COMPARISON OF TECHNICAL EFFICIENCY AND PROFITABILITY OF COTTON FARMERS GROUPING BASED ON SOWN AREA AND YIELD LEVEL IN TATKON TOWNSHIP, NAY PYI TAW

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A thesis submitted to the post-graduate committee of the Yezin Agricultural University as a partial fulfillment of the requirements for the degree of Master of Agricultural Science (Agricultural Economics)

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The thesis attached here to, entitled "**Comparison of Technical Efficiency and Profitability of Cotton Farmers Grouping Based on Sown Area and Yield Level in Tatkon Township, Nay Pyi Taw"** was prepared and submitted by Myo Min Zan under the direction of the chairperson of the candidate supervisory committee and has been approved by all members of that committee and the board of examiners as a partial fulfillment of the requirements for the degree of **Master of Agricultural Science (Agricultural Economics).**

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This thesis was submitted to the Rector of Yezin Agricultural University and was accepted as a partial fulfillment of the requirements for the degree of **Master of Agricultural Science (Agricultural Economics).**

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DECLARATION OF ORIGINALITY

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

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ABSTRACT

The study was carried out to analyze the comparisons of technical efficiency and profitability of cotton farmers based on the grouping of cotton sown area and yield level. In addition, this study also aimed to investigate the farmer's perception on future Myanma cotton sector and the problems facing in cotton production. The survey was conducted at six villages in Tatkon Township with a total sample of 120 cotton growing farmers in December, 2014. Descriptive analysis, cost and return analysis and technical efficiency analysis by using Data Envelopment Analysis (DEA) approach.

The result showed that the benefit-cost ratios of cotton production in small scale farmers, large scale farmers, low yielding farmers and high yielding farmers were 1.21, 1.36, 1.13 and 2.49 respectively. Large scale cotton farmers received more profit than small scale cotton farmers but not so different. The highest profit was obtained by high yielding group. Most of sampled farmers in large scale farmer groups and high yielding farmer groups used more fertilizers and F_1 seed while most of small scale farmers and low yielding group used F_2 seed in their cotton production.

According to the distribution of the efficiency scores, the CRS assumption would seem not to apply. Assuming that VRS do exist, the mean technical efficiency of small scale farmers, large scale farmers, low yielding farmers and high yielding farmers have been found 89%, 92%, 90% and 91% respectively. Mean technical efficiency was reasonably high in all groups and found not considerable different among the groups.

The major problems faced by most of the cotton farmers were labor scarcity, pest and disease infestation and insufficient capital resource in the study area for cotton production. Findings from the farmer's perception on future Myanma cotton sector indicated the cotton farmers hope that cotton price will be set by market mechanism and so they can get higher cotton farm gate price after changing privatization of cotton sector and became liberalized. They also expect that cotton demand will become stronger in line with the developing local textile industries.

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LIST OF ABBREVIATIONS

DICD	= Department of Industrial Crops Development
BCR	= Benefit-Cost Ratio
USDA	= United State, Department of Agriculture
et al.	= et ses collaborators
FYM	= Farm yard manure
ha	= Hectare
Kg	= Kilogram
MADB	= Myanma Agricultural Development Bank
MMK	= Myanmar Kyat
MOAI	= Ministry of Agriculture and Irrigation
MT	= Metric Ton
N	= Number of farm households
CRS	= constant return to scale
DRS	= decreasing return to scale
IRS	= increasing return to scale
VRS	=variable return to scale

LIST OF CONVERSION FACTORS

1 Hectare	= 2.471 acres
1 Kilogram	= 0.61 viss
1 Ton	= 1000 kilograms
1 Ton	= 2 cartloads of cow dung

CHAPTER I

INTRODUCTION

1.1 Background

Cotton (***Gossypium spp***) is one of the most important fibre producing plants in many countries. It provides not only fibre for the textile industry, but also a role in the livesock feed and oil industry with its seed which is rich in oil content (18-24 percent) and protein (20-40 percent). Cotton is raised in diverse climates such as tropical, sub-tropical and temperate climates. The development of the crop is sensitive to temperature. Depending on the temperature and variety, 50 to 85 days are required from planting to first bud formation, 25-30 days for flower formation and 50 to 60 days from flower opening to mature boll. Cotton is grown on a wide range of soils but medium and heavy textured, deep, well drained, fertile clayey and alluvial soils with good water holding characteristics are preferred. Acid or dense sub soils limit root penetration. The pH range is 5.5 to 8 with 7 to 8 regarded as optimum. The crop is tolerant to soil salinity. Other best management practices include irrigation scheduling, protection of crop from pests and disease, need weed management, defoliation, harvesting and post-harvesting operations to minimize yield losses (James 2010).

Cotton is an important cash crop to a number of developing countries. Goreux (2003) stated that the cotton has a strong poverty reduction impact because it is cultivated in small family farms in areas where opportunity for growing other crops are very limited and per capita income is very low. Cotton is the crop of choice for several reasons. It tolerates poor soil and hot temperature. It is non-perishable and can be transported when markets are away.

Cotton is grown in more than 100 countries accounting for 40 percent of the world fibre market. Australia and Egypt produce the best quality cotton in the world. Cotton is a major export earning source for Burkina Faso, Benin, Uzbekistan, Mali, Tajikistan, Ivory Coast, Kazakhstan, Egypt and Syria. The world’s lowest production cost cotton producers were Australia, China, Brazil and Pakistan while USA and Israel were two of highest production cost cotton producers. China, USA and India were the world’s cotton producing countries, accounting for nearly 60 percent of the world production. World’s main cotton exporters were the USA, Uzbekistan, Brazil and Australia (USDA 2014).

1.2 Economic Importance of Cotton in Myanmar

Historically, cotton played an important role in the national economy of Myanmar. On the evidence of some historical records, it is likely to be thought that cotton cultivation and utilization have been started since in the early days of Myanmar history. Since ancient time, it furnished clothing for the people and contributed to national revenues. Cotton takes priority over all other fiber crops in Myanmar. Myanmar's cotton producing region covers most of the central part of the country between the 600 mm and 1,000 mm rainfall isohyets. Its role has widened and diversified with time due to the technological advances, which enabled to produce various products from cotton rather than fiber for textile industries (Pye Tin 2003). In Myanmar, cotton is one of the agricultural products which are raw materials for agro-based industry producing industrial products for domestic market as well as international market.

Cotton provides not only clothing but also edible oil for human being. From one hectare of long staple cotton, 3,952 kilogram of seed cotton can be produced. It would give 3,025 yards of fabric which is sufficient for 252 persons for one year and in addition 118 liter of edible oil would become available (DAP, 2008) .Cotton seed oil is also used for margarine and other food products. It is an important raw material for soap and paint industries. Cotton seed meal is also used for animal feed stock but with careful processing it can become a rich protein source for human consumption.

Cotton linter, by-product of the cotton industry, is important raw material for local textile industries and in manufacturing photographic papers, x-ray films and explosive materials. Seed hulls available after de-hulling of seeds for oil extraction, are used roughage in animal feed stock, manure and fuel. Similarly, cotton stocks are used as fire-woods and fences in villages. Cotton plays a major role in the economy of Myanmar. Cotton fibre is the main raw material for developing modern national textile industry consisting of both public and private mills as well as cottage weaving sector producing mainly of traditional clothing. With gaining popularity in the use of cotton seed oil for cooking and cotton seed cake as feedstuff for livestock and fishery, cotton is being increasingly recognized as an important food and feed crop. Cotton also provides employment opportunities. In Myanmar, more than a half of million people derive their livelihood directly or indirectly from cotton farming, ginning, by-product processing and trade (Than Than Nu 2010). Cotton plays a dominant role in various aspects of the economy not only raw materials to the textile industries but also employments to millions of people in the production sector and textile industries. It also earns foreign income either through export of textile goods, raw cotton or by-products. Cotton makes up a relative portion of total gross agricultural income for the farmers (Pye Tin 2003).

1.3. Cotton Production and Consumption in Myanmar

Cotton is a traditional crop grown in Myanmar and is the principal fiber crop of the country. In 2013-2014 growing season, it occupies about 350,000 hectares, primarily in the central dry zone of the country which receives 600 mm to 1,000 mm rainfall (MOAI 2014). Commercial cotton varieties currently grown in Myanmar fall into two botanical species viz; ***Gossypium hirsutum***, popularly known as long staple cotton and ***Gossypium arboreum*** represented by native short staple varities. Traditionally, cotton farmers grew indigenously developed varieties of ***Gossympium arboreum*** until the large scale commercial adoption of upland cotton varieties of ***Gossypium hirsutum*** in the 1960s (Tun Win 2008).

Recognizing its importance for national economy, successive governments of Myanmar continually put a major emphasis on cotton development plans of agricultural sector. In 1994-95, a new government organization, Myanma Cotton and Sericulture Enterprise (MCSE) was established separately under the restructured Ministry of Agriculture and Irrigation to strengthen the cotton sector. However, in 2008-2009, MCSE was restructured under the Department of Industrial Crops Development (DICD). Long staple cotton has been widely grown since 1962 and significant progress has been made in cotton area, yield and production with the establishment of Myanma Cotton and Sericulture Enterprise in 1994-1995.

The Ministry of Agriculture and Irrigation (MOAI) conducts all activities related to research, development and seed multiplication on their own research farms, located in the central part of the country. In addition, there is a cotton fiber and miniature spinning laboratory, established in the 1980s designed to ensure compliance with quality parameters (Tun Win 2008).

In 2000-2001, a new strain from Thailand was found to be promising among exotics from other countries. As a result, a new cotton variety, Silver Sixth or Ngwe Chi-6 variety, high yielding and tolerance to bollworm which is most destructive pest of cotton was developed and released in 2006-2007. As a result, in 2009-2010 growing season, a cotton variety named 'Silver Sixth' or Ngwe Chi-6 was estimated to have been planted by 375,000 farmers on about 270,000 hectares (an average 0.7 hectare per farm), equivalent to 75 percent of all the cotton grown in Myanmar (James 2010). In the year 2011-2012, about 86 percent all of long staple cotton sown areas were replaced with Ngwe Chi-6 variety. Again, in 2013-2014, total sown area of Ngwe Chi-6 reached up to 229,696 hectares with an average yield of 2.08 MT ha^{-1}. Farmers who adopted improved production techniques and applied inputs obtained average yield of 2.84 MT/ha, with a highest yield was as high as 3.04 MT ha^{-1} (MOAI 2014). Currently, DICD releases the new two varieties; Shwe Taung -8 and Ngwe Chi-9 which can produce the highest yield up to about 4000 kilogram per hectare.

Although cotton research was initiated in central farm, Mandalay, Myanmar, along with the establishment of the Department of Agriculture by the government in 1906 and based on the research findings, systematic line sowing in cotton cultivation was introduced in 1927, research on production economics in cotton production has been initiated in 2003-04(Tun Win 2008).

In Myanmar, cotton is mainly grown in Sagaing Region, Mandalay Region, Magway Region, Bago Region, Shan State, Chin State and Nay Pyi Taw Council Area along with 101 townships (MOAI 2014). In 2013-2014 growing season, Magway Region and Mandalay Region have the highest cotton sown area while the small amount of cotton sown area was found in Shan State and Chin State. The cotton growing area in Myanmar in 2013-2014 growing season was shown in Figure (1.1). Cotton is grown in three largely overlapped cropping seasons mostly as a rain-fed crop. Long staple cotton is grown predominantly in pre and late monsoon seasons. Pre-monsoon season is started from February-March to June-July while late monsoon season extends from July-August to December-January. Short staple cotton varieties and part of long staple cotton are grown in rain-fed monsoon season from May-June (sowing time) to November-December (picking time).

The area and production of cotton in Myanmar was represented in Table (1.1). Although the cotton yield was increased continuously throughout all the observed years, the cotton sown area started decrease from 2010-2011 up to 2012-2013. It can be seen that the cotton yield was significantly increase in the later part of the years it is because of the developed and released of high yielding cotton varieties by MOAI.

Together with sown area and yield, cotton production was showing the increasing trend expect 2012-2013.

Myanmar was once a major cotton exporting country in South East Asia. However, with the expansion of national textile industry, the whole production of cotton is currently consumed domestically (Than Than Nu 2010). The cotton sub-sector is fairly complex because of a much diversified demand structure for processing and handling of seed cotton. Export oriented textile and garment industries currently import 99 percent of the raw materials and they will be an important market for Myanma cotton in future (Pye Tin 2003). Plans for the expansion of cotton cultivation, rising of productivity and increasing production in line with the government objectives are being implemented by DICD. In Myanmar, there are eleven textile factories operated by Textile Enterprise under the Ministry of Industry with an installed capacity of 270,720 spindles and 5405 looms consuming annually an estimated 15,670 MT of cotton lint (Aung Kyaw Soe 2012).

In Myanmar, since there has been no large amount were being imported or exported and being no data is available for the detail usage patterns of cotton, whatever amount the production supplies is assumed to be consumed for mill use and non-mill use purposes. With the liberalization of cotton industry, a number of private spinning mills have come into operation. During the early 2000s, the requirement in lint cotton for state-owned spinning and weaving mills was filled by MCSE. Hence, their supply condition becomes entirely dependent on the procurement of cotton by MCSE. While total production was much larger than the total mill use with MCSE's procurement lower than targets set for each year due to uncompetitive procurement prices, the requirement of the government mills have been met only by about 45 perceent. This implies that more cotton was sold to private traders, private cotton mills and local cottage industries, which are well developed in most cotton production areas (Pye Tin 2003).

1.4 Cotton Procurement in Myanmar

Generally, government agencies have been heavily involved in procurement of cotton in Myanmar both for domestic supply and export. Government established State Agricultural Marketing Board (SAMB) in 1950, to undertake cotton export as a major function. In 1952, cotton export and cotton marketing was solely handled by

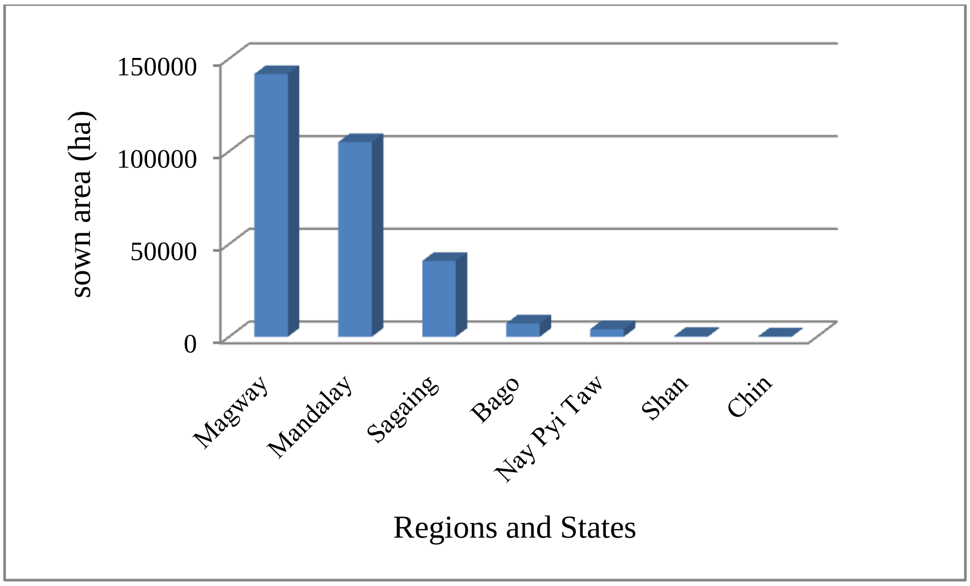

Figure 1.1 Cotton growing area in Myanmar, 2013-2014

Source: MOAI, 2014

Table 1.1 Area and production of cotton in Myanmar (2004/05 – 2013/14)

Year	Sown Area (Ha)	Yield (Kg ha^{-1})	Production (MT)
2004-2005	305,994	635	194,730
2005-2006	332,185	699	235,786
2006-2007	353,733	746	268,438
2007-2008	368,087	821	308,391
2008-2009	367,385	1,208	453,078
2009-2010	359,561	1,427	523,354
2010-2011	350,854	1,542	550,215
2011-2012	326,248	1,602	533,195
2012-2013	278,454	1,643	467,148
2013-2014	299,226	1,668	509,424

Source: MOAI, 2014

the Central Co-operative Organization (CCO) until private involvement in cotton marketing was allowed in 1959-1960.

In 1964, marketing of all types of cotton has been monopolized by Agricultural and Rural Development Corporation (ARDC). The newly formed Agriculture Corporation (AC), emerged in 1972, after the merging of Department of Agriculture (DA) and ARDC continued procurement of cotton during the same time of ARDC. In 1977, cotton procurement and ginning responsibilities were handed over to Textile Industries Corporation (TIC) from AC. In April 1978, the government has allowed TIC to continue monopolized procurement of long staple cotton while opening the procurement of short staple cotton for private business and cooperative societies.

In April 1994, cotton procurement and ginning has been taken over by MCSE. It introduced a relatively crude formal grading system for long staple cotton comprising two grades. In August 1998, the government directed MOAI to accord freedom to private traders and ginners in marketing and ginning of cotton subject to registration and formal approval by MCSE. According to directive, private traders are allowed to procure a pre-registered quality of a specified type of cotton in a specified area. They were liable to sell 50 percent of procure cotton to MCSE and are allowed to export through MCSE.

In 2008, the cotton growing farmers faced a condition in which the cotton price is much lower than the cost of cultivation. The government directed the Ministry of Industry No (1) to take over cotton procurement. Procurement of cotton by the government agencies was variable over the years reflecting government policy, procurement prices set for the respective period and production fluctuations attributable to weather conditions and technical issues. Historically, the government, supposedly considering cost of cultivation of cotton and prevailing prices of alternative crops, fixed cotton procurement prices so that cotton farmers can enjoy a competitive income from cultivation of cotton.

1.5 Problem Statement

In Myanmar, there are two growing seasons for long staple cotton production; pre-monsoon cotton growing season which extends from February-March (sowing time) to June-July (picking time) and late-monsoon cotton growing which extends from July-August (sowing time) to December-January (picking time). In this research, Tatkon Township is selected as one of the most cotton production area. It has only late-monsoon cotton cultivation in this township and no pre-monsoon cotton cultivation and also there is no irrigated cultivation. Most of the cotton growing farmers in the study area grow hybrid cotton. This area have favorable climate and soil conditions for cotton production, because cotton yield in Tatkon Township, was higher than national target yield (1,580 kilogram per hectare). The yield of cotton in Tatkon Township was reached up to 2,695 kilogram per hectare in 2013-2014 cropping season (DICD 2014). With the privatization of state-owned textile factories and cotton ginning factories, the cotton growing farmers expanded their sown area in 2013-2014 cropping season. The actual sown area in Tatkon Township was 4,049 hectare although the planned sown area of MOAI was 3,441 hectare in 2013-2014 cropping season (MOAI 2014).

There were significant differences in yield of cotton growing farmers in study area although no significant differences in soil type and weather conditions. High yield was range from 1,482 kilogram per hectare to 3,952 kilogram per hectare while low yield only from 328 kilogram per hectare to 1,423 kilogram per hectare. Regarding to this yield variation, it is necessary to identify this yield difference, the profitability of cotton production and problems faced by the cotton growing farmers for policy makers and agricultural economists. It is also required to investigate how about their technical efficiency in cotton production under the same market, weather and environmental condition. For the development of the cotton sector in Myanmar, the increasing demand of cotton is one of the external opportunities and farmer's management is the internal strength. While general consumption associated with the population growth is rising every year, opening of private spinning mills in recent years further raised the local demand of cotton resulting in its scarcity, a factor ultimately determining the market prices of cotton. Consequently, to improve the procurement of cotton by the government sector to supply to the state textile mills and to adequately satisfy needs of private sector for mill and non-mill uses, it appears that priority should be given to efforts to increase the production, which is in commensurate with the consumption. Therefore, the study of technical efficiency of cotton farmers could fill the gap of information concerned about extension service for cotton sector improvement via higher income of cotton farmers.

Department of Industrial Crops Development under the MOAI focuses on research and development especially varietal improvement program, extension and training functions rather than commercial activities. It is equally important to assess the production and scale efficiency of specific farming units, which can help producer to focus on necessary adjustments within their operations and improve productivity. Variation in production due to differences in efficiency may be affected by various factors (Chimai 2011). Variability in production is a function of differences in scales of operation, production technologies, operating environment and operating efficiency (Fried *et al*. 2008). This study can provide for policy makers and agriculturists to get some idea for their future decisions on improving cotton farms efficiencies by revealing and explaining variations in technical efficiencies of cotton farms and identifying the problems associated in cotton production.

1.6 Objectives of This Study

The objectives of this study are:

1. to compare the profitability of cotton productions based on the grouping of cotton sown area and yield level,
2. to examine the comparison of technical efficiency based on the grouping of cotton sown area and yield level,
3. to identify problems concerning the cotton production in the study area, and
4. to investigate the farmer’s perceptions on the future Myanma cotton sector.

CHAPTER II

LITERATURE REVIEW

2.1 Role of Efficiency Analysis for Agriculture in Developing Countries

Increasing agricultural productivity and technical efficiency is a very important policy objective in most developing countries, because it is one of the main sources of overall growth. Measuring agricultural productivity and technical efficiency has become an important and appealing research area due to the changes in agricultural economic and regulatory environment (Fried *et.al.* 2008).

The adoption of new technologies designed to enhance farm output and income has received particular attention as a means to accelerate economic development. However, output growth is not only determined by technological innovations but also by the efficiency with which available technologies are used. The potential importance of efficiency as a means of fostering production has yielded a substantial number of studies focusing on agriculture.

Analysis of technical efficiency in agriculture has received particular attention in developing countries because of the importance of productivity growth in agriculture for overall economic development. Improvements in technical efficiency constitute a major component of total factor productivity growth in developing countries.

Efficiency is an indication of whether the firms are able to use the current technology in the best way. Efficiency measurement can be used as guidance for planning and development decisions. Efficiency in production will enable firms to face successfully any future changes in the supply management system. Firm is said to be efficient if they can fully export the best available technology and therefore lie on the frontier of the technology. Any deviation from the best technology resulted in inefficiency. When firms are efficient, they incur lower cost of production, improved quality of products and hence higher profits. Such an efficient firm can only be competitive in the domestic as well as global market (Fried *et.al.* 2008).

According to Gillespie *et,al*. (1997), increase in efficiency and productivity of agricultural enterprises is likely to enhance small holder or subsistence farmers' opportunities to produce more, which in turn could lead to increase in their food security and income levels. This is because, improvement in agricultural efficiency level provides opportunities for farmers to produce more at the same level of resources, while productivity and efficiency affect agriculture and food production directly by increasing the available supply of food and indirectly by increasing household income. For government, an awareness of determinants of agriculture efficiency may help them in designing policies and to determine how successful the policy is, especially in achieving efficiency, productivity and financial performance of agriculture firms.

Myanmar government is recently trying to increase agricultural productivity and employment to achieve economic development for farmers and to alleviate poverty through various schemes such as micro-credit program, increased agricultural loan, establishing small cooperative group, encouraging to use prescribed package technology, and etc. However, agricultural growth should be linked to form profit. A considerable research for agricultural efficiency in the country is still very weak. Agricultural efficiency is gaining attention in the light of agricultural market liberalization and Myanmar currency appreciation (Nay Myo Aung 2012).

2.2 Productivity and Efficiency

Productivity refers to total factor productivity, which is a productivity measure involving all factors of production. Other traditional measures of productivity, such as labor productivity in a factory, fuel productivity in power stations and land productivity (yield) in farming are what are known as partial measures of productivity. These partial productivity measures can provide a misleading indication of overall productivity when considered in isolation (Coelli *et.al*. 1998).

Production efficiency can be measured technically, allocatively and economically. These three measures of production efficiency give general overview of the farmer's overall performance in resource utilization in the production process. Technical efficiency is the ability of a farmer to produce on the maximum possible frontier. A production process may be technically inefficient, in the sense that it fails to produce maximum output from a given bundle of inputs. Technical inefficiency results in an equi-proportionate over-utilization of inputs (Hazarika and Subramanian 1999).

Allocative efficiency is the farmer's ability to produce a given level of output using the cost minimizing input ratios. Invariably, a farm is considered to be allocatively efficient in the use of a given factor if the farm is able to equate the marginal value product (MVP) of the factor to the factor price (P). Economic efficiency is the farmer's ability to produce a predetermined quantity of output at minimum cost given the available technology. Economic efficiency is the ability of farmer to maximize profit (Adeniji 1988; Ohajianya and Onyenweaku 2001). Economic efficiency is the product of technical and allocative efficiency. It indicates the costs per unit of output for a firm which perfectly attains both technical and price efficiencies.

The distinction between the productivity and efficiency was illustratived in Figure 2.1, it is useful to consider a simple production process in which a single input (x) is used to produce a single output (y). The line OF' in Figure (2.1) represents a production frontier which may be used to define the relationship between the input and output. The production frontier represents the maximum output attainable from each input level. Hence, it reflects the current state of technology in the industry. Firms in that industry operate either on that frontier, if they are technically efficient or beneath the frontier if they are not technically efficient. Point A represents an inefficient point whereas points B and C represent efficient points. A firm operating at point A is inefficient because technically it could increase output to the level associated with the point B without requiring more input (Coelli *et.al*. 1998).

2.3 Technical Efficiency Analysis for Agricultural Production

The distinction between technical efficiency and productivity was illustrated in Figuree 2.2. In this figure, a ray through the origin is used to measure productivity at a particular data point. The slope of this ray is y/x and hence provides a measure of productivity. If the firm operating at point A were to move to the technically efficient point B, the slope of the ray would be greater, implying higher productivity at point B. However, by moving the point C, the ray from the origin is at a tangent to the production frontier and hence defines the point of maximum possible productivity. This latter movement is an example of exploiting scale economies. The point C is the point of (technically) optimal scale. Operation at any other point on the production frontier results in lower productivity (Coelli *et.al*. 1998).

A firm may be technically efficient but may still be able to improve its productivity by exploiting scale economies. Given that changing the scale of operations of a firm can often be difficult to achieve quickly, technical efficiency and productivity can be given short-run and long-run interpretations. If information on prices is available and a behavioral assumption, such as cost minimization or profit maximization, is appropriate, then performance measures can be devised which incorporate this information. In such cases, it is possible to consider allocative efficiency, in addition to technical efficiency. Allocative efficiency in input selection involves selecting that mix of inputs (e.g., labor and capital) which produce a given quantity of output at minimum cost (given the input prices which prevail). Allocative and technical efficiency combine to provide an overall economic efficiency measure.

Modern efficiency measurement begins with Farrell (1957) who drew upon the work of Debreu (1951) to define a simple measure of firm efficiency which could account for multiple inputs. He proposed that the efficiency of a firm consists of two components, technical efficiency which reflects the ability of a firm to obtain maximal output from a given set of inputs and allocative efficiency which reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices. These two measures are then combined to provide a measure of total economic efficiency (Coelli *et.al*.1998).

Technical efficiency is the ability of a firm to obtain maximal output for a given set of inputs. The aggregate productivity can be defined as the amount of output that can be obtained from given levels of input in a sector or on economy. Two main technologies have been developed for measuring efficiency and productivity, the parametric (econometric) and non parametric (mathematical programming) approach. These approaches have different strengths and weakness (Coelli *et.al*. 1998).

Assessing the production and scale efficiency of specific farming units can help producers' focus on necessary adjustments within their operations and improve productivity. Technical efficiency analysis can also give some idea to policy makers for their future decisions on improving farms' efficiencies by revealing and explaining variations in technical efficiencies of farms and determining the causes of inefficiencies.

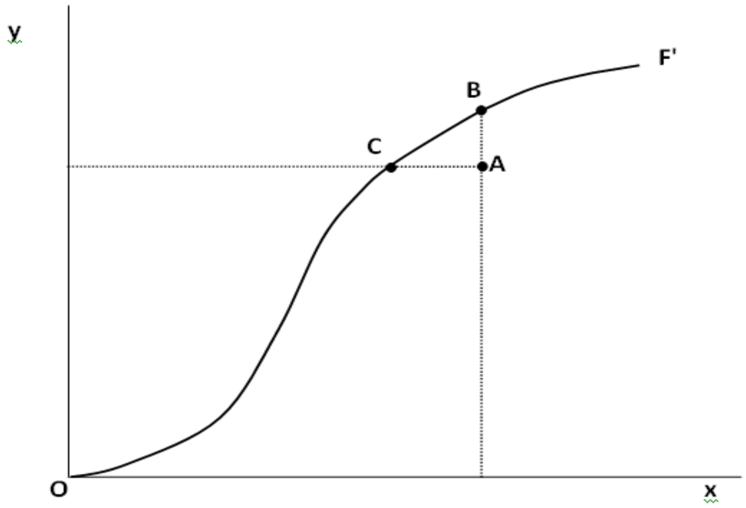

Figure 2.1 Production Frontiers and Technical Efficiency

Source: (Coelli *et.al*.1998)

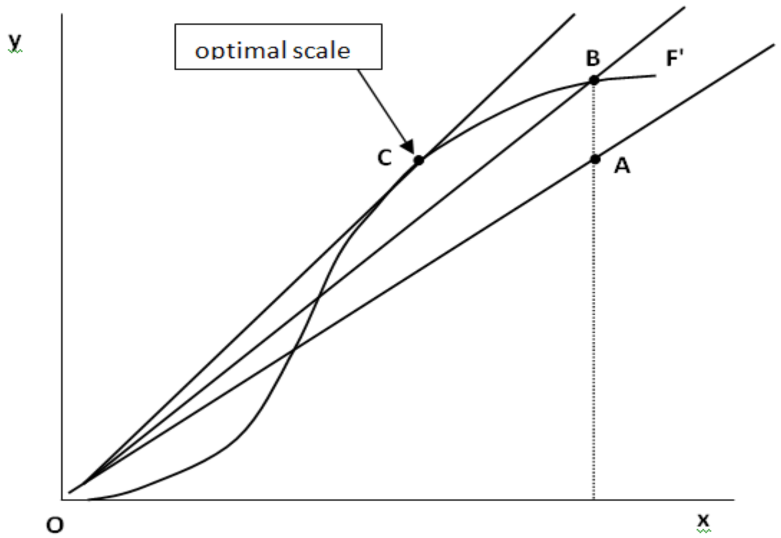

Figure 2.2 Productivity, Technical Efficiency and Scale Economies

Source:(Coelli *et.al*.1998)

2.4 Data Envelopment Analysis (DEA)

Data envelopment analysis (DEA) is a non parametric method widely used in efficiency measurement studies. In this research, DEA was used for calculating the efficiency of cotton farming.DEA has been applied in empirical efficiency studies in smallholder agriculture in developing countries. In DEA, two models, constant return to scale (CRS) and variable return to scale (VRS) can be chosen. In each model, there are two measures; input-oriented measure and output-oriented measure.

The constant return to scale (CRS) assumption is only appropriate when all units are operating at an optimal scale. Imperfect condition, constraints on finance, etc, may cause a unit not to operate at optimal scale. To overcome this problem, a DEA model with variable returns (VRS) to scale has been developed in which variables of technical efficiencies are measured which are confounded to scale efficiencies. This approach forms a convex hull of intersecting planes which envelope the data points more tightly than the CRS conical hull and thus provides technical efficiency scores which are greater than or equal to those obtained using the CRS model shown in Figure 2.3 (Coelli, T,*et.al*.,1998). A ratio of technical efficiency scores obtained from DEA under CRS (constant return to scale) and VRS (variable return to scale) assumptions measures scale efficiency (SE). This scale efficiency measure can be interpreted as the ratio of average product of a firm operating at a point of technically optimal scale.

A second concern is related to making a choice between input and output oriented models. DEA can be either input or output-oriented. If input oriented, the DEA method defines the frontier by seeking the maximum possible proportional reduction in input wage, with output levels held constant. If output-oriented, the DEA method seeks the maximum proportional increase in output production, with input levels held fixed. Although it is reported that in many cases , this choice does not affect the results an input oriented DEA model was chosen since farmers have more control on inputs than outputs. So, an input oriented DEA model was chosen in this study.

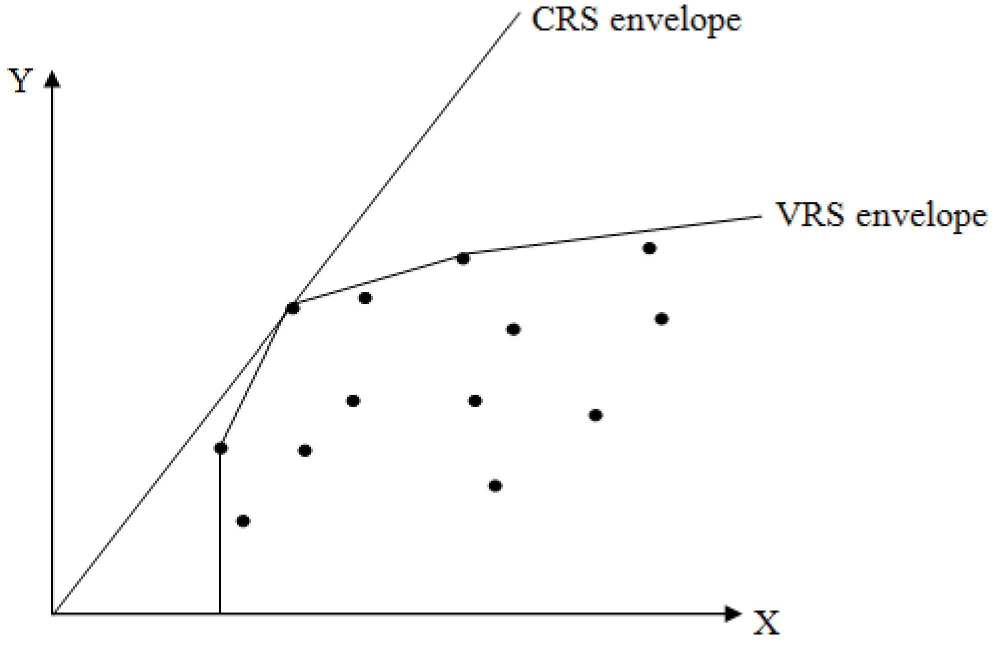

Figure2.3 CRS and VRS envelope

Source:(Coelli, T,*et.al*.,1998)

2.5 Review of the Selected Studies of Technical Efficiency Analysis by Using DEA Analysis

Chakraborty *et al*.(2002) studied cotton farmer' technical efficiency for four counties in West Texas using both stochastic (SFA) and non-stochastic (DEA) production function approaches. They stated that on average, irrigated farms are 80% and non-irrigated farms are 70% efficient. Findings showed that in Texas, the irrigated farms, on average, could reduce their expenditures on other inputs by 10% and the non-irrigated farms could reduce their expenditures on machinery and labor by 12% and 13% respectively, while producing the same level of output.

Frantisek (2006) studied the technical and scale efficiency and identified the determinants affecting farms' efficiency of rice farms in West Java. Data Envelopment Analysis (DEA) was used to estimate technical efficiency scores. The analysis of technical efficiency scores showed that farmers could benefit from the adoption of the best practice methods of production because the results indicated a wide range of differences in efficiency across farms. On average, the analyzed farms were relatively inefficient with a potential for reducing their inputs from 23% to 42% to grow the same amount of rice. The factors associated with the observed technical efficiency score indicated that the employment of modern varieties had a positive and significant effect on the rice farm' performance.

Metvlut *et al*. (2009) investigated the determination of technical efficiency in cotton growing farm in Turkey. Technical efficiency of cotton farms was estimated by using the Data Envelopment Analysis (DEA) and technical efficiency scores were calculated employing on input oriented DEA. Results indicated that cotton farms could save inputs by at least 20% while remaining at the same production level. Factors strongly affecting efficiency level of the farmers were found to be farmer's age, education level and groups of cotton growing areas.

Chimai (2011) measured technical efficiency and its determinant in sorghum production and the contribution of growing sorghum to technical efficiency in field crop production in smallholder sorghum farming in Zambia. The study used DEA followed by an Ordinary Least Squares (OLS) regress of the DEA scores on the household and farm characteristics. The results showed that average technical efficiency in sorghum production among the smallholder farmers was 34% and technical efficiency in sorghum production was affected by household size, number of dependents, use of animal drought power, gross value of field crop production, value of assets, income from livestock activities, access to credit, seed rate and whether a household was located in a low rainfall area or not. On average, sorghum farmers were significantly more efficient in field crop production than non sorghum farmers. They also found that sorghum production improved technical efficiency in overall field crop production among smallholder farmers.

Benjamin *et al.* (2011) studied to calculate farm resource management of Nigerian farmers by the cost approach constant returns to scale and variable returns to scale data envelopment analysis models. The research findings indicated that scale efficiency among the respondents varied substantially ranging between 0.002 and 1 with a mean scale efficiency of 0.7. The study showed that some of the decision making units are not all operating at the optimal scale. Most of the respondents operated vary far away from the efficiency frontier. The overall technical inefficiency among the respondent resulted more by scale inefficiency compared to pure technical inefficiency.

Evaline *et al*. (2014) studied the analysis of technical efficiency of sorghum production in lower Eastern Kenya by DEA approach. Results showed that the average technical efficiency was low 41% and implied that more than 50% of the output was due to technical inefficiency. In Makindu district, the mean technical efficiency was 47.9% compared with 43% in Machakos district. On average, there was potential to increase farm output by 52.1% in Makindu and 57% in Machakos from the existing levels of input use.

Luke *et al.* (2012) studied the analysis of farm household technical efficiency in Northern Ghana using bootstrap DEA. They examined the technical efficiency of 189 crops farms in Northern Ghana. The results indicated that the majority of farms were technically inefficient under VRTS. The average technical efficiency under VRTS was 85.90% with a range from 50.14% to 100.00%. The results also indicated that 81 farms (42.86% of the sample) were technically efficient under variable return to scale (VRS) while 65 (34.39% of the sample) and 56 (29.63% of sample) were technically efficient under constant return to scale (CRS).

Kelly *et al*. (2012) investigated the technical efficiency on a sample of Irish dairy farms. DEA was used in their study to generate technical efficiency scores under assumption of both constant return to scale (CRS) and variable return to scale (VRS). The average technical efficiency score was 0.785 under CRS and 0.833 under VRS. More technically efficient producers used less input per unit of output had higher production compared to the inefficient producers.

Yu Yu Tun (2013) studied the measuring production efficiency and identifying its determinants in Myanmar rice farming by using non-parametric and parametric approaches to obtain a better understanding the current rice production conditions, production efficiency and to find the ways to overcome the constraints faced by the farmers. The average technical efficiency values are 63% with constant return to scale and 69% with variable return to scale for non-parametric approach and 78% with variable return to scale for parametric approach, respectively. Among determinant variables, education variables, labor ratio and mechanical tools are significantly related to the efficiency indexes in DEA while only education variables and mechanical tools are significantly associated in SFA.

CHAPTER III

RESEARCH METHODOLOGY

3.1 General Description of the Study Area

Tatkon Township is situated between latitude 20˚ 20' north and east latitude 96˚ 30'. The area of Tatkon Township is 180,237 hectare and cultivated area is 39,639 hectare, which represented about 22% of the total area. The area of paddy land was about 18,704 hectare and dry land was about 20,930 hectare. The total cotton growing area in Tatkon Township was 4,049 hectare in 2013-2014 (DICD 2014). Tatkon was selected because most of the cotton farmers in this area, cultivated hybrid cotton and high quality cotton is produced in this township. The common crops grown in Tatkon Township are rain-fed lowland rice, irrigated rice, cotton, sugarcane, sunflower, green gram, chili, groundnut, lablab bean, chick pea and water melon. A map of Tatkon Township is shown in Appendix (1).

3.2 Data Collection and Sampling Procedure

3.2.1 Primary data collection

Primary and secondary data were collected to analyze in this study. The data were collected during the 2013-2014 cotton growing season. Two-stage random sampling technique and focus group discussion method were used in collecting primary data. Firstly, six villages were randomly selected from the cotton growing villages in Tatkon Township. Secondly, twenty respondents were randomly selected from each of the villages making a total of 120 respondents. Two main categorized groups of sample farmers were identified based on cotton sown area and yield level. Based on the cotton sown area, sampled farmers were categorized into two groups: small scale farmer group containing farmers who grow cotton less than one hectare and large scale farmer group consisting of farmers who have cotton sown area one hectare and above. Depending on the yield level, sampled farmers were categorized into two groups: low yielding farmer group (farmers who get cotton yield lower than 1,470 Kg ha^{-1}) and high yielding farmer group (farmers who get cotton yield 1,470 Kgkg ha^{-1} and above) where the value of 1,470 Kg ha^{-1} indicate the mean value of cotton yield in the study area. Data were collected using a pre-piloted questionnaire.

The principal socioeconomic variables collected in this study were age (years), sex, occupation and experience in years of cotton production, educational attainment, farm size, family size and marital status of cotton farmers. Information on variety of seed and seed source were also collected. Production characteristics collected were cost of fertilizer, insecticides, land preparation, seed rate, transportation, labor (planting, weeding, fertilizer application, spraying of insecticides, harvesting). Wages, capital assets and problems associated in cotton production faced by the cotton farmers were also collected. The farmers' perception on future Myanma cotton sector was collected by focus group discussion.

3.2.2 Secondary data collection

The necessary secondary information were taken from published and official records of Ministry of Agriculture and Irrigation (MOAI), the Department of Agricultural Planning (DAP), the Department of Industrial Crops Development (DICD), Settlement and Land Record Department (SLRD), Township Administrative Department, Central Statistical Organization (CSO) and other relevant data sources.

3.3 Analytical Methods

3.3.1 Descriptive analysis

Descriptive analysis was used to know social characteristics and to describe socio-economic features of the respondents, their cotton farming experience, existing cropping pattern, constraints on cotton production and access to extension service and agricultural loan. Mean, percentages, and frequency counts were included in descriptive measurement.

3.3.2 Economic analysis

An enterprise budget is a detailed accounting of revenues and expense related to a profit within a business. Enterprise budgets are important tools in determining profitability of individual ventures (Peabody 2007).

Enterprise budgets are important decision making tools which can help individual producers determine the most profitable crops to grow, develop marketing strategies, obtain financing necessary to implement production plans and make other farm business decisions. An enterprise budget is a physical plan because it indicates the type and quantity of production inputs and the output, or yield, per unit. It is also a financial plan, because it assigns costs to all the inputs used in producing the commodity. Budgets are calculated in units of one acre based to facilitate budgeting for different enterprise sizes and to simplify calculations (Carkner 2000).The concept of enterprise budget was used to evaluate the profitability of cotton production (Olson 2009). In this analysis, variable costs were taken into account as follow.

(1) Material input cost,
(2) Hired labor cost,
(3) Family labor cost, and
(4) Interest on cash cost.

These measurements could be expressed with equation as;

Measurement (1)

Return above variable cash cost = Total gross benefit – total variable cash cost

Measurement (2)

Return above variable cost = Total gross benefit – total variable cost
(Gross margin)

Measurement (3)

$$\text{Return per unit of capital invested} = \frac{\text{Total gross benefit}}{\text{Total variable cost}}$$

Measurement (4)

$$\text{Return per unit cash cost} = \frac{\text{Total gross benefit}}{\text{Total cash cost}}$$

The first measurement was the difference between the total gross benefits or total returns and total variable cash costs, excluding opportunity costs. This value was referred to as “return above variable cash cost”. The second measurement was the deduction of the opportunity cost and total variable cash costs from gross benefit. This return was referred to as “return above variable costs” or “gross margin”. The “return per unit of capital invested” could be calculated by gross benefits per total variable costs. The “return per unit of cash cost” could be calculated by gross benefits per total cash costs.

3.3.3 Data Envelopment Aanlysis (DEA)

Production efficiency means attainment of a production goal without waste (Ajibefun and Daramola 2003). Efficiency is concerned with relative performance of the processes used in transforming given input into output (Ohajianya and Onyeweaku 2001). The measurement of efficiency is important because it is a success indicator and performance measure by which production units are evaluated. Furthermore, the ability to quantify efficiency provides decision makers with a control mechanism with which to monitor the performance of the production system or units.

In this study, Data Envelopment Analysis (DEA) technique was used to measure farm-level technical efficiency of cotton growing farmers. DEA identifies a “frontier” on which the relative performance of all utilities in the sample can be compared against the best producers. It can be characterized as an extreme point method that assumes that if a farm can produce a certain level of output utilizing specific input levels, another firm of equal scale should be capable of doing the same.

DEA was first introduced by Farrell (1957), as input and output-oriented technical measures. However, DEA did not receive wide attention until the paper presented by Charnes, Cooper and Rhodes CCR (1978). The simple model started that a firm using two inputs to produce a single output under constant returns to scale condition and then he generalized this model to the case of many inputs and outputs. Farrell (1957) proposed that the evaluation of farm performance is usually based on economic efficiency, which is composed of two major components: technical efficiency and price or allocative efficiency.

The basic DEA analysis requires two choices of formulation: choice of orientation and choice of envelopment surface. The choice of orientation or focus of analysis is possible as maximization of outputs or minimization of inputs or no orientation. The choice of envelopment surface is possible as CRS (conical hull) or VRS (convex hull) (Lovell 1993). In addition, DEA analysis requires one solution of linear programming problem for each decision making unit (DMU); n DMUs need n solutions of linear programming problem. The outcomes of DEA analysis are efficiency scores, which represent as performance indicators: one is the best performance and zero is the worst performance.

Technical efficiency relates to the degree to which a farmer produces the maximum feasible output from a given bundle of inputs, or uses the minimum feasible amount of inputs to produce a given level of output. These two definitions of technical efficiency lead to what are known as output-oriented and input-oriented efficiency measures. These two measures of technical efficiency will coincide when the technology exhibits constant return to scale, but are likely to differ, otherwise (Coelli *et al.* 1998). Also, technical efficiency of a firm obtained from CRS indicates whether the firm is operating at an optimal scale. The optimal weights are obtained by solving the following mathematical programming envelopment form.

$$\text{Max}_{\Phi\lambda}\ \Phi,$$

$$\text{Subject to} - \Phi y_i + Y\lambda \geq 0$$

$$x_i + X\lambda \geq 0$$

$$\lambda \geq 0 \qquad (1)$$

Here, there are assumed K inputs and M outputs for each of N farms. For the i[th] firm, these are specified by the column vectors x_i and y_i respectively. The K×N input matrix, X and the M×N output matrix, Y, represent for all N farms. Again, Φ is a scalar and λ is an N×1 vector of constants. Where, $1 \leq \Phi < \infty$, and Φ-1 is the proportional increase in outputs for the i[th] farm, while input quantities held constant. Note that 1/Φ defines a TE score which varies between zero and one.

On the other hand, imperfect competition, constraints on finance, etc., may cause a firm to be not operating at optimal scale (Coelli *et al*. 1998). Therefore, Banker, Charnes and Cooper (1984) proposed an extension of the CRS DEA to a variable return to scale (VRS) model. In the case of CRS when not all firms are operating at the optimal scale, the results TE is confounded by the scale efficiencies (SE). However, as mention above, the use of VRS application obtains the results of TE free from these scale effects. The CRS DEA can be modified to VRS DEA by adding the convexity constraint: $N1'\lambda = 1$ to provide the following output-oriented VRS DEA model.

In this study, TE is calculated by using the input-oriented variable return to scale DEA model. Farmers have more control on inputs than they have on outputs.

Therefore, it is assumed that input-oriented VRS model would be more appropriate in the study. One output and four inputs were used in the DEA model for the study. The only output is the cotton production per unit area (Kg ha^{-1}). The inputs included are (1) cotton sown area (ha), (2) the number of total labor used (3) the material costs of seeding and agrochemical application (MMK ha^{-1}) and (4) the operation costs including the land preparation and harvesting activities expenses (MMK ha^{-1}). Following Coelli *et al*. (1998), an input-oriented variable return to scale DEA model for technical efficiency was defined as:

$$\begin{aligned}
&\text{Min}_{\theta,\lambda} \quad \theta \\
&\text{subject to} \\
&\qquad y_i + Y\lambda \geq 0 \\
&\qquad \theta x_i - X\lambda \geq 0 \\
&\qquad N1'\lambda = 1 \\
&\qquad \lambda \geq 0 \qquad\qquad (2)
\end{aligned}$$

Where;

θ is a scalar

N 1′ is convexity constraint,

λ is N×1 vector of constant,

Y represents output matrix,

X represents input matrix.

The value of θ will be the efficiency score for the i-th firm. This linear programming problem must be solved N times, once for each firm in the sample. A θ value of one (1) indicates that the firm is technically efficient according to the Farrell (1957) definition.

X_{1i} represents cotton sown area used on the i^{th} firm.

X_{2i} indicates the number of total labor used on the i^{th} firm.

X_{3i} represents the material costs of seeding and agrochemical application on the i^{th} firm.

X_{4i} shows the operation costs including the land preparation and harvesting activities expenses used on the i^{th} firm.

CHAPTER IV

RESULTS AND DISSCUSION

4.1 Information on Sample Population from Tatkon Township

4.1.1 Socio-economic characteristics of small scale farmers and large scale farmers (household heads)

In small farm groups, average age of the sampled farmer household head was found to be 42 years old, ranging from the youngest (19 years) to the eldest (76 years) old. Average farming experience was around 7 years in cotton production within the range between 1 to 20 years. Most of the sampled farmers had primary education level (75% of the sampled farmers).

In large farmers groups, average age of the sampled household head farmers was around 53 years, ranging from the youngest (26 years) to the eldest (71 years) old. Average farming experience was around 11 years in cotton production within the range between 3 to 20 years. Most of the sampled farmers had primary education level (73.4% of the sampled farmers). Age and farming experience of the sampled farmers in cotton production were presented in Table (4.1) and educational level was shown in Table (4.2).

Small farmer group family size ranged from 1 to 7 persons with average family size was 4.35 persons. Number of family labor ranged from 1 to 4 persons and average family labor was 2.21 persons. Average farm size (cotton and other crops) of small farmers group was 1.53 hectares and ranged from 0.40 to 6.07 hectares. In large farmers group, family size ranged from 2 to 7 persons and average family size was 4.55 persons. Number of family labor ranged from 1 to 5 persons and average family labor was 2.76 persons. Average farm size (cotton and other crops) of large farmers group was 3 hectares and ranged from 1.21 to 10.93 hectares. Family size, family labor and farm size of the sampled farmers was presented in Table (4.1).

4.1.2 Socio-economic characteristics of low yielding farmers and high yielding farmers (household heads)

In low yielding farmer groups, average age of the sampled household head farmers was found 50 years, ranging from the youngest (23 years) to the eldest (71 years) old. Average farming experience was around 8 years in cotton production

Table 4.1 Socio-economic characteristics of the sampled farmers (small scale and large scale cotton farmers)

Item	Unit	Small farmer (N=60)			Large farmer (N=60)		
		Mean	Range	SD	Mean	Range	SD
Age	Year	47.00	19 - 76	12.88	53.00	26 - 71	10.30
Farming experience	Year	6.82	1 - 20	4.29	10.50	3 - 20	4.44
Family size	No.	4.35	1 - 7	1.47	4.55	2 – 7	1.24
Family labor	No.	2.21	1 - 4	0.94	2.76	1 – 5	0.96
Farm size (cotton)	ha	0.72	0.4 – 1.0	0.19	1.82	1.2 - 4.0	0.64
Farm size (cotton and other crops)	ha	1.53	0.4 -6.0	1.08	3.00	1.2 -10.9	1.61

Table 4.2 Education level of sampled farm household heads of (small scale and large scale farmers)

Item	Small farmers (N=60)		Large farmers (N=60)	
	Frequency	Percent	Frequency	Percent
Illiterate	1	1.70	0	0.00
Primary level	45	75.00	44	73.40
Middle level	8	13.30	11	18.30
High level and above	6	10.00	5	8.30

within the range between 1 to 20 years. Most of the sampled farmers had primary education level (74% of the sampled farmers).

In high yielding farmer groups, average age of the sampled household head farmers was around 50 years, ranging from the youngest (19 years) to the eldest (76 years) old. Average farming experience was around 9.7 years in cotton production within the range between 2 to 20 years. Most of the sampled farmers had primary education level (61% of the sampled farmers). Age and farming experience in cotton production was presented in Table (4.3) and educational level was shown in Table (4.4).In low yielding farmer group, family size ranged from 1 to 7 persons with average family size was 4.6 persons. Number of family labor ranged from 1 to 5 persons and average family labor was 2.52 persons. Average farm size (cotton and other crops) was 2.2 hectares and ranged from 0.40 to 6.1 hectares. In high yielding farmer group, family size ranged from 1 to 7 persons with average family size was 4.73 persons. Number of family labor ranged from 1 to 5 persons and average family labor was 2.48 persons. Average farm size (cotton and other crops) of high yielding farmer group was 2.6 hectares and ranged from 0.4 to 10.9 hectares. Family size, family labor and farm size of the sampled farmers were presented in Table (4.3).

4.1.3 Assets of sampled farmers

The majority of sampled farmers in the study area possess a range of farming implements and productive equipments such as plough, harrow, cattle, temporary storage barn, and bullock cart because these farm assets were essential equipment for traditional farming system. The farm assets of sampled farmers were shown by Table (4.5).The sampled farmers have plough, harrow, cattle, temporary storage barn, bullock cart and sprayer at approximately 94%, 94%, 87%, 38%, 75%and 95 %, respectively. Power tiller was owned by a few sampled farmers (about 8% of total sampled farmers) in the study area. The ownership of the tractor was found only in one farmer. It can be seen that the higher percentage of the cotton growing farmers in the study area possessed most of the traditional farming tools with some of the modernized equipments such as sprayers, water pumps and power tillers. This showed they can easily accept the modernized technology changes if they got support programs. Because of the modern technology and changing society, over half of the sampled farmers use motorcycle and mobile phone, 52% and 58%, respectively.

Table 4.3 Socio-economic characteristics of the sampled farmers (low yielding and high yielding farmers)

Item	Unit	Low yielding farmer (N=71)			High yielding farmer (N=49)		
		Mean	Range	SD	Mean	Range	SD
Age	Year	50	23 - 71	12.45	50	19 - 76	10.19
Farming experience	Year	7.6	1 - 20	4.34	9.7	2 - 20	4.96
Family size	No.	4.6	1 - 7	1.63	4.73	1 - 7	1.53
Family labor	No.	2.52	1 - 5	1.04	2.48	1- 5	0.96
Farm size (cotton)	ha	1.2	0.4 - 3.2	6.73	1.3	0.4 - 4.0	0.80
Farm size (cotton and other crops)	ha	2.2	0.4 - 6.1	1.25	2.6	0.4 -10.9	1.86

Table 4.4 Education levels of household heads of sampled farmers (low yielding and high yielding farmers)

Item	Low yielding farmers (N=71)		High yielding farmers (N=49)	
	Frequency	Percent	Frequency	Percent
Illiterate	1	1.4	0	0.00
Primary level	53	74.4	30	61.2
Middle level	13	18.4	11	22.4
High level and above	4	5.8	8	16.4

Table 4.5 Farm assets of the sampled farmers

Item	Unit	Sampled farmers (N=120)	
		Frequency	Percent
Plough	No.	113	94
Harrow	No.	113	94
Cattle	No.	104	87
Temporary Storage Barn	No.	45	38
Bullock Cart	No.	90	75
Sprayer	No.	114	95
Tractor	No.	1	1
Power tiller	No.	9	8
Pump	No.	29	24
Motorcycle	No.	62	52
Mobile Phone	No.	70	58
Other	No.	9	8

4.2 Inputs Use of Sampled Farmers

4.2.1 Comparison of inputs use between small and large scale farmers

The different rate of inputs used by the small scale farmers and large scale farmers were shown in Table (4.6) and Figure (4.1). It can be seen that the majority of the sampled farmers used both organic fertilizer (FYM) and inorganic fertilizers (urea fertilizer and compound fertilizer) for their cotton cultivation. In the study area, compound fertilizer was applied for both basal and side dressing for cotton cultivation.

Some of the sampled farmers used a greater amount of cotton seed to get the high germination percentage and after that, they made thinning. Small scale farmers applied an approximate average of 9.35 kilogram of cotton seed per hectare while the average of 7.44 kilogram of cotton seed applied by large scale farmers. Both farmer groups applied cotton seed with a minimum amount of 2.5 kilogram per hectare and maximum amount of 15.8 kilogram per hectare for their cotton cultivation. The t-test shows that there is significant difference in seed rate application between these two farmer groups.

In the case of FYM application, small scale farmers applied an average amount of 5.77 ton of FYM per hectare within a range of minimum of 1.2 ton and maximum of 12 ton per hectare. Large scale farmers applied FYM an average amount of 1.8 ton per hectare with a minimum amount of 1.8 ton and maximum amount of 12 ton per hectare. FYM especially cow dung, which was collected from their own and other animals was used to apply as organic fertilizer.

The average rate of urea fertilizer applied by the small scale farmers was 77.18 kilogram per hectare within a range between minimum amount 30.8 kilogram and maximum amount 124 kilogram per hectare. For large scale farmers, the average amount of 78.59 kilogram urea fertilizer per hectare with a minimum amount of 30.8 kilogram and a maximum amount of 210 kilogram per hectare. The result of t-test showed that there was no significant difference in the level of urea fertilizer application between two different farmer groups. The average rate of compound fertilizer used by the small scale farmers was 126.37 kilogram per hectare and that by the large scale farmers was 140.97 kilogram per hectare. Small scale farmers applied compound fertilizer with a minimum amount of 61.7 kilogram and a maximum amount of 247 kilogram per hectare while large scale farmers applied compound fertilizer with a minimum amount of 30.8 kilogram and maximum amount of 247 kilogram per hectare. The t-test shows that there is no significant difference in the use of compound fertilizer between these two farmers group. It can be seen that the majority of small scale farmers applied more urea fertilizer and less compound fertilizer than the large scale farmers. In both small and large scale farmer groups, some farmers did not use FYM, urea and compound fertilizer. In small farmer group, the number of farmers who did not use FYM, urea and compound fertilizer were 6, 42 and 2 respectively. In large farmer group, the number of farmers who did not use FYM, urea and compound fertilizer were 11, 38 and 1 respectively.

Majority of all farmers used pest control measure. In the study area, with the expand of market by the different agro-chemical companies, different pesticides were available in their villages and Tatkon. The farmers can buy either cash down payment or credit system. So, sampled farmers applied more or less amount of pesticides. The average amount of pesticide was 3.99 liter and 3.88 liter per hectare by the small and the large scale farmers, respectively. For both farmer groups, the minimum amount of pesticide application was 1.2 liter and the maximum was 9.9 liter per hectare. The result of t-test showed that there was no significant difference in the use of pesticide between these two farmer groups. The results of the comparison of resource application in the small scale and large scale farmers with t-test were founded not significantly different expect the seed rate.

4.2.2 Comparison of input use between low yielding and high yielding farmer groups

The different rate of inputs used by the low yielding and high yielding farmers were shown in Table (4.7) and Figure (4.2). Low yielding farmers applied an average of 10.13 kilogram of cotton seed per hectare while the high yielding farmers applied 5.88 kilogram of cotton seed. Both farmer groups applied cotton seed with a minimum amount of 2.5 kilogram and maximum amount of 15.8 kilogram per hectare for their cotton cultivation. The result of t-test showed that there was significant difference in seed rate application between these two farmer groups. In the case of FYM application, the average amount of FYM applied by low yielding farmers was 6.29 ton per hectare and high yielding farmers was 5.76 ton per hectare. Low yielding farmers applied FYM within a range of minimum amount of 1.2 ton and maximum amount of 12 ton per hectare while high yielding farmers applied FYM with minimum amount of 1.8 ton and maximum amount of 12 ton per hectare.

The average rate of urea fertilizer applied by low yielding farmers was 65.6 kilogram per hectare within a range between minimum amount 30.8 kilogram and maximum amount 123 kilogram per hectare. In the case of high yielding farmers, the average amount of 86.19 kilogram urea fertilizer per hectare with a minimum amount of 30.8 kilogram and a maximum amount of 210 kilogram per hectare. The result of t-test showed that there was significant difference in the level of urea fertilizer application between two different farmer groups. The average rate of compound fertilizer used by low yielding farmers was 111.51 kilogram per hectare and that by high yielding farmers was 165.69 kilogram per hectare. Low yielding farmers applied compound fertilizer with a minimum amount of 30.8 kilogram and a maximum amount of 247 kilogram per hectare and high yielding farmers applied compound fertilizer with a minimum amount of 61.7 kilogram and a maximum amount of 247 kilogram per hectare. The result of t-test showed that there was significant difference in the use of compound fertilizer between these two farmers group. It can be seen that the majority of high yielding farmers applied more urea and compound fertilizer and less FYM than the low yielding farmers.

In both low and high yielding farmer groups, some farmers did not use FYM, urea and compound fertilizer. In low yielding farmer group, the number of farmers who did not use FYM, urea and compound fertilizer were 9, 55 and 2 respectively. In high yielding farmer group, the number of farmers who did not use FYM, urea and compound fertilizer were 8, 25 and 1 respectively.

The growing of cotton F1 seed also needs intensive pest and disease control. So, all of sampled farmer applied more or less pesticide. The average amount of pesticide used was 3.27 liter and 4.85 liter per hectare by the low yielding farmers and high yielding farmers, respectively. The result of t-test showed that there was significant difference in the use of pesticide between these two farmer groups. The results of t-test in the comparison of resource applications was significantly different except FYM application in the low yield and high yield sampled farmers in the study area.

4.2.3 Cotton varieties used by sampled farmers

Seed stands as a vital role in crop production. Crop status largely depends on seed varieties used for sowing and response of other inputs used in crop production and also depends on seed used. The quality seeds response well to the applied fertilizers and nutrients and made uniform in plant population and maturity. In the study area, cotton farmers used not only local varieties but also F_1 and F_2 seeds which have the features such as better yield, greater uniformity, improved quality, disease resistance and so on. An F_1 hybrid is the first filial generation of offspring of distinctly different parental types. F_1 hybrids mature at the same time when raised under the same environmental conditions. They all ripen simultaneously and can be more easily harvested by machine. F_2 hybrid, the result of self or cross pollination of F_1 seeds, lack of the consistency of F_1, though they may retain some desirable traits and can be produced more cheaply because hand pollination or other interventions are not required. The cotton varieties used by sampled cotton farmers in the study area was shown in Table (4.8).

Table 4.6 Comparison of resources use of small-scale farmers and large-scale farmers

Item	Unit	Sampled farmer		t value
		Small farmer (n=60)	Large farmer (n=60)	
Seed rate	Kg ha^{-1}	9.35	7.44	2.188**
Range		2.5-15.8	2.5-15.8	
FYM	Ton ha^{-1}	5.77	5.33	0.00^{ns}
Range		1.2-12	1.8-12	
Urea	Kg ha^{-1}	77.18	78.59	0.686^{ns}
Range		30.8-124	30.8-210	
Compound	Kg ha^{-1}	126.37	140.97	1.449^{ns}
Range		61.7-247	30.8-247	
Pesticide	Liter ha^{-1}	3.94	3.88	0.225ns
Range		1.2-9.9	1.2-9.9	

Note: ** is significant at 5% level, ns = not significant

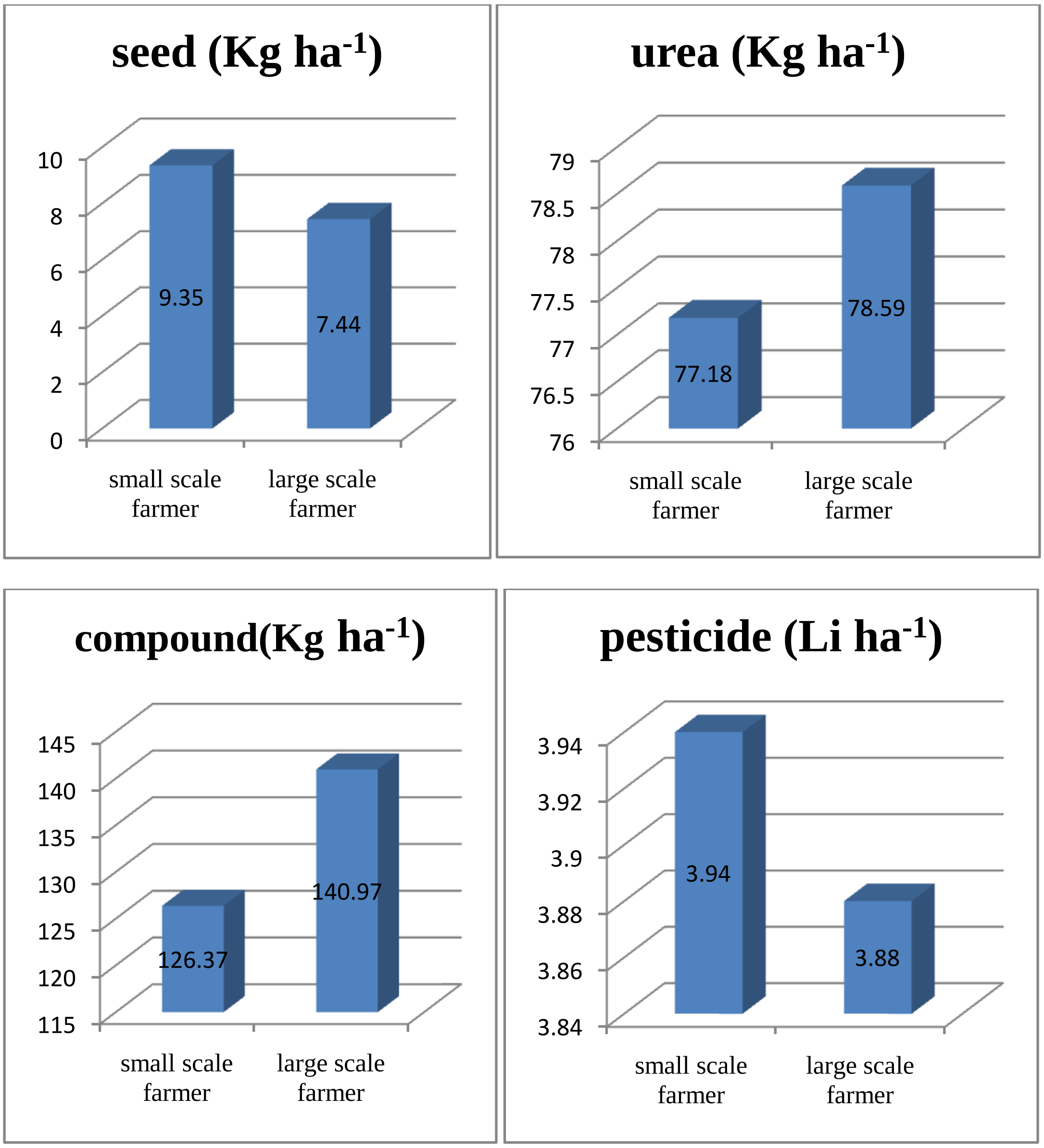

Figure 4.1 Resource allocations of small scale and large scale farmers

Table 4.7 Comparison of resources use of low yielding and high yielding farmers

Item	Unit	Sampled farmer		t value
		Low yielding farmer (N=71)	High yielding farmer (N=49)	
Seed rate	Kg ha^{-1}	10.13	5.88	5.220***
Range		2.5-15.8	2.5-15.8	
FYM	Ton ha^{-1}	6.29	5.76	1.047^{ns}
Range		1.2-12	1.8-12	
Urea	Kg ha^{-1}	65.60	86.19	-3.436***
Range		30.8-123	30.8-210	
Compound	Kg ha^{-1}	111.51	165.69	-5.131***
Range		30.8-247	61.7-247	
Pesticide	Liter ha^{-1}	3.27	4.85	-5.894***
Range		1.24 – 5.56	2.47- 9.88	

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

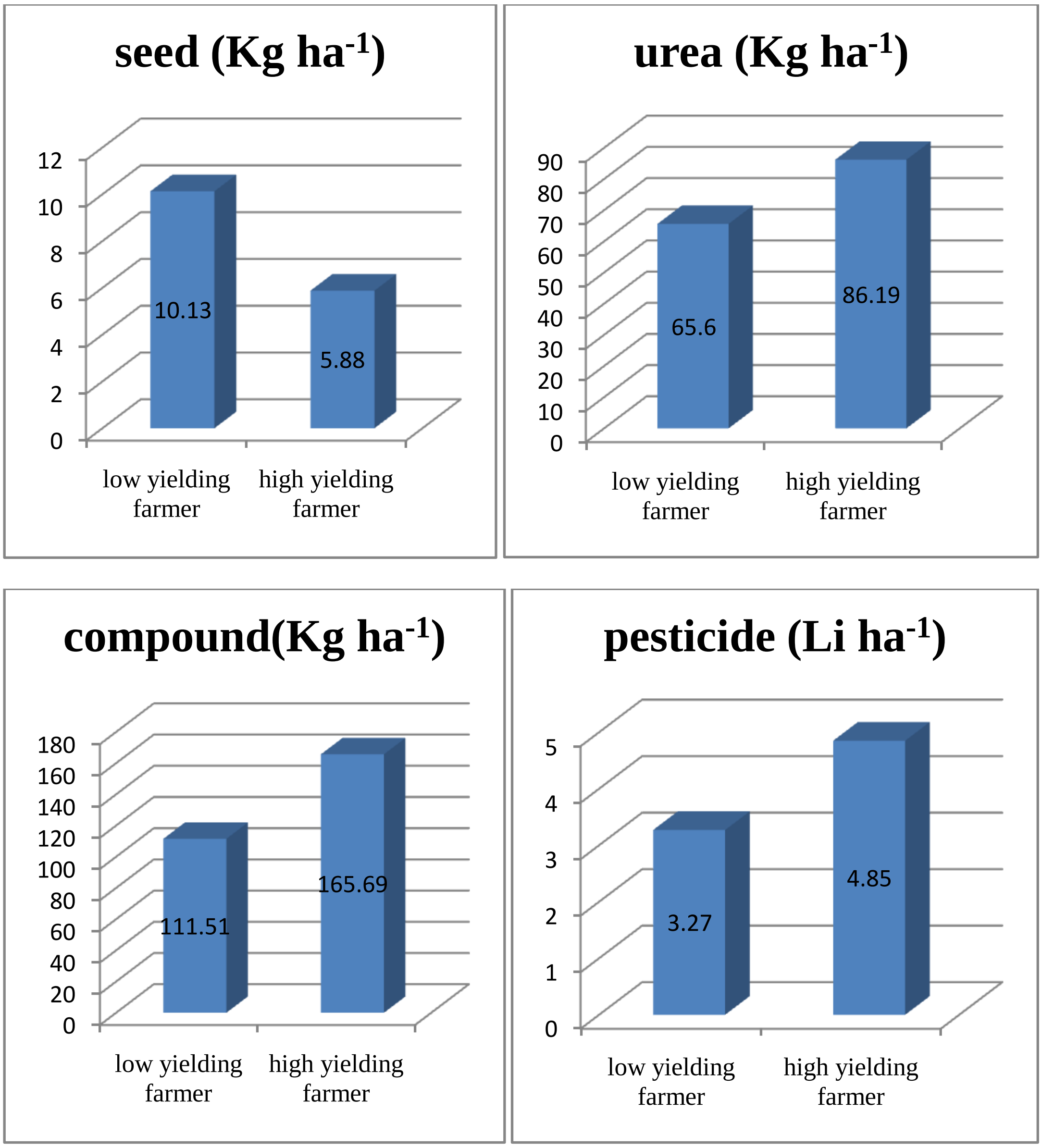

Figure 4.2 Resource allocations of low yielding and high yielding farmers

Table 4.8 Cotton varieties used by sampled farmers

Item	Small scale farmer group	Large scale farmer group	Low yielding group	High yielding group
Raka F_1	12 (20)	26 (43)	10 (17)	28 (57)
Raka F_2	38 (63)	22 (36)	4(69)	19 (39)
Raka F_1 + Raka F_2		1 (1.5)	-	1 (2)
Ngwe chi-6	10 (17)	6 (10)	15 (25)	1 (2)
Raka F_2 + Ngwe chi-6	-	4 (6)	4 (7)	-
Raka F_2 + Shwe Taung-8	-	1 (1.5)	1 (2)	-
Total	60	60	71	49

Note: Figures in the parentheses present percentage

Majority of large scale farmer group and high yielding farmer group (about 43% and 57%) used Raka F_1 seed for their cotton production. Moreover, it was found that the second largest percentage of large scale farmers and high yielding farmers used Raka F_2 seed about 36% and 39% respectively. Most of small scale and low yielding farmer group used Raka F_2 seed, 63% and 69% respectively. For Raka F_1, they used only about 20% and 17%. Therefore, the most commonly used cotton varieties in the study area were Raka F_1 and Raka F_2 seed. Only a few percentage of sampled farmers utilized Ngwe Chi-6 and Shwetaung-8 varieties in the study area.

4.3 Results of Cost and Return Analysis

4.3.1 Comparison of cost and returns for cotton production of small scale and large scale farmers

In some cases, the maximum yield does not lead to maximum profit. So, the profitability of farmer' input level needs to be examined. In this section, the comparing results of cost and return for small and large scale farmers were presented. The detail analysis results of enterprise budgets for two different farmer groups were explained in Appendix 2. It was found that the small scale farmer group incurred a relatively lower total variable cost (740,091 MMK ha^{-1}) than that of large farmer group (784,875 MMK ha^{-1}).The average gross benefit obtained by the small scale farmers was 898,359 MMK ha^{-1} while by large scale farmers was 1,071,146 MMK ha^{-1}. In calculating the total variable costs, four types of costs were calculated such as material cost, hired labor cost, family labor cost and interest on cash cost.

Table 4.9 showed yield differences and received prices differences of cotton between small scale and large scale farmers. The average yield of the small scale farmers was 1,362 Kg ha^{-1} and that of large scale farmers was 1,577 Kg ha^{-1}. The respective prices received by small scale farmers and large scale farmers were 658 MMK Kg^{-1} and 679 MMK Kg^{-1}.

For expenditure on material cost, small scale farmers expended a total of 219,164 MMK ha^{-1} whereas the large farmers had 240,045 MMK ha^{-1}. In regard to the total hired labor cost, the small scale farmer group used an average of 362,498 MMK ha^{-1} while the large scale farmer group expended 364,257 MMK ha^{-1} and it was found that there was very little difference for total hired labor cost between these two farmer groups. The small scale farmers had a total family labor cost of 146,797

MMK ha^{-1} while the large farmers had 168,448 MMK ha^{-1} for this category. The total family labor cost of the small scale farmer was relatively lower than that of large scale farmers. Calculating the total interest cost of cash invested, there was very little difference, on cost per hectare base, between the small scale farmers and large scale farmers. Thus, there was not much difference in total variable cost of both farmer groups can be seen.

The return above variable cash cost was 305,365 MMK ha^{-1} for the small scale farmers and 454,759 MMK ha^{-1} for the large scale farmers. The return above variable cost for small scale farmers and large scale farmers were 158,268 MMK ha^{-1} and 286,271 MMK ha^{-1} , respectively. Consequently, the benefit-cost ratios were 1.21 and 1.36 for the small scale and large scale farmers, respectively. Benefit cost ratio takes into account the amount of monetary gain realized by performing a farm versus the amount it costs to execute the farm. The higher the benefit cost ratio, the better the investment. The result of t-test showed that there was no significant difference in received benefit-cost ratios between these two farmer groups. Therefore, it can be concluded that there was no significantly difference statistically in the profitability of growing cotton of the two groups in the study area.

The break-even yields and break-even prices for cotton production of sampled small scale and large scale farmers are shown in Table (4.10). The breakeven yields of cotton production are estimated by dividing total variable costs by the current market price. It was observed that the breakeven yield for small scale farmer was lower than that of large scale farmers. For small scale farmers, with the market price of cotton, currently at the time of their sale, the break even yield became 1,124 Kg ha^{-1}, that is, the yield that indicated just to cover the total variable cost. If farmers achieve a higher yield than break even yield, he can earn a profit. A break even yield of 1,155 Kg ha^{-1} was calculated for large scale farmers. The lowest break even yield is the most economically attractive for the farmers. Therefore, small farmer group had the preferable breakeven yield.

The breakeven price is calculated as total variable cost by current effective yield of cotton. The lowest breakeven price to cover the given variable cost of cotton production is most preferable. The breakeven price for small scale farmers was 543 MMK Kg^{-1} while for the large farmers was 497 MMK Kg^{-1}. According to the given

Table 4.9 Yield and price of cotton received by small scale farmers and large scale farmers

Item	Unit	Farmer group		t value
		Small scale (n=60)	Large scale (n=60)	
Yield	Kg ha^{-1}			
Mean		1,362	1,577	1.430***
Minimum		395	328	
Maximum		3,952	3,952	
Price	MMK Kg^{-1}			
Mean		658	679	2.220^{ns}
Minimum		531	500	
Maximum		750	813	

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

Table 4.10 Break-even yields and break-even prices of the sampled small scale farmers and large scale farmers

Item	Unit	Sampled farmers	
		Small scale farmer	Large scale farmer
Break-even yield	Kg ha^{-1}	1,124	1,155
Break-even price	MMK / Kg	543	497

current cost structure and given current yield level, if the market price of cotton is higher than the breakeven price, farmers will receive a profit.

4.3.2 Comparison of cost and returns for cotton production of low yielding and high yielding farmers

The yield and price received by the low yielding and high yielding farmers were shown in Table (4.11). The average yield of low yielding farmers was 1,144 Kg ha^{-1} within the range between 328 Kg ha^{-1} and 1,423 Kg ha^{-1} while that of large scale farmers was 3,295 Kg ha^{-1} with a minimum yield of 1,482 Kg ha^{-1} and maximum yield of 3,656 Kg ha^{-1}. Here, it can be seen that there was a high and significantly difference in the respective yield levels between the two groups of sampled farmers. The respective prices received by low yielding farmers and high yielding farmers were 663 MMK Kg^{-1} and 677 MMK Kg^{-1}. The lowest price of cotton received by low yielding farmers was 531 MMK Kg^{-1} and that of high yielding farmer was 500 MMK Kg^{-1}. Both groups received the highest cotton price, 813 MMK Kg^{-1}.

The data concerned with enterprise budgets for two different farmer groups is presented in Appendix 3. It was found that low yielding farmer group incurred a relatively lower total variable cost (669,524 MMK ha^{-1}) than that of high yielding farmer group (897,194 MMK ha^{-1}).The average gross benefit obtained by low yielding farmers was 758,637 MMK ha^{-1} while the showing that high yielding sample farmers applied more inputs than low yielding farmers. Moreover, the average gross benefit obtained by high farmers was 2,230,869 MMK ha^{-1} which indicated that the yield differences can determine the profit levels.

For expenditure on material cost, low yielding farmers expended a total of 183,688 MMK ha^{-1} whereas high yielding farmers had the relatively higher expense of 296,141 MMK ha^{-1}. In regard to the total hired labor cost, low yielding farmer group expended an average of 316,957 MMK ha^{-1} while high yielding farmer group expended 430,644 MMK ha^{-1} . Low yielding farmers had a total family labor cost of 157,387 MMK ha^{-1} while high yielding farmers had 158,081 MMK ha^{-1} for this category and it was found that there was no significantly difference in expending of total family labor cost between these two farmer groups. In the case of the total interest cost of cash invested, there was very little difference, on a cost per hectare base, between low yielding farmers and high yielding farmers.

The return above variable cash cost was 246,500 MMK ha^{-1} for the low yielding farmers and 1,491,693 MMK ha^{-1} for high yielding farmers while the return above variable cost for low yielding farmers and high yielding farmers were 89,113 MMK ha^{-1} and 1,333,675 MMK ha^{-1} , respectively. It can be seen that high yielding farmers had a higher return as they expended more on variable cost. Consequently, the benefit-cost ratios were 1.13 and 2.49 for low yielding farmers and high yielding farmers and the result of t-test showed that there was significant difference in received benefit-cost ratios between these two farmer groups. Therefore, it can be concluded that there was statistically significant difference in the profitability of growing cotton even though the price received is not much difference between the two groups in the study area.

The break-even yields and break-even prices for cotton production of sampled low yielding and high yielding farmers were shown in Table (4.12). It was observed that the breakeven yield for low yielding farmer was lower than that of high yielding farmers. For low yielding farmers, with the market price of cotton, currently at the time of their sale, the break even yield becomes 1,009 Kg ha^{-1}, that is, the yield that will just cover the total variable cost of cotton cultivation. A break even yield of 1,325 Kg ha^{-1} was calculated for high yielding farmers. Therefore, low yielding farmer group had the preferable breakeven yield. The breakeven price for low yielding farmers was 708 MMK Kg^{-1}. For high yielding farmers, total variable costs of cotton production were covered if the price of cotton is at least 402 MMK ha^{-1}. The lowest breakeven price to cover the given variable cost of cotton production is most preferable.

Table 4.11 Yield and price of cotton received by low yielding farmers and high yielding farmers

Item	Unit	Farmer group: Low yielding farmers (N=71)	Farmer group: High yielding farmers (N=49)	t value
Yield	Kg ha^{-1}			
Mean		1,144	3,295	-12.944***
Minimum		328	1,482	
Maximum		1,423	3,952	
Price	MMK Kg^{-1}			
Mean		663	677	1.445^{ns}
Minimum		531	500	
Maximum		813	813	

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

Table 4.12 Break-even yields and break-even prices of the sampled low yielding and high yielding farmers

Item	Unit	Sampled farmers: Low yielding farmer	Sampled farmers: High yielding farmer
Break-even yield	Kg ha^{-1}	1,009	1,325
Break-even price	MMK / Kg	708	402

4.4 Measurement of technical efficiency for cotton production

4.4.1. Distribution of technical efficiency index

The results of input-oriented technical efficiency indexes of the sample cotton producing farmers were displayed in Table (4.13) and (4.14) and the histograms charts of the technical efficiency index distribution were presented in Figure (4.3) for small scale farmers and Figure (4.4) for large scale farmers. In the case of small scale farmers, the average overall technical efficiency index (CRS-TE) was 0.61 with a minimum 0.23 and maximum 1. It can be seen that most of the small scale farmer's overall technical efficiency indexes were fallen within the range of 0.51 and 0.80.The pure technical efficiency (VRS-TE) resulted the mean index of 0.89 within a range of 0.63 to 1. The majority of small scale farmer's pure technical efficiency indexes were between 0.91 and 1.Similarly, the observation of scale efficiency index found 0.69 of average value with a minimum 0.23 and a maximum 1 and the majority of the small scale farmers fell the scale efficiency score of 0.61-1.0.

For large scale farmers, the average overall technical efficiency index (CRS-TE) was 0.43 with a minimum 0.10 and maximum 1. It was evident from the results that the majority of the sample farmer's overall technical efficiency indexes were between 0.11 and 0.60. Then, pure technical efficiency (VRS-TE) resulted the mean index of 0.92 within a range of 0.68 up to 1 and the pure technical efficiency indexes of majority of large scale farmers were fallen within the range of 0.91 and 1.Similarly, the observation of scale efficiency index found 0.46 of average value with a minimum 0.10 and a maximum 1 and the majority of the large scale farmers fell the scale efficiency score of 0.11-0.50.

Based on the results, it can be concluded that the small-scale farmers have pure technical inefficiency accounted approximately 11% and scale inefficiency accounts approximately 31% while the large scale farmers have pure technical inefficiency accounted approximately 8% and scale inefficiency accounted approximately 54%. Because technical inefficiency scores from CRS-DEA is made up of two components, one due to technical inefficiency and one due to scale inefficiency. Alternatively, this implies that the small scale farmers have the potential to reduce their physical inputs on average by 42% while large scale farmers have the potential to reduce their physical inputs on average by 62%; and still to produce the same level of cotton output. Again, technical inefficiency can be reduced without reducing the level of output with existing technology and level of input used.

According to the distribution of the efficiency scores, the CRS assumption would seem not to apply. Assuming that VRS do exist, there were 32 and 40 of small scale and large scale farmers' farms with efficiency scores of 0.91 to 1.

4.4.2. Returns to scale result of small scale and large scale farmers

The results of return to scale of the sample farmers were summarized in Table (4.15) and Appendix (2) and (3). Return to scale is a long-run concept which reflects the degree to which a proportional increase in all inputs increases output. For small scale farmers, this study results contributed that 54 of the sample farm were under increasing return to scale (IRS) and 5 of the sample farm was constant return to scale (CRS). In turn, it can be said that majority of sample farmers are operating at increasing return to scale, indicating that these farmers can get more output by having additional input. The remaining 8% which operated at CRS mean that when a proportional increase in all inputs results in the same proportional increase in output. These results can be used to provide information to cotton growing farmers encouraging more farms to operate towards the optimal scale. For large scale farmer, it was found that 56 of the total farm were under IRS and the remaining 4 farms operated at CRS.

For both small farmer and large farmer groups, it was found that there was only one farm in small scale farmer group working at decreasing return to scale (DRS), a condition that they can get more output by reducing the use of inputs.

4.4.3. Distribution of technical efficiency index of low yielding and high yielding farmers

The result of input-oriented technical efficiency indexes of low yielding and high yielding sampled cotton producing farmers were displayed in Table (4.16) and (4.17) and frequency and percentage distribution of the technical efficiency index of low yielding farmers were also shown in the Figure (4.5) and of high yielding farmers in the Figure (4.6). In the case of low yielding farmers, the average overall technical efficiency index (CRS-TE) was 0.69 with minimum 0.24 and maximum 1. It can be seen that majority of the low yielding farmer's overall technical efficiency indexes were between 0.71 and 1. The pure technical efficiency (VRS-TE) resulted the mean index of 0.90 within a range of 0.60 to 1 and the pure technical efficiency indexes of the majority of low yielding farmers were fallen within the range of 0.81 and 1. Similarly, the observed scale efficiency index fell 0.76 of average with minimum 0.24 and maximum 1 and the majority of the small scale farmers fell the scale efficiency score of 0.71-1.0.

For high yielding farmers, the average overall technical efficiency (CRS-TE) index was 0.52 with a minimum level of 0.30 and maximum level of 1. It was evident from the results that the majority of the sampled high yielding farmer's overall technical efficiency indexes were fallen within the range of 0.31 and 0.50. Then, pure technical efficiency (VRS-TE) resulted the mean index of 0.91 within a range of 0.67 up to 1 and the pure technical efficiency indexes of majority of high yielding farmers were fallen within the range of 0.91 and 1.Similarly, the observation of scale efficiency found 0.57 of average value with a minimum value of 0.31 and a maximum value of 1 of the sample farmers and the majority of the small scale farmers fell the scale efficiency score of 0.31-0.60.

Based on the results, it can be concluded that low yielding farmers have pure technical inefficiency accounted approximately 10% and scale inefficiency accounted approximately 24% while the high yielding farmers have pure technical inefficiency accounted approximately 9% and scale inefficiency accounted approximately 43%. Because technical inefficiency scores from CRS-DEA is made up of two components, one due to technical inefficiency and one due to scale inefficiency. Alternatively, this implies that low yielding farmers have the potential to reduce their physical inputs on average by 34% while high yielding farmers have the potential to reduce their physical inputs on average by 52%; and still to produce the same level of cotton output. Again, technical inefficiency can be reduced without reducing the level of output with existing technology and level of input used.

4.4.4. Returns to scale result of low yielding and high yielding farmers

The results of return to scale of the sample farmers were summarized in Table (4.22) and Appendix (4) and (5). For low yielding farmers, this study results contributed that 65 of the sample farms were under IRS and 5 of the sample farm was CRS. In turn, it can be said that majority of sample farmers were operating at increasing return to scale, indicating that these farmers can get more output by having additional input. The remaining 7 percent of total farm operated at CRS. For high yielding farmer, it was found that 45 of the total farm were under IRS and the remaining 4 farms operated at CRS. For both low yielding and high yielding groups, it was found that there was only one farm in low yielding group working at decreasing return to scale.

Table 4.13 Frequency distribution of the technical efficiency index of DEA approach for small-scale farmers

Efficiency Level	Technical Efficiency					
	CRS-TE (overall TE)		VRS-TE (Pure TE)		Scale Efficiency	
	Number of farm	%	Number of farm	%	Number of farm	%
0.01 - 0.10	0	0.00	0	0.00	0	0.00
0.11 - 0.20	0	0.00	0	0.00	0	0.00
0.21 - 0.30	4	6.67	0	0.00	3	5.00
0.31 - 0.40	5	8.33	0	0.00	3	5.00
0.41 - 0.50	6	10.00	0	0.00	7	11.67
0.51 - 0.60	13	21.67	0	0.00	7	11.67
0.61 - 0.70	11	18.33	2	3.33	9	15.00
0.71 - 0.80	10	16.67	13	21.67	6	10.00
0.81 - 0.90	6	10.00	13	21.67	16	26.67
0.91 - 1.00	5	8.33	32	53.33	9	15.00
Mean TE		0.619		0.896		0.694
Minimum TE		0.237		0.637		0.237
Maximum TE		1		1		1

Table 4.14 Frequency distribution of the technical efficiency scores of DEA approach for large-scale farmers

Efficiency Level	Technical Efficiency					
	CRS-TE (overall TE)		VRS-TE (Pure TE)		Scale Efficiency	
	Number of farm	%	Number of farm	%	Number of farm	%
0.01 - 0.10	0	0.00	0	0.00	0	0.00
0.11 - 0.20	11	18.33	0	0.00	10	16.67
0.21 - 0.30	11	18.33	0	0.00	8	13.33
0.31 - 0.40	9	15.00	0	0.00	9	15.00
0.41 - 0.50	10	16.67	0	0.00	9	15.00
0.51 - 0.60	7	11.67	0	0.00	8	13.33
0.61 - 0.70	4	6.67	1	1.67	6	10.00
0.71 - 0.80	2	3.33	9	15.00	2	3.33
0.81 - 0.90	1	1.67	10	16.67	3	5.00
0.91 - 1.00	5	8.33	40	66.67	5	8.33
Mean TE		0.434		0.925		0.469
Minimum TE		0.101		0.681		0.101
Maximum TE		1		1		1

Table 4.15 Summary of return to scale results for small and large scale farmers

Characteristic	Small scale farmers N=60		Large scale farmers N=60	
	frequency	percentage	frequency	percentage
Constant return to scale (CRS)	5	8	4	7
Decreasing return to scale (DRS)	1	0	0	0
Increasing return to scale (IRS)	54	92	56	93
Total	60	100	60	100

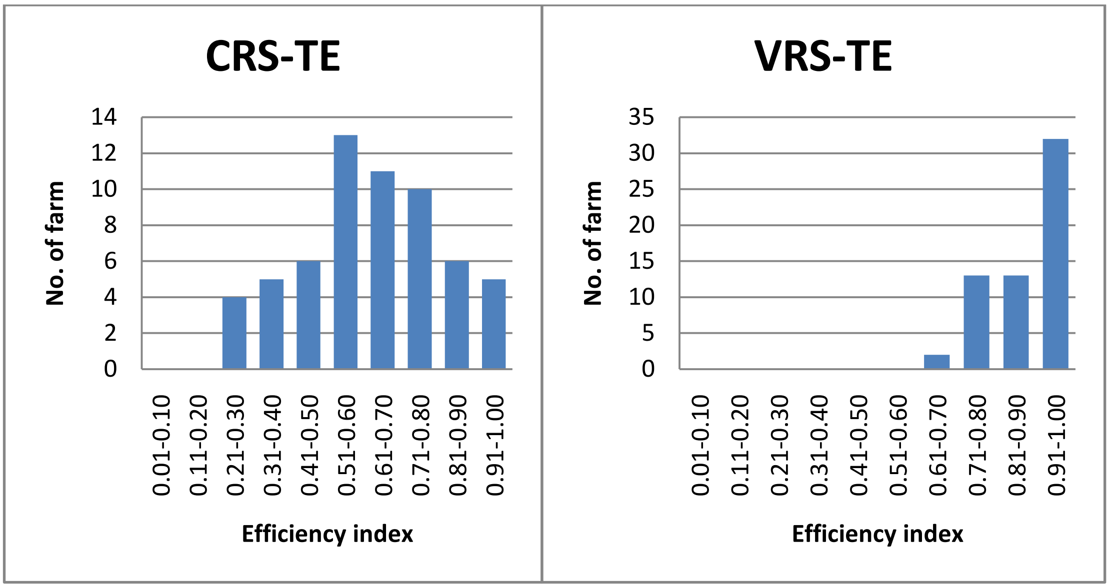

Figure 4.3 Frequency distribution of the technical efficiency of CRS and VRS of small scale farmers

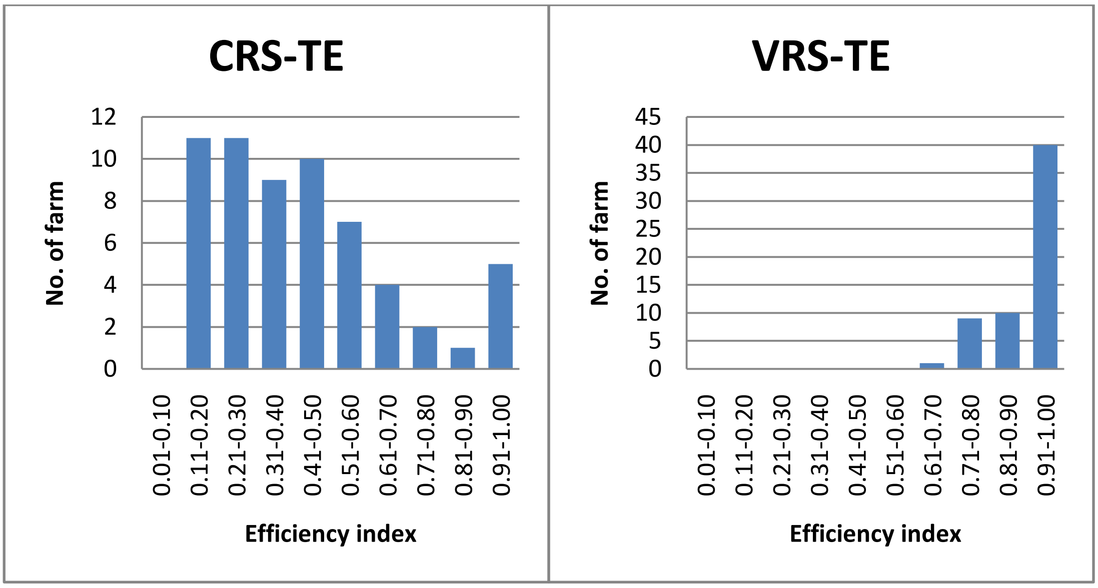

Figure 4.4 Frequency distribution of the technical efficiency of CRS and VRS of large scale farmers

Table 4.16 Frequency distribution of the technical efficiency index of DEA approach for low yielding farmers

Efficiency Level	Technical Efficiency					
	CRS-TE (overall TE)		VRS-TE (Pure TE)		Scale Efficiency	
	Number of farm	%	Number of farm	%	Number of farm	%
0.01 - 0.10	0	0	0	0	0	0
0.11 - 0.20	0	0	0	0	0	0
0.21 - 0.30	4	5.63	0	0	2	2.83
0.31 - 0.40	2	2.83	0	0	3	4.23
0.41 - 0.50	11	15.49	0	0	3	4.23
0.51 - 0.60	10	14.08	0	0	13	18.30
0.61 - 0.70	8	11.27	3	4.23	8	11.27
0.71 - 0.80	6	8.45	11	15.49	5	7.03
0.81 - 0.90	19	26.76	20	28.17	13	18.31
0.91 - 1.00	11	15.49	37	52.11	24	33.80
Mean TE		0.69		0.90		0.76
Minimum TE		0.24		0.60		0.24
Maximum TE		1		1		1

Table 4.17 Frequency distribution of the technical efficiency index of DEA approach for high yielding farmers

Efficiency Level	Technical Efficiency					
	CRS-TE (overall TE)		VRS-TE (Pure TE)		Scale Efficiency	
	Number of farm	%	Number of farm	%	Number of farm	%
0.01 - 0.10	0	0	0	0	0	0
0.11 - 0.20	0	0	0	0	0	0
0.21 - 0.30	3	6.12	0	0	0	0
0.31 - 0.40	16	32.65	0	0	14	28.58
0.41 - 0.50	10	20.41	0	0	10	20.41
0.51 - 0.60	6	12.24	0	0	4	8.16
0.61 - 0.70	5	10.20	2	4.09	7	14.29
0.71 - 0.80	3	6.12	6	12.24	6	12.24
0.81 - 0.90	1	2.04	11	22.45	3	6.12
0.91 - 1.00	5	10.20	30	61.22	5	10.20
Mean TE		0.52		0.91		0.57
Minimum TE		0.30		0.67		0.31
Maximum TE		1		1		1

Table 4.18 Summary of return to scale results for low and high yielding farmers

Characteristic	Low yielding farmers N=71		High yielding farmers N=49	
	frequency	percentage	frequency	percentage
Constant return to scale (CRS)	5	7	4	8
Decreasing return to scale (DRS)	1	0	0	0
Increasing return to scale (IRS)	65	93	45	92
Total	71	100	49	100

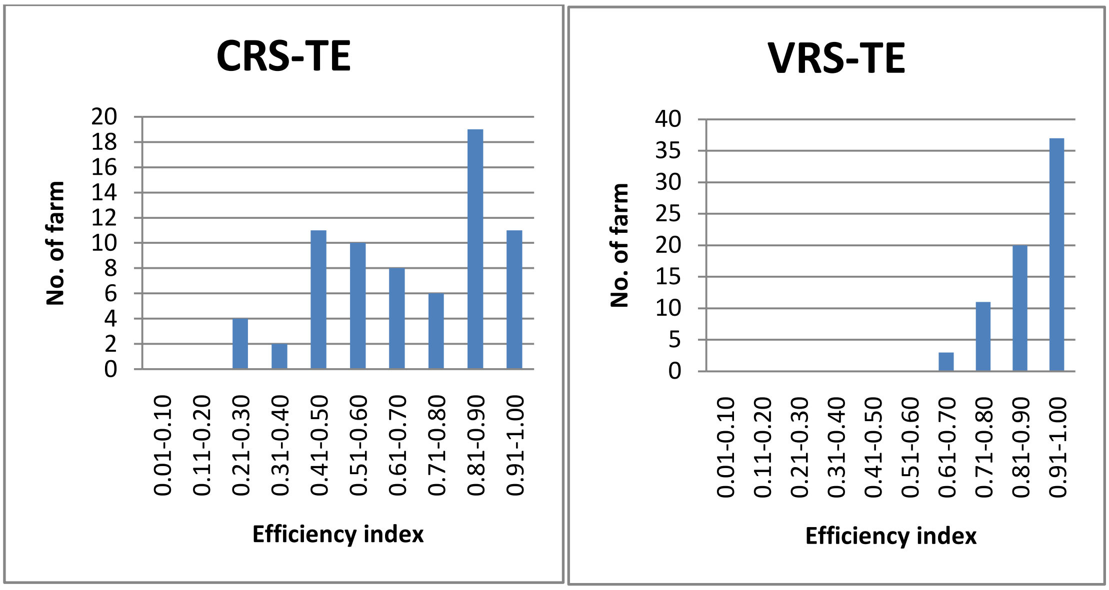

Figure 4.5 Frequency distribution of the technical efficiency of CRS and VRS of low yielding farmers

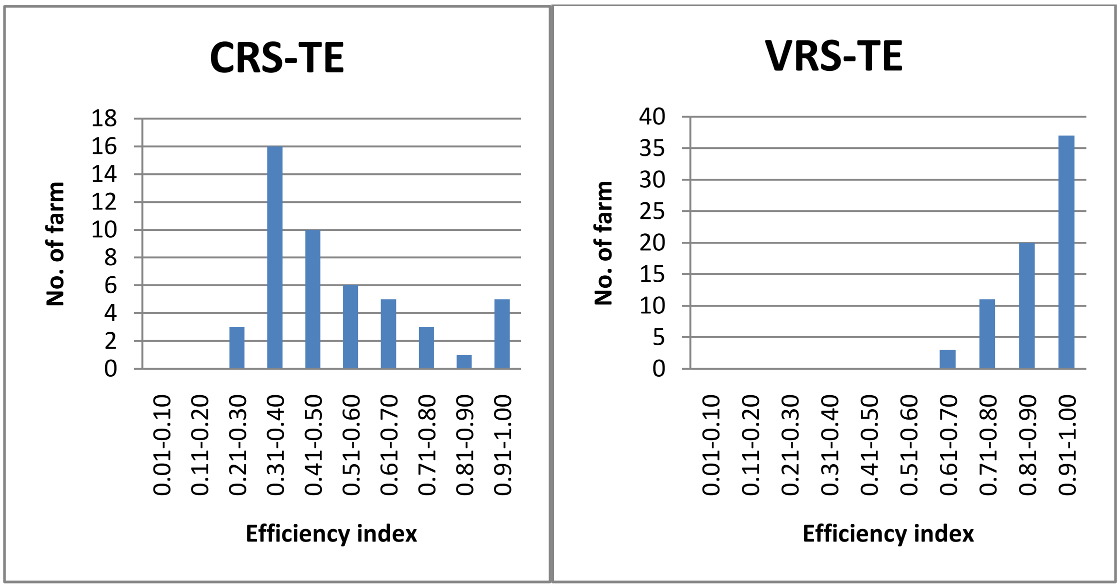

Figure 4.6 Frequency distribution of the technical efficiency of CRS and VRS of high yielding farmers

4.5 Constraints and Problems in Cotton Production

Agricultural production is affected by biotic and abiotic factors at different levels of influence. Abiotic factors can be partially controlled by improving physical infrastructure such as soil, climate and location of field. Biotic factors such as crop, other plants and animals are controlled by applied biology domains. Based on the various difficulties facing the cotton growers in the study area not only crop biological conditions but also the productive activities such as labor, inputs requirement, capital needs were identified as problems and constraints in cotton production in this study.

The farmers were surveyed with a qualitative basis about the constraints and problems they faced in cotton production and their responses were shown in Figure (4.7). There were nine questions as the problems and constraints concerning labor scarcity, pest and disease infestation, credit access from Myanmar Agricultural Development Bank (MADB), labor cost, cotton price, lack of financial asset to buy fertilizer, seed impurity, extension contact and unavailability of F2 seed.

Among these problems, 90.5% of the total sampled farmers pointed out that labor scarcity was happened for cotton production, especially weeding and cotton picking period. About 83% of total sampled farmers expressed that pest and disease infestation in their cotton farm was a problem for them. About 58% of total sampled farmers mentioned that they did not receive credit from MADB, and 53.1% of total farmers expressed that they paid high labor charges for hired labor. The problems of low cotton price, lack of financial asset to buy fertilizer, seed impurities, less extension service and unavailability of F2 seed were faced by 47.3%, 46.5%, 13.2%, 8.3% and 6.6% of the total sampled farmers, respectively.

4.6 Farmer's Perception on the Future Myanma Cotton Sector

In the few recent years, farmers became to grow the crop as they preferred without government intervention. Upland farmers used to choose the crop grown based on climate condition, market demand and crop price. In this study, focus group discussion with sampled cotton farmers was done to identify their perceptions on future cotton sector. With the technological changes in community, the farmers can get market information, agricultural technologies and weather forecasts from mobile

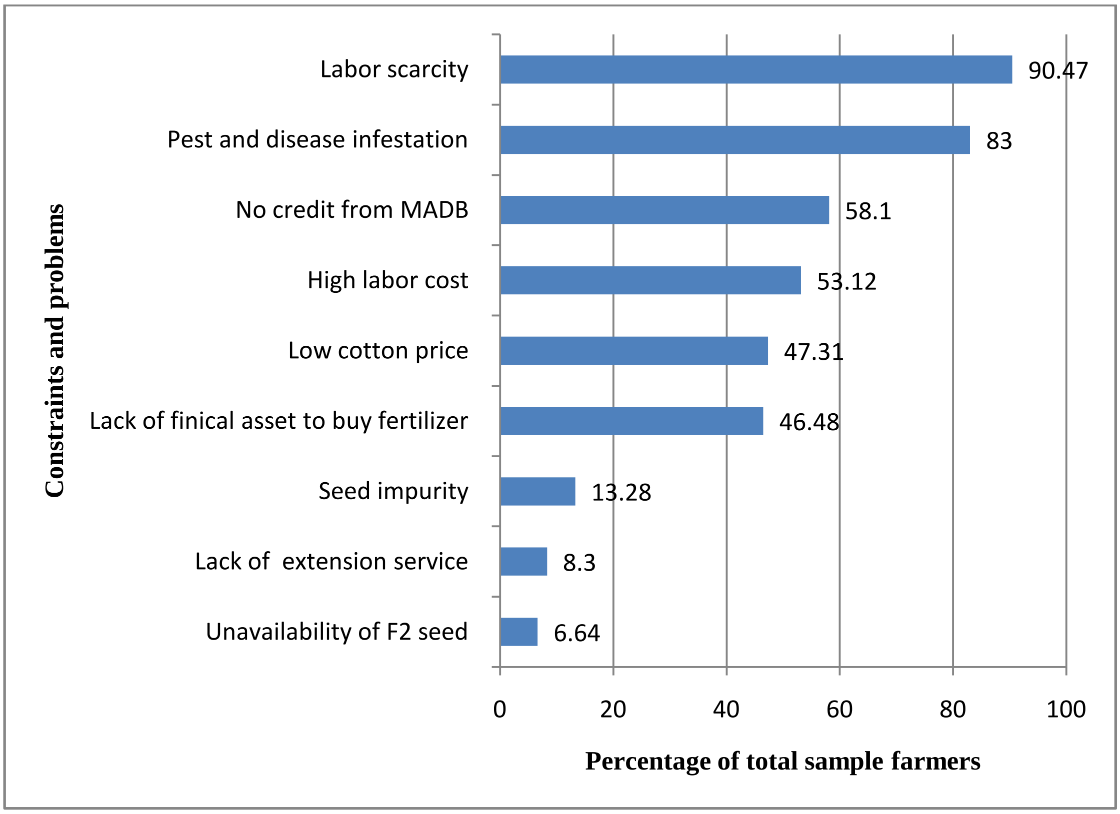

Figure 4.7 Constraints and problems in cotton production faced by sampled cotton farmers

Phone, radio, television and journals and there are perceptions of farmers for future Myanma cotton sector regarding their livelihood.

With the market expansion of agro-chemical companies, cotton farmers hoped some of the inputs such as F1 seed, fertilizers and pesticide, can be bought at their village either in cash down or credit system with the supply of agro-chemical companies. They also expected that cotton sown area will be decreased because of climate change and pest and disease infestation; however, cotton will exist as an important industrial raw material.

Nowadays, after changing the privatization of cotton sector, establishment of cotton purchasing centers and small-scale ginning factory at farm level, farmers hoped that they can get the high cotton farm gate price. Moreover, Myanmar textile industry is now mainly relying on imports which would be improved for substitution import textiles with domestic cotton production. Cotton producers hope cotton demand will be strong as the increasing demand of textile industry based on the economic improvement of customer, so that cotton price will be high expectation for future because cotton is the main raw material for local textile industries.

With more and more usage of F_1 seed and agro-chemicals by cotton farmers in the cotton production, extension services of modernized production technologies by both public and private sectors are needed for farmers. Extension services regarding to the production technologies of private sector, especially agro-chemicals companies seem to provide which is also one of the expectations of the sampled respondents. They also hoped that the amount of loan for cotton production by MADB will be increased for higher production costs.

Now, Myanmar state-owned textile factories were privatized and became liberalized, therefore, cotton farmers expected that cotton price will be set by market mechanism as the interaction of high demand and low supply in our country which can result higher incentive for cotton farmers. Finally, cotton sector would have bright future via Myanmar textile industry improvement through privatization by expectation of cotton farmers.

CHAPTER V

CONCLUSION AND POLICY IMPLICATION

5.1 Conclusion

This study was aimed to investigate the comparisons of technical efficiency and profitability of cotton farmers based on the grouping of cotton sown area and yield level, problems faced by cotton farmer and the farmer's perception on future Myanma cotton sector.

Average age and average farm experience of household heads in large scale farmer group is higher than that of small scale farmer group. Although average age of farm household heads of low yielding farmers and high yielding farmers are same, farming experience of high yielding farmers is higher than that of low yielding farmers. Regarding the education level of farmers, majority of sampled farmers have primary education level. The highest education level of farmers were in high yielding group, also farm experience was the high in this group. Family size of sampled farmers ranged from 1 to 7 persons and family labor were between 1 and 5. Total farm size (cotton and other crops) ranged from 0.4 ha to 10.93 ha. Seeing the possession of sampled farmers on their farming equipments and some of the household assets indicated that the farmers can easily adaptable interested in the modernized technology changes in their farming enterprise. Among the sampled farmers, 87% of farmers possess cattle and only one farmer owns tractor.

The majority of the sampled farmers used both organic fertilizer (FYM) and inorganic fertilizers (urea fertilizer and compound fertilizer) for their cotton cultivation. In the case of small scale farmer and large scale farmer groups, the small scale farmer group used more urea fertilizer and large farmer group used more compound fertilizer. The amounts of pesticide used by both farmers groups are not quite different. Likewise, the amount of FYM used is same for both groups. However, the amount of seed rate use is statistically different between the groups; the small scale farmers used more seed rate than large scale farmers because most of the small scale farmers used Raka F_2 seed while most of large scale farmers used Raka F_1 seed for their cotton cultivation.

In the case of low yielding farmer group and high yielding farmer group, the amount of FYM, urea, compound fertilizer, pesticide used by high yielding farmers is higher than that of low yielding farmers except seed rate used by high yielding farmers is lower than that of low yielding farmers. This is because most of low yielding farmers used Raka F_2 seed while most of high yielding farmers used Raka F1 seed for their cotton cultivation and more inputs is needed for F_1 seed growing compared with F_2 seed growing.

According to the enterprise budget results, which is used to compare the cost and return of the cotton growing farmer groups, the benefit-cost ratios of cotton production in small scale farmers, large scale farmers, low yielding farmers and high yielding farmers were 1.21, 1.36, 1.13 and 2.49 respectively. The highest benefit-cost ratio 2.49 is in the high yielding farmer group. It can be seem that the enterprise budget results of small and large scale farmers were not much significantly differences based on their resources used. In the case of low and high yield farmer groups, there was also significant difference in the use of material inputs and hired labor used. Therefore, the benefit-cost ratio results were found significantly difference.

In this study, Data Envelopment Analysis has been used in measuring the level of cotton growing farmers' technical efficiency with DEAP 2.1 software. According to the distribution of the efficiency scores, the CRS assumption would seem not to apply. Assuming that VRS do exist, the mean technical efficiency of small scale farmers, large scale farmers, low yielding farmers and high yielding farmers have been found 89%, 92%, 90% and 91% respectively. Mean technical efficiency was reasonably high in all groups and found not considerable different among the groups. Majority of the sampled farmers had technical efficiency more than 90%. There has a scope for increasing cotton production by about 9% by existing production technology under farmer current condition in the short-run. Mean technical efficiency has been found not considerable different among the groups, but high yielding group can get the higher economic profit by their ability resource management in cotton production. Even though TE is reasonably high in all groups, economic profit was not so attractive except high yielding group. This result pointed out that the cotton grower can get more profit by efficient and systematic utilization of their input management. Moreover, scale efficiency and return to scale are related what happens as the scale of production increases in long run, when all inputs levels are variables. In this study, the mean value of scale efficiency for small scale farmers, large scale farmers, low yielding farmers and high yielding farmers have been found 69%, 46%, 76% and 57% respectively. According to the results of return to scale of the sampled farmers, majority of farms were operating at increasing return to scale and so they can get more output by additional input systematically with input application technologies.

The major constraint faced by farmers in the study area is labor scarcity for their cotton production as labor migration to other sectors occurred. About 90 % of the sampled farmers confronted with labor scarcity in their crop production. The problem of high labor cost was found in about 53% of sampled farmers because wages in other sectors were relatively higher compared with wages in farming and labor scarcity. Moreover, pest and disease infestation in cotton production is also a major problem; it was accounted up to 83% of total sampled farmers. It was found that about 58% of sampled farmers did not receive credit from MADB. The problems of low cotton price, insufficient fertilizer, seed impurities, less extension service and insufficient seed were faced by 47.3%, 46.5%, 13.2%, 8.3% and 6.6% of the total sampled farmers, respectively.

According to the findings of farmers' perception on future Myanma cotton sector, farmers in the study area expect that cotton demand will be strong in the very near future because cotton is the main raw material for local textile industries so that they can get higher cotton farm-gate price. They also hope that cotton sector will have bright future and cotton price will be set by market mechanism because of privatization of state-owned textile factories and liberalization of cotton sector in Myanmar. In the case of input supply program, cotton farmers hoping that the inputs should be delivered to their villages either in cash down or in credit system and they also expecting to provide the efficient extension services related to the cotton production technologies.

5.2 Policy Implication

Myanmar has a unique potential to significantly expand the current area and step up cotton yields not only to meet its domestic needs but also contribute to world consumption. Cotton consumption is bounded to rise in long term perspective with increased population and consumer taste and life style changes favoring pure natural cotton textile. Cotton is the main raw material for local state-owned and private cotton industries and also traditional cottage weaving sector, it is necessary to maintain and increase the current cotton production and sown area.

According to the results of the study, most of the cotton farmers have primary education level in the study area. There is an improved and quality investment education in their rural area. Among the sampled farmers, the higher percentage of the cotton growing farmers possessed most of the traditional farming tools with some of the modernized equipments such as sprayers, water pumps and power tiller and about 90% of total sampled farmers faced labor scarcity for cotton production. Therefore, farm mechanization department under MOAI should emphasize the support program with not only machineries but also mechanized farming technology to cotton farmers.

Majority of the sampled farmers grow F_1 seeds and the rest farmers are willing to grow F_1 seed. Therefore, with the current cotton sector development, cotton industry improvement should more emphasizes cotton varieties with high yielding capacity, better fiber quality and high ginning outturn with specific adaptability under rain fed conditions. Consequently, to produce the good quality seeds of improved varieties, the cotton enterprise should foster by establishing a systematic seed production programs by private sector since majority of cotton farmers in the study area had faced high in diseases and pest infestation. It is necessary to strengthen research on IPM, including pesticide resistance management and plant management to enable farmers to control pests in a sustainable, economically viable system.

The result of cost and return indicated the high yielding farmers get the highest and attractive economic profit among the sampled farmers. It indicated cotton farmers can get more economic profit through efficient and systematic application of resource use and production technology method through strengthen extension activities by upgrading the technical capability of field agents and providing extension aids with sufficient facilities. Technical efficiency indices were 0.89 for small scale and 0.92 for large scale with 0.90 and 0.91 for low yielding and high yielding cotton growers, two things should be considered in the improvement of cotton industry. On one hand, the technological change would be the source of cotton productivity; therefore, the government should continue to increase its support for public investment in infrastructure and technology such as roads, irrigation, and research and extension. On the other hand, the private sector should be enforced for contract farming in cotton production to get better resource utilization and getting higher economic profit. Myanmar textile sector should be improved via privatization with fair macro policy environment for sustain operation of business which is the critical expectation of cotton sector by the Myanmar cotton farmer for their future.

Among the sampled farmers, about 58% of total sampled farmers did not received credit from MADB and about 53% of farmers paid high labor charges for hired labor. Credit for cotton growing farmers (50000 MMK ha^{-1}) is not sufficient and it covers only approximately 15% of the total production costs. The government should increase the amount of credit at least 50% of the total production cost and credits from private sources should also be encouraged. Microfinance program of MADB should be improved and covered all cotton growing area because most of the farmers in the study area are resource poor. Moreover, the private sector should be enforced for contract farming in cotton production for better resource utilization and higher economic profit.

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Appendix 1 Map of Tatkon Township

Appendix 2 Enterprise budget for cotton production of small scale and large scale farmers (MMK ha^{-1})

	Small scale farmer	Large scale farmer
1.Gross Benefit		
Total gross benefit	**898,359**	**1,071,146**
2.Variable Cost		
(a) Material Cost		
Seed	32,964	49,726
FYM	39,170	38,809
Urea	10,456	12,709
Compound	68,114	73,511
Insecticide	68,460	65,290
Total Material Cost	**219,164**	**240,045**
(b) Hired labor cost		
Land preparation	30,100	25,983
Seeding	7,200	6,991
Fertilizer application	6,133	3,791
Insecticide application	5,833	2,798
Inter-cultivation	10,633	15,858
Weeding	84,166	73,333
Harvesting	218,433	235,503
Total Hired Labor Cost	**362,498**	**364,257**
(c) Family labor cost		
Land preparation	33,283	34,583
Seeding	9,766	12,600
Fertilizer application	9,633	12,023
Insecticide application	10,066	11,833
Inter-cultivation	28,050	28,433
Weeding	10,666	13,466
Harvesting	45,333	55,550
Total Family Labor Cost	**146,797**	**168,488**
(d) Interest on cash cost		
Material cost	4,383	4,800
Hired labor cost	7,249	7,285
Interest on cash cost	**11,632**	**12,085**
Total variable cost (TVC)	**740,091**	**784,875**
Return above cash cost	**305,365**	**454,759**
Return above variable cost (Net benefit)	**158,268**	**286,271**
Benefit-cost ratio	**1.21**	**1.36**
t-test		**$t_{(0.05)}$=1.175^{ns}**

Note: ns = not significant

Appendix 3 Enterprise budget for cotton production of low yielding and high yielding farmers (MMK ha^{-1})

	Low yielding farmer	High yielding farmer
1.Gross Benefit		
Total gross benefit	**758,637**	**2,230,869**
2.Variable Cost		
(a) Material Cost		
Seed	29,075	59,126
FYM	40,103	37,378
Urea	6,540	18,889
Compound	57,266	90,442
Insecticide	50,704	90,306
Total Material Cost	**183,688**	**296,141**
(b) Hired labor cost		
Land preparation	24,373	33,357
Seeding	6,563	7,867
Fertilizer application	4,535	5,582
Insecticide application	3,387	5,661
Inter-cultivation	10,993	16,510
Weeding	74,669	84,663
Harvesting	192,437	277,004
Total Hired Labor Cost	**316,957**	**430,644**
(c) Family labor cost		
Land preparation	34,761	32,734
Seeding	11,056	11,367
Fertilizer application	10,324	11,559
Insecticide application	10,549	11,596
Inter-cultivation	28,218	28,275
Weeding	11,986	12,183
Harvesting	50,493	50,367
Total Family Labor Cost	**157,387**	**158,081**
(d) Interest on cash cost		
Material cost	4,451	4,797
Hired labor cost	7,041	7,594
Interest on cash cost	**11,492**	**12,391**
Total variable cost (TVC)	**669,524**	**897,194**
Return above cash cost	**246,500**	**1,491,693**
Return above variable cost (Net benefit)	**89,113**	**1,333,675**
Benefit-cost ratio	**1.13**	**2.49**
t-test		**$t_{(0.05)}$=-1.447****

Note: ** is significant at 5% level

Appendix 4 Technical efficiency indices of small scale farmers

firm	crste	vrste	scale	
1	0.515	0.821	0.628	irs
2	0.826	0.917	0.902	drs
3	1.000	1.000	1.000	-
4	0.406	0.637	0.638	irs
5	0.647	1.000	0.647	irs
6	0.788	1.000	0.788	irs
7	0.570	1.000	0.570	irs
8	0.507	0.800	0.633	irs
9	0.321	0.738	0.435	irs
10	0.323	0.860	0.376	irs
11	0.606	0.746	0.811	irs
12	0.254	1.000	0.254	irs
13	0.460	0.988	0.466	irs
14	0.651	1.000	0.651	irs
15	0.511	1.000	0.511	irs
16	0.518	1.000	0.518	irs
17	0.866	0.984	0.880	irs
18	0.643	1.000	0.643	irs
19	0.569	0.734	0.775	irs
20	0.611	0.719	0.849	irs
21	0.526	0.706	0.745	irs
22	0.584	0.723	0.808	irs
23	0.493	1.000	0.493	irs
24	0.427	1.000	0.427	irs
25	0.588	1.000	0.588	irs
26	0.588	1.000	0.588	irs
27	0.299	1.000	0.299	irs
28	0.397	1.000	0.397	irs
29	0.805	1.000	0.805	irs
30	0.636	0.779	0.817	irs
31	0.237	1.000	0.237	irs
32	0.672	0.858	0.783	irs
33	0.531	1.000	0.531	irs
34	0.470	1.000	0.470	irs
35	0.667	0.773	0.863	irs
36	1.000	1.000	1.000	-
37	0.399	0.790	0.505	irs

firm	crste	vrste	scale	
38	1.000	1.000	1.000	-
39	0.737	0.808	0.912	irs
40	0.844	0.864	0.977	irs
41	0.843	0.861	0.980	irs
42	0.729	1.000	0.729	irs
43	1.000	1.000	1.000	-
44	0.724	0.895	0.809	irs
45	0.739	0.862	0.857	irs
46	0.588	0.712	0.826	irs
47	1.000	1.000	1.000	-
48	0.314	0.722	0.435	irs
49	0.636	0.742	0.858	irs
50	0.840	1.000	0.840	irs
51	0.797	0.921	0.875	irs
52	0.542	0.827	0.656	irs
53	0.413	0.868	0.476	irs
54	0.254	0.698	0.365	irs
55	0.726	1.000	0.726	irs
56	0.791	0.916	0.863	irs
57	0.755	0.817	0.924	irs
58	0.607	0.873	0.695	irs
59	0.714	0.811	0.880	irs
60	0.647	1.000	0.647	irs
mean	0.619	0.896	0.694	

Note:
crste = technical efficiency from CRS DEA
vrste = technical efficiency fromVRS DEA
Scale = scale efficiency = crste/vrste

Appendix 5 Technical efficiency indices of large scale farmers

firm	crste	vrste	scale	
1	0.673	0.984	0.684	irs
2	0.275	0.782	0.352	irs
3	0.518	1.000	0.518	irs
4	1.000	1.000	1.000	-
5	0.277	0.759	0.364	irs
6	0.675	0.794	0.851	irs
7	0.754	0.956	0.789	irs
8	0.916	1.000	0.916	irs
9	0.542	0.921	0.588	irs
10	0.535	1.000	0.535	irs
11	0.264	1.000	0.264	irs
12	0.170	0.875	0.194	irs
13	0.822	1.000	0.822	irs
14	0.411	0.932	0.441	irs
15	0.451	0.859	0.525	irs
16	0.415	1.000	0.415	irs
17	0.383	0.804	0.476	irs
18	0.109	1.000	0.109	irs
19	0.175	1.000	0.175	irs
20	0.158	1.000	0.158	irs
21	0.520	0.920	0.566	irs
22	0.263	0.857	0.306	irs
23	0.239	1.000	0.239	irs
24	0.308	0.797	0.387	irs
25	0.594	0.961	0.618	irs
26	0.101	1.000	0.101	irs
27	0.345	0.825	0.418	irs
28	0.128	1.000	0.128	irs
29	0.193	1.000	0.193	irs
30	0.282	1.000	0.282	irs
31	0.385	1.000	0.385	irs
32	0.379	1.000	0.379	irs
33	1.000	1.000	1.000	-
34	0.268	1.000	0.268	irs
35	0.361	0.950	0.380	irs
36	0.295	1.000	0.295	irs
37	0.161	1.000	0.161	irs
38	0.240	0.846	0.284	irs
39	0.374	0.886	0.423	irs
40	0.796	0.965	0.825	irs
41	1.000	1.000	1.000	-
42	0.655	0.974	0.673	irs
43	0.513	0.881	0.582	irs
44	0.463	0.721	0.641	irs
45	0.436	1.000	0.436	irs
46	0.444	0.729	0.608	irs
47	0.403	0.681	0.592	irs
48	1.000	1.000	1.000	-
49	0.463	0.977	0.473	irs
50	0.347	1.000	0.347	irs
51	0.267	1.000	0.267	irs
52	0.555	0.904	0.613	irs
53	0.237	0.788	0.301	irs
54	0.441	0.951	0.463	irs
55	0.656	0.870	0.754	irs
56	0.494	0.826	0.598	irs
57	0.489	1.000	0.489	irs
58	0.133	1.000	0.133	irs
59	0.118	0.761	0.154	irs
60	0.196	0.798	0.246	irs
mean	0.434	0.926	0.470	

Note:

crste = technical efficiency from CRS DEA

vrste = technical efficiency fromVRS DEA

Scale = scale efficiency = crste/vrste

Appendix 6 Technical efficiency indices of low yielding farmers

firm	crste	vrste	scale	
1	1.000	1.000	1.000	-
2	1.000	1.000	1.000	-
3	1.000	1.000	1.000	-
4	0.985	1.000	0.985	irs
5	0.985	1.000	0.985	irs
6	0.973	1.000	0.973	irs
7	0.973	0.980	0.993	irs
8	0.973	1.000	0.973	irs
9	0.969	0.983	0.986	irs
10	0.834	0.836	0.998	irs
11	0.838	0.841	0.996	irs
12	0.834	0.895	0.932	irs
13	0.870	0.950	0.915	irs
14	0.838	0.856	0.979	irs
15	0.863	1.000	0.863	drs
16	0.831	0.849	0.979	irs
17	0.834	0.840	0.993	irs
18	0.834	0.840	0.993	irs
19	0.834	0.868	0.962	irs
20	0.834	0.860	0.970	irs
21	0.834	0.840	0.993	irs
22	0.834	0.841	0.992	irs
23	0.834	0.974	0.857	irs
24	0.836	0.943	0.887	irs
25	0.834	0.939	0.888	irs
26	0.831	1.000	0.831	irs
27	0.791	0.845	0.937	irs
28	0.781	0.950	0.822	irs
29	0.754	0.862	0.875	irs
30	0.760	1.000	0.760	irs
31	0.734	0.841	0.873	irs
32	0.848	1.000	0.849	irs
33	1.000	1.000	1.000	-
34	0.695	0.780	0.891	irs
35	0.695	0.787	0.884	irs
36	1.000	1.000	1.000	-
37	0.697	0.784	0.889	irs
38	0.656	1.000	0.656	irs
39	0.655	1.000	0.655	irs
40	0.670	0.870	0.771	irs
41	0.619	1.000	0.619	irs
42	0.624	0.980	0.637	irs
43	0.804	1.000	0.804	irs
44	0.556	0.796	0.699	irs
46	0.558	1.000	0.558	irs
47	0.556	0.988	0.563	irs
48	0.556	0.815	0.682	irs
49	0.554	1.000	0.554	irs
50	0.556	1.000	0.556	irs
51	0.554	1.000	0.554	irs
52	0.563	1.000	0.563	irs
53	0.857	1.000	0.857	irs
54	0.487	0.607	0.802	irs
55	0.461	0.764	0.603	irs
56	0.461	0.892	0.517	irs
57	0.467	0.833	0.560	irs
58	0.461	0.747	0.617	irs
59	0.557	0.767	0.727	irs
60	0.419	0.620	0.676	irs
61	0.417	0.785	0.531	irs
62	0.417	0.864	0.483	irs
63	0.443	1.000	0.443	irs
64	0.417	0.784	0.558	irs
65	0.417	0.872	0.478	irs
66	0.389	0.705	0.552	irs
67	0.363	0.932	0.930	irs
68	0.279	0.723	0.386	irs
69	0.283	0.728	0.390	irs
70	0.277	1.000	0.277	irs
71	0.245	0.992	0.247	irs
mean	0.690	0.902	0.764	

Note:
crste = technical efficiency from CRS DEA
vrste = technical efficiency fromVRS DEA
Scale = scale efficiency = crste/vrste

Appendix 7 Technical efficiency indices of high yielding farmers

firm	crste	vrste	scale	
1	1.000	1.000	1.000	-
2	1.000	1.000	1.000	-
3	0.777	1.000	0.777	irs
4	1.000	1.000	1.000	-
5	0.822	1.000	0.822	irs
6	0.797	0.925	0.862	irs
7	0.611	1.000	0.611	irs
8	0.673	0.863	0.779	irs
9	0.675	0.780	0.866	irs
10	1.000	1.000	1.000	-
11	0.655	0.890	0.736	irs
12	0.536	0.833	0.644	irs
13	0.499	1.000	0.499	irs
14	0.505	1.000	0.505	irs
15	0.554	0.819	0.677	irs
16	0.542	0.728	0.744	irs
17	0.512	0.775	0.661	irs
18	0.457	0.879	0.520	irs
19	0.519	0.834	0.623	irs
20	0.437	0.688	0.635	irs
21	0.490	1.000	0.490	irs
22	0.754	1.000	0.754	irs
23	0.916	1.000	0.916	irs
24	0.463	0.678	0.683	irs
25	0.656	0.911	0.720	irs
26	0.385	0.748	0.514	irs
27	0.383	0.924	0.414	irs
28	0.388	1.000	0.388	irs
29	0.410	1.000	0.410	irs
30	0.385	0.873	0.441	irs
31	0.451	1.000	0.451	irs
32	0.350	1.000	0.350	irs
33	0.452	0.898	0.503	irs
34	0.334	1.000	0.334	irs
35	0.444	0.761	0.583	irs
36	0.518	1.000	0.518	irs
37	0.383	0.850	0.450	irs
38	0.380	1.000	0.380	irs
39	0.348	0.934	0.372	irs
40	0.311	1.000	0.311	irs
41	0.311	1.000	0.311	irs
42	0.307	0.924	0.322	irs
43	0.342	0.913	0.375	irs
44	0.307	0.756	0.406	irs
45	0.307	0.853	0.360	irs
47	0.333	0.958	0.348	irs
48	0.322	0.940	0.343	irs
49	0.374	0.893	0.419	irs
mean	0.525	0.915	0.575	

Note:
crste = technical efficiency from CRS DEA
vrste = technical efficiency fromVRS DEA
Scale = scale efficiency = crste/vrste