71
	Harvesting	Md/ha	2.47	2000.00	4940.00
	Transportation	Md/ha	4.94	1500.00	7410.00
	Subtotal (b) Opportunity Cost				**51720.43**
	c. Labor-input (Hired)				
	Land Preparation	Amd/ha	6.10	3958.82	24158.14
		Md/ha	2.18	2000.00	4358.82
	Seeding/Transplanting	Md/ha	28.91	2500.00	72283.82
	Fertilizer application	Md/ha	0.15	1000.00	145.29
	Manual Weeding	Md/ha	7.85	1500.00	11768.82
	Transportation	Md/ha	6.10	1500.00	9153.53
	Subtotal (c) Cash Cost				**121868.43**
	d. Machinery Cost	Ks/ha			
	Land Preparation				74100.00
	Harvesting & Threshing				49400.00
	Subtotal (d) Cash Cost				**123500.00**
	e. Interest on Cash Cost				
	Interest on subtotal (a)		0.12	94667.84	11360.14
	Interest on subtotal (c)		0.12	121868.43	14624.21
	Interest on subtotal (d)		0.12	123500.00	14820.00
	Total Interest on Cash Cost				**40804.35**
	TVC				432561.05
	TVCC				380840.62
	(RAVCC)				337107.19
	NB (RAVC)				285386.75
	BC Ratio				**1.66**

Appendix 5. Enterprise Budget for Summer Rice (PR) in Pyay

No	Items	Unit	Level		Benefits
1	**Gross Benefit**				
	Crop Yield	Kg/ha	4915.45		
	Effective Price	Ks/Kg	166.95		
	Total Gross Benefit (Ks/ha)				**820617.76**
		Unit	**Level**	**Effective cost/unit**	**Total Cost**
2	**Variable Costs**				
	a.Non Labor Cost				
	Seed	Kg/ha	57.36	190.48	10926.12
	FYM	Ton/ha	1.16	4000.00	4649.41
	Fertilizer (Urea)	Kg/ha	94.44	420.00	39665.29
	(T-super)	Kg/ha	58.12	400.00	23247.06
	(Compound)	Kg/ha	87.18	360.00	31383.53
	Subtotal (a) Cash Cost				**109871.41**
	b. Labor-input (Family)				
	Land Preparation	Amd/ha	4.21	3941.18	16606.26
		Md/ha	3.63	2000.00	7264.71
	Seeding/Transplanting	Md/ha	3.34	2500.00	8354.41
	Fertilizer application	Md/ha	2.47	1000.00	2470.00
	Manual Weeding	Md/ha	2.76	1500.00	4140.88
	Harvesting	Md/ha	2.47	2000.00	4940.00
	Transportation	Md/ha	4.07	1500.00	6102.35
	Subtotal (b) Opportunity Cost				**49878.62**
	c.. Labor-input (Hired)				
	Land Preparation	Amd/ha	5.52	3941.18	21759.93
		Md/ha	2.91	2000.00	5811.76
	Seeding/Transplanting	Md/ha	31.67	2500.00	79185.29
	Fertilizer application	Md/ha	0.87	1000.00	871.76
	Manual Weeding	Md/ha	10.90	1500.00	16345.59
	Transportation	Md/ha	2.32	1500.00	3487.06
	Subtotal (c) Cash Cost				**127461.40**
	d. Machinery Cost	Ks/ha			
	Land Preparation				61750.00
	Harvesting & Threshing				37050.00
	Subtotal (d) Cash Cost				**98800.00**
	e. Interest on Cash Cost				
	Interest on subtotal (a)		0.16	109871.41	17579.43
	Interest on subtotal (c)		0.16	127461.40	20393.82
	Interest on subtotal (d)		0.16	98800.00	15808.00
	Total Interest on Cash Cost				**53781.25**
	TVC				439792.68
	TVCC				389914.06
	(RAVCC)				430703.69
	NB (RAVC)				380825.08
	BC Ratio				**1.87**

Appendix 6. Enterprise Budget for Summer Rice (PU+PR) in Pyay

No	Items	Unit	Level		Benefits
1	**Gross Benefit**				
	Crop Yield	Kg/ha	5000.88		
	Effective Price	Ks/Kg	174.23		
	Total Gross Benefit (Ks/ha)				**871301.47**
		Unit	**Level**	**Effective cost/unit**	**Total Cost**
2	**Variable Costs**				
	a.Non Labor Cost				
	Seed	Kg/ha	77.81	190.48	14820.00
	FYM	Ton/ha	1.74	5352.94	9333.01
	Fertilizer (Urea)	Kg/ha	101.71	420.00	42716.47
	(T-super)	Kg/ha	61.75	400.00	24700.00
	(Compound)	Kg/ha	79.91	360.00	28768.24
	Subtotal (a) Cash Cost				**120337.72**
	b. Labor-input (Family)				
	Land Preparation	Amd/ha	3.34	3988.24	13327.74
		Md/ha	3.78	2000.00	7555.29
	Seeding/Transplanting	Md/ha	3.78	2500.00	9444.12
	Fertilizer application	Md/ha	2.47	1000.00	2470.00
	Manual Weeding	Md/ha	3.49	1500.00	5230.59
	Harvesting	Md/ha	2.47	2000.00	4940.00
	Transportation	Md/ha	1.02	1500.00	1525.59
	Subtotal (b) Opportunity Cost				**44493.33**
	c.. Labor-input (Hired)				
	Land Preparation	Amd/ha	6.39	3988.24	25496.55
		Md/ha	2.62	2000.00	5230.59
	Seeding/Transplanting	Md/ha	33.42	2500.00	83544.12
	Fertilizer application	Md/ha	0.58	1000.00	581.18
	Manual Weeding	Md/ha	10.03	1500.00	15037.94
	Transportation	Md/ha	6.39	1500.00	9589.41
	Subtotal (c) Cash Cost				**139479.79**
	d. Machinery Cost	Ks/ha			
	Land Preparation				61750.00
	Harvesting & Threshing				37050.00
	Subtotal (d) Cash Cost				**98800.00**
	e. Interest on Cash Cost				
	Interest on subtotal (a)		0.14	120337.72	16847.28
	Interest on subtotal (c)		0.14	139479.79	19527.17
	Interest on subtotal (d)		0.14	98800.00	13832.00
	Total Interest on Cash Cost				**50206.45**
	TVC				453317.29
	TVCC				408823.96
	(RAVCC)				462477.52
	NB (RAVC)				417984.19
	BC Ratio				**1.92**

APPENDIX 7. OUTPUT FROM THE FRONTIER V.4.1C

7. A Cobb-Douglas Production Function (Instruction file for Pyay Township)

```
2           1=ERROR COMPONENTS MODEL, 2=TE EFFECTS MODEL
MZ.txt      DATA FILE NAME
MZ-out.txt  OUTPUT FILE NAME
1           1=PRODUCTION FUNCTION, 2=COST FUNCTION
y           LOGGED DEPENDENT VARIABLE (Y/N)
90          NUMBER OF CROSS-SECTIONS
1           NUMBER OF TIME PERIODS
90          NUMBER OF OBSERVATIONS IN TOTAL
3           NUMBER OF REGRESSOR VARIABLES (Xs)
y           MU (Y/N) [OR DELTA0 (Y/N) IF USING TE EFFECTS MODEL]
6           ETA (Y/N) [OR NUMBER OF TE EFFECTS REGRESSORS (Zs)]
n           STARTING VALUES (Y/N)
            IF YES THEN  BETA0
                         BETA1 TO
                         BETAK
                         SIGMA SQUARED
                         GAMMA
                         MU          [OR DELTA0
                         ETA             DELTA1 TO
                                         DELTAP]
                         NOTE: IF YOU ARE SUPPLYING STARTING VALUES
                         AND YOU HAVE RESTRICTED MU [OR DELTA0] TO BE
                         ZERO THEN YOU SHOULD NOT SUPPLY A STARTING
                         VALUE FOR THIS PARAMETER.
```

7. B Output from the program FRONTIER (Version 4.1c) for Pyay Township

instruction file = god-ins.txt

data file = MZ.txt

Tech. Eff. Effects Frontier (see B&C 1993)

The model is a production function

The dependent variable is logged

the ols estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.37178333E+01	0.24392800E+00	0.15241519E+02
beta 1	-0.27058275E-02	0.35597779E-01	-0.76011134E-01
beta 2	0.14902641E+00	0.27201235E-01	0.54786635E+01
beta 3	0.35548049E-01	0.37893650E-01	0.93810041E+00
sigma-squared	0.63894683E-02		

log likelihood function = 0.10173103E+03

the estimates after the grid search were :

beta 0	0.37612071E+01
beta 1	-0.27058275E-02
beta 2	0.14902641E+00
beta 3	0.35548049E-01
delta 0	0.00000000E+00
delta 1	0.00000000E+00
delta 2	0.00000000E+00
delta 3	0.00000000E+00
delta 4	0.00000000E+00
delta 5	0.00000000E+00
delta 6	0.00000000E+00
sigma-squared	0.79867702E-02
gamma	0.37000000E+00

iteration = 0 func evals = 19 llf = 0.10175795E+03

0.37612071E+01-0.27058275E-02 0.14902641E+00 0.35548049E-01 0.00000000E+00

0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00

0.00000000E+00

0.00000000E+00 0.79867702E-02 0.37000000E+00

gradient step

iteration = 5 func evals = 45 llf = 0.10537612E+03

0.37636840E+01 0.10254263E-01 0.14069474E+00 0.31732450E-01 0.53314877E-02

0.46653429E-01-0.92244571E-02 0.28677865E-02-0.60935895E-01-0.75541797E-01

0.43265799E-01 0.71611832E-02 0.37051179E+00

iteration = 10 func evals = 65 llf = 0.10744296E+03

0.39856043E+01 0.14470658E-02 0.13498621E+00 0.11210848E-02 0.22290193E+00

0.64502928E-01-0.97104468E-01-0.28865876E-03-0.93270680E-01-0.80172930E-01

0.84525230E-01 0.86503958E-02 0.69440271E+00

iteration = 15 func evals = 80 llf = 0.11146716E+03

0.42912706E+01 0.83046243E-02 0.70970449E-01-0.16919852E-01 0.50925841E+00

0.45905719E-01-0.14831586E+00 0.32438748E-02-0.16313219E+00-0.11270915E+00

0.75688434E-01 0.98599807E-02 0.92117125E+00

iteration = 20 func evals = 147 llf = 0.11325499E+03

0.42229744E+01 0.22147563E-01 0.31722133E-01 0.20672019E-01 0.52826049E+00

0.29787064E-01-0.14323672E+00 0.18532839E-01-0.17101920E+00-0.10978390E+00

0.42863427E-01 0.11612840E-01 0.96787963E+00

iteration = 25 func evals = 235 llf = 0.11336481E+03

0.42419632E+01 0.19544719E-01 0.28015983E-01 0.21935595E-01 0.56246213E+00

0.33704470E-01-0.15605232E+00 0.17856732E-01-0.18797708E+00-0.12334199E+00

0.47580572E-01 0.13274835E-01 0.97176146E+00

iteration = 30 func evals = 335 llf = 0.11336703E+03

0.42406257E+01 0.19272010E-01 0.28109482E-01 0.22408442E-01 0.56344858E+00

0.34052618E-01-0.15713092E+00 0.18937469E-01-0.18960069E+00-0.12412100E+00

0.46680580E-01 0.13430675E-01 0.97237473E+00

iteration = 31 func evals = 338 llf = 0.11336703E+03

0.42406257E+01 0.19272010E-01 0.28109482E-01 0.22408442E-01 0.56344858E+00

0.34052618E-01-0.15713092E+00 0.18937469E-01-0.18960069E+00-0.12412100E+00

0.46680580E-01 0.13430675E-01 0.97237473E+00

the final mle estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.42406257E+01	0.14133646E+00	0.30003762E+02
beta 1	0.19272010E-01	0.23325538E-01	0.82621932E+00
beta 2	0.28109482E-01	0.21622520E-01	0.13000095E+01
beta 3	0.22408442E-01	0.24912826E-01	0.89947412E+00
delta 0	0.56344858E+00	0.33628249E+00	0.16755216E+01
delta 1	0.34052618E-01	0.28026392E-01	0.12150197E+01
delta 2	-0.15713092E+00	0.13146203E+00	0.11952571E+01
delta 3	0.18937469E-01	0.30529043E-01	0.62030994E+00
delta 4	-0.18960069E+00	0.63221323E-01	0.29989991E+01
delta 5	-0.12412100E+00	0.48583872E-01	0.25547779E+01
delta 6	0.46680580E-01	0.45511278E-01	0.10256926E+01
sigma-squared	0.13430675E-01	0.47712926E-02	0.28148924E+01
gamma	0.97237473E+00	0.21674863E-0	0.44861862E+02

log likelihood function = 0.11336703E+03

LR test of the one-sided error = 0.23271994E+02

with number of restrictions = 8

[note that this statistic has a mixed chi-square distribution]

number of iterations = 31

(maximum number of iterations set at : 100)

number of cross-sections = 90

number of time periods = 1

total number of observations = 90

thus there are: 0 obsns not in the panel

covariance matrix :

0.19975996E-01 -0.22449174E-02 -0.46319521E-03 -0.20258674E-02 0.23445551E-02

0.26369277E-03 -0.72731617E-03 0.81123425E-04 -0.86133518E-04 -0.97428678E-03

0.44299381E-03 -0.49622098E-04 -0.51034175E-03

-0.22449174E-02 0.54408073E-03 -0.70447336E-04 0.57085291E-04 -0.19420143E-03

-0.56308692E-04 0.21654565E-03 -0.26401906E-04 -0.25904520E-03 0.62280244E-04

-0.10369102E-03 0.79179831E-05 0.11996751E-03

-0.46319521E-03 -0.70447336E-04 0.46753338E-03 -0.23733140E-03 -0.62373469E-03

-0.48134598E-05 0.10959246E-03 -0.63870764E-04 0.59384750E-03 0.26373675E-03

0.87951125E-04 -0.35667757E-04 -0.29847329E-03

-0.20258674E-02 0.57085291E-04 -0.23733140E-03 0.62064888E-03 0.16513148E-03

-0.10916521E-04 -0.11216854E-03 0.60119631E-04 -0.21208002E-03 -0.48178052E-04

-0.88942051E-04 0.32879502E-04 0.26724095E-03

0.23445551E-02 -0.19420143E-03 -0.62373469E-03 0.16513148E-03 0.11308591E+00

0.25027296E-03 -0.41650114E-01 -0.60287044E-03 -0.49466172E-02 0.28450331E-03

0.21274664E-02 0.35416325E-03 0.86475937E-03

0.26369277E-03 -0.56308692E-04 -0.48134598E-05 -0.10916521E-04 0.25027296E-03

0.78547864E-03 -0.10941062E-02 0.29021568E-03 -0.54628397E-03 -0.37256214E-03

0.44188877E-03 0.30975471E-04 0.50378061E-04

-0.72731617E-03 0.21654565E-03 0.10959246E-03 -0.11216854E-03 -0.41650114E-01

-0.10941062E-02 0.17282266E-01 -0.47877749E-03 0.20318235E-02 -0.31084353E-03

-0.17639467E-02 -0.15611007E-03 -0.30608768E-03

0.81123425E-04 -0.26401906E-04 -0.63870764E-04 0.60119631E-04 -0.60287044E-03

0.29021568E-03 -0.47877749E-03 0.93202246E-03 -0.29165783E-03 -0.36369837E-03

0.32558240E-05 0.21455025E-04 0.80965987E-04

-0.86133518E-04 -0.25904520E-03 0.59384750E-03 -0.21208002E-03 -0.49466172E-02

-0.54628397E-03 0.20318235E-02 -0.29165783E-03 0.39969357E-02 0.17548499E-02

-0.51378108E-03 -0.23935257E-03 -0.72919706E-03

-0.97428678E-03 0.62280244E-04 0.26373675E-03 -0.48178052E-04 0.28450331E-03

-0.37256214E-03 -0.31084353E-03 -0.36369837E-03 0.17548499E-02 0.23603926E-02

-0.13807010E-03 -0.12338917E-03 -0.33577248E-03

0.44299381E-03 -0.10369102E-03 0.87951125E-04 -0.88942051E-04 0.21274664E-02

0.44188877E-03 -0.17639467E-02 0.32558240E-05 -0.51378108E-03 -0.13807010E-03

0.20712764E-02 0.28021309E-04 -0.22575043E-04

-0.49622098E-04 0.79179831E-05 -0.35667757E-04 0.32879502E-04 0.35416325E-03

0.30975471E-04 -0.15611007E-03 0.21455025E-04 -0.23935257E-03 -0.12338917E-03

0.28021309E-04 0.22765233E-04 0.67642503E-04

-0.51034175E-03 0.11996751E-03 -0.29847329E-03 0.26724095E-03 0.86475937E-03

0.50378061E-04 -0.30608768E-03 0.80965987E-04 -0.72919706E-03 -0.33577248E-03

-0.22575043E-04 0.67642503E-04 0.46979970E-03

technical efficiency estimates :

firm	year	eff.-est.
1	1	0.96092322E+00
2	1	0.87523247E+00
3	1	0.96188309E+00
4	1	0.84806793E+00
5	1	0.97518207E+00
6	1	0.77050792E+00
7	1	0.76520459E+00
8	1	0.77169306E+00
9	1	0.76534191E+00
10	1	0.76716363E+00
11	1	0.77875092E+00
12	1	0.76729893E+00
13	1	0.76519077E+00
14	1	0.77633441E+00
15	1	0.76867899E+00
16	1	0.97747819E+00
17	1	0.72260048E+00
18	1	0.77099180E+00
19	1	0.96520461E+00
20	1	0.86962212E+00

21	1	0.78680765E+00
22	1	0.88431033E+00
23	1	0.92835910E+00
24	1	0.97842322E+00
25	1	0.87078270E+00
26	1	0.98771897E+00
27	1	0.96288487E+00
28	1	0.88666071E+00
29	1	0.86885341E+00
30	1	0.89847516E+00
31	1	0.85250066E+00
32	1	0.97499159E+00
33	1	0.86695134E+00
34	1	0.78530777E+00
35	1	0.85449334E+00
36	1	0.90689874E+00
37	1	0.90177484E+00
38	1	0.82028180E+00
39	1	0.73046626E+00
40	1	0.96692859E+00
41	1	0.99226835E+00
42	1	0.97561013E+00
43	1	0.96093964E+00
44	1	0.80690944E+00
45	1	0.95388462E+00
46	1	0.96385790E+00
47	1	0.85515096E+00
48	1	0.97596012E+00
49	1	0.97128580E+00
50	1	0.96939195E+00

51	1	0.92113081E+00
52	1	0.87146861E+00
53	1	0.86592332E+00
54	1	0.96271793E+00
55	1	0.95734966E+00
56	1	0.96230140E+00
57	1	0.95765011E+00
58	1	0.89800282E+00
59	1	0.94042879E+00
60	1	0.95668966E+00
61	1	0.96607550E+00
62	1	0.89604152E+00
63	1	0.87225901E+00
64	1	0.99226133E+00
65	1	0.95489302E+00
66	1	0.85271340E+00
67	1	0.98839420E+00
68	1	0.85874695E+00
69	1	0.96726594E+00
70	1	0.97412193E+00
71	1	0.97827399E+00
72	1	0.94781114E+00
73	1	0.89451535E+00
74	1	0.82845549E+00
75	1	0.86908186E+00
76	1	0.98093426E+00
77	1	0.96877550E+00
78	1	0.96025207E+00
79	1	0.94410603E+00
80	1	0.96846428E+00

81	1	0.94241227E+00
82	1	0.87508359E+00
83	1	0.96983803E+00
84	1	0.97011157E+00
85	1	0.87040436E+00
86	1	0.96921372E+00
87	1	0.87688581E+00
88	1	0.87333149E+00
89	1	0.92948674E+00
90	1	0.97903714E+00

mean efficiency = 0.89972657E+00

APPENDIX 8. Activities of Public (DOA) and Private (KHRSC) in Pyay Township