YANGON UNIVERSITY OF ECONOMICS

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Ph.D. PROGRAMME

AN ANALYSIS OF THE TECHNICAL EFFICIENCY OF PADDY PRODUCTION IN AYEYARWADDY REGION

(A Case Study of Danubyu Township)

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ABSTRACT

Agriculture is indispensable as food security and as an employment source for rural areas, which are associated with rural development and poverty alleviation. The objectives of this study are to estimate the level of technical efficiency and to examine factors affecting technical efficiency in paddy production among farmers of Danubyu Township in the Ayeyarwaddy region. In this study, the two-stage simple random sampling method, the Cobb-Douglas type stochastic frontier production function, and the Tobit regression model were used. The maximum likelihood estimates of the parameters of the frontier production function showed that paddy output was positively and significantly influenced by land area, fertilizer, and pesticide. The estimated mean level of technical efficiency of the sample farmers was about 89%. This result shows that there exists a possibility to increase levels of paddy output by 11% by efficiently utilizing the existing resources. Gender, educational level, farm experience, and farm income from individual farmers' socioeconomic factors; plant protection from farm-specific factors and the amount of credit; extension services; training; and membership in agricultural associations from institutional characteristics were found to have a positive and significant effect on technical efficiency. As a result, the study recommends that local governments or other concerned bodies should engage in developmental activities aimed at increasing production efficiency and should focus on improving productivity by emphasizing the critical factor of technical efficiency that can be considered when developing agricultural policy in order to increase the current level of technical efficiency and productivity in paddy production.

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LIST OF ABBREVIATIONS

ADS	Agriculture Development Strategy
AE	Allocative Efficiency
CDZ	Central Dry Zone
CRS	Constant Returns to Scale
CSO	Central Statistical Organization
DEA	Data Envelopment Analysis
DOA	Department of Agriculture
EE	Economic Efficiency
ERS	Economic Research Service
GDP	Gross Domestic Product
HYVs	High Yielding Varieties
IP	Investment Plan
LIFT	Livelihoods and Food Security Trust Fund
MADB	Myanmar Agriculture Development Bank
MAS	Myanmar Agricultural Statistics
MOALI	Ministry of Agriculture, Livestock and Irrigation
PER	Public Expenditure Review
REE	Research, Education and Extension
SFA	Stochastic Frontier Approach
TE	Technical Efficiency
USDA	United States Department of Agriculture

CHAPTER I
INTRODUCTION

1.1 Rationale of the Study

Agricultural productivity can contribute significantly to economic growth by connecting the supply and demand sides (Johnston & Mellor, 1961). The agriculture sector provides raw materials to the industrial and non-agricultural industries and requires inputs from the modern sectors. On the demand side, higher agricultural productivity can enhance rural population wages, potentially increasing demand for local industry products (Dethier & Effenberger, 2011). In this approach, a link can be established between agriculture and modern sectors, potentially creating new job opportunities and improving rural income and livelihood. From the standpoint of optimizing growth, it is critical to understand which economic sectors offer the 'greatest' prospects or pay-offs for total economic growth, particularly in resource-constrained economies that cannot concurrently increase all sectors. This necessitates paying special attention to the potential for growth of sectors, their share of total output, and the strength of their links with the rest of the economy.

Agriculture has generally been seen as presenting opportunities for growth in developing countries. The size of the agricultural sector relative to the rest of economy in developing countries implies growth of the sector has potential for large direct effects on economic growth and transformation of the national economy. Many developing countries' agricultural output remains severely hampered by technology and the wider infrastructure for connecting small-holder farmers to the agri-food supply chain. Thus, it is frequently maintained that efforts to increase agricultural production have the potential to favorably contribute to the growth of the national economy and the reduction of poverty in many low-income nations. Agriculture contributes to economic growth in two ways: market and factor contributions. Market contribution occurs when one sector creates chances for other sectors to emerge or for the economy as a whole to participate in international trade and other international economic flows. Agriculture contributed to economic growth by purchasing some production items from other sectors and selling and purchasing some of its own products. When resources are transferred from one sector to another, the factor contribution emerges. Thus, if agriculture improves, it contributes a product, and if it trades with others, it contributes to the market. Then, if it transfers resources to other sectors, and these resources are productive factors, it contributes a factor. Agriculture makes significant contributions to economic development by providing food and fiber, labor, capital, foreign exchange, and rural welfare (Kuznets, 1965).

Agriculture directly or indirectly supports the livelihood of a large majority of the developing world's population. According to the World Bank, 2.5 billion people rely on agriculture as their primary source of income, with 1.3 billion of them being small farmers and landless workers (Mozumdar, 2012). Around 75% of the world's poor reside in rural areas, and 86% of them make their living in the agricultural sector (ECG, 2011). Increased agricultural output is critical for all of these individuals. In recent years, agricultural productivity growth has stagnated. The world yield of key food grains is increasing at a level of roughly 1% per year (FAO, 2009a), while the world's current population growth rate is about 1.2 percent. Land is a limited resource; many emerging countries cannot expand their farmed land (ECG, 2011). As a direct consequence, increasing agricultural production may be the only way to fulfill the growing population's future food need. Because cultivable fertile land and related inputs are limited in most regions of the world, a new method to increasing future agricultural productivity development may be intensive agricultural growth rather than extensive growth. As a result, together with diversification, intensification of production and upgrading of inputs or resource use efficiency are important essential strategies (Dixon et al., 2001). The difference between exact achievable and actual yields for most crops implies a tremendous opportunity to increase food and agricultural production by enhancing productivity (Zepeda, 2001). According to FAO, in the developing world, 80 percent of the increase in food production will have to come from increased yields and cropping intensity, with only 20 percent coming from increased arable land (FAO, 2009c). As a result, intensification is critical not only to fulfill the growing demand for food grains, but also to reduce deforestation, ecological degradation, and global warming.

The increasing rate of the population will be one of the signals for maximizing agricultural productivity. To be able to supply food for an increasing population and export the surplus, crop production needs to be increased by all means, including the use of modern technology. Food security, as well as securing food for all, is a major concern for the global community. Food security is defined as "the condition in which all people have physical, social, and economic access to sufficient, safe, and nutritious food that fulfills their dietary needs and food preferences for an active and healthy life at all times" (FAO, 2010). Many people regard it as a basic human right, but nearly one billion people worldwide, particularly in food-deficit and low-income developing nations, continue to suffer from chronic poverty and malnutrition (IEG, 2011). The majority of them lives in rural areas and relies on agriculture for their daily needs as well as a source of income. In that view, the primary instruments for decreasing poverty, increasing food security, and improving rural livelihoods are strengthening agricultural production, raising agricultural productivity, and improving resource use efficiency (Pinstrup-Andersen and Pandya-Lorch, 1998). Food security is comprised of three major components: (i) food availability: includes three elements related to production, allocation, and exchange; (ii) food access: includes elements related to affordability such as income and wealth, provision, and preferences; and (iii) food utilization: includes elements related to dietetic value, social value, and food safety (Ingram, et al., 2005). Rosegrant et al. 1995 discovered that well-off and typical fast-growing economies typically have fairly priced food supply, but slow-growing poor countries suffer from food shortages and hunger. It means that developing, least developed and slow-growing impoverished countries must advance in agricultural production, and greater agricultural productivity is required to provide food self-sufficiency, which is the first component of food security.

In the context as developing countries, Myanmar's agricultural sector is characterized by low productivity, inequalities, and high volatility. Despite its potential, it has experienced decades of inadequate investment in basic infrastructure, such as rural roads, as well as low research, extension, and financial support services. The majority of public investment in agriculture has concentrated on irrigation infrastructure, particularly the development of dams, reservoirs, and major canal systems to provide surface irrigation in order to produce paddy, but the availability of water remains uncertain for many farmers. While in some subsectors there has been production growth, farm gate prices have generally been low and highly volatile. This has resulted in stagnant or diminishing rural wages, a rise in landlessness, and a high degree of rural indebtedness, with consequent widespread rural poverty, inequitable land allocation, and highly seasonal agricultural labor demand. The variations in agro-ecological zones and the unequal use of agricultural inputs and expertise are the reasons for the differing production and paddy output between regions and individual farmers. Furthermore, the output differential between agro-ecological zones and paddy farmer fields remains significant, implying a big chance to enhance individual farmers' efficient productivity.

Paddy is a significant and important food crop for the entire world's population. Paddy is a subsistence crop in most countries, with farm households keeping and consuming around half of the output. Increasing food production is a dynamic mechanism that necessitates greater and more widespread utilization of land and water, a higher supply of basic agricultural inputs such as fertilizers, proper agricultural policies and rural institutions, and improved agricultural research. However, if an attempt is made, the ability to improve food production will be significant. It has a large potential to produce additional paddy by increasing paddy output in existing production regions, creating new and sustainable irrigation infrastructure, and converting land and natural habitats to paddy production. Recent favorable government policies, the expansion of irrigated areas, the availability of agricultural credit, intensive extension services, and the accessibility of agrochemicals, particularly fertilizers and herbicides, have accelerated the wide application of new production technology.

This thesis title was chosen based on the reasons for boosting the productivity and prospects of paddy production to achieve a higher level of output, provide people with stability, and to consider the efficient allocation of resources among farmers.

1.2 Problem Statement

Myanmar has average paddy yields than neighboring countries. However, within the country the disparity in paddy output reflects the current unequal distribution of agricultural inputs and capacities, in addition to the fundamental factors impacting pesticides, irrigation, and rural institutional changes. Changes in paddy production, thus, have a direct and profound effect on the whole population. Paddy production remains low, despite the country's significant potential for demand growth.

In Myanmar, there are many problems with paddy production. Paddy production constraints are closely related to the fact that land ownership and land management problems, as well as weak farmers' skills and practice in land preparation, are key factors in this township. Most new agricultural technologies are only partly effective because they require a high cost of production. Farmers are still using low-yielding agricultural technologies, which leads to low productivity. In addition, the existence of structural and cultural limitations arising from the conventional agricultural system has a negative effect on the effective production of paddy. Furthermore, the lack of adequate rewards is currently competitiveness. Problems with seed selection and cultivation mean stronger seedlings from high-quality seeds will not increase yield unless adequate fertilizer is applied, and paddy crops will not respond to fertilizer application if weed infestation is severe and the water system is inadequate. Most farmers apply fertilizers to their paddy fields, but the fertilizers are often not available when farmers require them. Farmers often lack the skills and knowledge for proper plant nutrient management. The most common fertilizer applied is urea, and often the rates applied are low and not done at the right crop stage. Fertilizer applied can significantly increase output by nutrient use efficiency at the right time and in the right amount. Farmers' lack of knowledge of proper pest management will result in pesticide misuse and the eventual occurrence of pest problems and loss of biodiversity in the paddy fields.

In Myanmar, the levels of technical efficiency in paddy production are may be still different among farmers. Due to the age difference between paddy farmers, there is a problem with the ability to use modern paddy production techniques. Older farmers have more experience in farming than younger farmers, who have less experience. There are also problems with sharing these experiences with other farmers. Farmers have limited capacity to use modern farming techniques and equipment in paddy fields. These problems include the low level of education of farmers; a lack of training in agricultural techniques and equipment; and problems with the protection of weeds and diseases that can occur in paddy fields with the right methods and timing. They also include poor cropping mechanisms for problems such as local flooding, droughts, and untimely rains. In addition, price instability has reduced farmers' incomes from paddy production. But because of the consequences of high production costs, farmers are becoming more dependent on credit. In addition to not getting enough credit and weak local credit market growth, farmers also face challenges in using inputs. There are problems with the use of technical services in the production of paddy, as well as the proper use of seeds and inputs. However, in this township, agricultural associations and extension agencies, as well as an inability to provide adequate services related to farmers' and their poor membership in agricultural associations.

Danupyu Township has a lot of potential to increase paddy production, such as by improving paddy output on current production technologies, extending paddy farming lands, and constructing and sustaining the irrigation system and infrastructure. Increase paddy productivity through making better use of inputs and technological improvements. An improvement in paddy productivity has a vital role not only for better harvesting but also for farmers' livelihoods. For various reasons, it is necessary to investigate the current technical efficiency in paddy production and, therefore, it is important to consider the efficient input allocation among farmers. The following are some research questions related to this study that are supported by these facts:

1. What is the range of technical efficiency for paddy production among farmers?
2. Are there socioeconomic, institutional, and farm characteristics that explain the variation in technical efficiency of paddy production?

1.3 Objectives of the Study

The following are the study's objectives:

1. To estimate the level of technical efficiency in paddy production in the study area.
2. To examine factors affecting the level of technical efficiency in paddy production among farmers.

1.4 Method of Study

To achieve the objective of the study, both quantitative and qualitative approaches and primary and secondary data were used in this study. The primary data were collected based on farm level cross-sectional data for the 2020 paddy growing season. A well-structured questionnaire and a two-stage simple random sampling method were used to collect primary data. Secondary data were collected from the several of sources. including books, journals, research papers, and reports on productivity and efficiency analysis, among others. In this study, the Cobb-Douglas stochastic frontier production function was employed to determine technical efficiency. The Tobit regression model was used to examine the factors influencing the level of technical efficiency in paddy production.

1.5 Scope and Limitations of the Study

The study was carried out in Danubyu Township, in the Ayeyarwaddy region, for the 2020 paddy growing season. This study only consider the farmers who uses local paddy seeds in the paddy production while analyzing the level of technical efficiency and the factors affecting the level of technical efficiency.

1.6 Organization of the Study

This study is divided into six chapters. Chapter one gives an introduction to the study, including a rationale, problem statements, objectives, method, scope and limitations, and study organization. Chapter two includes literature reviews pertaining to measures of efficiency, including the general definition of efficiency, productivity, and usefulness. This section discusses the empirical analysis of techniques and examines the measuring the level of technical efficiency. Subsequently, chapter three gives a brief overview of paddy production in Myanmar and the Ayeyarwaddy region, which focuses on historical trends and also policy cooperation with the respective generations of governments. Chapter four describes research methodology, which was organized with some facts about the field of survey and briefly describes the contents of the data and, as a result, the analytical tools and techniques used to measure the level of technical efficiency. Chapter five gives the results of the level of technical efficiency from the stochastic frontier production model and the estimate of the factors affecting technical efficiency. Chapter six draws a conclusion on the estimated results of technical efficiency measurements and makes recommendations for policy makers who can decide on effective programs for farmers.

CHAPTER II
LITERATURE REVIEWS

2.1 Concepts and Definition of Productivity

Productivity is defined as a production system's efficiency and the ratio of output units to input units (James & Carles, 1996). Productivity is critical to sustaining long-term socioeconomic development and maintaining organizational and national competitiveness. The diverse productivity-enhancing technologies, techniques, procedures, and practices that have been invented and used in the production and consumption of goods and services over the years are critical to the dynamism of economies. Productivity is seen as a critical driver of economic growth and competitiveness, and it forms the basis for many international comparisons and country performance assessments. Productivity growth is a key factor in estimating an economy's productive potential. It also allows analysts to calculate capacity utilization, which allows them to forecast economic growth and evaluate the position of economies in the business cycle. Furthermore, productive capacity is utilized to predict demand and inflationary pressures.

Productivity is generally described as the ratio of output volume to input volume. In other words, it assesses how effectively an economy's production inputs, such as labor and capital, are employed to generate a particular level of output. Productivity is a measure of productivity and profitability (OECD, 2001). Productivity growth is defined as an increase in the value of outputs generated for a given level of inputs over time. Productivity is defined as the relationship between the amount of output and the amount of input used in production. Productivity is calculated by multiplying output by input. Productivity is concerned with the efficiency with which goods and services are produced, as well as the value created by the production process. A product's productivity level is regarded high if it is made at the lowest possible cost while maintaining good quality and can be sold competitively in the market at a price greater than its cost of production. The goal of productivity is to maximize output while minimizing input. Productivity is the sum of efficiency and effectiveness. Another aspect of productivity is effectiveness. This refers to achieving the expected goals or outcomes specified by the manufacturer of a product or service. Customers that are extremely delighted with the product or service may result in higher revenues and repeat purchases for the product or service. It may also imply a greater return on investment for investors and, in some cases, a better image or reputation for the firm or organization.

Productivity measurement has its roots in microeconomics' "theory of the firm," where it can be stated that inputs can be optimally combined to allocate limited resource, allows firms to maximize profits subject to a cost constraint or minimize cost subject to an output constraint. Both will result in an efficient or optimal input allocation (GSARS, 2017). Productivity is examined because higher productivity allows enterprises, industries, and countries to better allocate scarce resources to other endeavors. It raises national income as a result of this reallocation, as inputs are used more efficiently and the "surplus" is reallocated to other enterprises. Both outcomes are directly related to productivity analyses.

Productivity measures, in their most basic form, reflect the relationship between the output of a commodity and the inputs utilized to generate those goods. It might be the interaction of one or more products with one or more inputs. Because productivity measures reflect how efficiency and technological progress effect the transformation of inputs into products, productivity measurements are frequently volume based.

2.2 Agriculture Productivity Measurement

Agricultural productivity is the amount of agricultural output produced for a given amount of input or combination of inputs. Productivity can be defined and measured in a variety of ways. For example, output per unit of input, or an index of many outputs divided by an index of many inputs (Wiebe, 2003). The usual measure of productivity is the quantity of output relative to the quantity of inputs. If output grows at the same rate as inputs, productivity remains constant. Conversely, if the rate of increase in output exceeds the rate of growth in input utilization, productivity is positive.

In productivity, two measurements are frequently used. The first is a partial factor productivity measure, such as the amount of output produced per unit of a certain input, such as land or labor, and the second is a total factor productivity measure. Land productivity, i.e., yield or output per unit of land, and labor productivity, i.e., output per economically active person or each agricultural person-hour, are the two most widely used partial metrics (Zepeda, 2001). Sometimes the information from limited measurements of productivity is insufficient to explain why output is changing. This is due to the fact that numerous factors influence productivity. Land or labor productivity, for example, can increase as a result of better and more efficient fertilizer use, power tillers, the use of high-yielding varieties (HYV), and so on. To avoid such issues, total factor productivity (TFP) should be measured to account for proper agricultural productivity. As a result, the measure of multifactor or total factor productivity implies that total production is related to a broader meter of all quantifiable inputs, such as land, labor, capital, livestock, chemical fertilizers, pesticides, and other purchased inputs (Alston et al., 2009).

It is worth noting that different productivity measurements are employed for various objectives. Yield or land productivity, for example, are commonly employed to assess the success of new technologies. It is also important in determining how much land is required to meet future global food demands (Wiebe, 2003). Labor productivity is commonly used to compare productivity within or between economies (Block, 1994). It also allows us to calculate the incomes and well-being of agricultural workers (Wiebe, 2003). TFP growth is typically used to analyze technological progress, which may be attributed to the advancement of scientific agricultural research, improved extension services, human capital development such as education, and the development of infrastructure and government restrictions (Ahearn et al., 1998).

TFP, or aggregate agricultural output, is commonly assessed using a variety of economic models, including index numbers or growth accounting techniques, econometric estimation of production linkages, and nonparametric approaches. The growth accounting model compiles precise financial records of inputs and outputs and combines them into input and output indices to compute the TFP index (Diewert, 1980). The econometric approach is founded on an econometric estimation of the manufacturing technology (Antle and Capalbo, 1988). It calculates the marginal contribution of each type of input to total output (Chavas, 2001). It can determine the effect of a one-percent change in fertilizer use on overall agricultural output, with all other inputs remaining constant. In non-parametric methods Chavas and Cox (1992), linear programming techniques are used to calculate TFP. It doesn’t impose assumptions on the technology that generates agricultural output; therefore, it has the advantage of flexibility (Capalbo and Vo, 1988).

2.2.1 Factors Affecting Agricultural Productivity

The factors affecting a farmer's production can be divided into three, namely, the physical inputs used (capital, land, and labor), farm and farmer characteristics, and factors external to the farmer, such as environment and government and administrative policies (Wiebe, Soule and Schimmelpfennig, 2001). The capital inputs used include herbicides, fertilizers, seeds, chemicals as well as field instruments and implements. Topography and cultivated land area, farm distance from input and export markets, education level, age, gender, family size, and availability to credit, and engagement with extension are all examples of farm and farmer characteristics. The climatic conditions are soil conditions and environmental variables, including temperature, rainfall, and humidity (Michele, 2001). One of the essential inputs in crop production, especially paddy, is fertilizer.

The most of scholars have focused on the role of traditional inputs such as land, labor, water, chemical fertilizers, physical capital, and so on in explaining productivity development (Lachaal, 1994). Human capital, R&T development or technology transfer, public investment in agricultural research, extension services, and infrastructure development, sustainable natural resource management, policy reform, and political stability, among other things, are important strategies that are closely linked to agricultural productivity (Auraujo et al., 1997). Several variables can lead to increased agricultural output. Numerous scholars have undertaken research on various aspects influencing worldwide agricultural productivity (Hayami, 1969; Hayami and Ruttan, 1970; Nguyen, 1979; Kawagoe and Hayami, 1983; Kawagoe, Hayami and Ruttan, 1985; and Bhattaccharjee, 1995). They emphasize the importance of education, training, and human capital in increasing production. Evenson and Kislev (1975) investigate the importance of research in explaining cross-country differences in agricultural output, whereas Antle (1983) focuses on infrastructure development. Chavas (2001) shows a limited relationship between technological change and agricultural productivity increase across countries over time, despite evidence that technology advancement has led to high agricultural productivity growth over the last few decades. Though there are certain consequences to Asia's green revolution, such as environmental destruction. Aside from human capital and infrastructure development, changes in agro-climatic conditions might help boost agricultural productivity across the country.

2.2.2 Land Productivity in Agriculture

Land productivity measures the amount of output produced by a given amount of land. It is mainly applicable in the sense of cropping operations, but it can also be applied, in some cases, as shown below, to the production of livestock. There are many indicators of productivity that can be calculated: the ratio between the value of all agricultural products (crops and livestock) and the total land used in agriculture is a large indicator. Other measurements of land productivity can be determined by dividing crop production by the quantity of land planted, expressed in units of area, such as hectares or acres. Land productivity refers to crop yields when expressed in terms of physical production. Land output, as expressed in monetary terms, is more commonly referred to as land returns.

Plant area was chosen over other field terms such as cultivated area because it is more important in estimating the effective yield or productivity of the soil than theoretical or biological yield. Until harvest, inputs (such as fertilizer applications) are applied to the sown/planted area rather than the harvested area, which is often unknown at the pre-harvest phase. In addition to external effects like as weather events, which should be reflected in the productivity predictor, the discrepancy between harvested and planted areas can also represent the quality and significance of farming activities (GSARS, 2017). Because the most profitable areas of the plot are employed, it appears that using the cultivated area rather than the planted area leads to an overestimation of yields and returns to the soil. It is preferable to use the planted area for mono-cropping and the cultivated area for mixed cropping, including fallow land.

Agricultural production used to estimate productivity could include the production of crops cultivated on the same land during a comparison period, whether for a single crop season or a year. This is significant because farmers may plant more than one crop on the same plot during the year; they may cultivate a mixture of crops on the same plot or rotate the crops planted on the plot during the season. Kelly et al. (1996) emphasized that one of the reasons for developing countries' tendency to underestimate output and yields is a lack of accounting for crops grown in a mixture or in series, as well as a lack of assessment of by-products that may be marketed, consumed by households, or used in the processing of other products. As a result, it is critical that all crops be included in the productivity estimate, particularly in underdeveloped countries where these methods are widespread. To the greatest extent possible, productivity should account for changes in soil and land quality by collecting data on soil/land characteristics and their related elements, particularly land prices and rents.

Vesterby and Krupa (1993) demonstrated that low-physical-quality soils can sometimes offer very high yields. Furthermore, the environmental characteristics of soil quality are not commonly reflected in land valuations. Land prices in underdeveloped nations, may be more closely related to the presence of irrigation infrastructure on the farm. Typically, irrigation facilities and equipment dictate the capital input. When measuring land productivity, it is required to define at least the percentage of irrigated land in relation to total accessible land.

2.2.3 Natural Capital and Productivity

Natural capital is the natural ecosystem in which development takes place and involves considerations such as the condition of the soil in terms of the structure and environmental patterns of natural materials and fossils (rainfall, temperature, and sunshine, among others).To determine the environmental sustainability of agricultural activities or their ability to obtain adequate yields without producing any kind of negative externalities to the environment where development occurs, understanding the role of natural capital for agriculture and its interactions is important. Natural capital depletion may theoretically contribute to short-term economic growth or yield increases, but this will be at the expense of future growth if short-term growth revenues are not reinvested in order to sustain or increase the physical and natural capital base (Schreyer, Brandt and Zipperer, 2015).

2.2.4 Labor Productivity in Agriculture

In agriculture, labor productivity measures the number of units of output(s) produced per unit of labor used in the production process. It is a partial measure of efficiency and is determined by dividing the output quantity by the total units of labor used. There are several ways of measuring the labor input: the number of employees on the holding; the number of working time units (such as hours, days, and months), or full-time equivalent units where it is feasible to calculate an approximate number of working hours per working day in compliance with particular country requirements. OECD (2001) suggests calculating labor performance using the number of hours worked efficiently. For the distinction between seasonal and non-seasonal employees and the various working regimes (part-time versus full-time), the usage of the number of hours is right. This makes it easier to accurately compare manufacturing processes, regions, and nations, the amount of employees or days per worker cannot reflect the labor input used efficiently on the farm.

The shift the number of registered hours, however, does not always reflect the use of resources, employee productivity, and technology. USDA-ERS indicates that the various forms of labor employed in the sector are captured by productivity metrics because labor input varies depending on employee categories. Distinctions between the various ages of employees, family labor, and hired labor and men and women are recommended. It is also feasible to create distinctions between part-time and full-time jobs. There should also be a distinction between the various levels of education, as the standard of one hour offered by a worker also depends on his expertise and abilities.

Labor productivity is correlated with other variables, such as land and capital. For example, farmers in countries where labor is scarce and the land is abundant tend to follow production systems that provide high productivity for labor, as noted by (Kelly et al., 1996). In labor productivity, capital also plays a major role. Because of the rise in crop yields globally, labor productivity in agriculture has increased. This rise in yield is primarily attributable to the use of genetically enhanced, high yield potential crops, along with a rise in the use of organic fertilizers and pesticides and, in some situations, an increase in irrigation. Increased mechanization is also often connected to increases in labor efficiency, as more powerful machines need less labor to farm a larger field. The difference in projected labor productivity across countries and regions can therefore be partly explained in relation to developing countries by the broader usage of machinery in developed countries. This highlights the shortcomings of partial productivity metrics in accounting for fundamental shifts in farm inputs and their structure, which alter each input's respective contribution to farm productivity.

The standard of labor varies across countries, types of operations, regions, and many other aspects. High-skilled workers produce output that is different from low-skilled workers, resulting in very different production effects (OECD, 2001). When labor input is expressed in value terms (wage), variations in labor quality: failure to separate labor types in labor input valuation, for example, using wages for low skilled workers to measure labor given by high skilled labor results in biased calculations of labor costs and returns to labor. By using a physical measurement of labor productivity, this problem becomes absent: labor efficiency and working hours is accurately measured, this is shown in this country's higher labor productivity.

2.2.5 Capital Productivity in Agriculture

The contribution of labor engaged in the production process to capital productivity is estimated. Capital is commonly described as a farm-owned input that supplies services for many years. Most production measurements still reflect on farmhouses, machines, and facilities while calculating capital (GSARS, 2017). Labor supplied by hired and owner is usually considered as a type of capital (human), but it is generally calculated as labor input (OECD, 2001). However, due to the uniqueness of these features, the difficulty of calculating them (especially in developing countries), and the relative scarcity of literature on the subject, traditional assets such as machinery, equipment, and buildings are not suitable. It is good to analyze Ball & Harper (1990), for a detailed discussion of livestock as capital assets.

Capital productivity is measured using the following formula: productivity of capital = output volume/input volume of capital. The input of capital is estimated by calculating the service flows resulting from the capital employed. It is important to first estimate the stock of productive capital used by each type of asset in order to estimate the capital service, then to calculate rental rates, and, finally, to estimate the capital service flows.

2.2.6 Productivity of Intermediate Inputs

Intermediate inputs are products and resources that, during the accounting period or the farming season, are converted or completely used in the manufacturing process. They make up what is also known as intermediate use. In agriculture, intermediate inputs comprise farmer purchases of raw and auxiliary items utilized as inputs for various agricultural operations. These inputs include, but are not limited to, animal feed, electricity, diesel, oil and lubricants, crops, fertilizers, and soil improvers, plant health, veterinarian, maintenance, and repair services.

Because intermediate inputs are of a somewhat different type, a standard unit, usually a monetary unit must be used to sum them together. In general, intermediate inputs are priced at the farmer's efficient price, which may include subsidies and taxes. It is also suggested that subsidies and taxes be specified and quantified, as this is a useful source of information for assessing the value and impact of these benefits on farmers. In order to measure the productivity of intermediate inputs, the total agricultural yield, which consists of final products and intermediate (agricultural) products used for agricultural production, should be the numerator of the productivity ratio. The consequence of intermediate inputs consumption is already taken into consideration when value-added or net performance is used as the numerator. The inputs that have undergone some type of transformation from their original state in order to increase their efficiency are improved agricultural inputs. Farm inputs are classified into four major categories, namely biological, chemical, mechanical, and management forms.

High-yielding varieties, disease-resistant varieties, and drought-resistant varieties require biologically enhanced inputs. Chemically enhanced inputs include organic fertilizer, pesticides, fungicides, insecticides, and herbicides while mechanical inputs include field machinery and equipment used in tilling, weeding, drainage, spraying, and transportation. Management was focused with decision-making abilities and agricultural operations management in order to increase agricultural production. (Knight, Parker and Keep, 1972). The implementation and use of hybrids, greenhouse technology, genetically engineered crops, chemical fertilizers, insecticides, tractors, and other technological expertise are new agricultural inputs/technologies. Among other things, improving productivity in the agricultural sector would require a concerted effort to provide the farming community with high-yielding varieties that are resistant to drought and pests. Higher crop yields contribute to the arable sector's sustainable production because they decrease costs per product unit.

The features of factor inputs alone have an impact on the understanding of farmers and consequently the decision to use these inputs in production. The tastes of choice, market competition of fuel-wood of an enhanced choice influence the decision of the farmer to use an enhanced variety. The yield uncertainty associated with the use of such plants, such as their resistance to agro-climatic conditions, pests, and diseases, has been shown to have a substantial effect on the seed variety selection of farmers (Zeller, Diagne and Mataya, 1998).

2.3 Measurement of Efficiency

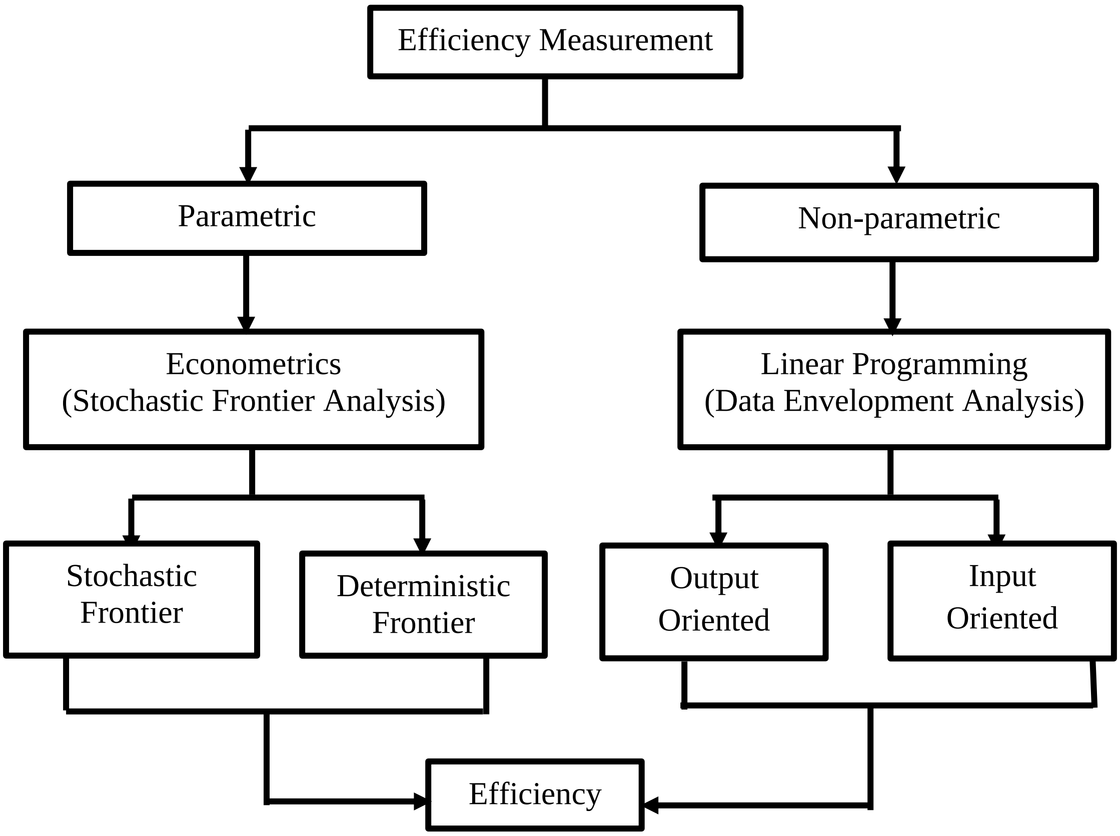
The word "efficiency" means that a farm’s performance allows the best use of its available capital to achieve optimum possible output levels. A farm is efficient if and only if it is not feasible without more inputs (without decreasing output) to increase output (decreasing inputs) (Cooper, Kumbhakar, Thrall and Yu, 1995). Failure to reach this possible maximum output leads to inefficiency. (Koopmans, 1951) studies the formal concept of economic efficiency. According to this analysis, when the output is maximized at the given amounts of inputs, a point of production is efficient. A firm's quality, or optimum possible output, is determined by the frontier of production. The distance to the boundary from the data point measured was included in efficiency analysis (Coelli, Rao, O'Donnell, & Battese, 2005). The neoclassical production theory describes production in terms of efficiency, which gives the best feasible output for the input quantities given. Recognizing this maximum output though by observing the actual quantity of output is impossible since the output measured is a maximum: various farms generate different levels of output despite using the same input vector (Kumbhakar, 1994). Differences in efficiency can explain the variation in output among farmers.

The terms efficiency and productivity are sometimes used interchangeably, but they are not necessarily the same. Productivity is an absolute term, like partial factor productivity and total factor productivity, and is determined by the proportion of outputs to inputs. Efficiency is a relative term that is calculated by comparing the real quality-to-input ratio with the optimal performance to input ratio. The modern history of calculating efficiency starts with Ferrell (1957), who described a measure of business efficiency. The efficiency of a company is defined as the ratio of future output to maximum potential output. This measures the performance of the firm in producing as much output as feasible from a given set of inputs. Technical inefficiency, allocative inefficiency or both may reflect a farm's production process. Ferrell (1957) is attributed to the notion of functional inefficiency. A farm is a technical productivity if, considering the amounts of inputs and technology, it achieves maximum output. The production frontier is therefore related to the maximum quantity of output possible. In other words, it is the location of the maximum possible output for each input combination. Technical inefficiency results from the farm's failure to accomplish the frontier quantity of produce given the number of inputs (Kumbhakar, 1994). Allocative inefficiency exists if, given relative input costs, farms fail to distribute inputs that reduce the cost of generating a given product. Such studies do not distribute inputs in the most appropriate way, i.e., resource misallocation or allocative inefficiency occurs. Failure to optimally distribute capital results in higher costs and reduced benefits. In fact, if the marginal input price, that is, allocative inefficiency, is when the farm fails to use cost-minimizing input mixes, a farm is considered to be allocatively inefficient. Weak adjustment to price increases and regulatory restrictions can be due to this (Atkinson & Cornwell, 1994). Allocative efficiency is thus characterized as the ability of farmers, given production technology, to change inputs and output to reflect relative prices. The difference between technical and allocative efficiency provides four different perspectives on farm productivity. First, a farm may display technical and allocative inefficiency; second, it may be technically successful but allocatively inefficient; third, it may display allocative efficiency but technical inefficiency; and fourth, it may be both technically and allocatively productive.

Economic efficiency includes both technical and allocative efficiency, and it represents a farm's ability to produce at the lowest possible cost. Therefore, any of the efficiencies will be necessary, but not adequate conditions to determine that a farm is economically efficient. The simultaneous achievement of all efficiencies offers the requisite conditions for economic efficiency to be ensured (Ellis, 1998). Ferrell (1957) suggested that a firm or a farm's economic productivity consists of two components. Technical productivity analyses the farm's capacity to achieve optimum production from a given range of inputs (output-oriented measures); or the least possible volume of inputs (input-oriented measures) to generate a given output level. Allocative efficiency examines the farm's capacity to make efficient use of resources in terms of their respective costs and processing technologies. Allocative inefficiency arises when production inputs are used to their fullest without minimizing the cost of producing a given output level. Economic efficiency is the result of technological efficiency and allocative effectiveness. A technically and allocatively productive firm is considered to be an economically efficient industry.

2.3.1 Approaches to Efficiency Measurement

In Figure 2.1, shows approaches to measuring efficiency are characterized as parametric or nonparametric. There are two types of parametric approaches: frontier approaches and non-frontier approaches. The frontier approach entails stochastic frontier analysis, while basic regression analysis is used in the non-frontier methodology. The nonparametric method can also be divided into non-frontier and frontier techniques. The frontier methodology involves the study of the data envelope, while the approach consists of the use of index numbers outside of the frontier. The key distinction between the parametric and the nonparametric is that a basic functional type for the output or cost function is defined by the parametric method, whereas the non-parametric does not (Vasilis, 2002). The parametric approach also relies on econometric methods that include stochastic frontier analysis and basic regression analysis Kumbhakar (1994), while mathematical programming methods are used for the nonparametric approach. Stochastic frontier analysis (SFA) is the most widely used parametric approach, and data envelopment analysis (DEA) is the nonparametric approach.

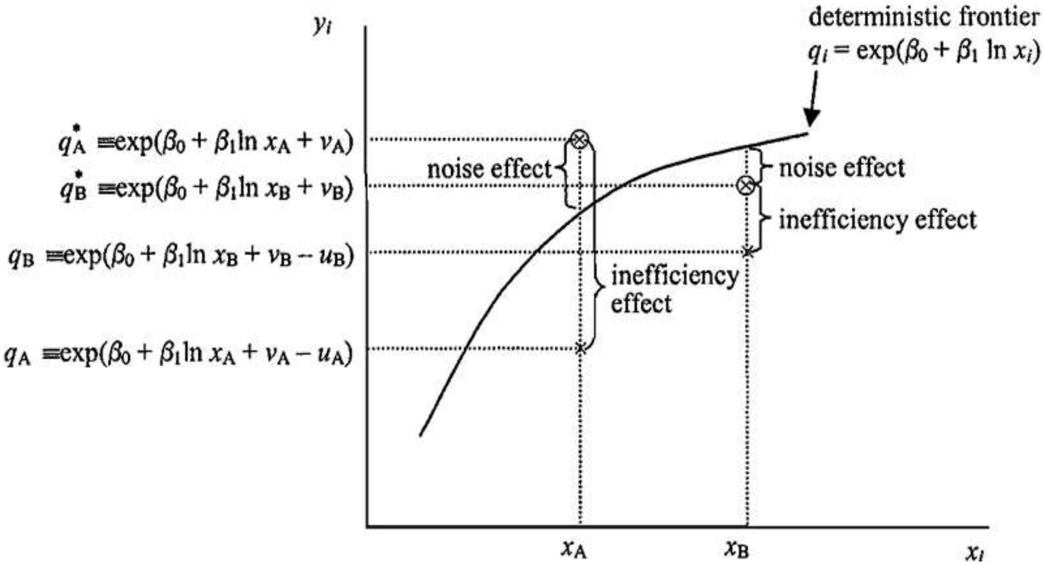


Source: Vasilis (2002), p.3

Figure (2.1) Approaches to Efficiency Measurement

2.3.2 Stochastic Frontier Analysis (SFA)

Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977) suggested the stochastic production frontier method, implying that deviations from the production frontier could not be completely under the firm's control being studied. For example, an unusually high number of random equipment failures, or even bad weather, could ultimately appear to the analyst as inefficiency under the interpretation of the deterministic frontier. A more attractive formulation holds that any specific company faces its own production border, and that border is randomly placed outside the Firm’s control. Therefore, the deterministic frontier is applied to the measurement error, all other statistical noise, and random variations Coelli et al. (2005), and this form of output frontier is called the stochastic frontier. SFA's main strength is its ability to distinguish error components (thus, measurement error and statistical noise) from inefficiency components. Separate assumptions are made about the distributions of the components of inefficiency and error, possibly leading to more precise relative efficiency measurements (Ferrell, 1957; Coelli, et al., 2005). The stochastic frontier production function model, however, is not without any problems. The key drawback of the stochastic frontier analysis is that the selection of some unique distributional type for the inefficiency variable of the error term is usually not justified a priori (Greene, 1990). The fundamental characteristics of the stochastic frontier model are seen in two dimensions in the figure;



Source: Coelli et al. (2005), p.244

Figure (2.2) The Stochastic Frontier Production Function

Limitation of attention to firms that generate the output q_i using only the one input x_i is easy. In this example, the form is taken by a Cobb-Douglas stochastic frontier model;

$$Lnq_i = \beta_0 + \beta_1 Lnx_i + v_i - u_i \tag{2.1}$$

or

$$Lnq_i = \exp(\beta_0 + \beta_1 Lnx_i + v_i - u_i) \tag{2.2}$$

or

$$Lnq_i = \underbrace{\exp(\beta_0 + \beta_1 Lnx_i)}_{\substack{deterministic \\ component}} \times \underbrace{\exp(v_i)}_{noise} \times \underbrace{\exp(u_i)}_{inefficiency} \tag{2.3}$$

The model is referred to as the stochastic frontier output, defined by equation (2.1), this is because the output values are bounded by the stochastic (random) $\exp(x_i\beta + v_i)$ vector above. The random error, v_i , may be positive or negative, so the outputs of the stochastic frontier differ from the deterministic component of the frontier model, $\exp(x_i\beta)$.

In figure, such a frontier is represented, the inputs and outputs of two firms, A and B, are plotted, and the deterministic component of the frontier model has been drawn to reflect the existence of a deterministic component of decreasing return to scale. The input value is determined along the horizontal axis and the inputs are estimated along the vertical axis. In order to create the outputq_A, Firm A uses the input levelx_A, while Firm B uses the input level x_B to obtain the output levelq_B.

If there were no efficiency effects (if $u_A = 0$ and $u_B = 0$) then for firm A and B respectively, the so-called frontier outputs would be $q_A^* \equiv \exp(\beta_0 + \beta_1 Inx_A + u_A)\ and\ q_B^* \equiv \exp(\beta_0 + \beta_1 Inx_B + u_B)$. The points indicated by $\otimes$ in the figure show these frontier values. It is obvious that firm A's border output is above the deterministic segment of the production boundary only because the noise effect is positive ($v_A > 0$), whereas firm B's border output is below the deterministic segment of the border because the noise effect is negative ($v_B < 0$). It can also be shown that since the amount of the noise and inefficiency is negative ($v_A - u_A < 0$) the measured performance of firm A is below the deterministic portion of the boundary.

Such aspects of the frontier model generalize to the condition where multiple inputs are used by businesses. In particular, (unobserved) border outputs tend to be distributed uniformly above and below the deterministic portion of the border. Observed production, however, continues to lie below the deterministic portion of the boundary. Indeed, if the noise effect is positive and greater than the inefficiency effect (q_i^*> exp ($x_i'\beta$) if $\varepsilon_i \equiv v_i - u_i > 0$, they can only lie above the deterministic part of the frontier.

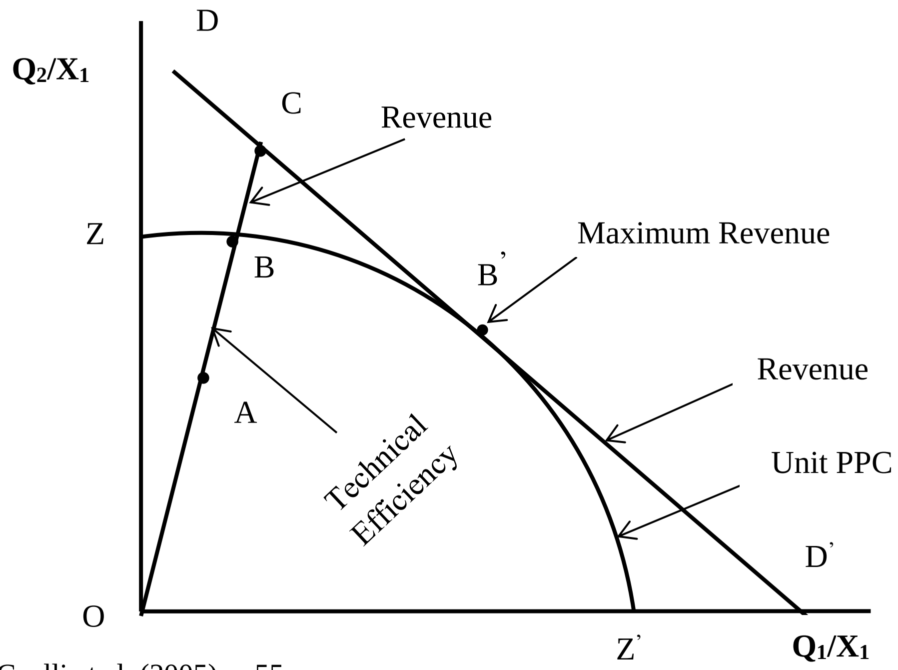
2.3.3 Data Envelopment Analysis (DEA)

Based on Ferrell's (1957) seminal work, Charnes, Cooper, and Rhodes (1978) were the first to implement the approach of data envelopment to estimate efficiency. The approach has become the basis for most subsequent developments in the technical efficiency nonparametric estimation approach since its introduction. The DEA employs statistical linear programming strategies to determine the range of weights for each firm that maximizes its efficiency scores, with the caveat that none of the firms has an efficiency score greater than 100 percent at those weights, according to Charnes et al. (1978) and Vasilis (2002). For each firm, the weights will differ in such a way that the output of each particular firm correlates with the remaining firms in the most favorable way. If the weighting range that maximizes its relative output produces scores greater than 100 percent for every other industry, the model will reject the solution for a particular firm. If a firm's score in the approximate range of weights that maximize relative efficiency is less than 100 percent, it is said to be inefficient. These successful firms are referred to as the inefficient firm's peer group (Vasilis, 2002).

The primary strength of the DEA is that a prior definition of the functional type for the output frontier is not necessary. In addition, no specific assumptions regarding the distribution of error terms are required by the DEA. The key drawback of the DEA is that it assigns to inefficiency any deviation of an experiment from the frontier, indicating that the model does not provide for statistical noise or measurement error. Ray (1985) and Coelli et al. (2005) are two examples.

2.3.4 Output-oriented Efficiency Measures

In order to demonstrate the output-oriented measurement, the input-oriented efficiency measure can be adapted. Figure (2.3) shows the two output cases (Q_1 and Q_2) and the single input case (X_1).



Source: Coelli et al. (2005), p.55

Figure (2.3) Output-oriented Efficiency Measures

In order to demonstrate the output-oriented measurement, the input-oriented efficiency measure can be adapted. Figure (2.3) shows the two output cases (Q_1 and Q_2) and the single input case (X_1).

$$TE = OA/OB$$

The curve ZZ 'represents the frontier of production. The inefficient firm is represented by Point A as it lies below the effective boundary. The distance AB represents inefficiency of production. Thus, without requiring any extra input, the firm producing at point A could boost output to point B. Technical efficiency is calculated according to the ratio;

$$AE = OB/OC$$

It is presumed in the output-oriented case that the behavioral aim of the organization is to maximize sales. Price data is expressed by the DD 'isorevenue line. When moving from point B to B, 'the distance BC can be imply that the increase of revenue, and define allocative efficiency.

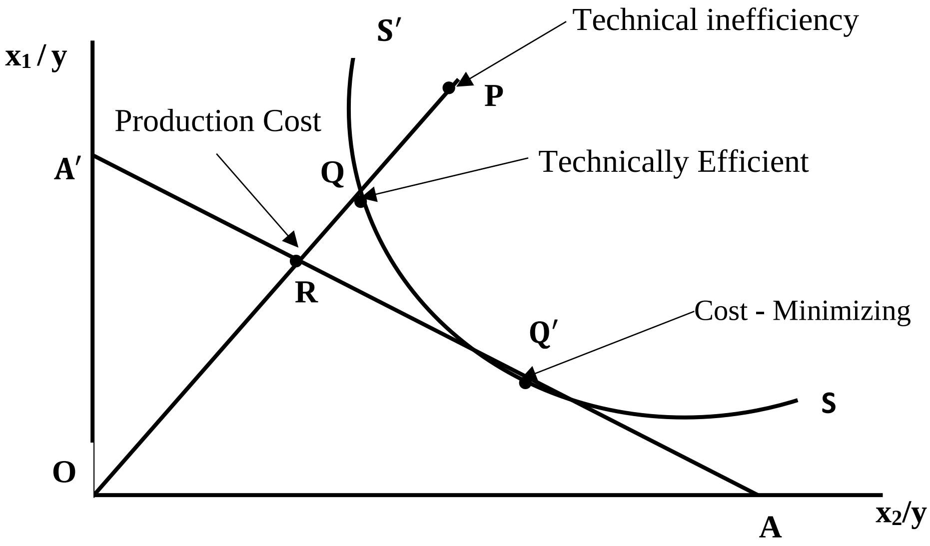
$$EE = TE \times AE = (OA/OB) \times (OB/OC) = (OA/OC)$$

Notice that the OA / OC ratio is the product of technical efficiency and allocative efficiency. These two examples illustrate the radial measurements of input-oriented and output-oriented performance introduced by Farrell. These steps are identical to returns to scale. e orientation must be chosen in accordance with the technology used in the decreasing and increasing return to scale scenarios.

2.3.5 Input-Oriented Efficiency Measures

Ferrell's (1957) approach established a solid foundation for the study of efficiency and production. There are two components of total economic efficiency (OE) in this study: technical efficiency (TE) and allocative efficiency (AE). Koopmans' work appears to have had a significant impact on Ferrell's explanation of efficiency. Technical efficiency is the ability to generate a material from a variety of inputs identified on the Production Possibilities Frontier. Allocative efficiency is the ability to utilize inputs combination to generate a material that corresponds to the minimum cost of output. In other words, allocative efficiency is the ability to use the optimum inputs combination to produce a given level of output. The economic, technical and allocative efficiency descriptions based on the work of Farrell are discussed below.

Figure (2.4) graphically illustrates technical, allocative, and economic efficiency. This is used to demonstrate the idea of steps directed towards input. In the figure, it is assumed that farm use two inputs (x_1 and x_2) to generate a single output (y) and that the processing technology is summarized by a linearly homogeneous production function, assuming that constant returns to scale, and P, respectively, depict the frontier unit isoquant for this technology and an inefficient production activity.



Source: Coelli et al. (2005) p.52

Figure (2.4) Input-Oriented Efficiency

P is a technically inefficient farm.

Q = a technically efficient farm (any point onSS′)

Q′ = an allocatively efficient farm (Cost-Minimizing)

AA′ = the isocost line

SS′ = the unit isoquant

OP = production activity

Because it lies on the isoquant boundary, the production operation represented by Q and defined by the intersection of the line segment OP with the isoquant SS' along the ray OP provides a effective input combination. The distance QP indicates the farm's inefficiency at point P, and it is the total by which all inputs will be proportionally reduced while maintaining the same level of output. Technical efficiency is represented in percentage terms by the QP/OP ratio, which shows the proportion by which all inputs must be decreased in order to produce a technically efficient output. The farm working at point Q is fully technically effective since it is situated on the isoquant and TE = 1, effective and frontier. The technical output of the farm at point P is expressed as;

$$\text{Technical Efficiency: } TE = 1 - QP/OP. \quad (0 \leq TE \leq 1)$$

In the figure, "AA" refers to the input price ratio, which is specified by the slope of the isocost line. The OR/OQ ratio is defined as the farm's allocative efficiency (AE) at P as the distance RQ indicates the cost decrease that would occur if production took place utilizing the allocative efficient input ratio at point Q' rather than the allocative inefficient input ratio at point P. The equivalent cost-minimizing point for the input combination is point Q. At point P, the farm's allocation efficiency will be stated as follows:

$$\text{Allocative Efficiency: } AE = OR/OQ \ (0 \leq AE \leq 1)$$

The distance QR indicates the cost of output that could be minimized if the farm produced at the technically and allocatively productive point Q rather than at the technically but not allocatively efficient point Q. The total economic efficiency is measured by the OR/OP ratio, although the RP distance can also be defined in terms of cost savings. Technical and allocative efficiency steps result in overall economic efficiency.

$$\text{Economic Efficiency: } EE = OQ/OP = (OQ/OP) \times (OR/OQ) = TE \times AE \ (0 \leq EE \leq 1)$$

Efficiency typically has three components, namely: technical efficiency, allocative efficiency, and efficiency of scale. Technical efficiency shows whether the maximum output from a given input bundle can be achieved by a firm. A firm's allocative productivity reflects the capacity to use inputs, provided their respective costs are in optimum proportions. That is, if its inputs maximize its profit or minimize its costs at given prices (Latruffe, 2010). Allocative efficiency means technological efficiency since the firm must first lie on the frontier of output in order to increase its profits. However, technological efficiency does not inherently imply allocative efficiency, because the mix of outputs and inputs can be maximized in terms of production possibilities but not profitably. Scale efficiency, on the other hand, determines whether or not the firm works optimally at its current size. Scale-efficient enterprises compete with constant returns to scale (CRS) and have a scale elasticity of one, whereas scale-inefficient firms can benefit from scale economies or diseconomies (Coelli, 1996). The firm's economic performance is comprised of technical, scale, and allocative productivity ratings added together (Latruffe, 2010). It is also critical to recognize that a farmer may be technically efficient but not allocatively efficient, and that economic efficiency is thus required.

According to Ferrell's pioneering work (1957), efficiency is the ability to produce at the lowest cost for a given level of production. Technical productivity is the farm's ability to produce a maximum volume of output given an equal volume of production inputs. Allocative productivity is the degree to which farmers relate a factor of production's marginal value product to its price. According to Ogundele and

Okoruwa (2006), economic efficiency combines both allocative and technological efficiency. It is accomplished by integrating the producer's resources in the simplest possible way to generate maximum production (technical) and secure maximum revenue at the lowest possible cost (allocative). According to Douglas (2008), if the farm is efficient in terms of technique and allocation, the enterprise is deemed to be cost-effective. To allow the commercialization of agriculture from subsistence agriculture, these farmers must be both technically and allocatively productive.

2.3.6 Allocative or Price Efficiency

The efficiency of allocation is a condition in which a firm's limited resources are distributed in accordance with customers' preferences. An "optimal combination" of goods produces an allocatively productive market. When the price in perfect competition equals the firm's marginal costs, the firm is allocatively efficient. Allocative efficiency indicates an optimal division of resources within an economic situation in which no conceivable reorganization of output resources will make certain customers better off without leaving others worse off. Allocative efficiencies and technical efficiencies can be estimated if pricing information is accessible and a conducting goal is appropriate. ehavior objectives may include cost minimization or income or benefit maximization. Benefits are maximized when costs are minimized and income is maximized (Mendes, Emiliana, and Azevedo Santos, 2013).

The firm must therefore select a combination of inputs to be applied in the correct proportions and be technically efficient at low prices in order to achieve production at reduced costs. It induces profit maximization. While new approaches are being developed to estimate allocative efficiency, it has historically been difficult to estimate allocative efficiency without input and output prices. Based on this claim, it was called "price efficiency" by some scholars like Farrell, referring to a firm's capacity to select the optimum combination of inputs given input prices.

Allocative effectiveness is a measure of how well a firm uses output and inputs to maximize profits in the best possible combination (Inoni, 2007). he farm's allocatively productive level of output is hence where it operates with the lowest-cost input combination. Most studies have used the benefits obtained by adjusting input ratios based on the assumption that maize production and factor markets are the future price structures of the goods that this research examines (Chukwuji, Inoni, Ogisi, &

Oyaide, 2006). Assume that farmers allocate capital to maximize income, and that farmers are those who choose the best combination (low cost) of inputs to generate a profit, optimizing the level of production. In perfect competition markets, producers are price takers and are presumed to have perfect market information. All inputs are of the same quality from all market producers. Allocative efficiency may be defined as the ratio of the total cost of generating a given level of output in a technically efficient manner using actual factor proportions to the whole cost of producing a given level of output in a technically efficient manner utilizing maximum factor proportions (Inoni, 2007). Thus, in fully competitive markets, in order for the farm to maximize profit, the extra income generated by the employment of an extra unit of a resource (marginal value product) must equal its unit cost (marginal cost = unit price of input), Chukwuji et al (2006).

2.3.7 Technical Efficiency

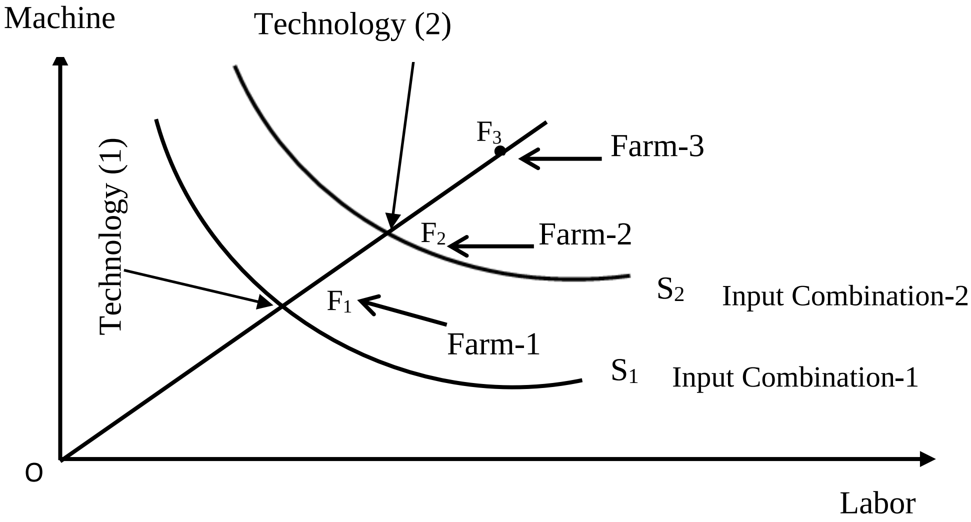
Technical efficiency is only one aspect of total economic efficiency. However, in order to achieve economic efficiency, a company must be technically efficient. In order to maximize profits, a company must attain technological input and output allocative efficiency (Kumbhakar & Lovell, 2003). Technical efficiency is the rate at which the maximum output is produced from a given set of inputs, or the use of the fewest inputs to achieve a given amount of output. These two technical efficiency explanations result in output-oriented and input-oriented efficiency approaches. When technology shows constant returns to scale, these two indices of technological efficiency will coincide (Coelli et al., 2005). A farm is considered to be technically inefficient if, given the available resources, it does not produce the full amount of output that can be projected (GSARS, 2017a). Increasing technical efficiency or decreasing technical inefficiency boosts productivity by allowing more output from the same set of resources. The concept of technical efficiency is founded on the concept of the development frontier, which is the maximum performance that technology allows. Because technology varies, this frontier differs among nations, regions, and agro-climatic zones in the sense that production factors, such as soil types, rainfall, sunlight intensity, or skilled workforce availability, frequently fluctuate (GSARS, 2018).

According to Battese and Coelli, technical efficiency is defined as the ability to maximize output from a given set of inputs (1995). It is concerned with productivity in respect to product transformation factors. A farm must produce at the output border level in order to be physically competitive. However, as Adeoti and Baruwa point out, this is not always the case due to random variables such as adverse weather, animal loss, and/or farm-specific characteristics that result in production below the expected performance frontier (2019). As a result, efficiency analysis seeks to categorize farm-specific characteristics that limit development along the frontier. According to Battese and Coelli (1995), as cited in Douglas (2008), functional quality extends beyond an overall production-based measurement to one based on the best results in a given group, and it is linked to competitiveness when inputs are turned into outputs. Efficiency evaluation also provides the capacity to identify output results from management failure (Ogundari & Ojo, 2005). It is also concerned with the quality of the input-to-output transformation.

The efficiency of the production process is frequently assumed to represent agricultural output based on two components: the form and nature of the inputs used in the production line, as well as how well they are integrated. The first element concerns production technique, while the second addresses the technical efficiency of manufacturing operations. The efficiency of the production process is usually assumed to represent agricultural output, and it is controlled by two factors: the type and quality of inputs utilized in the production process, as well as their combination. Due to the technological change, agricultural plans tend to rely more on promoting productivity than on making better use of current technologies. However, given the scarcity of natural resources such as land and water, as well as the need to reduce agricultural production's environmental footprint, refocusing agricultural policies on efficiency is critical. It is conceivable to foresee equivalent physical production benefits, if not bigger economic benefits, through better utilization of current technologies rather than switching to new technology. For example, before recommending farmers to employ chemical fertilizers (technological change), conventional fertilizing options involving organic fertilizers and crop rotations or mixes (technical efficiency) may be advocated.

Productivity is the amount of output that can be generated from a given number of resources, whereas technical efficiency is how well a farm is able to integrate the numerous inputs and production elements into the production process to obtain the highest output quantity. It is more efficient if a farm produces the same quantity of product with fewer resources or produces more products with the same resources. It is not inherently more effective, however, because this increase in efficiency may be attributable to the availability of better inputs (i.e., technological progress), such as newer seed varieties or more potent fertilizers or pesticides, rather than to better use or combination of existing resources.

Technical efficiency is based on the concept of the production frontier, which is the greatest performance allowed by technology. This boundary fluctuates throughout nations, regions, and agro-climatic zones because technology differs and development conditions, such as soil types, rainfall, sunshine intensity, or the availability of skilled labor, vary.



Source: Rada and Valdes (2012), p.25

Figure (2.5) Technology Change and Efficiency

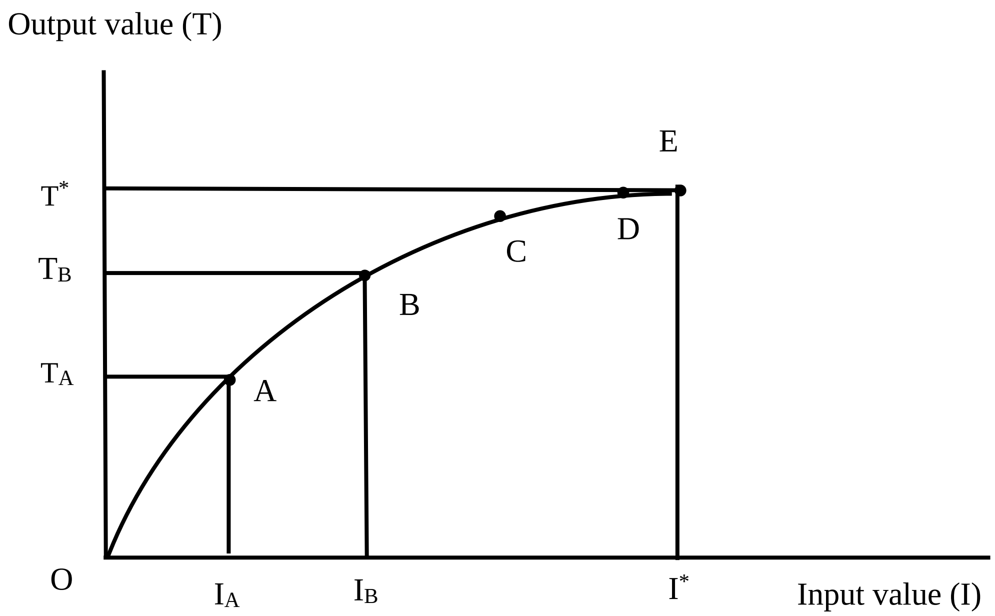
The conceptual discrepancy between productivity and technological performance is illustrated in figures by Rada and Valdes (2012). To produce the same amount of output, the S_1 and S_2 curves reflect different input combinations: two different processing technologies with different levels of productivity. Farms running on the technology (1) need less input to generate the same amount of output as those running on the technology, and (2) are more efficient. For each respective technology, any combination of inputs on the frontiers is consistent with technical efficiency.

Therefore, farms F_2 and F_1 are both technically efficient when their productivity is measured against their respective technologies. Given that F_3 has access to the same technologies as F_2 (the same farm size locality), any movement of F_3 to the frontier is an improvement in both technological efficiency and productivity. Assuming that technology (1) (the introduction of new high-yielding or pest-resistant varieties) is now accessible to F_2 and F_3, the shift from F_2 to F_1 is equal to an increase in productivity, as fewer inputs are needed to generate a given production quantity, but not an increase in technical efficiency; the increase in productivity is due solely to technological improvements.

2.3.8 Economic Efficiency

According to Kelly et al. (1996), when the marginal value of the inputs is equal to their respective unit costs, an agricultural holding achieves economic efficiency; if the marginal value is greater, by producing more, the holding will gain a higher income, thereby being more productive. If the marginal value is lower, to increase its income, the farm should reduce its output.

Figure (2.6) demonstrates the trend of convergence towards economic efficiency. The y-axis reflects the output value and the input cost of the x-axis. The line illustrates how inputs are converted into outputs; the points on this line mean that the farm performs at the maximum possible output or output, provided the kind and nature of inputs used, that is, that it is technically effective. Given set input and output costs, any rise in production value for a technically efficient holding (from TA to TB, for example) is attributed to the input quantity used (from I_A to I_B).



Source: FAO (2017), p-20

Figure (2.6) Economic Efficiency

The output value to input value ratio calculates the amount of value produced by a single monetary input unit; in other words, the economic return on investment per monetary unit spent. This measurement is also known as unit margins or profits. The figure demonstrates that the additional return provided by increasing input utilization decreases as more inputs are used; the additional value generated by moving from A to B is greater than the additional value generated by moving from B to C, and so on until reaching E. Any additional input utilized after E does not result in a greater output, implying that the additional output is 0. E can alternatively be thought of as the point at which the farm is economically efficient: before E, there is the opportunity to raise total profitability by using more inputs; after E, higher input consumption results in decreased income. This is related to the occurrence of decreasing returns to scale in agriculture, which is a well-known and often seen phenomenon due to physical restrictions on yields and production.

In fact, a technically effective farm can be economically inefficient. It is especially true in poor countries where markets are often thin or non-existent, inputs are constrained (inaccessible or difficult to access), and transaction costs are high. For example, a farm may need to use more of one type of input to reach technical efficiency standards, but it may not have an economic incentive to do so under present market conditions (for example, very high input costs). Understanding the output restrictions that farmer's face requires information on the marginal productivity of essential inputs as well as their acquisition costs.

Moreover, the notion of economic efficiency is largely irrelevant for certain groups of farms, especially those in which the subsistence of their related households is their prime objective. For certain businesses, the production of more food may not be a goal if self-sufficiency is assured, even if higher economic returns are obtained by doing so. Agricultural households that do not produce enough to meet their needs cannot envision reducing production in order to maximize economic efficiency. The analysis of farms through the economic efficiency method should be limited to commercial farms. The first step is to evaluate how profitable farming might be compared to other alternative industries by gathering information on the underlying economic profitability of subsistence farms. Second, the dividing line between commercial and subsistence farming were not clear. Farms may operate activities that serve various purposes, such as household food production, cash income generation, or both.

2.4 Factors Affecting Technical Efficiency in Farming

While it is beneficial and very important to use improved inputs in production, not all farmers use improved agricultural inputs for different reasons. The determinants of the use of productivity efficiency are defined by (Langyintuo & Mekuria, 2005), as farmers' characteristics, institutional factors, and input characteristics. The characteristics of farmers include gender, age, education, and household size, while institutional variables include such as farm size, association membership, access to knowledge, and access to credit (Das, 2016). Production input characteristics refer to the subjective qualities of the input as viewed by the farmer.

2.4.1 Socioeconomic Characteristics of Farmers

The characteristics of farmers, such as gender, age, level of education, and marital status, etc., have their own effects on the decision of the farmer's applied of agricultural inputs. Gender influences the quality of farmer productivity, such as enhanced seeds and animal traction. Women dominate their production patterns and usage of agricultural productivity due to socioeconomic variables such as land access limits and poverty (Appleton & Scott, 1994). The findings those women's perceptions of productivity are dependent on their risk levels, such that utilization of productivity decreases when the harm is thought to be high. As a result, Wongnaa (2016) proposed that gender be included as one among the variables to consider in enhancing input usage, noting that the provision of extension services, which are critical in the use of production, is often organized by men, who are partially towed in most cases. While women dominate African agriculture, they have a soft spot for their male counterparts. Gender should be included as a variable in improved input utilization research because women-headed farm families are poorer than male-headed farm families (Uganda Bureau of Statistics, 2010). Okoboji (2011) discovered, for example, that a higher percentage of male-headed households use various agricultural inputs in agriculture than female-headed households. The greater likelihood of male-headed households using fungicides/herbicides in development than female-headed households can be linked to household economic status and/or access to expertise.

The reasons given for mixed outcomes in terms of age and increased use of inputs are that young farmers may have lower wages and resources, be restricted to credit access and extension services, and face labor restrictions, all of which may make them less likely to embrace and use improved agricultural technology than older farmers and thus have a positive relationship with adoption (Langyintuo & Mekuria, 2005). Young farmers, on the other hand, are often assumed to be more open to improvement and thus willing to pursue new ways of doing things, thus a negative association between age and increased use of inputs. Other variables that have a major effect on technological productivity include the age of farmers and years of farming experience. Many tests have found that younger farm heads are technically more effective than older farm heads. Several research findings have found that younger farm heads are technically more successful than older farm heads. Amaza and Maurice (2005); Coelli, Rahman, and Thirtle (2002); Dhungana, Nuthall, and Nartea (2004); Javed, Adil, Ali, and Raza (2010); Mariano, Villano, and Fleming (2010); Villano and Fleming (2006); Vu (2008), discovered that agricultural experience had a considerable favorable impact on technical efficiency. There have been no significant findings on the association between farm household members or staff numbers and technical efficiency in rice-based farming.

In Bangladesh and the Philippines, Coelli et al. (2002) and Mariano et al. (2010) observed the negative effect of family size on technical efficiency, suggesting that big families were likely to be more inefficient. Sanzidur and Mizanur (2008), estimated that increasing the number of farm family members engaged boosted the technological efficiency of paddy farmers in Java, Indonesia, and Bangladesh, respectively. Dhungana et al. (2004), observed an insignificant positive effect on the share of family labor in rice output. Amaza and Maurice (2005) and Mariano et al. (2010) have found that farming experience has had a substantial positive impact on technical efficiency. Off-farm work also affects the efficiency of rice-based farms. The data suggest that off-farm income is adversely associated with rice farms' technical efficiency (Villano and Fleming, 2006). The relationship between the share of off-farm income, which is off-farm income to total income, and technical efficiency is also observed. Coelli et al. (2002) observed that higher technical efficiency is more likely for farms with a smaller share of off-farm production.

Asadullah and Rahman (2009); Dhungana et al. (2004); Huynh and Yabe (2011); Mariano et al. (2010), found that in terms of farmers' education, the influence of education on technical efficiency is relatively unclear, despite the fact that the vast majority of research concluded that fewer schooling years for farm heads diminishes technical efficiency. Coelli et al. (2002); and Sanzidur and Mizanur (2008); Villano and Fleming (2006), there was no significant effect on rice farm farmer education's technical productivity. Vu (2008) revealed that middle and higher education had a negative influence on technical efficiency. Higher-education farmers prefer to transition to non-farm operations, but their education does not lead to technical efficiency. In literature, the role of education in the use of enhanced inputs by farmers is widely discussed. Skilled farmers are believed to have a higher capacity than their peers with very little or none knowledge to perceive, interpret and react to new knowledge about advanced technology (Langyintuo and Mekuria, 2005, Tabi, Vabi, and Malaa, 2010). Therefore, more trained farmers are more able to access knowledge and advice from extension workers concerning their acceptance and utilization of enhanced inputs.

Human capital, especially the expertise and education of farmers, has been the most widely investigated factor. Dhungana et al., 2004; Stefano and Saxena, 1988; studies have shown that schooling for farm operators and the age of farmers can have an effect on productivity levels. Other researchers found that the level of knowledge of farmers was a critical factor in productivity. (Coelli and Battese, 1996; Dhungana et al., 2004). There is, however, contradictory data regarding the effect on farmers of schooling. Most studies argue that because of their improved skills, access to technology, and effective farm preparation, there will be more economically productive farms with more skilled farmers. Coelli and Battese (1996), Dhungana et al. (2004), Villano and Fleming (2006), and Asadullah and Rahman (2009) revealed that farmers' education was important for the enhancement of agricultural technical efficiency in India, Nepal, the Philippines, and Bangladesh. Coelli et al. (2002), on the other hand, failed to recognize a significant impact of education on technical efficiency in Bangladesh. Coelli and Fleming (2004); Fleming and Hardaker (1994): Villano and Fleming (2006) observed a significant negative influence of schooling on technical efficiency in Papua New Guinea and West Sumatra, respectively. Rios and Shively's analysis of Vietnamese coffee farms revealed that higher levels of education on small farms reduce production because education increases the possibilities for off-farm job and so reduces the strength of on-farm management (Rios & Shively, 2005).

2.4.2 Institutional Factors

The impact of institutional factors on farmers' usage of improved inputs, such as credit, information, infrastructure, and association membership, has received considerable attention from researchers. According to Langyintuo and Mekuria (2005), farmers with large farms use lumpy inputs like tractors or animal traction to plow soil, whereas farmers with small farms do not. According to Zhou, Yang, Mosler, and Abbaspour (2010), there is an inverse relationship between inputs usage and farm size. This suggests that the relationship between farm size and increased input utilization may not be straightforward. Credit's importance in financing farmer investments in enhanced technologies such as high-yielding seeds, fertilizers, and machinery cannot be emphasized, especially in developing nations where smallholder farmers are often financially limited. Credit access constraints have been identified as one of the barriers to the acceptability and usage of improved agricultural inputs in industrialized countries. Feder, Just, and Zilberman (1985) conducted a literature review and determined that most studies find a favorable link between farmer access to financing and the deployment of upgraded technologies.

Furthermore, according to some studies, financing availability, irrigation, and environmental degradation all have an impact on technical performance. Access to irrigation may have an impact on rice-based agricultural systems. Non-cereal crop expansion, for example, has stalled in Bangladesh's rice-based cropping system due to incompatibility with contemporary irrigation methods (Mahmud et al., 1994). According to Wadud and White (2000), diesel-powered irrigation systems improved technological inefficiency in Bangladesh. Huynh and Yabe (2011) discovered that irrigated fields produced rice more efficiently than non-irrigated farms in Vietnam. Wadud and White (2000) discovered that farms with adequate soil quality were physically less inefficient. According to Javed et al. (2010), farms with greater credit access were technically more effective than those with restricted or no credit access. In encouraging better agricultural practices for farmers, extension programs are considered a great source of information and play a major role as they establish ties between the stimulus mechanism and the acquisition system (Sunny, Huang & Karimanzira, 2018). Any of the most significant providers of agricultural knowledge in any country are extension officers. Through increased government spending on extension programs, farmers' access to knowledge on agricultural technology is crucial in exposing the possibilities of using such technologies, thus minimizing subjective confusion on the one side and encouraging increased adoption on the other (Langyintuo & Mekuria, 2005). In the agricultural production process, facilities such as highways, storage, and irrigation are important. In terms of proximity to input and export markets, roads are important while storage is important for storage to preserve crop quality in order to delay immediate sales to a future date. Ransom et al. (2003) illustrate that the availability and usability of these infrastructures enhance the possibility of improved technology being used. Agricultural expansion can be considered one of the most important sources of information directly related to agricultural production activities, particularly in countries where access to information is very restricted for farmers. Extension education has a significant impact on the deployment of advanced technology and technical efficiency in rice-based agriculture, according to studies by Adesina and Zinnah (1993), Baidu-Forson (1999), Javed et al. (2010), and Sanzidur and Mizanur (2008). Extension programs appear to be significantly related to farm technical efficiency.

2.4.3 Farms Characteristics

In developed countries, most agricultural productivity research follows the theory set out in Schultz's paper (1964) in which he indicated that smaller farms were more productive because the land was used more intensively or allocated to labor more efficiently. A study on the relationship between farm size and productivity is included in the literature. Several studies have identified a negative association between farm size and farm technological efficiency, although Huang and Bagi (1984), Ray (1985), and Croppenstedt (2005) discovered that small and large farms are nearly equally successful. According to Helfand and Levine (2004), the relationship between farm size and efficiency is nonlinear, with performance initially declining and then increasing with volume.

Several researchers have determined that changes in management feedback affect more than size. According to research, productivity is not tied to the relationship between size and output, but rather to managerial control (Adesina & Djato, 1996; Hoque, 1988; Shively & Zelek, 2003). An important study is to assess farm size and other considerations. Gordon and Davidova (2004) discovered that the ideal farm scale is dependent on a number of criteria for a specific production system in a given area. In research designed to explore variations in individual farm efficiency, two types of factors were examined: agency and systemic impacts. First, the most prevalent agency consideration analyzed was human resources, such as the impact of expertise and training for farm headers (Stefano and Saxena, 1988; Summer & Leiby, 1987). With regards to systemic causes, these may be divided into on-farm and off-farm concerns. The most influential on-farm topics investigated were agri-environmental factors, including soil quality, altitude, temperature, rainfall, and access to water. Institutional variables such as partnerships and the occurrence of transaction costs between participants in the agricultural supply chain are examples of off-farm systemic considerations. According to the majority of studies, the smaller the farm scale, the lower the technological productivity of farms in terms of farm size (Kompas, 2004; Fabiosa, Jensen, & Yan, 2004; Vu, 2008). Javed et al. (2010), analyzing the rice-wheat system in Pakistan, found that technical efficiency and farm size were inversely correlated. The contradictory evidence presented by observational studies indicates that individual economies within developing countries would exhibit a uniform relationship between farm-scale, land fragmentation, crop diversification, and other technical productivity determinants.

Crop diversification is the practice of growing several crops on a single farm. The move from subsistence food preparation to agricultural production often improves crop diversification (Ibrahim, Ramman, Envulus, and Oyewole, 2009). Crops that are mixed and diverse can be cash crops, subsistence crops, or alternative or non-traditional cash crops (Vedenov et al., 2007). In relation to agricultural diversification, the choice of crops will be determined by the commercial preferences of farm households. According to Pingali and Rosegrant (1995), food processing processes can be described as subsistence, semi-industrial, and commercial systems. As economies grow, households shift away from traditional objectives of self-sufficiency and towards decision-making based on profit and revenue, so farm production is more vulnerable to demand trends as a result. Both seasonal diversification from rice monoculture systems by incorporating non-rice crops in rice rotation and the implementation of advanced goods led to expanded commercialization of rice farming systems.

Farmers grow different kinds of crops as a precaution against risks that could occur due to bad weather, crop disease, and falling crop prices. However, knowledge of the type of soil and its nutrients, the quantity of inputs to be used and when the crop needs to be cultivated, and estimates of potential markets are required for the additional crop to be cultivated on a given land plot and crop diversification outcomes of administrative uncertainty (Haji, 2006). The healthy functioning of an ecosystem can be sustained by diversified crop systems and allow it to absorb not only shocks to the natural resource base but also shocks generated by sudden economic changes.

Smallholder farmers improved productivity more successfully by diversifying their activities through an adaptive growth plan that included a combination of new cash farming activities. Fleming and Hardaker (1994), found that the main pathway to the growth of smallholder farming systems has been modern technologies, managerial strategies, and field husbandry practices that are simple and cost-effective. This technique necessitates significant skill in order to make good use of family labor and managerial resources, particularly through crop diversity. Few studies have been conducted to analyze the relationship between crop diversification and farm technical efficiency, with varying results. Crop diversification enhances farm technological efficiency in Papua New Guinea and Bangladesh, according to Coelli and Fleming (2004) and Rahman (2009), respectively, whereas Haji (2006) indicated that crop diversification reduces farm economic efficiency and allocation in Ethiopia. According to Vedenov et al. (2007), coffee or other cash crop production from staple crops results in increased productivity due to economies of diversification, however coffee production from other cash crops results in lower quality.

2.5 Review of Empirical Studies on Technical Efficiency of Paddy Production

Researchers studied the technical efficiency of paddy production in various regions, employing models and variables to analyze and determine the level and determinants of technical efficiency.

Baten and Hossain (2014) used panel data and the stochastic frontier development model with either truncated normal or half-normal distributional assumptions to examine the state of technological efficiency in paddy production in Bangladesh. Inefficiency impacts were calculated using both time-variant and time-invariant models. When the half-normal distribution was determined to be superior to the truncated normal distribution in terms of technical inefficiency effects, technical efficiency progressively improved over time. For both time-variant and invariant distributions, the value of technological efficiency for paddy production in Bangladesh was determined to be high. According to the study, the most efficient paddy processing system had a technical efficiency of 0.98.

The Stochastic Frontier Model is used in the Balde, Kobayashi, Nohmi, Ishida, Matsumura, Esham, and Tolno (2014) analysis to examine the technological efficiency of mangrove rice production in Guinea. The study relied on primary data gathered during a field survey. The study found that increasing farm acreage and lowering the cost of depreciation on farm equipment improves mangrove rice yield significantly. The inefficiency model revealed that the age of the household head, household size, farming experience, off-farm income, and remittance all had a significant impact on technological efficiency. The average level of technical efficiency was 23 percent, with efficiency ranging from 0% to 100%.

Fatima, Mukhtar, and Badar (2016) investigated the primary factors of farm income and technical productivity in the Punjab, Pakistan districts of Bahawalpur and Rahim Yar Khan. They used the Stochastic Frontier Cobb Douglas production function. Technical efficiency was assessed to be around 65 percent. According to the data, farm managers are only around 65% effective on average in controlling farm income, and there is still space for a 35% rise in farm income through improving productivity. Low farm product prices compared to input prices were the most significant farm-specific factor affecting farm revenue and productivity.

Ghee-Thean, Ismail, and Harron (2012) analyzed the technological productivity of Malaysian paddy cultivation. The researchers evaluated the level of technical efficiency and the factors of technical inefficiency for a sample of 230 paddy farmers using stochastic trans-log production frontiers. The average level of technical efficiency for the sample paddy farmers was 85.8 percent, with production ranging from 0.263 to 0.982 percent. The inefficiency model revealed that attendance at the workshop seminar significantly reduced technical efficiency, which prompted paddy farmers to cover the opportunity cost of seminar or workshop participation.

Heriqbaldi, Purwono, Haryanto, and Primanthi (2015) used the stochastic frontier output function model to assess the technical efficiency of rice fields in Indonesia, as well as the effect of socioeconomic factors on production. According to this study, the average technical efficiency is 0.77 percent. Land size, income, and financing source are also found to be strong determinants of technological efficiency. Younger farmers have also been demonstrated to be more productive in terms of age. Expanding the agricultural sector, increasing farmer income, and enticing young people to work will boost technical efficiency and consequently productivity, as well as overall rice production.

Huynh Viet Khai and Mitsuyasu Yabe (2011) conducted a study that measured agricultural productivity and defined households farming efficiency. The goal of this study was to assess rice production's technical efficiency (TE) and to identify some of the technical efficiency determinants for rice farmers in Vietnam. The Cobb-Douglas production function was investigated in this work using the stochastic frontier analysis method. Technical efficiency was judged to be 81.6 percent in this investigation. According to the findings, labor in rice production, irrigation, and education are the most important elements influencing technical efficiency levels. They play a significant impact in influencing the TE score, although agricultural policies have not assisted farmers in growing more rice.

According to Idiong (2007), rice farmer productivity in Nigeria was assessed using a maximum likelihood method to offer technical efficiency estimates and its determinants using data obtained from 112 small-scale swamp rice farmers in Cross-River State. In this study, a stochastic frontier function with inefficiency factors was applied. According to the data, the rice growers were not technically entirely effective. The average efficiency received was 77%, suggesting a 23% efficiency increase allowance was available. The results also show that farmers' educational level, cooperative/farmer association participation, and access to credit all have a significant positive influence on their output. As a result, policies that enable educated people to form and join cooperatives and provide them with accessible access to institutional finance should be developed and implemented.

Taraka, Latif, Shamsudin, and Sidique (2012) analyzed the technical efficiency of rice farmers in Thailand's central area, and the factors influencing technical efficiency were identified using the stochastic frontier analysis (SFA) approach, which is described as a translog output function. The researchers collected cross-sectional data from 384 farmers in nine central Thai provinces who utilized pre-germinated broadcasting methods on their fields during the 2009/2010 rice harvest year. The results show that technical efficiency ranged from 49.69 to 97.17 percent, with an average of 85.35 percent. Sex, agricultural knowledge, good agricultural practices (GAP), and crop intensity have all been identified as factors that contribute to farm technical efficiency. Farmers should be trained in GAP awareness and accept GAP in their farming techniques. To boost farming production and revenue, agricultural extension staff should coordinate the sharing of information and experience among farmers and support the adoption of certified seeds.

Mailena, Shamsudin, Radam, and Zainalabidin (2014) employed stochastic frontier analysis to study and estimate the productivity of rice producers in Malaysia. The output and substitution elasticity, the current degree of productivity of the rice farm, and the determinants of productivity are all calculated using stochastic frontier analysis in this study. Ground, crop, and pesticides are the three inputs that have the most impact on Malaysian rice farms. According to the findings of this study, rice farmers working at a growing return to scale could increase productivity by increasing input utilization. The average technical efficiency of the farms was 85.4 percent. Farmers' credit availability and education level were key drivers of technical efficiency.

Meenasulochani, Rajendran, Pushpa, and Senthilnathan (2018) conducted research in the Tamil Nadu district of Nagapattinam. This study investigated the technological effectiveness of paddy production as well as factors influencing productivity in paddy cultivation. Well-structured questionnaires employed multi-stage random sampling to collect data from 120 farmer samples. To assess the factors influencing efficiency, the stochastic frontier output function and the tobit model were utilized. The findings revealed that the average technological productivity was 80.42 percent and that the coefficients of variables such as organic fertilizer, plant safety, chemical, laboratory, and machinery usage were negative, indicating that the production volume varies inversely with the quantity of these variables, whereas the coefficients of field size, crop, chemical fertilizer, and irrigation were positive, implying that the production volume varies positively with the quantity of these variables.

Mukwalikuli (2018) evaluated the technical efficiency of smallholder rice growing in Zambia's Lukulu region. The farm level data used in this study were gathered from a survey of 120 smallholder rice farmers chosen using simple random sampling. The Cobb-Douglas estimated stochastic frontier production function revealed that farm scale, fertilizers, and agrochemicals had a statistically significant positive effect on rice production. Technical efficiency at the farm level ranged from 40.4 percent to 97.6 percent, with an average of 76.9 percent. This suggested that by employing available technologies, small farmers may increase rice output by 23.1 percent without increasing input use. Expansion, credit, planting method, and quantity of owned cattle were all significant in the efficiency model. Age, race, household size, and marital status were all insignificant, showing that they had no direct impact on technical effectiveness.

Sikdar, Alam, and Hossan (2008) investigated the factors determining Boro rice technical efficiency in Bangladesh. The Cobb-Douglas stochastic production function was calculated in the analysis to evaluate the technical efficiency of rice output. A technical efficiency effect model was also created in order to identify variables. The empirical findings indicate that the coefficients of fertilizer, irrigation, and human labor were found to be highly positive in the stochastic frontier function. The coefficient of extension activity was negative and significant in the efficiency effect model. Overall, the technical quality was 92 percent. Farmers can increase their productivity by 8% without changing their input because of inefficiency.

Using the SFA model, Sokvibol Kea, Hua Li, and Linvolak Pich (2016) estimated the technical efficiency (TE) of rice production in Cambodian households and its important affecting variables. Structured questionnaires were used to collect primary data from 301 rice farmers in three Battambang districts. The analytical results revealed that the mean TE is 0.34, indicating that farmers yield 34% of rice at best practice at the current level of production inputs and technology, indicating that if farmers had been technically effective, rice output could have been increased by 66% at the same level of inputs. Data also suggest that land, fertilizer, and pesticides are the most important influencing input variables for household rice production.

Lema, Tessema, and Abebe (2018), Employed that the technical efficiency of rice production in the Fogera District of Ethiopia. The stochastic frontier method was applied on data from 200 sample households. Except for manure, all variables in the Cobb-Douglass stochastic frontier model, including soil, fertilizer, oxen, seed, and labor, were strongly and positively related to rice output. Cobb-Douglas' estimated stochastic frontier output feature had a 77.2 percent technical efficiency score. The study also found that the availability of extension facilities, rice product enhancement training, rice farming experience, agrochemicals, and literacy were positively and strongly related to technical efficiency, but household size was negatively and significantly related.

Kyi and Oppo (1999) investigated the problems associated with increasing irrigated rice efficiency and productivity in Myanmar. During the 1997 agricultural season, it employs the method of stochastic frontier production functions from cross-sectional data. The data indicate that using seed levels in rice production in the study irrigated area will have a substantial impact on overall yield. Furthermore, in order to improve rice farm output, it is necessary to increase the capacity of human capital and to increase awareness. Farmers that do not use fertilizer have efficiency scores ranging from 0.79 to 0.99, with an average of 0.88. The majority of farmers are highly technical efficiency in their rice cultivation.

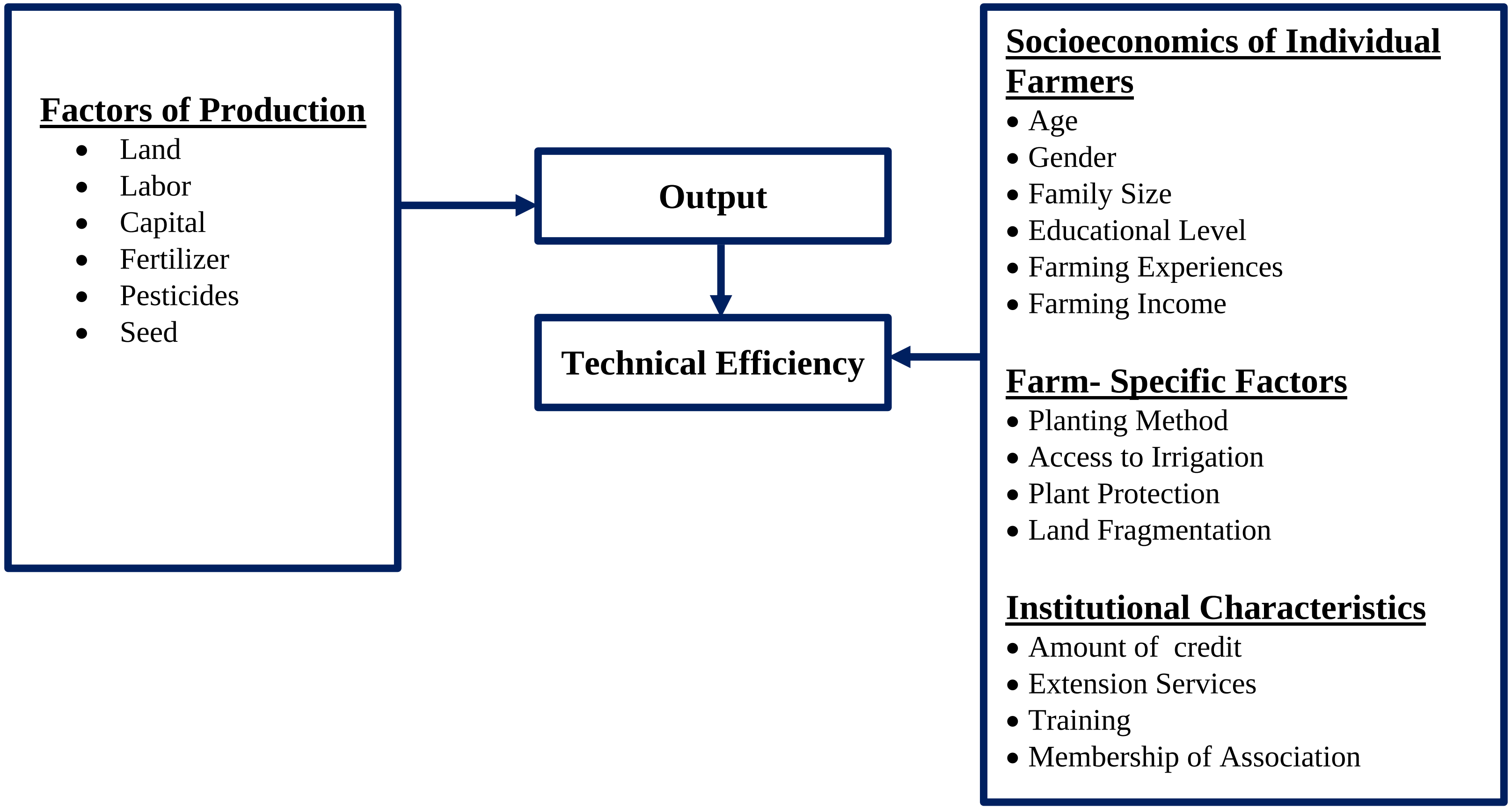
Sayavong (2018) studied the production of paddy rice in Laos using the stochastic production frontier and inefficiency models to determine the factors that impede its efficiency. Main inputs such as land, labor, capital, water supply, and other expenses are evaluated in the production model using cross-sectional data from 343 farm households in the region. Similarly, the influence of specific variables such as farmers' schooling, land quality, credit access, extension facilities, and environmental circumstances was explored in the inefficiency model. According to the data, 77.75 percent of paddy production capacity has been realized, and the most productive technique to improve output is to share information among farmers through rice association membership and training.

Tun and Kang (2015) analyzed the effect of farm mechanization on Myanmar's rice production. The Data Envelopment Approach (DEA) and the Stochastic Frontier Approach (SFA) were both used in this study. According to this study, agricultural mechanical instruments significantly increase the yield of rice cultivation in Myanmar. As a result, the average technical efficiency (constant return to scale) is 63%, with a minimum of 44% and a maximum of 100%. The average farmer's technical efficiency score is 78 percent, with a range of 69 percent to 100 percent, indicating that the average farmer achieved 78 percent of the maximum feasible production for a given input amount.

2.6 Conceptual Framework of the Study

Productivity is defined as the ratio of the output value to the value of the inputs used to produce it. Productivity increases are caused by the usage of production factors such as land, labor, capital, fertilizers, insecticides, and seeds in the paddy production process. Efficiency in the production process can be defined as resource utilization or obtaining the maximum potential output level with a given set of inputs. A farmer's production efficiency affects paddy yield levels. Socioeconomic, demographic, farm-specific, and institutional factors were expected to affect farmers' technical efficiency. Age, gender, agricultural experience, educational level, and farm income level were all expected to influence technical efficiency. Credit amount, extension service, training, and agricultural association participation are elements of institutional variables. Planting methods, land fragmentation, irrigation availability, and plant protection are all farm-specific characteristics. There are many functional forms that can be used to estimate the physical relationship between inputs and outputs. To estimate the level of technical efficiency, a stochastic frontier production function of the Cobb-Douglas type was used. To estimate technical efficiency levels, the maximum likelihood technique was applied, and the Tobit regression model was used to determine the factors affecting technical efficiency.

Figure (2.7) depicts the study's conceptual framework along with all of the variables that may affect the productivity and technical efficiency. In the stochastic frontier production function, the output of paddy is the dependent variable, while the factor of production is the independent variable. In the Tobit regression model, the level of technical efficiency is a dependent variable, while socioeconomic characteristics of individual farmers, farm-specific factors, and institutional characteristics are independent variables.



Source: Own Compilation

Figure (2.7) Conceptual Framework of the Study

CHAPTER III
OVERVIEW OF PADDY PRODUCTION IN MYANMAR AND AYEYARWADDY REGION

3.1 Background of Myanmar Agriculture Sector

Agriculture development can have a good impact on poverty alleviation and rural development. As a result, agricultural development initiatives must receive adequate attention in order to stay on the right track of development. The development of the agriculture sector can also lead to agro-based industrial development. Even if industrialization is accompanied by excellent potential, agriculture will continue to play a role in a country's economic development. This economic development approach is based on the assumption that increasing agricultural productivity will result in the transition of rural regions that are heavily reliant on agriculture to generating earnings driven by income from the commercial, service, and industrial sectors. Increased agricultural production would result in positive outcomes such as higher rural income, lower food prices in urban regions, and higher rural savings, allowing capital to be mobilized for domestic industry and the local market for non-agricultural commodities.

Myanmar is primarily an agrarian economy, with agriculture playing a critical role in economic development. It has experienced economic growth through agriculture development since the pre-war period. Despite the fact that agriculture employs 61% of the population and that the rest farmers are smallholders, agriculture is crucial in the fight against hunger and poverty (MOALI, 2018). Comparatively favorable and diverse production conditions compared to other Southeast Asian countries such as Thailand and Vietnam. Climate change, access to farmer financing, labor availability, access to machinery, access to information, access to inputs, and marketing of agricultural products (including livestock products) are the primary issues facing Myanmar's agricultural sector.

Myanmar is organized into four primary Agro-Ecological Zones (AEZs): deltaic, coastal, central dry, and mountainous (MOALI, 2018). Farmers in the Delta region, which has a population of almost 22 million people, are largely engaged in rice production, especially during the monsoon season. The CDZ, which has a population of over 19 million people, is located in a monsoon shadow and receives 600 mm of rain each year. Farmers are predominantly concentrated along the main river valleys, depending on paddy production, oilseeds, beans, and pulses, as well as rainfed and irrigated agriculture, the latter of which is supported by surface storage and artisanal water supplies. Farmers cultivate a wide variety of rain-fed tree crops and horticultural goods, as well as rice, maize, and pulses, in the hilly zone, which has a population of roughly 6.5 million people and is favored by Shan State. Livestock farming can be discovered in all three regions, while aquaculture is most prevalent in the delta and coastal areas. Agriculture is the largest sector contributing to the economic activities of Myanmar. The productivity of agriculture can be evaluated in terms of its contribution to GDP growth.

Table (3.1) Share of Agriculture in GDP (At Current Producers' Prices) (Millions of Kyat)

Year	GDP	Agriculture	Share in GDP%
2005-2006	12286765.4	4718474.3	38.4
2006-2007	16852757.8	6068007.3	36.0
2007-2008	23336112.7	8246217	35.3
2008-2009	29233288	9235953.3	31.6
2009-2010	33905665.6	9956185.7	29.4
2010-2011	39776764.9	11108404.4	27.9
2011-2012	46307887.7	11113043	24.0
2012-2013	51259260	11349615.2	22.1
2013-2014	58011626	12316081.8	21.2
2014-2015	65262092.5	12780581.2	19.6
2015-2016	72780464.5	13417668.2	18.4
2016-2017	79760096.5	13748224	17.2
2017-2018	90450949	13964771.2	15.4

Source: (CSO, 2017, 2018)

Table 3.1 shows the share of agriculture in GDP from 2005-2006 to 2017-2018. The share of agriculture in GDP has fallen on a year-over-year basis over the past decade. According to the table, there is a decreasing trend in agriculture's share of GDP, falling from 38.4% in 2005-2006 to 15.4% in 2017-2018. The agricultural sector's share of GDP has shifted dramatically in recent years as the non-agriculture sector, particularly the manufacturing, mineral, gem, readymade garment, oil, and natural gas subsectors, has provided a large share of GDP. The agricultural sector's contribution to GDP has changed significantly in recent years as the non-agriculture sectors, particularly the manufacturing and services sectors, production has increased significantly. In terms of GDP, the value of basic agricultural production is declining.

3.2 Agricultural Transformation and Implications

Agriculture plays an important role in ensuring food security, providing food and nutrient stability, reducing household vulnerability, increasing agricultural land and labor productivity, and contributing to rural production and environmental conservation. MOALI's function has evolved from a concentration on crop farming to a focus on diversification into high-value items such as livestock and fisheries, in addition to the expansion of the non-farm rural sector. These are critical components of the agricultural transition mechanism that contributes to the country's "modernization" program, which also attempts to eliminate the gender wage gap and increase gender equality (MOALI, 2018).

The ADS is an agricultural policy operationalization strategy that will govern the Myanmar agricultural sector over the next five years, during which time agribusiness expansion is predicted to outstrip agricultural growth. Strong links between agriculture and other economic sectors will be critical to poverty reduction, particularly in rural areas where the development of agricultural-based non-farm activities will be critical to the expansion of a robust economy as a whole, a more balanced rural economy, and the employment creation. The agricultural sector as a whole has a linkage effect that includes not only the farming sectors (cultivation, livestock, and fisheries), but also the manufacturing sector, trade, and other services (storage, transport, logistics, banking, distribution, research, and extension), as well as factors that will help farmers' organizations become financially sustainable. The plan lays the strategic foundation for Myanmar's agricultural transition from agriculture as a primary sector to one that earns the majority of its income from services and industry. This process has far-reaching implications for the Myanmar population's food production and distribution processes; the expansion of rural areas, including the non-farm rural sector; the competitiveness of labor and property; the balance of trade, youth jobs, and migration; the role of women in agriculture; and the management of natural resources in an increasingly difficult context. The MOALI will ensure that the agricultural transition process is improved and modified in accordance with the expectations and restrictions of Myanmar society.

The role of MOALI has evolved from one of focus on crop agriculture to one of diversification towards high-value products, including livestock and fisheries, and the development of the rural non-farm sector. These are key elements of the process of agricultural transformation and bear on the government's "modernization" objective, which also aims to reduce the gender wage gap and increase gender equality. In this process of transformation, several factors are happening at the same time during this transition period (Timmer, 2007). Agriculture's sector and labor share of GDP are declining, but agricultural productivity and total GDP are rising. As a result, agricultural GDP is expanding while contributing less as a ratio to total GDP. According to Goletti (2011), an overview of the associated lessons learnt from the agricultural transformation experiences of many countries is as follows:

i. Investment in research by the government and the private sector. Investment in the Research, Education, and Extension (REE) Knowledge Triangle, in particular, has a significant impact on agricultural production development, particularly where innovation is available locally from a variety of sources.
ii. To ensure broad-based and inclusive agricultural growth. Investing in programs that reduce fiscal, social, and regional inequality leads to faster and more prosperous growth.
iii. Incorporating smallholder farmers' organizations and integrating them into dynamic supply networks. Smallholder farmers are the foundation of Myanmar's agriculture; connecting connected smallholder farmers to agri-food firms within the integrated supply chain would increase their ability to satisfy the more demanding needs of rising urban populations in Myanmar and beyond.
iv. Build rural infrastructure and promote rural agro-enterprise and local business settings to strengthen Myanmar's rural economy.

3.3 Agricultural Policy in Myanmar

Myanmar's agricultural policy aims to improve food and nutrition security and food safety for all people, in addition to enable smallholder farmers to increase their incomes through higher productivity and diversified production in response to market demand, in additional to increase exports through a globally competitive private agri-business sector. These policies will provide a favorable legal and regulatory framework for agricultural consumers, producers, and enterprises, in additional to vital public investment, infrastructure, and services, as well as the mobilization of domestic and foreign capital. Myanmar's agricultural policy aims to improve food and nutrition security and food safety for all people, in additional to enable smallholder farmers to increase their incomes through higher productivity and diversified production in response to market demand, in additional to increase exports through a globally competitive private agri-business sector. These policies will provide a favorable legal and regulatory framework for agricultural consumers, producers, and enterprises, in additional to vital public investment, infrastructure, and services, as well as the mobilization of domestic and foreign capital. Developing policies and utilizing land, water, and other natural resources in an inclusive, competitive, efficient, safe, and sustainable way, as well as having an access to production inputs and technologies, and value-added processing, marketing, and export potential are grossly embraced by agricultural development.

Agricultural policy and planning in Myanmar were developed under the scope of national economic policy legislation, plans, and regulations. Regardless of the fact that it addresses general concerns and is not particular to agriculture, it has many crucial consequences for agricultural development. The National Economic Policy's goal is to create an economic framework that fosters national reconciliation by striking an equal balance between the mobilization and allocation of renewable natural resources across states and regions. It includes 12 policies that address the following issues: financial resource expansion; efficient public and private enterprises; human capital development; rapid development of key economic infrastructures; job creation; balanced sectoral growth while improving food security; economic rights; financial stability; environmental sustainability; equitable and effective taxation; intellectual property rights protection; and a business climate that is adaptive. The objectives of the economic and social reform system are to implement reforms and policies that increase food security, agricultural production, and the welfare and income of producers, farm workers, and their dependent families. It aims to increase competitiveness through extended extension facilities and government loans, eliminate supply chain constraints, and convert to demand-driven market support mechanisms, (MOALI, 2016).

The long-term goal for agriculture and rural development is to "raise the earnings and living conditions of rural people who are more dependent on Myanmar's agricultural sector than neighboring countries and who are more competitive with developing countries." To realize this vision, the following outcomes are desired: to obtain full market share in domestic and worldwide markets for specialty foods and other agro-based value-added items; to improve rural people's food security; and to create green growth that is environmentally friendly. In the short run, the sector's priorities include: increasing the productivity of agricultural sector; increasing the production of small and medium-sized rural agricultural enterprises; and increasing the attractiveness of foreign direct investment inflows into the agricultural sector for advanced technologies, financing, industry, and employment opportunities: access to domestic and export markets; market information infrastructure; pure and applied agricultural research projects; and, elimination of transaction costs across the value chain to the maximum extent possible.

3.3.1 Land Use and Management Policy

All farmers who produce crops, cattle, or fish can access land in line with existing farm land laws, and they can also transfer, sell, mortgage, lend, swap, give away, or inherit their land rights, including tilling and other land uses. The Land Use and Management Policy aims to: catch both fresh and brackish water fisheries and produce fish in a systematic manner in accordance with the law; to create special zones for agricultural development, animal, and fishery goods in order to boost productivity; Farmers shall be given the freedom to engage in any farming operations that are economically viable in compliance with the laws (agriculture, livestock, and fishing sectors) on farm land that has been authorized to till and use. Formation of farmer groups, encompassing crops and cattle, as well as fishermen, will be encouraged and supported, with the goal of working within the Land Consolidation and Land Use Management system in the transformation to a larger scale farm parcel. Those interested in farming activities, particularly small-holder farmers and farm laborers who are landless and have severely low financial resources, will be given the opportunity to till the land that they have cleared or developed as new farm ground.

New farmland will be developed in conformity with the National Land Use Policy (MOALI, 2016).

3.3.2 Water Use and Management Policy

Myanmar's existing policy and administrative environment for water resources is disjointed and misdirected. Conflicting interests result in ambiguous jurisdiction. A consolidated water resources law that clearly outlines jurisdiction, institutes a fairer water use management system for all sorts of water users, and builds a more effective legal and operational framework is desperately needed.

The Water Use and Management Policy is to take the necessary action and feasible measures to ensure that the entire irrigation system leading from each and every completed irrigation dam, canal, and water pumping station becomes fully operational; the water user's participatory approach will be used in the water management system to maximize water use efficiency; to carry out feasible water supply projects for the benefit of farmers in various regions; to investigate the possibility of exploiting underground water for agriculture, livestock, and fishing and related activities without negatively impacting the natural environment or water resources; to build and maintain inland and sea dikes to prevent fresh and brackish water intrusion; and to excavate priority drainage canals in flood-prone areas of various regions and states to ensure that irrigation water is accessible and efficiently utilized by farmers when needed for crops; forming water user groups in respective regions and states to ensure that irrigation water is used effectively and efficiently; and carrying out rural drinking water projects based on current conditions (MOALI, 2016).

3.3.3 Agricultural Financing Policy

Myanmar's agricultural finance prospects have a lot of room for expansion, but there are several obstacles that impede the country's having a strong and thriving agricultural finance market. The MADB is the primary provider of agricultural finance, but its focus on landholding borrowers and loan size restrictions make this credit source inadequate or inaccessible for many. Furthermore, MADB's low interest rates make other loan options less competitive, creating a reliance on subsidized credit. Myanmar should think about improving the MADB's functioning and expanding credit prospects. More research that satisfy the diverse demands and in order to serve more borrowers, agricultural firms must improve their financial positions.

Myanmar's government should also learn from the experiences of its neighbors in reforming their financial sectors, particularly their attempts to evaluate and account for risk, cut operating costs, and diversify lending alternatives. The Agricultural Financing Policy has the following goals: to help farmers obtain financial support, loans, credit, capital investment, and inputs for agriculture, livestock, fishing, and cooperative activities; to assist in the construction of people-centered financial facilities such as revolving funds, microfinance, and block grants in order to improve the livelihood and income of the rural population; and to reform and upgrade the Myanmar Agriculture Development Bank in order for it to operate at full capacity and provide long-term, short-term, and seasonal loans; and that Loans from the national budget can be made available on time and used to attract foreign direct investment, which is essential to financially and technically aid agricultural, livestock, and fishery development, and also gain access to new international markets (MOALI, 2016).

3.3.4 Agricultural Mechanization and Input Policy

The Myanmar government considers mechanized farming to be one of the most essential agricultural improvement initiatives. This need is based on the assumption that increased automation, in conjunction with other better inputs, will lead to enhanced agricultural production and that increased mechanization will alleviate labor shortages during the busiest seasons of the farming calendar. Human or draught labor is no longer sufficient or economically justified, and mechanized agriculture has become highly profitable.

The Agricultural Mechanization and Input Policy is intended to encourage the greater use of well-adapted quality farm machinery and equipment in order to transition to a more advanced mechanized agricultural system. Agricultura value chains are being transformed by incorporating machinery and equipment into postharvest and value-added activities, resulting in the production of higher-quality agricultural products; to support capacity building for technological development in agro-based industries through the use of modern machinery and equipment in primary and value-added processing; to create and put into action regulations, processes, and directives to ensure the safe and systematic use of fertilizer, pesticides, herbicides, medicines, and vaccinations; to assist essential infrastructure development and improvement projects in order to assure the production of safe, high-quality agricultural and livestock products for high-end domestic and worldwide markets; and to increase access to and utilization of high-quality crop seeds, animal breeds, and fish fingerlings in order to increase productivity and increase the quality of agricultural, livestock, and fishery products (MOALI, 2016).

3.3.5 Policy on Cooperative Societies and Cooperative System Development

Cooperative societies and cooperative system development strategies are intended to help successful agricultural initiatives, including cooperative enterprise investment in machinery and equipment, by providing funding and existing microfinance lending programs, to aid in the development of cooperative societies, including the monitoring and evaluation criteria stipulated in the Cooperative Laws and Procedures, and also to provide Cooperative Education Trainings, in partnership with relevant organizations, to raise the economic, educational, health, and living standards of members of cooperative societies, to strengthen cooperative societies focusing on production, service supply, and trade factors, to encourage small-scale business, traditional weaving, and handicraft development, including the creation of ten traditional artworks and crafts (MOALI, 2016).

3.3.6 Policy for Rural Infrastructure Development

Rural infrastructure development policy is to encourage the long-term development of rural roads and bridges, including farm-to-market projects, in order to improve the socioeconomic position of rural populations. Support rural lighting and electrical projects in places outside of national electrical networks, with the goal of improving rural inhabitants' living standards and livelihoods while also assisting in the development of key social infrastructures through a people-centered approach. (MOALI, 2016).

3.3.7 Policy on Research, Development, and Extension

Myanmar's research and extension systems are poorly funded, and they need to improve their ability to connect research and extension must meet the requirements of all farmers. Extension remains top-down rather than bottom-up, with research centered in certain agro-ecological zones and largely focused on rice. Investments and reorganization of priorities across the system of research and extension are required to address these inadequacies.

The Research, Development, and Extension Policy seeks to foster private-sector involvement in the development of new technologies; to build cooperation and collaboration with foreign organizations in order to exchange contemporary agricultural, livestock, and fishing technologies; to aid in the conservation of genetic resources; the development of varied agricultural types resistant to climate, pests, and diseases; the conservation of fish resources; the production of good livestock breeds and fish species resistant to diseases and the negative effects of climate change; and to assist in the protection and management of genetic resources in coordination with appropriate departments and organizations, active participation of various government departments, non-governmental organizations, and civil society organizations, to strengthen and improve existing awareness-raising initiatives for farmers, livestock keepers, and fishermen. (MOALI, 2016).

3.3.8 Policy on Marketing, Processing, and Export

Marketing, Processing, and Export Policy are intended to collaborate in the development and standardization of quality standards, in addition to the collection and dissemination of price and trade information, with the goal of developing and improving agricultural, livestock, and fishery product access to markets, to support the entire value chain, from raw material export to value-added product manufacturing and export, with the goal of improving income and minimizing producer postharvest losses, encouraging mutual consent among government trade partners; gathering and disseminating internal and external market information; and issuing relevant certificates using advanced information technologies (MOALI, 2016).

3.3.9 Policy on Governance, Institutions, and Human Resource Development

Policy development and implementation will take place in consultation and coordination with relevant departments as well as private sector organizations at the union and regional/state levels. New organizations will be developed, and existing ones will be transformed; strategic thrusts and performance capacities must be strengthened in order to effectively and successfully implement policies and strategic thrusts. Academic education, vocational education, as well as pre-service and in-service training, will all be enhanced in order to further develop human resources.

Focus on the development and spread of good governance, with the goal of increasing administrative staff performance and service delivery, in additional to generating sector-specific certified technicians and effectively assigning them to relevant services and activities (MOALI, 2016).

3.3.10 Environmental Conservation and Climate Change Resilience Policy

The policy's aims are to collaborate with internal and external organizations to acquire needed technologies, construct basic infrastructure, and enhance the capabilities of relevant departments and organizations in order to mitigate losses and damage caused by natural disasters; and to implement resilient agriculture, livestock, and fishery activities to assist farmers', livestock keepers', and fishermen's socioeconomic responsiveness in the face of the harmful effects of climate change and natural disasters; to protect natural ecological systems in order to maintain higher consumption, to reduce land degradation, soil and biodiversity loss, and to improve soil fertility

MOALI has developed an Agricultural Policy (2016) to guide the Second Five-Year Plan's implementation. During the second five-year plan period, the policy aims to improve food security and safety while also balancing diet intake; to ensure farmers fully enjoy their rights and benefit from emerging economic growth; and that small-scale farmers, livestock keepers, and fisher folk, organized into groups or cooperatives (with women's participation mandated), modernize and improve the performance of the entire sector based on transferred knowledge (MOALI, 2016).

3.4 Paddy Production in Myanmar

Paddy is a key staple food and the primary source of nourishment for the Myanmar people. Paddy is grown throughout the monsoon season from June to November and the summer season from December to May. Rainfall during the monsoon season is adequate for crop cultivation without the need for extra irrigation from dams, river and stream diversions, or groundwater. However, when available irrigation is combined with drainage systems, it improves production stability and reduces the hazards of flooding and stagnant water. Irrigation and water supplies in Myanmar are used for paddy farming. Except for the middle part of Myanmar's dry zone, which mostly practices irrigated paddy agriculture, most of Myanmar's regions are cultivated with rain-fed paddy. In the central dry zone, supplemental irrigation is used for monsoon season paddy cultivation.

3.4.1 Sown Acre, Production and Yield per Acre by Paddy

Paddy is grown during the monsoon and summer season in four growing zones: the delta, the dry zone, the coastal zone, and mountainous areas. Approximately 80% of annual production is harvested during the monsoon season and the remaining 20% during the summer season. About 50% of the overall output comes from the delta. About 25% is produced in the dry zone. The rest is produced in the coastal and mountainous areas. More than 60% of the summer season production comes from the delta (MOALI, 2015).

Table (3.2) Sown Acre, Production and Yield per Acre of Paddy (Included Summer and Monsoon)

Year	Sown Acre (Million Acres)	Production (Million Tons)	Yield Per Acre (Basket)
2005-2006	18.26	27.25	73
2006-2007	20.08	30.44	74
2007-2008	19.99	30.95	76
2008-2009	20.00	32.06	78
2009-2010	19.93	32.17	79
2010-2011	19.89	32.07	79
2011-2012	18.76	28.55	74
2012-2013	17.89	26.22	74
2013-2014	18.00	26.37	75
2014-2015	17.72	26.42	76
2015-2016	17.82	26.21	76
2016-2017	17.70	25.67	75
2017-2018	17.93	25.62	75

Source: Myanmar Agricultural Statistics, (2017, 2018)

According to Table 3.2, 18.26 million acres of paddy land were used in 2005-2006. The sown area was increased in 2006-2007 and 2008-2009. From 2009-2010 to 2017-2018, the paddy sown area rapidly declined due to farmers' expressing little interest in dam restoration, obtaining less access to water, and supplying insufficient water. They shifted to farming other crops with low water needs in order to earn more profits. As a result of this, greater work is required for summer paddy cultivation, in addition to the development of methods for increasing summer paddy cultivation. Heavy rains during the time of growing monsoon paddy in July and August were less than normal rainfall. Lack of adequate water, destruction of dams, turning to farming as a garden, and getting into the decrease in sown acres was caused by the building of factories and village land.

Paddy output rose year after year from 2006-2007 to 2010-2011, and then began to decline from 2011-2012 to 2017-2018. Because of climate change, limited mechanization, and natural disasters, paddy production has been reduced since 2011-2012. The successful policies evidently lack incentives for farmers; insufficient irrigation facilities; farmer personal inefficiency; a lack of capital and good marketing arrangements; and a paddy price incentive. In order to increase paddy production, the cultivation process should be taken into account, harvesting method, seed distribution system, cleaning, and storage. The paddy production boosted total paddy production and personal consumption.

According to Table 3.2, the paddy yield per acre has increased gradually from 2008-2009 to 2010-2011. Paddy yield per acre has decreased since 2011-2012. Regardless of the fact that farmers were using high-yielding paddy varieties (HYVs) instead of traditional paddy varieties, average paddy yields have stagnated at around 76 baskets per acre as a consequence of soil degradation, overuse of fertilizer and pesticides, climate change, and natural disasters, with the consequences including crop damage and decreased yield.

3.5 Land Utilization

Myanmar is favored in terms of agricultural land resources. Several million hectares remain undeveloped. To aid in the effective development of these land resources, the government has made many concessions and established long-term and short-term land development plans. The soil of Myanmar varies based on the climate, topography, and location. The most prevalent soil types are 50 percent alluvial, 30 percent clayey, and 20 percent red literate. Land consolidation of existing agricultural land is also being conducted, with suitable drainage, irrigation, and farm roads. Aside from conventional small-scale crop agriculture, the private sector is encouraged to build sophisticated large-scale agricultural businesses. Examples of agricultural land development projects are reclamation of fallow and cultural waste land, development of farmers' embankment and paddy-fish, integrated farming in deep water locations, soil erosion prevention, as well as the expansion of terrace farming in high-land and slope land areas.

3.5.1 Land Utilization of Net Sown Area of Paddy

Myanmar divides land utilization into six categories: net area sown, fallow area, cultivable waste land, reserved forest area, other forest, and other land. The net area sown is growing, but cultivable land, fallow land, and other land areas are decreasing. The increase in sown area is due to the government's land reclamation activities as well as the allocation of fallow land to the private sector for commercial farming. As a result of industrialization, urbanization, and population growth, the pattern of land use is changing.

Table (3.3) Total Land Utilization of Net Sown Area of Paddy

Year	Total Land Area (Million Acres)	Paddy Sown (Million Acres)	Share of Net Sown Area for Paddy (%)
2005-2006	167	15.33	9.2
2006-2007	167	15.74	9.4
2007-2008	167	15.87	9.5
2008-2009	167	15.91	9.5
2009-2010	167	15.99	9.6
2010-2011	167	16.00	9.6
2011-2012	167	15.75	9.4
2012-2013	167	15.60	9.3
2013-2014	167	15.55	9.3
2014-2015	167	15.63	9.3
2015-2016	167	15.66	9.4
2016-2017	167	15.63	9.3
2017-2018	167	15.67	9.4

Source: Myanmar Agricultural Statistics (2017, 2018)

Table 3.3 displays the overall land utilization of net sown area and also the percentage share in terms of total paddy area. In Myanmar, the land area is estimated to be around 167 million acres, with an average net paddy sown area of 15.72 million acres in consecutive years. In 2005-2006, paddy net sown area accounted for 9.2 percent of total land area. Land use for paddy has gradually decreased starting in 2011-2012, despite the fact that there is an increasing trend in net area sown. This condition has occurred in paddy production because of increasing usage of land for other crops. There is a diverse use of land for crop cultivation.

3.5.2 Area of Paddy Production under Irrigation

Water is a limited resource in most developing nations, and farmers must compete with other consumers for it. The level of agricultural productivity is dependent on rainfall. Farmers can supplement rainfall and gain some control over climatic conditions by investing in irrigation. Irrigation is the technique of regularly applying controlled amounts of water to plants. Irrigation aids in the growth of agricultural crops, the preservation of landscapes, and the re-vegetation of dry distributed soils, and also during periods of below-average rainfall. Crop production success is dependent on the availability of stored water. The Ayeyarwady, Chindwin, Sittaung, and Thanlwin rivers, as well as their tributaries, are designated national water assets in Myanmar. In the meantime, the government was making efforts to construct irrigation infrastructure wherever possible across the country.

Irrigation systems differ based on the type of water source (surface water or ground water), the length of the irrigation program, new projects or rehabilitation projects, and the agent in charge of each component relating to irrigation system. Proper irrigation water management in all components of the system is required to reap the complete set of advantages of the investment. The government has also paid enough attention to other requirements, and water resources continue to be a significant factor. Groundwater irrigation was enhanced as well as innovative techniques of irrigation, such as pump irrigation, and irrigated areas of paddy have increased dramatically. There are four types of irrigation: government irrigation, private irrigation, wells, and other sources are included.

For many years, the area of paddy production under irrigation has declined. The availability of appropriate water for agriculture is a vital issue that will continue to be important in increasing per unit yields. More importantly, irrigation water allows for both the growth of the created area and the intensification of land use through double cropping. Paddy fields in Myanmar are largely located in the delta and central dry zone zones. Irrigated paddy is mostly grown in the Mandalay, Sagaing, and Magway regions of Myanmar's central dry zone. Irrigation, flood protection, and drainage are the primary infrastructures for agricultural sector improvement.

Table (3.4) Area of Paddy Production under Irrigation

Year	Total Irrigation Area (Thousand Acres)	Total Area of Paddy Under Irrigation (Thousand Acres)	Share of Total area for Paddy (%)
2005-2006	7109	5188	73
2006-2007	7332	5425	74
2007-2008	7123	5453	77
2008-2009	7021	5323	76
2009-2010	7337	5546	76
2010-2011	7249	5402	75
2011-2012	6682	4927	74
2012-2013	6419	4619	72
2013-2014	6696	4805	72
2014-2015	6626	4633	70
2015-2016	6652	4641	70
2016-2017	6705	4636	69
2017-2018	6961	4939	71

Source: Myanmar Agricultural Statistics (2017, 2018)

According to Table 3.4, in 2005-2006, 5188 thousand acres of land were irrigated to cultivate paddy, accounting for 73 percent of the total area under paddy crop irrigation. In 2007-2008, irrigation was used to cultivate paddy on 5453 thousand acres, with another 1669 thousand acres irrigated for other crops. In 2009–2010, the irrigated area totaled 5546 thousand acres, with other crops occupying 1791 thousand acres. In 2010-2011, 5402 thousand acres were irrigated to cultivate paddy, accounting for 75% of the entire area under paddy crop irrigation. In 2011–2012, the irrigated area declined to 4827 thousand acres, with paddy crop irrigation accounts for 74% of total irrigation. Paddy crop irrigation covered 4939 thousand acres in 2017–2018, accounting for 71% of total irrigated area. Every year, the area of paddy irrigated decreases. Summer paddy cultivation is heavily reliant on irrigation. The government should develop water resources in addition to operating and maintaining current irrigation infrastructure by building, rehabilitating, operating, and maintaining flood protection dikes and polders. More irrigation water will be supplied via pumped irrigation projects and groundwater tube wells in the Sagaing, Magway, and Mandalay regions.

3.6 Distribution of Quality Seeds of Paddy

MOALI gives registered seeds to contract farmers in order to generate certified seeds that are distributed to other farmers. To prevent seed quality deterioration, certified seed must be replaced every three years for each type. In actuality, MOALI is unable to offer certified seeds to rice growers throughout the country. At present, Myanmar's rice seed production and marketing are sluggish. The level of quality seed provision is lower than the planned level. Harmonization of the commercial and governmental sectors is also required in this area to increase supply capacity. Because of seed business issues, development policies should adhere to international standards in intellectual property rights and plant variety protection. It is vital to increase the availability of paddy improved seed varieties to vulnerable paddy farmers through direct distribution or through a market-based approach.

Table (3.5) Distribution of Quality of Paddy Seeds (Thousand Baskets)

Year	Quality Seeds (Basket)
2007-2008	102
2008-2009	105
2009-2010	120
2010-2011	277
2011-2012	168
2012-2013	111
2013-2014	104
2014-2015	955
2015-2016	1065
2016-2017	914
2017-2018	110

Source: Myanmar Agricultural Statistics (2017, 2018)

According to Table 3.5, the distribution of paddy quality seed by DOA in 2007-2008 and 2007-2008 was 102 and 105 thousand baskets, respectively. In 2007-2008, the delivery of paddy quality seed was raised by 120 thousand baskets. In 2010-

201, the distribution of paddy quality seed was 277 thousand baskets, 955 thousand baskets in 2014-2015, and the distribution of quality seed was maximized in 2015-2016. The distribution of high-quality seeds is increasing more gradually than in the past. So, in 2016–2017, around 914 thousand baskets of paddy quality seed were delivered, and in 2017–2018, the amount of quality seeds supplied declined. Quality seeds must be used to increase yield and improve paddy quality. Quality seeds are vital for improving rice quality. In order to increase paddy output, farmers must understand of the value of seed and grain, in addition to the quality of their produce. Aside from that, private seed companies should encourage the long-term dissemination of high-quality seeds. High-yielding varieties (HYV) are being promoted to boost paddy yields.

3.7 Utilization of Fertilizer and Pesticides for Paddy Production

Chemical fertilizer use has led to adoption of fertilizer-responsive high-yielding varieties in paddy's key growing areas. With the government policy encouragement, the private sector became active in fertilizer marketing, importation, distribution, and sales promotion. Fertilizer policy covers tools that the government can employ to accomplish economic outcomes such as lower fertilizer costs, higher product quality, increased availability, and more farmer use. Government regulations and activities are aimed at influencing fertilizer supply and use behaviors among traders and farmers. However, the amount of chemical fertilizer provided to the market was insufficient to meet the demand. In the private sector, chemical fertilizers were unsubsidized and highly competitive. Fertilizer supply and distribution systems are as follows: increasing access to high-quality fertilizers for farmers; increasing farmers' access to appropriate soil nutrient management guidance; and increasing efficiency in the fertilizer sector.

The government strives to promote agricultural production and profitability and anticipates that agricultural productivity will ensure equity in household food security, income, employment, and use of natural resources. The Ministry of Agriculture, Livestock, and Irrigation is carrying out its mission of promoting the country's economic growth by increasing farm incomes, employment, and household food security through the formation of partnerships and the promotion of private sector investment in agricultural productivity, diversification, commercialization, and the sustainable use of natural resources. Farmers' ability to use the optimal level of fertilizer is limited, as is financial availability and technical support services. The private sector is allowed to import and distribute fertilizer, but its potential is limited by a lack of a distribution network, current import and export rules, and a shortage of foreign exchange.

Table (3.6) Utilization of Fertilizer (Thousand Metric Tons)

Year	Total Fertilizer
2005-2006	3
2006-2007	7
2007-2008	3
2008-2009	7
2009-2010	5
2010-2011	7
2011-2012	6
2012-2013	93
2013-2014	75
2014-2015	28
2015-2016	2427

Source: Myanmar Agricultural Statistics (2017, 2018)

Table 3.6 shows the utilization of fertilizers in paddy production. Fertilizers are primarily nitrogen, phosphorus, or potassium-containing chemicals. Urea, Tsuper, potash, compounds, and other fertilizers were used as chemical fertilizers. Total fertilizer use fluctuated yearly from 2005-2006 to 2009-2010. Fertilizer used for paddy declined from 7 thousand MT in 2010-2011 to 6 thousand MT in 2010-2011. The amount of fertilizer used in Myanmar increased significantly between 2015–2016 and 2017–2018. According to the World Bank (2016), the use of fertilizer in Myanmar is expected to be 17.9 kg/ha of arable land, which is low when compared to surrounding countries such as Bangladesh (289 kg/ha), China (503 kg/ha), India (166 kg/ha), Thailand (162 kg/ha), and Vietnam (430 kg/ha). The amount of fertilizer used in Myanmar is determined by the type of agricultural area, seed variety, and soil nourishment.

Table (3.7) Pesticides Utilized for Paddy Production

Year	Total Pesticides Utilization		Pesticides Utilization	
	(Thousand Gallon)	(Thousand Pound)	(Thousand Gallon)	(Thousand Pound)
2005-2006	12	8	4	1
2006-2007	8	10	3	2
2007-2008	518	1585	367	1332
2008-2009	622	1602	414	1342
2009-2010	660	1620	439	1353
2010-2011	1283	5381	596	1362
2011-2012	1527	2619	732	1885
2012-2013	1122	8240	130	5971
2013-2014	1162	2338	133	1126
2014-2015	1114	5947	293	3063
2015-2016	3161	17616	450	4026
2016-2017	5814	25106	655	4602
2017-2018	12663	1517	1185	142

Source: Myanmar Agricultural Statistics (2017, 2018)

Table 3.7 shows that pesticides were applied in extremely low quantities in 2005-2006 and 2006-2007. The amount of pesticides used was 367 thousand gallons in 2007-2008, 130 thousand gallons in 2012-2013, and 655 thousand gallons in 2016-2017. In 2010-2011, pesticides were used in 596 thousand gallons (1362 thousand pounds), and in 2011-2012, pesticides were used in 732 thousand gallons (1885 thousand pounds). Pesticides used in paddy production were increased on an annual basis. Pesticide use increased by 655 thousand gallons (4062 thousand pounds) in 2016-2017, then steadily increased to 1185 thousand gallons and decreased by 142 thousand pounds in 2017-2018. Paddy cultivations can be harmed by numerous types of insects. Pesticides were occasionally used by farmers to kill pests or insects that were harmful to crops.

3.8 Agricultural Loans for Paddy

The main lender for agricultural loans is the Myanmar Agricultural Development Bank, now part of MOPF. MADB overwhelmingly focuses its lending on seasonal crop loans to smallholder farmers in paddy production. MADB provides both seasonal loans (monsoon, winter, and summer) and term loans (short-term and long-term loans). MADB offers up to 150,000 MMK per acre for 10 acres of monsoon paddy and up to 100,000 MMK per acre for 10 acres of other crops; all loans have an interest rate of 8%. The MADB also requires borrowers to hold part of the loan value as a savings deposit (typically 10-15 percent), which also pays an 8 percent interest rate.

Table (3.8) Agricultural Loans for Paddy (Kyat, Thousand Million)

Year	Total Amount of Loans	Loan for Paddy	Percentage
2005-2006	34	29	85
2006-2007	45	39	87
2007-2008	60	50	83
2008-2009	69	58	84
2009-2010	93	76	82
2010-2011	191	156	82
2011-2012	353	311	88
2012-2013	558	507	91
2013-2014	1159	1036	89
2014-2015	1167	1048	90
2015-2016	1091	993	91
2016-2017	1631	1535	94
2017-2018	1708	1458	85

Source: Myanmar Agricultural Statistics (2017, 2018)

Table 3.8, shows agricultural loans by paddy crop from 2005-2006 to 2017-2018. In 2005-2006, MADB lent 29 million kyats in agricultural loans for paddy. MADB has significantly boosted paddy lending in recent years, from 156 million Kyats in 2010-2011 to 1535 and 1458 million Kyats in 2016-2017. During the four years from 2010-2011 to 2014-2015, MADB gradually increased the amount of seasonal loans for paddy from 20,000 kyats to 100,000 kyats per acre. In the 2016–2017 fiscal years, MADB increased the seasonal loan for paddy from 100,000 to 150,000 kyats per acre. MADB has taken the lead in loan disbursement to paddy farmers. Due to the absence of legal credit procedures, especially for those without a solid financial foundation, individuals must rely on informal lending sources such as relatives, friends, and traders and pay high interest rates ranging from 5 to 15% each month. The payback of the interest on those informal loans frequently cuts into the minimal profits that farmers might get from their crops. Along with improving MADB operations, encouraging private bank involvement in agricultural financing and establishing small-scale loan schemes for agriculture-related financing would assist rural people.

3.9 Paddy Production in Ayeyarwaddy Region

Agriculture is the primary source of livelihood for the people of Myanmar. Paddy is the most crucial agricultural crop, representing more over half of all planted land. The country is segmented into four agro-ecological zones based on agro-climatic conditions and characteristics: the delta region, the coastal region, the central dry zone region, and the mountainous region. The Ayeyarwaddy region has the highest population density, the highest land productivity (mainly alluvial soil), reasonably high rainfall, generally flat topography, and an ideal climate for paddy cultivation.

The Ayeyarwady Region includes of 26 townships that encompass a total area of 35,964 km^2. Most locations are suitable for paddy cultivation, but some are prone to floods during the monsoon and saline intrusion during the monsoon and summer season. The region lies between approximately latitudes 15° 40' and 18° 30' north and longitudes 94° 15' and 96° 15' east. The region's water is irrigable with 456559 acres, flood protection with 1865152acres, net area sown, 5346 thousand acres, total paddy sown acres of 5174716, and total irrigated area of paddy of 1418578 acres. The region has a monsoonal climate that produces an average annual rainfall of 200 mm to 300 mm, accounting for the rainfall between mid-May and mid-November. Flooding in large portions of the region can last anywhere from a few days to two or three months, posing considerable threats to farmers. Despite the importance of agriculture to the region, landlessness is common in rural households. The majority of farms are small; over half have less than 5 acres. During the monsoon, paddy is the primary crop, although irrigation is restricted, particularly on smaller farms, during the dry season.

Seeds are obtained from their own sources with regard to specialist traders. Some of the region is suited to deep-water paddy, a low-yielding paddy variety that must be elongated to remain above rising water.

Table (3.9) Paddy Production Calendar in Ayeyarwaddy Region

Area	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Mar
Monsoon Paddy												
Ayeyarwaddy	S	S/G	S/G	S/G	S/G	G/H	G/H	H	H			
Summer Paddy												
Ayeyarwaddy						S	S/G	S/G	S/G	H	H	H

S: Sowing G: Growing H: Harvesting

Source: Myanmar Rice Sector Development Strategy, (MOALI, 2015)

The Ayeyarwaddy region's paddy production calendar is presents in Table 3.9. Monsoon crop seeding begins in late May to June, followed by transplanting from July to August. Cropping in deep-water areas begins in September, when the water begins to subside, allowing farmers to prepare the field. The harvest season for the regular monsoon crop is from October to November, MOALI (2015), while the late monsoon crop is from January to February. During the summer, this region has limited access to fresh water. Paddy is typically planted near rivers and small dams. Summer paddy cropping typically begins in late October and lasts until January, with harvesting taking place from February to April.

Table (3.10) Sown Acreage, Harvested Acreage of Paddy in Ayeyarwaddy Region

Year	Sown Acre (Thousand)	Harvested Acre (Thousand)	Difference
2005-2006	4801	4801	0
2006-2007	4904	4893	11
2007-2008	4956	4876	80
2008-2009	4925	4925	0
2009-2010	5000	5000	0
2010-2011	4998	4998	0
2011-2012	4778	4772	6
2012-2013	4837	4803	34
2013-2014	4901	4899	2
2014-2015	4980	4980	0
2015-2016	5027	4863	164
2016-2017	5037	4909	128
2017-2018	5129	5061	68

Source: MOALI, 2019

According to Table 3.10, which shows paddy sown acres and harvested acres in the Ayeyarwaddy Region from 2005–2006 to 2017–2018, the sown and harvested acreage were the same from 2008–2009 to 2010–2011. From 2006-2007 to 2010-2011, the sown acres and harvested acres increased. In 2011–2012, both the sown acres and the harvested acres were significantly reduced. In the region, most areas are favorable for paddy production, while some are flooded in the monsoon, and salinity intrusion occurs toward during the monsoon and the summer season. Hence, paddy sown acres and harvested acres were affected by the rise in temperature, more frequent occurrences of drought, flooding, salinity, heat, and other stressors and extreme weather events. Water shortages at critical paddy stages can affect paddy growth and output.

Table (3.11) Productions and Yield per Acre of Paddy in Ayeyarwaddy Region

Year	Production (Thousand Basket)	Yield Per Acre Baskets
2005-2006	377368	78.61
2006-2007	389052	79.52
2007-2008	397298	81.49
2008-2009	407852	82.81
2009-2010	414236	82.85
2010-2011	413038	82.64
2011-2012	342371	71.74
2012-2013	347484	72.34
2013-2014	363870	74.28
2014-2015	380373	76.38
2015-2016	375526	77.23
2016-2017	375347	76.45
2017-2018	387679	76.6

Source: MOALI, 2019

In Table 3.11, depicts from 2005–2006 to 2017–2018, paddy production in the Ayeyarwaddy region. In this region, paddy production gradually increased from 2005-2006 to 2010-2011, then decreased significantly in 2011-2012, and again, from 2012-2013, it gradually increased. In 2011-2012, paddy production fell due mainly to climate change, natural disasters, a lack of incentives for farmers, insufficient irrigation facilities, and paddy pricing incentives. Paddy production increased from 2014-2015 to 2017-2018 because of the growth of irrigated lands and the government's effort to use high-yielding cultivars and fertilizers. Because of contemporary paddy varieties and the heavy application of fertilizers, paddy production is relatively better in other regions of the country. The yield per acre of paddy was around 78 baskets. The region has the highest rate of chemical fertilizer consumption among other agricultural regions. The drainage-type irrigation system is the most frequent type of irrigation. If agricultural intensification is the primary concern, the nature and production methods of paddy must be considered. Some of the seed varieties were indigenous and required six to seven months to mature and harvest.

CHAPTER IV
RESEARCH METHODOLOGY

4.1 Study Area Descriptions

Paddy is the main crop produced in the Ayeyarwaddy region, which is also known as Myanmar's "rice bowl". It is located near the southern end of Myanmar's central plains and is endowed with alluvial soil, which is ideal for paddy cultivation. Within the region of 3.5 million people, around 70% of the households are farmers, fishermen, and farm laborers. Paddy growing in this area is distinguished by monsoon paddy where fresh water is accessible and summer paddy production as a second crop following the monsoon.

Danubyu Township is located in the Ayeyarwaddy region, which is one of the key paddy production zones in the Ayeyarwaddy region. This township is situated between the latitudes of 17° 14' 10" N and 17° 25' 10" N, and the longitudes of 95° 20' 50" E and 95° 42' 30" E. Danubyu Township has a total area of 185,184 average miles, a population of 190228 people, 20552 of whom are paddy farmers living in 449 villages. In this area, farming is prioritized as the primary source of income. Fisheries are also a significant food supply and the second source of income for farmers in this region. It might be a flourishing farming community with fertile alluvial soils suitable for paddy production. Farmers are no longer relying on dam irrigation; instead, they want more freedom in deciding what to cultivate based on weather and market conditions. Farmers prefer crop rotation, which involves alternating between paddy and legumes such as black grams. Deep-water fields in the lowland make them vulnerable to annual floods during the monsoon season, resulting in low yields for farmers who own such paddy fields. New trends to explore in the region include the rise of contract farming and the construction of high-quality rice mills that will process rice to world-class standards. Paddy is typically the predominant crop in both the monsoon and summer seasons, with additional secondary crops including black gram, green gram, and sunflower. Monsoon paddy planting begins in the last week of June and ends in November or December, depending on variety and the weather. During this season, most traditional cultivars with a longer growth period were cultivated. As a summer paddy farmer, they used to plant types with a short growth season, primarily HYV, using irrigation and fertilizer treatments.

4.2 Survey Design

A survey was conducted in Danubyu Township to collect the necessary information on production factors from farmers, socioeconomic characteristics of farmers, farm-specific characteristics, and institutional factors of technical efficiency in the township.

4.2.1 Sampling Design

In this study, a two-stage simple random sampling design was used to conduct the survey. For the first-stage sampling, 45 villages growing paddy were randomly selected with simple random sampling without replacement from 449 villages. There were 1706 farmers in the 45 sample villages and those farmers are treated as the second stage units. At the second stage, sample farmers (447) were chosen by using simple random sampling with probability proportional to size.

4.2.2 Sample Size Determination

The villages were taken as the first stage units and farmers were taken as the second stage units. To determine the appropriate sample size, the following Taro Yamane (Yamane, 1967) formula was used.

$$n = \frac{N}{1 + N(e)^2}$$

Where, n = sample size

N = population size

e = 5% level of error

$$n_0 = \frac{N}{1+N(e)^2} = \frac{1706}{1+1706\,(0.05)^2}$$

$$= \frac{1706}{5.265} = 324$$

The sample size will be at least 324. Assuming that the response rate was 72%, the required sample size was 447. The selected villages with a sample allocation of farmers for each village are displayed in Table 4.1. In this study, 400 farmers were chosen from among these who employed traditional paddy seeds to examine technical efficiency and factors affecting the level of technical efficiency.

Table (4.1) List of Selected Villages and Farmers in Danubyu Township

No.	Selected Villages	Number of Farmers	Number of Selected Farmers
1	V_1	75	20
2	V_2	89	23
3	V_3	15	4
4	V_4	15	4
5	V_5	9	2
6	V_6	39	10
7	V_7	86	23
8	V_8	31	8
9	V_9	107	28
10	V_{10}	24	6
11	V_{11}	22	6
12	V_{12}	10	3
13	V_{13}	16	4
14	V_{14}	17	4
15	V_{15}	17	4
16	V_{16}	89	23
17	V_{17}	70	18
18	V_{18}	52	14
19	V_{19}	31	8
20	V_{20}	42	11
21	V_{21}	42	11
22	V_{22}	27	7
23	V_{23}	30	8
24	V_{24}	37	10
25	V_{25}	14	4
26	V_{26}	15	4
27	V_{27}	36	9
28	V_{28}	12	3
29	V_{29}	54	14
30	V_{30}	18	5
31	V_{31}	82	21
32	V_{32}	29	8
33	V_{33}	25	7
34	V_{34}	102	27
35	V_{35}	12	3
36	V_{36}	14	4
37	V_{37}	10	3
38	V_{38}	21	6
39	V_{39}	42	11
40	V_{40}	23	6
41	V_{41}	12	3
42	V_{42}	74	19
43	V_{43}	49	13
44	V_{44}	46	12
45	V_{45}	24	6
Total		1706	447

Source: Survey Data (2020)
Note that: V_1 to V_{45} are village name, See Appendix (2)

According to Table 4.1, the total number of the 447 sampled villages, there were 9 villages with paddy production farmers of between 100 and 50, 24 villages with fewer than 50 farmers, and 2 villages with over 100 farmers.

4.3 Questionnaire Design

The questionnaire aimed to achieve two goals: to collect relevant data and to gather reliable and valid data. A pilot survey was carried out on 50 farmers to check whether the questionnaire was capable of generating the required data, the respondent's grasp of the survey, and the time taken to complete the questionnaire. The pilot survey examines not only the questionnaire aspects but also the framework, the quality of the interviews, the justification and adequacy of the sample instruction, the frequency of different reasons for refusals, and the overall correctness of the survey method. After this pilot survey, an integrated questionnaire was prepared.

The questionnaire consists of four major sections. The first section contains a number of personal questions discussing the name, marital status, educational status, demographic characteristics, and social status of the household. The second section is about production, and it includes questions about total land owned, total cultivable land, total plots, average plot size, labor utilization, irrigation information, fertilizer utilization, pesticide utilization, yield and output, input prices, and farm characteristics, such as cropping pattern, rotation crops, sharecropping, land tenure, land fragmentation, and plant protection. The third section discusses institutional factors such as credit availability, access to extensive services, technical information sources, and paddy production training, while the fourth section provides general information about farm activities.

4.4 Functional Form of the Efficiency Measurement

In econometric analysis, the Cobb-Douglas production function has been extensively used. The function has a large number of input variables and its implications on the production process can be studied. Furthermore, the size of economies can be estimated as a series of modest input coefficients that describe the many types of size for the market, business, region, and organization, etc., and can be summed up to one or without constraint. The other main trait is that unity is the elasticity of substitution. The known formula in the economic literature for the production function, while holding other inputs constant, is;

$$Q_t = AK_t^{\alpha} L_t^{\beta} \quad (4.1)$$

Where, output, capital and labor are Q, K and L. A is the stage of technique or technology, or the total productivity factor. The parameters α and β are, respectively, the elasticity of output with regard to capital and labor. In the instance of calculating equation (1) without any constraints, the number of α and β coefficient is equal to one, if greater than one increases and less than one decreases return to scale. Stochastic frontier production model takes the form:

$$Lny_i = \beta_0 + \sum_{j=1}^{k} \beta_j Lnx_j + v_i - u_i \quad (4.2)$$

A Trans-log stochastic frontier model takes the form:

$$Lny_i = \beta_0 + \sum_{j=1}^{k} \beta_j Lnx_j + \frac{1}{2}\sum_{i=1}^{k}\sum_{j=1}^{k} \beta_{ij} Lnx_i Lnx_j + v_{ij} - u_{ij} \quad (4.3)$$

where y_i = denotes the output of the firm or farm,

x_i = Denotes the (1 ×K) input value vector and other relevant variables associated with an appropriate functional type representing the input vector used in production,

β is an undefined scalar parameter (K×1) vector to be calculated.

v'_is are random errors, normal random variables with zero mean and constant variance as N $(0,\sigma^2)$

u'_is are the efficiency effects in the model

4.4.1 The Model of Stochastic Frontier Production Function

Ferrell began the pioneering research on efficiency in 1957, which derived from the present system of estimation. Over time, two general approaches have continued to follow the estimation of the production frontier: the full frontier, in which all observations are supposed to be with the frontier, and deviation from the frontier is referred to as inefficient. The other approach was the stochastic frontier prediction where the divergence from the boundary is caused by random component that represents measuring error and statistical noise and a component of inefficiency (Ogundele and Okoruwa, 2006). The full frontier calculation was based either on a non-parametric method where technological efficiency is calculated by solving the linear programming for each individual farm on a parametric approach, where statistical estimation provides the result. There are two approaches under the parametric approach, namely the deterministic and frontier approaches.

However, the stochastic parametric approach incorporates a random regression error. Therefore, the random error catches the influence of unimportant left-out variables and dependent variable errors as well as inefficiencies unique to the farm. It is because of this error decomposition that makes this estimation process superior to others. It offers farm productivity estimates of much smaller uncertainty than any other approach (Neff, Dixon, & Zhu, 1994).

The stochastic frontier output function model of the form was independently proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977).

$$LnY_i = X_i\beta + \varepsilon_i \qquad i = 1, 2\ldots\ldots N \qquad (4.4)$$

Where Y_i = the output of the firm or farm,

X_i = values of inputs used for the i^{th} firm or farm

β = parameter to be estimate

ε_i = the total deviation which is decomposed in the two independent elements, a random error component (v_i) and efficiency term (u_i)

The mathematical expressed as:

$$\varepsilon_i = v_i - u_i \qquad (4.5)$$

Where, v_i is a symmetrical two-sided random error for the random factor such as temperature, natural disasters, omitted variables, calculation error, and other statistical noise, (Coelli et al., 2005). The structural random error component (v_i) is assumed to be distributed with zero mean and variance, N $(0,\sigma_v^2)$ independently and identically. The asymmetric non-negative random error component that measures technological inefficiency is denoted by (u_i). Assumed that the non-negative variables, (u_i) are independently and identically distributed truncations (at zero from below) of the distribution, N $(0,\sigma_U^2)$.

The variance parameters are also estimated, such as sigma-square (σ^2) and gamma (γ). In order to assess efficiency, the gamma values are used. The gamma (γ) value gives the proportion of the deviation of the paddy yield from the production frontier caused by technical inefficiency. If (γ) = 0, it means that u_i is absent from the model, and hence deviations from the frontier are attributed to noise, and technical inefficiency is absent from the estimation, which would be an adequate representation. While the sigma-squared value is used to evaluate the effect of efficiency is correctly defined. The model's variance parameters were defined as:

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \tag{4.6}$$

$$\gamma = \sigma_u^2 / \sigma^2 \quad \text{and} \quad 0 \le \gamma \le 1 \tag{4.7}$$

Where the total variance of error terms is expressed by σ^2, while the gamma parameter (γ) describes the effect of efficiency on production (Stefan, et al., 2011). Therefore, the gamma value may be measure of the existence of efficiency.

In order to estimate these two random terms, some assumptions are held: each v_i is distributed independently of each u_i and both errors are not related with the X_i explanatory variables. Furthermore, the following assumptions have to be hold:

$E(v_i) = 0$	Zero mean	(4.8)
$E(v_i^2) = \sigma_v^2$	Homoskedastic	(4.9)
$E(v_i v_j) = 0$ for all $i \neq j$	Not correlated	(4.10)
$E(u_i^2) =$ Constant	Homoskedastic and	(4.11)
$E(u_i u_j) = 0$ for all $i \neq j$	Not correlated	(4.12)

Under these assumptions, the ordinary least square method is utilized to achieve consistent estimators of slope coefficients. However, the intercept coefficient's OLS estimator is skewed downwards. This means, among other aspects, that OLS calculations should not be applied to compute technical efficiency measures. A maximum - likelihood estimator follows the distributional expectations for two error terms from equation (4.8) and (4.9) and has broad asymptotic data sample properties, so it is preferred to other estimators such as COLS. The maximum likelihood estimate was developed under additional assumptions by Aigner, et al., (1977),

$$v_i \sim iidN(0, \sigma_v^2) \tag{4.13}$$

$$u_i \sim iidN(0, \sigma_u^2) \tag{4.14}$$

Assumption (4.13),v_i's is independent and identical distributed normal random variables with zero means and variancesσ_v^2 , and assumption (4.14),u_i's is independent and identical distributed half-normal random variables with a scale parameter of σ_u^2 .

In addition, the log-likelihood function estimates parameters in terms of $\sigma^2 = \sigma_v^2 + \sigma_u^2$ *and* $\lambda^2 = \sigma_u^2 / \sigma_v^2 \geq 0$. If λ = 0, then there is no effect of efficiency and statistical noise is responsible for all deviations from the frontier. The model is unable to solve β, σ, γ analytically, and since there is a nonlinear relationship to the first-order condition. The probability function then uses the iteration optimization technique, and this process systematically updates the undefined parameter values before the values of the log-likelihood function are maximized.

These hypotheses can be carried out using a generalized probability ratio test, according to (Coelli, 1995), given that:

$$LR = -2\left[Ln\{L(H_0)\} - Ln\{L(H_1\}\right] \tag{4.15}$$

Where, for the null and alternative hypotheses, L (H0) and L (H1) are the likelihood function values for the unrestricted (H0) and restricted (H1) models, respectively (Coelli, 1996). If the null hypothesis is correct, then LR has a chi-square (or mixed square) distribution with degrees of freedom of parameters specified to be zero in the null hypothesis (Kodde & Plam, 1986), so the Kodde & Plam chi-square distribution tables are used and compared to critical values at a 5% significance level. This L (H0) is rejected if the LR is greater than the chi-square critical value.

During a given time period, a farmer's technical efficiency is defined as the ratio of observed output to maximum output produced by a totally efficient firm with a zero inefficiency effect. Given the assumptions of the stochastic frontier model, the i^{th} farmer's technical efficiency can be expressed as equation;

$$TE = \frac{y_i}{y_i^*} = \frac{\exp(x_i\beta + v_i - u_i)}{\exp(x_i\beta + v_i)} \tag{4.16}$$

$$= \exp(-u_i) \tag{4.17}$$

Where, y_i is observed output and y_i^* is maximum output or frontier output

The technical efficiency score is a number between 0 and 1. It compares the output of the firm to the performance of a perfect efficiency firm with the same input. When the score is close to one, it means that the farm is technically efficient in producing the output given a certain amount of input. When the score is close to zero, it indicates that a farm has the potential to increase output without increasing the amount of inputs.

4.4.2 Tobit Regression Model

Tobin (1958) proposed the Tobit regression model in the econometrics literature. These models are also referred to as truncated or censored regression models because the anticipated errors do not equal zero. Because OLS assumes a normal and homoscedastic distribution of the disturbance and the dependent variable, estimation with an ordinary least squares (OLS) regression of technical efficiency level would result in a biased parameter estimate Amemiya (1984); Maddala (1983). Because technical efficiency indexes between 0 and 1, it has a lower and upper bound, thus applying ordinary least square regression will result in biased and inefficient estimates. Tobit regression analysis assumes that the dependent variable has a number of values clustered at a limiting value, typically zero (McDonald & Moffitt, 1980). The Tobit model has been frequently utilized to identify the factors influencing technical efficiency (Obare, Nyagaka, Wilson, & Mwakubo, 2010). According to Tobin (1958), Wooldridge (2002), and Cameron and Trivedi (2005), the standard Tobit model for observation i^{th} farm is as follows:

$$Y_i = Y_i^* = X_i + \beta + \varepsilon_i \quad (4.18)$$

$$Y_i = 0, if Y_i^* \leq 0 \quad (4.19)$$

$$Y_i = Y_i^* if Y_i^* > 0 \qquad i= 1, 2, 3 \ldots n \quad (4.20)$$

Where: Y_i is the observable but censored variable measuring technical efficiency. Y_i^* is the latent variable indicating that technical efficiency, it could be observable or not. Hence, technical efficiency is observed if $Y_i^* > 0$ and unobservable if $Y_i^* \leq 0$

X_i is a set of explanatory variables in the efficiency model

β is estimated parameters

ε_i is the term "error" or "disturbance" is assumed to have a normal distribution with a zero mean and constant variance.

4.5 Specification of the Model for Paddy Production

This section defines the input and output variables as well as the specification of the stochastic frontier production function of the examined technical efficiency of paddy production. A variable description of the model is used to specify a Tobit regression model.

4.5.1 Stochastic Frontier Production Function

The technical efficiency of paddy production in the study area was assessed using the stochastic frontier production function. The optimum output given the technology available to the firm is defined as the stochastic production frontier. The following are the specifications of the Cobb-Douglas stochastic frontier production function:

$$LnY_i = \beta_0 + \beta_1 LnX_{1i} + \beta_2 LnX_{2i} + \beta_3 LnX_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + (v_i - u_i)$$

Where,

Ln = Natural Logarithm

LnY_i = Quantity of output, measure in paddy yield per acre

β_s = Estimated parameters

LnX_{1i} = Areas of land cultivated with paddy (acre)

LnX_{2i} = Quantity of labor employ in the paddy production of per acre (man per acre)

LnX_{3i} = Capital used in paddy production per acre (Cost of Machineries and Equipment)

LnX_{4i} = Quantity of fertilizer used in paddy production per acre (kg)

LnX_{5i} = Quantity of pesticides used in paddy production per acre (Litre)

LnX_{6i} = Quantity of local seed used per acre (basket)

v_i = Random errors

u_i = Non negative random variable

4.5.2 Definitions of Input and Output Variables

Output (Y): This is the dependent variable and the amount of paddy output of the sample farmers.

Land (X1): The number of acres under paddy cultivation. It includes all types of plots, such as plots of land owned and cultivated through different land use arrangements, such as renting-in, leasing, or sharecropping of land under paddy production for each farmer. Farm size will have a positive effect on paddy output.

Labor (X_2): This represents the total labor (family and hired) utilized in various farm activities (plough, sowing and fertilizer application, weeding, harvesting, and threshing). The record was kept on the people who participated in the given activity by categorizing them as children, men, and women. The quantity of labor employed in paddy production is measured in men per acre, and its quantity may be positively related to the output.

Capital (X_3): Capital is measured as total machine hours and user costs of capital per acre of capital service in paddy production. Farm tools and implements are necessary for carrying out farm activities, and therefore, capital will have to be positively related to the output.

Fertilizers (X_4): The amount of fertilizer used in paddy production in kilograms per acre. Farmers commonly utilize urea, phosphate, compounds, and other fertilizers for paddy production. Fertilizers may have a positive impact on output.

Pesticides (X_5): The amount of pesticides used in paddy production, expressed in litres per acre. The use of pesticides may have a positive relationship to output.

Seed (X_6): The amount of paddy seed used, expressed in baskets per acre. Most farmers are using mainly traditional or local varieties. Paddy seed varieties have a positive impact on output.

4.5.3 The Model

Tobit regression analysis is used to identify the determinants of factors affecting the technical efficiency of paddy production. Because the value of efficiency ranges from 0 to 1 and is a continuous variable, this is a case of a restricted dependent variable. To evaluate the factors affecting technical efficiency, individual socioeconomic and demographic factors of individual farmers, institutional factors, and farm-specific characteristics were regressed. Because OLS regression is not appropriate for this regression analysis, the technical efficiency level ranges from 0 to 1. Therefore, the dependent variable does not have a normal distribution. For Tobit regression, it is more convenient to have data censored at zero than at 1. The following regression model was specified as:

$$U_i = \delta_0 + \delta_1 Z_{1j} + \delta_2 Z_{2j} + \delta_3 Z_{3j} + \delta_4 Z_{4j} + \delta_5 Z_{5j} + \delta_6 Z_{6j} + \delta_7 Z_{7j} + \delta_8 Z_{8j} + \delta_9 Z_{9j} + \delta_{10} Z_{10j} + \delta_{11} Z_{11j} + \delta_{12} Z_{12j} + \delta_{13} Z_{13j} + \delta_{14} Z_{14j} + W_j$$

U_i = Technical efficiency level for i^{th} farmer

δ_j = The coefficient of explanatory variables

δ_0 = The intercept terms

Z_{1j} = Gender of farmer, expressed as a dummy (1 for male and 0 for female)

Z_{2j} = Age of farmer measured in years

Z_{3j} = Farmer's educational level, expressed in years of schooling

Z_{4j} = Family size is defined as the number of members of a family who live with the farmer.

Z_{5j} = Farming experience, defined by the number of years of paddy cultivation

Z_{6j} = Farm income, measured income from all activities that have direct relation with paddy production during production year

Z_{7j} = Planting method, measured as a dummy (1 for broadcasting and 0 row planting)

Z_{8j} = Land fragmentation, measured as a dummy (1for greater plot size and 0 otherwise)

Z_{9j} = Access to irrigation, measured as a dummy (1for irrigated and 0 otherwise)

Z_{10j} = Plant protection, measured weeding of crop field, diseases and both diseases and weeding

Z_{11j} = Amount of credit, measured as a credit received from the MADB

Z_{12j} = Extension services, measured as a dummy (1 for farmer received for farmer with agricultural agents and government institution and 0 otherwise)

Z_{13j} = Training, measured as a dummy (1for training received for farmer and 0 otherwise)

Z_{14j} = Membership of association, measured as a dummy (1 for member of agricultural association and 0 otherwise)

W_j = Unobservable random variables, which are assumed that independently distributed with a positive half normal distribution.

4.5.4 Variable Description of the Model

The following factors were expected to determine efficiency differences among sample farmers.

Gender of the farmer (Z_1): This is a dummy variable that represents the farmer's sex, with 1 being a male farmer and 0 representing a female farmer. Female farmers may also have additional responsibilities, such as child care, and may need to allocate their time between these responsibilities and farm operations. Hence, it was assumed that male farmers would be more efficient than female farmers.

Age (Z_2): The farmer's age is expressed in years and is used to reflect the farmer's experience and physical strength. However, as a farmer gets older, he becomes less efficient, and his ability to handle farming tasks is likely to deteriorate. Younger farmers are more open to new methods and techniques and are more likely to be exposed to them. It may have a negative impact on efficiency.

Educational level (Z_3): This is a continuous variable that represents the farmer's year of schooling. This is utilized as a proxy variable for the decision-making unit's managerial skill. The quality of labor is expected to improve as a result of education, and workers will be more willing to adopt new technologies. Access to education, combined with increasing experience, may lead to better farm management. As a result, education is one of the most widely recognized aspects in evaluating a farmer's efficiency level and efficiency determination. It was thought that education would have a positive impact on paddy production efficiency.

Family Size (Z_4) is a measurement of the number of family members who live under one roof. The size of a family is significant when determining whether or not a farmer with a large family is more efficient. It was expected that family size would have a significant impact on the technical efficiency of farmers.

Farming experience (Z_5): Years of paddy cultivation experience. Farmers with many years of paddy production experience will more likely be familiar with the required skills needed for paddy production and, therefore, are more likely to have higher outputs and, consequently, be more technically efficient. Farming experience may have a positive relationship with the efficiency of paddy production.

Farming income (Z_6): The income from paddy output during the production year is used to measure farm income. Farm income is the sum of all activities that have a direct link to paddy production income. It has been proven that farmers with larger agricultural earnings are more efficient. Increased farm income has the potential to boost paddy production efficiency. Farm income was assumed to have been positive related to technical efficiency.

Planting method (Z_7): The planting method can influence the efficiency of paddy production. The row-planting approach helps improve agrochemical application and harvesting. Even though the broadcasting method is relatively less difficult and faster, the paddy plants become randomly grown on the field, which leads to overcrowding of paddy plants. The planting method was assumed to have positive effect on efficiency.

Land Fragmentation (Z_8): Land fragmentation is measured by the farmer's maintaining the location of distinct plots during the production year. Farm plots in the area are fragmented and dispersed, making it difficult to undertake farming chores on time and successfully. Increased land fragmentation causes inefficiency by reducing family labor availability, costing time and other resources that should have been accessible at the same time. A negative relationship between fragmentation and technical efficiency was predicted.

Access to Irrigation (Z_9): Irrigation is crucial in paddy cultivation, especially in the face of climate change. Hence, irrigation was expected to be positively or negatively related to paddy production efficiency.

Plant Protection (Z_{10}): Plant protection can be affected by paddy production efficiency, such as weeding of crop fields and disease control in the paddy farm. The quantity of plants protected was assumed to have a positive effect on efficiency.

Amount of credit (Z_{11}): This variable shows the amount of credit received by the farmer for farm-related purposes throughout the production year. Credit is an essential source of finance for smallholder farmers' productive operations. Farmers that receive agricultural credit are more likely to purchase and employ productivity and efficiency-enhancing inputs. Therefore, the amount of credit has a favorable impact on agricultural production and efficiency.

Extension services (Z_{12}): This is a measure of access to extension services, and an extension agent visited the farmer during the specified production season. Extension workers may play a central role in informing, motivating, and educating farmers about available technologies. Hence, extension services may have a significant effect on farmers through the improvement of their managerial ability and general agronomic practices. The number of extension contacts was expected to be positively related to efficiency.

Training (Z_{13}): Training is a crucial instrument in developing a farmer's managerial skills. Farmers, who received crop production and marketing training, or any other agricultural training, were seen to be more efficient than those who did not. It is a dummy variable with a value of 1 if the farmer received training at least once during the cropping season and 0 otherwise. It was thought that training would improve technical efficiency.

Membership of an agricultural association (Z_{14}): Membership in a farmer's agricultural association is evaluated as a dummy variable (1 for membership in an association and 0 otherwise). Farmers that belong to farmers' associations have more access to extension services. Hence, this variable is likely to have a significant effect on output and efficiency of production.

CHAPTER V

ANALYSIS ON SURVEY RESULTS

The chapter has been divided into two main sections. The first section discusses the descriptive analysis of sample farmers' demographic and socioeconomic variables. The second section presents and discusses the econometric results relating to the technical efficiency indexes obtained and the factors affecting the level of technical efficiency.

5.1 Descriptive Results

The descriptive statistics presented the farmer’s socioeconomic aspects of individual farmer, farm specific factors and institutional characteristics and is a description of the factors applied in the stochastic production function.

5.1.1 Farmer Demographics and Socioeconomic Factors

Farmer Demographics and Socioeconomic factors included in the study are described in Table (5.1).

Table (5.1) Demographic and Socioeconomic Characteristics of Sample Farmers

Sr	Variable Descriptions	No. of Respondents	Percentage
1	**Gender**		
	Male	369	92.3
	Female	31	7.8
2	**Age**		
	Below 40 years	25	6.2
	40-50	143	35.8
	Above 50 years	232	58.0
3	**Family Size**		
	1-3 members	108	27.0
	4-6 members	261	65.3
	7-9 members	31	7.8
4	**Educational Level**		
	Uneducated	5	1.3
	Reading and writing	14	3.5
	Primary	202	50.5
	Middle	109	27.3
	Higher	48	12.0
	Still attending University	4	1.0
	Graduate	18	4.5
5	**Farm Income (Kyats)**		
	Below 30 lakhs	181	45.3
	30-60 lakhs	142	35.5
	Above 60 lakhs	77	19.3
6	**Farming Experiences**		
	Below 10 years	24	6.0
	10-30 years	236	59.0
	Above 30 years	140	35.0

Source: Own Survey, 2020

According to Table (5.1), one of the main factors influencing farming operations is the farmer's age. It is widely assumed that age is a measure of farming expertise. Older farmers are more likely to have greater experience and hence produce more. On the other hand, elderly farmers may be more conventional and conservative, with less desire to adopt new farming technologies, making them less efficient. The average farmer was under 40 year's old, accounting for 6.3 %of the sample farmers, and was engaged in economic activity. Their ages ranged from 40 to 50 years old, accounting for 35.8% of all responses, and over 50 years old accounted for 58%. Farmers are 92.3% male and 7.8% female, according to gender statistics. Female farmers face greater challenges in paddy production and marking compared with their male counterparts. In addition, female farmers have farm management tasks that increase the burden, and these tasks combined with less resource access and ownership lead to more frequent and perhaps severe economic and social shocks, including poverty and food insecurity.

The educational level was categorized into non-educated, write and read, primary, middle, higher, undergraduate and graduate. Primary education indicates that the respondent has 4 years of formal schooling, middle is 8 years, higher is 10, undergraduate is 11 to 13 years, and graduate is 14 years, respectively. According to the survey findings, 1.3% of farmers were non-educated, 3.5% of farmers can read and write, 50.5% of farmers were in primary education, 27.3% of farmers were in middle education, 12% of farmers were in high school, 1% was still in university, and 4.5% of farmers were graduated. Education enhances the acquisition and utilization of information on improved technologies by farmers, which increases knowledge and could guide farmers to better manage their farm activities. Higher levels of education on small farms, productivity falls because education raises the potential for off-farm work and thus decreases the strength of on-farm management (Rios & Shively, 2005).

According to survey results, 27% of farmers had one to three members in their households; 65.3% had four to six members in their households; and 7.8% had seven to nine people in their households. The majority of responders had one to three members in their families. A greater family size is often correlated with a larger labor force available for farm tasks to be carried out on time. The overall number of family members within that group impacts the availability of farm labor. Farmers' farming experience is 6 percent have been farming for less than ten years, 59 percent have been farming for ten to thirty years, and 35 percent have been farming for more than thirty years. Farmers with several years of farming experience in dealing with the requirements for paddy cultivation. Farming experience can help farmers improve their technical efficiency in paddy production. According to the survey results, 45.3% of farmers have farm incomes of less than 30 lakhs, 35.5% have farm incomes of between 30 and 60 lakhs, and 19.3% have farm incomes of more than 60 lakhs. According to the survey findings, the majorities of farmers earn less than 30 lakhs and have obtained agricultural credit from credit institutions.

5.1.2 The Farm Specific Factors

The information on farm specific factors of sample farmers is described in Table (5.2). The farm's specific factors are planting method, land fragmentation, irrigation, and plant protection.

Table (5.2) Farm Specific Characteristics of Farmers

Sr	Farm Specific Factors	No. of Respondents	Percentage
1	**Planting Method**		
	Broadcasting	335	83.8
	Row Planting	65	16.3
2	**Land Fragmentation**		
	Yes	193	48.3
	No	207	51.7
3	**Access to Irrigation**		
	Yes	100	25.0
	No	300	75.0
4	**Plant Protection**		
	Weeding	67	16.8
	Disease	24	6.0
	Both Weeding and Diseases	309	77.3

Source: Own Survey, 2020

The planting method has an effect on the efficiency of paddy output. Row planting can enhance the application of agro-chemicals and make harvesting easier. Even though the broadcasting method is relatively less laborious and quicker, the paddy plants become haphazardly grown on the field, which leads to overcrowding of paddy plants. According to survey results, most farmers applied to cultivate their seeds in paddy by the broadcasting method and 16.3% of farmers planted their paddy seeds by row plating, which is an improved planting technology.

Land fragmentation is measured by plot size, so the smaller the plot size, the greater land fragmentation, and the greater the plot size, the less fragmentation. Farmers with less land fragmentation have a better opportunity to use new technologies like tractors and irrigation, and hence, farmers with less land fragmentation are presumed to be more efficient. The study results show that 48.3% of farmers have smaller plot sizes (greater land fragmentation) and 51.7% have larger plot sizes (lower land fragmentation). The majority of farmers have lower land fragmentation.

Access to irrigation is critical for paddy productivity, particularly for summer paddy production. Paddy yields could be boosted even further by improving irrigation water availability. According to survey results, 25% of paddy farmers had access to irrigation for paddy production, whereas 75% of paddy farmers did not. However, access to irrigation appears to be extremely limited, and farmers have insufficient access to irrigated water.

Plant protection is a practice of growing concerned with preventing crop losses caused by diseases and weeds. Insect, disease, and weed pressures are among the most serious risks to paddy cultivation because they compete for critical nutrients and reduce yield and quality. Plant protection is used by farmers to keep pests from harming their crops and restricting their harvest. However, as the effects of climate change become more serious, this pet pressure will become more significant, making proper plant protection more necessary than ever. According to survey results, 16.8% of farmers have weeded paddy fields, 6% of farmers have disease control, and 77.3% of farmers have both weeding and disease control for their paddy production. Weeding and disease prevention must be prevented to increase paddy yield.

5.1.3 Sample Farmers' Institutional Characteristics

The information on the institutional characteristics of farmers is described in Table (5.3). The institutional characteristics are credit amount, extension services, training, and membership in agricultural associations.

Table (5.3) Institutional Characteristics of Farmers

Sr	Institutional Characteristics	No. of Respondents	Percentage
1	**Amount of Credit**		
	Below 5 lakhs	67	16.8
	5-10 lakhs	111	27.8
	Above 10 lakhs	222	55.5
2	**Extension Services**		
	Yes	137	34.3
	No	263	65.8
3	**Training**		
	Yes	81	20.3
	No	319	79.8
4	**Membership of Agricultural Association**		
	Yes	54	13.5
	No	346	86.5

Source: Own Survey, 2020

Credit is essential in paddy production since it is required to purchase farm inputs. The credit amount is both official and informal. In the research area, the formal sources of credit are MADB and cooperatives, but informal sources of credit include friends, relatives, dealers, millers, and the like. Farmers can benefit from low-interest loans from the MADB. Credit from other lenders has high interest rates and burdens farmers. The quantity of loans available to farmers from the MADB is determined by their land ownership. According to the survey results, 16.8% of farmers have borrowed less than 5 lakhs from the MADB, 27.8% have borrowed between 5 and 10 lakhs, and 55.5% have borrowed more than 10 lakhs. Every farmer, it has been noticed, obtains a loan from the MADB.

Extension services are mainly a means of introducing new knowledge and ideas into rural regions in order to effect change and enhance the lives of farmers and their families. If agricultural extension did not exist, farmers would not have access to the assistance and services they need to improve their agriculture and other productive activities. Extension is a non-formal educational activity aimed at farmers. Extension also strives to improve the efficiency of the farm, enhance productivity, and raise the farm family's overall standard of living. Agricultural extension services are mostly provided by MOLIA, non-governmental organizations, and agricultural-related businesses. According to the study results, 34.3% had access to an extension service, whereas 65.8% of farmers did not. Farmers are unable to get extension services due to a lack of agents, which might have an impact on paddy output because extension agents offer farmers with the application of input utilization and technical improvements.

Training improves the abilities of individuals and thus contributes positively to production and productivity. Knowledgeable employees are the most valuable assets of the firm. Training equips individuals with unique skills and competencies that contribute to improved firm productivity. According to the survey results, 20.3% of farmers were getting training for their farming practices and 79.8% of farmers had not received any training. Appropriate training for farmers may increase productivity by improving their management capacity. The farmers had a lack of access to extension services, poor credit orientation, and little knowledge of medium-scale farming. Farmers have been in great need of training in agronomical practices.

Membership of an agricultural association plays a vital role for paddy production farmers. Several organizations promote efforts to increase agricultural production. These are governmental and non-governmental organizations (NGOs) that provide support to farmers in order to boost agricultural productivity, such as technology, inputs, and financing. Agricultural production aid groups also give significant help with paddy production techniques, inputs, credit unions, and market-related organizations. According to survey results, 13.5% of farmers were members of an agricultural organization and 86.5% of farmers did not belong to an agricultural organization. Members of these associations of paddy farmers have brought many benefits to their paddy production activities. Farmers have been benefiting from access to modern paddy farming techniques, access to modern fertilizers and pesticides, modern machinery, and credit and pricing information. Membership as a paddy farmer in these organizations will bring many benefits to their paddy production. Paddy farmers who do not belong to these organizations may face many difficulties in growing paddy and may have reduced output potential.

5.1.4 Descriptive Statistics of Variables

The descriptive statistics results of variables used for analysis in the production function are presented in Table (5.4). The production function and technical efficiency were estimated using six types of inputs, which are land, labor, capital, fertilizer, pesticide, and seed.

Table (5.4) Descriptive Statistics of Variables for the Sample Farms

Variables	Mean	Std. Dev.	Minimum	Maximum
Output Per Acre (Basket)	71.02	11.66	40	120
Land Area Per Farmer (Acre)	8.37	4.84	2	25
Labor Use Per Acre (Man)	14	2.52	6	20
Capital Per Acre (Kyat)	11628	8724.68	667	42500
Fertilizer Per Acre (Kg)	102.42	37.07	37.5	250
Pesticide Per Acre (Litre)	2.73	1.68	0.47	10
Seed Per Acre (Basket)	2.72	0.46	1	4

Source: Own Survey, 2020

The sample farmer's average output per acre of paddy is 71 baskets, ranging from a minimum of 40 baskets to a maximum of 120 baskets per acre, with a standard deviation of 11.66 among the sample farmers. This indicates the greater variability of output among the farmers.

Land area refers to the sown area used for paddy per farmer and was measured in acres for both the summer and monsoon paddy growing seasons when surveys were conducted. The paddy farmers in the sample area have an average paddy growing area of 8.37 acres, ranging from 2 acres to 25 acres. Inequalities in farm size will always exist and equal development will never occur because farmers are not all the same in any economy. However, farm size is relatively unimportant; it relates to the usage of agricultural aid (extension, infrastructure, inputs, credit, and membership in agro-based organizations). Where new technologies are available and the opportunity exists, farmers take advantage of it and adapt and use it.

Labor inputs account for the total labor used in paddy production activities per acre for each farm. The average labor used by paddy growers was 14 men per acre, which was obtained by aggregating labor used for all paddy production activities that include land preparation, planting, fertilizer application, weeding, and harvesting. The minimum and maximum levels of labor used were 6 and 20 men per acre, respectively.

The cost of mechanical power used per acre by paddy production activities can be calculated as a capital input. The average amount of capital is 11628 kyats per acre of paddy production. The amounts of capital were utilized, in the paddy production activities ranging from 667 kyats to 42,500 kyats, respectively.

Farmers commonly used organic, urea, potash, and compound fertilizers. The average applied fertilizer per acre was 102.42 kg, which ranged from 37.5 kg to 250 kg, the minimum and maximum application rates. Fertilizer application is therefore quite high. Pesticide application per acre of farmers: an average of 2.73 litres of pesticide applied by farmers on their paddy production ranges from a minimum of 0.47 litres to a maximum of 10 litres. Most farmers still use traditional seed varieties for paddy production. The average local paddy seed input sown per acre was 2.7 baskets, which ranges from 2 baskets to 25 baskets, the minimum and maximum quantity of seed.

5.2 Results of the Stochastic Frontier Production Function

This section presented the results of the maximum likelihood estimates of the parameters used in the production function. The Cobb-Douglas production frontier is estimated by maximum likelihood, which has been widely adopted in stochastic frontier production studies, assuming a normal or half-normal distribution by using the STATA computer program.

Table (5.5) Maximum Likelihood Estimates of the Parameters

Variable	Coefficient	St. Error	P-value
Intercept	1.491	0.116	0.000
Ln(Land) (acres)	0.714***0	0.063	0.000
Ln(Labor) (man per acre)	.006	0.041	0.888
Ln(Capital)(kyat)	0.001	0.019	0.945
Ln(Fertilizer) (kg)	0.192***	0.021	0.000
Ln(Pesticide) (litre)	-0.014	0.013	0.299
Ln(Seed) (basket)	0.092**	0.040	0.023
$Sigma^2$ V	-6.200***	0.275	0.000
$Sigma^2$ U	-5.051***	0.280	0.000
Sigma -V	0.045	0.006	
Sigma-U	0.080	0.011	
Sigma Square($\sigma^2 = \sigma_U^2 + \sigma_V^2$)	0.008	0.001	
Lambda ($\lambda = \sigma_U/\sigma_V$)	1.776	0.017	
Gamma $\gamma = \lambda^2/(1+\lambda^2)$	0.758		
LR test of Sigma U=0: Chi bar-square (01)			5.60***
Wald Chi^2 (6)			7702.19***
Pro>Chi^2			0.0000

***, ** and * denote 1%, 5% and 10% significant levels respectively

Source: Own Survey, 2020

Table 5.5 shows the variance parameters (γ) (λ), and (σ^2) for paddy farmers in the study area. If (γ) = 1, it means all deviations from the frontier are due to technical inefficiency. The γ value is 0.758 for paddy production, with a value close to or equal to 1, implying that the frontier model is appropriate. The values of gamma mean that about 76% of the total variance is composed of errors and can be presented by the variance of the technical inefficiency terms of the respective production functions. This also means that about 76% of the total variations in outputs for paddy farmers in the sample area and that variation in paddy outputs could be attributed to inefficiency. That is, the differences between actual (observed) and potential (frontier) output have been dominated by technical inefficiencies. The findings imply that random shocks outside of the farmer's control account for around 24 percent of the variability in paddy output.

The lambda (λ) parameter measures the ratio of the standard deviation of the two error components. If the value of lambda (λ) is equal to 0, there are no technical inefficiency effects exits, and all deviations from the frontier are attributable to noise. Lambda (λ) is measure the ratio of the U and V error terms and its far greater than one (1) indicating that the one sided error term U dominates the symmetric error term V , which variation in actual output comes from the difference in farmers' specific factors rather than random variability.

The sigma-squared (σ^2) indicates the goodness of fit of the model and the distributional form assumed for the composite error term. The estimated sigma-square (σ^2) value is 0.008 and this value is also significantly different from zero, indicating that the model is characterized by better goodness of fit and also that the distributional assumption of the efficiency term is correctly specified. The results revealed the existence of inefficiencies among paddy farmers and hence the appropriateness of the application of modeling.

The maximum-likelihood ratio (LR) test and Wald-Chi square test the presence of technical inefficiency effects in the farmer's paddy production. Moreover, the likelihood ratio (LR) test, which yielded 5.6, was less than the critical Chi-square value of 16.074 (given by Kodde & Plam, 1986). The inefficiency term is at a 1% level of significance, implying that it is present in the model. The significant Wald-Chi square values indicate the explanatory variables included in the model sufficiently describe the variation of paddy output.

The estimated coefficients of the variables in the production function are given in the table. According to the table, the factors of land area, labor inputs, capital, fertilizer, and seed have the desired positive signs, while pesticides have negative signs. The variables with positive signs indicate that they are positively related to those variables, while the variables with negative signs show that increased input utilization will have to reduce paddy output.

The coefficient of land area (0.714) is positive and statistically significant at the 1% level, indicating that a 1% increase in paddy cultivation land area has a positive relationship with paddy outputs. This means that if large landholder farmers assign additional land area to paddy cultivation, they will produce more, but smallholder farmers' paddy output may be reduced because paddy arable land cannot be enlarged. Land area is a critical factor in promoting paddy production.

The coefficient of fertilizer (0.192) is positively and significantly at the 1% level, indicating that a 1% increase in fertilizer application leads to an increase in paddy output. Farmers are using the proper combination of different nutrients. The improper combination of different nutrients means fertilizer being used is less than the recommended level, and high levels of fertilizer used without appropriate balance result in negative effects on paddy outputs. Farmers heavily depend on fertilizer applications to maximize paddy output.

The coefficient of paddy seed (0.092) is positive and significant at 5% level for paddy output, which implies that the seed had a significant effect on paddy output. Paddy seed varieties are one of the production components that contribute to increased paddy production output. If farmers could use high-yielding paddy seeds on their paddy fields, they would be able to get a higher yield than they currently get. Therefore, paddy farmers should cultivate by choosing high-yielding seeds rather than traditional paddy seeds. Paddy output will be increased when using high-yielding seeds varieties in sufficient quantities.

5.3 Sample Farmer Technical Efficiency Level Distribution

This section present the distribution of the sample farmers' technical efficiency level was derived from maximum likelihood estimates of the parameters based on the normal/half-normal distribution of the study of the stochastic frontier function. Table (5.6) shows the estimated outcomes of the technical efficiency levels.

Table (5.6) Farmer Technical Efficiency Level Distribution

Efficiency Level	No. of farmers	Percentage
0.50 - 0.60	14	3.5
0.61 - 0.70	24	6.0
0.71 - 0.80	29	7.2
0.81 - 0.90	53	13.3
0.91 - 1.00	280	70.0
Total	**400**	**100.0**
Minimum TE	0.507077 (51%)	
Maximum TE	0.979996 (98%)	
Mean TE	0.89270843 (89%)	
Standard Deviation	0.109481407	

Source: Own Survey, 2020

The ability of farms to achieve the highest level of output given a set of inputs is referred to as technical efficiency. The estimates results of the level of technical efficiency in the study area range from 0 to 1. Efficiency level 0 is totally inefficient, whereas efficiency level 1 is totally efficient. To calculate the level of technical efficiency (TE) of paddy production the following formula was used; $TE = Y_i / Y_i^*$ where Y_i is the individual paddy farmers observed (actual) output; Y_i^* is the individual paddy farmers frontiers (potential) output.

According to the findings, the average technical efficiency of paddy output is 0.89 (89 %). This suggests that paddy output is still not technically efficient, and that farmers could increase production by around 11% if they operated at totally efficiency. Farmers' overall technical efficiency is less than one. The farmers are still not able to utilize the inputs that they own, which cause the paddy production they do have to be technically inefficient. This result indicates that farmers are generally overly dependent on the inputs they own, which leads to inefficiency. Thus, farmers may need to make efficient use of factors of production to improve the efficiency of paddy production.

Technical efficiency is estimated to be 89% on average, with a range of 51% to 98%, implying that average paddy production produces 89% of the maximum possible output for a given input level. Depending on present production conditions, the technical efficiency level of paddy production might grow by 11%. According to the distribution of efficiency level, 70% of the farmers in the sample had a maximum efficiency level between 0.90 and 1.00, with 13.3% having 0.81- 0.90, 7.2 percent having 0.71- 0.80, 6% having 0.61- 0.70, and 3.5 percent having 0.51- 0.60. The average technical efficiency level was 0.89 (89 percent), indicating that the majority of farmers have a higher level of technical efficiency and that there is potential to achieve totally efficient paddy production by utilizing existing resources effectively.

5.4 Factor Affecting Sample Farmers' Technical Efficiency

In this section, the Tobit regression model was used to analyze the determinants of factors affecting the technical efficiency of paddy production. The Tobit regression model was applied to technical efficiency level as a dependent variable and some key socioeconomic characteristics of individual farmers, farm specific factors, and institutional characteristics are independent variables related to technical efficiency. Instead of using the ordinary lease square (OLS) estimate that might produce biased results. The OLS regression model is ineffective for regression analysis because its technical efficiency level is limited to 0 to 1. It is more convenient to have data filtered at zero than at one for tobit regression. The parameter coefficients are used to investigate the directional relationship between efficiency and covariance.

Table (5.7) Estimate Results of Tobit Regression Model

Variables	Coefficient	Std. Error	P-Value
Intercept	0.6235***	0.02760	0.000
Gender	0.0845***	0.01400	0.000
Age	0.0007	0.00042	0.119
Family Size	0.0007	0.00211	0.744
Educational level	0.0042***	0.00093	0.000
Farming Experience	0.0012***	0.00033	0.000
Farm Income	2.64e-09*	1.43e-09	0.066
Planting method	0.0053	0.00785	0.501
Access to Irrigation	0.0085	0.00701	0.223
Plant protection	0.0280*	0.01424	0.050
	0.0353***	0.01251	0.005
Land Fragmentation	0.0094	0.00641	0.143
Amount of credit	1.77e-08**	8.12e-09	0.030
Extension services	0.0417***	0.00654	0.000
Training	0.0326***	0.00820	0.000
Membership of association	0.0171*	0.00920	0.064
Pseudo R^2			0.4460
LR Chi^2			226.45
Pro > Chi^2			0.000
Number of Observation			400

The symbols ***, **, and * represent a 1%, 5%, and 10% significant level, respectively.

Source: Own Survey, 2020

The empirical findings indicate that all of variables have a positive sign, which indicates increased efficiency. In this variables such as educational level, farming experience, plant protection (both weeding and diseases), extension services, and training were statistically significant at 1%, while the amount of credit was significant at 5%, and farming income, plant protection (diseases), and membership of agricultural associations were significant at 10%, respectively. The likelihood ratio chi-square of 226.45 with a P-value of 0.0000 and which means that the model fits and significant.

The farmer's gender coefficient (0.0845) is positive and statistically significant at the 1% level, indicating that being a male farmer boosts technical efficiency over being a female farmer. It can be show that male farmers have more opportunities to obtain knowledge, better access to technology, information, and farm inputs than female farmers. In addition, most female farmers are physically weak, and farming practices, which leads to less efficiency for female farmers. Sokvibol (2017) revealed that a farmer's gender had a large and detrimental effect on the technical efficiency of paddy production. Betty (2005) found that male farmers were more technically efficient than female farmers.

The level of education (0.0042) is positive and significant at 1% level of output. It suggests that highly educated farmers are more technically efficient than less educated farmers. This could be because more educated farmers have access to more information and better communication media, which allows them to employ current paddy production technologies. Farmers' acquisition and utilization of information about new technologies is improved by education. Farmers with a higher education level have stronger technical efficiency and managerial capacity to absorb information technology, which increases their ability to apply technology and efficiently allocate available resources.

The coefficient of farming experience (0.0012) is positive and significant at 1% level of technical efficiency. This means that farmers with more experience are more technically efficient in paddy production. Farming experience can be defined as the practical knowledge and abilities obtained over time on how to overcome the majority of the key difficulties confronting expanding paddy production, output, processing, and marketing. The age of a farmer is a measure of their farming experience. Some older farmers are less open to modern farming technologies and methods. This demonstrates that farmers with fewer years of farming experience are more likely to be efficient than their older counterparts.

The farm income coefficient (2.64e-09) is positive and significant at a 10% level. According to the findings, farmers require financing to purchase seed, fertilizer, pesticides, and herbicides, as well as pay for hired labor. This is in addition to funding the demand for household consumer goods. Hence, increased farm income equates to increased purchasing power for various farm supplies. As a result, increased agricultural income can boost technological efficiency.

The coefficients of plant protection, method of disease protection, (0.0280) and both methods of diseases and weeds (0.0353) were positive and statistically significant at 10% and 1% levels. This meant that disease control was more effective than only weed control. Furthermore, weeds and diseases, both methods of protection, boost efficiency rather than only weed management in paddy production. Weeds in paddy farming produce a large amount of viable seed, which is difficult to remove after it has contaminated the soil and may remain viable for many years. Broadcast paddy sowing reduces the likelihood of weed elimination by cultivation after emergence. Weeds significantly increase production, harvesting, drying, and cleaning costs, and they exacerbate pest infestations by harboring insects and diseases. Plant diseases are caused by microbes such as viruses, bacteria, and fungi.

The credit amount coefficient (1.77e-08) is positive and significant at a 5% level. This indicates that credit availability transfers the cash restriction outwards, allowing farmers to make timely purchases of inputs that they would not be able to afford with their own resources. It also improves the utilization of inputs, resulting in greater efficiency. Credit access to farmers may serve as an operational motive to produce more efficiently, in addition to being able to obtain the essential inputs for production. Farmers will improve the technical efficiency of paddy production if more finance is made available to them. In this regard, the amount of credit has a favorable impact on paddy production efficiency. One of the causes is a limitation on the provision of further credit. Farmers can obtain credit from the MADB for up to 10 acres. Hence, this credit system mostly helps farmers with smaller farm sizes as opposed to those with bigger farm sizes.

The coefficient for extension services (0.0417) is positive and statistically significant at the 1% level. This meant that access to extension services would boost efficiency in paddy production. It could be linked to information and knowledge obtained by paddy farmers, which would supplement training. Farmers who have contact with extension agents are more likely to use modern paddy production techniques such as land preparation, planting, agrochemical application, and harvesting. Farmers were given the information they needed about current technologies, allowing them to raise their technical efficiency levels.

The training coefficient (0.0326) is positive and statistically significant at the 1% level. This meant that farmers who had received paddy production training were more technically efficient. Farmers who had received training were technically more efficient than farmers who had not received training. Farmers need paddy production training since it may help them enhance their production practices and other abilities. A number of farmers received paddy production training, which focused on production practices and the need for improved packaging. It is also critical to provide continual training to farmers and to monitor farmers' farming activities regarding input practices during paddy cultivation. According to Onyenweaku and Nwaru (2004), extension service centers should provide farmers with training in order to increase their efficiency in paddy production.

The coefficient of agricultural association membership (0.0171) is positive, and the 10% level was statistically significant. This means that when more farmers belong to an agricultural association, their efficiency will improve. Agricultural associations help paddy farmers improve their technical efficiency. Farmers have greater access to agricultural knowledge, credit, and other inputs from the agricultural associations. Dolisca and Curtis (2008) revealed that involvement in agricultural associations improved technical efficiency.

CHAPTER VI
CONCLUSION

Productivity can be increased in two ways: by introducing new agricultural production technology or by enhancing farmers' technical efficiency levels, which are two alternate strategies for increasing agriculture sector productivity in the country. Technical efficiency has remained an important empirical concern, particularly in resource-limited developing countries. Productivity growth could also be related to technological advancements or efficiency improvements.

According to the estimated stochastic production frontier model, land, labor, capital, fertilizers, pesticides, and seeds are all important determinants of paddy output. The presence of a positive coefficient for these variables indicates that increasing the use of these inputs will result in higher outputs. Individual farmer socioeconomic, farm-specific factors and institutional characteristics are variables in the Tobit regression model for factors influencing the technical efficiency of paddy production. These factors' predicted positive coefficients imply increased technical efficiency.

6.1 Findings and Discussions

According to farmer socioeconomic factors, male farmers dominate female farmers in paddy cultivation. More than half of the farmers are over the age of 50. Since many paddy farmers are older than the national average, aging may hinder their ability to adopt new paddy production practices and access advanced equipment. The majority of farmers have only a primary education, and those with a higher degree are relatively rare. Farmers required simple and straightforward educational training for modernized paddy growing technologies due to their lower educational levels. In addition to education are crucial in making production selections. Farmers' educational levels influence their ability to implement new productive technologies. More than half of the households in the sample areas have four to six people, and the majority of farmers have a large family. The negative relationship between family size and productivity has been linked to the increased spending pressure that comes with having a large family. The number of family members, on the other hand, has been identified as the key potential source of family labor engagement in farming operations. The majority of paddy farmers have ten to thirty years of experience in paddy cultivation. They have a variety of paddy production farming methods, but it appears to be a traditional method. The majorities of farmers earns between 30 and 60 lakh kyats per year and have received agricultural loans from credit institutions. Farm income was generally low, and farmers relied on loans as a condition of their low agricultural earnings.

Broadcast farms accounted for 83.8 percent of all farmers. This planting method is also a low-cost approach to paddy cultivation. Farmers have bigger plots (less land fragmentation). The majority of farmers have larger plots and less land fragmentation. The paddy field's large size saves on agricultural costs such as machinery relocation and transportation of other inputs. Hence, 75% of paddy farmers lacked access to water for irrigating their paddy crops. Rainfall is essential for the paddy growers. Furthermore, a few irrigated farmers live beside the river and use irrigation water to pump water from it. Several paddy growers were also seen preserving their plants. Most farmers preserve it for weed management and disease prevention in order to increase paddy output.

The amount of the credit is decided by who owns the land. Farmers with more land are able to borrow more, whereas farmers with less land may borrow less. The majority of credit was provided by the MADB, with only a few borrowings from other lending organizations. Despite MADB loans, farmers do not have enough money to carry out agricultural tasks. Farmers rely heavily on MADB loans, which have the lowest interest rates when compared to other banking institutions. MADB has increased loans to small farmers, who may not be as efficient and may use the funds for spending rather than improving technical efficiency.

Farmers had no access to extension services. Farmers' inability to obtain extension services is due to a lack of agents, which may have an impact on paddy productivity because extension agents provide farmers with critical information on resource usage technical advancements. Farmers' training eventually adds to agricultural human capital development. Farmers' basic demands are improved information on seeds, fertilizers, soil testing, irrigation, new technologies, plant protection measures, and credit information. Most farmers have received little or insufficient training in paddy production. Membership in agricultural associations has brought a variety of opportunities to their farming activities. Most farmers were not members of an agricultural organization that provided sophisticated farming techniques, fertilizers, herbicides, and contemporary technology, as well as credit and pricing information.

According to data on paddy production inputs and outputs, the sample farm's mean per acre of output for paddy cultivation is 71 baskets, with a range of 40 to 120 baskets. The mean farm size is 8.37 acres, ranging from 2 to 25 acres per farmer. The mean number of laborers per acre is 14, with the range being 6 to 20 men per acre. The mean value of capital used per acre is around 11628 Kyats, with a range of 667 Kyats to 42500 Kyats. The mean rate of fertilizer application per acre is 102.42 kg, with rates ranging from 37.06 kg to 250 kg. Application of pesticides by paddy farmers means 2.73 liters per acre and ranges from 0.47 to 10 liters. The mean seed input used per acre in a given production year is 2.72 baskets, with volumes ranging from 2 to 25 baskets.

The Cobb-Douglas production functional form was used to perform stochastic frontier analysis has been widely used in empirical analysis due to its modeling flexibility. Individual farmers' input-output factors were assigned to produce output. The estimated technical efficiency levels for variables such as land, labor, capital, fertilizer, pesticide, and seed used in paddy production were estimated as well. In this analysis, variables such as land, fertilizer, and seed were found to be significantly related to the level of technical efficiency. Furthermore, the existence of efficiency effects in this analysis is represented by the variance parameters, λ and γ .Therefore, utilizing technological methods and input usage alone will be insufficient to achieve full efficiency in the areas.

The overall mean efficiency level is 0.89, implying that the average farm only produces 89% of the maximum attainable output for the given input levels. The sample farms also accounted for a range of efficiency levels, from 0.51 (51%) to 0.98 (98%). According to this study, average farm technical efficiency might grow by 11% under current production conditions. It implies that the mean level of technical efficiency has the ability to improve efficiency without reducing both the amounts of input used and the present technology. According to the theoretical assumption, the most efficient farmer is located on the production frontier line. Farmers are generally increasingly dependent on the factors of production they own, resulting in inefficiency, with a predicted level of technical efficiency of less than one.

The factors affecting the technical efficiency of the sample paddy farmers are examined based on the empirical findings mentioned above. The Tobit regression model was used to investigate the factors that affect the technical efficiency of paddy production. Gender, educational level, farm experience, farm income, level of credit, plant protection, extension services, training, and membership in agricultural associations were factors that determined the levels of technical efficiency of paddy production.

The gender measure is a dummy variable, with a value of one for a male farmer and zero for a female farmer. Female farmers may also be needed to perform additional jobs such as child care, and their time may be divided between these tasks and actual farm activities. Male farmers would thus be more efficient than female farmers. Female farmers, in general, have limited access to productive resources and will be forced to allocate their resources more efficiently. Education level was positively and significantly related to technical efficiency. According to these findings, highly educated farmers are improving technical efficiency, which means farmers are less conservative and more open to new technology and innovation, contributing to increased technical efficiency. Experience in farming improves paddy productivity and efficiency. Years of paddy farming experience were used to estimate farming experience. Farmers with many years of paddy production expertise are more likely to be familiar with the necessary paddy production abilities, resulting in higher yields and, as a result, increased technical efficiency.

The farm income coefficient is both positive and significant. Farmers who earn a higher income from paddy production are more efficient than their peers. According to the facts, farmers with both farm and non-farm income should be encouraged to increase their productivity. The plant protection coefficient has a positive and significant value. Weeds and diseases are both used to measure plant protection. The amount of credit has a positive effect on efficiency. The amount of credit available on large farms indicated that farmers improve their paddy production efficiency if they have access to more finance.

Extension services are defined as the number of times a producer is visited by an extension agent during a given production season. An Extension agent can help farmers learn about available technology by informing, inspiring, and educating them.

It may boost technical efficiency levels by improving managerial abilities and general agronomic practices. Training has significant and positive effect on technical efficiency. Through training, farmers enhance their abilities in improved seed, resource management, and general farm management. In addition to improving farmer practical training, efforts should be made to train farmers for a longer length of time by utilizing already constructed farmer training centers and research facilities. Farmers that belong to an agricultural association have more access to extension services; hence membership in an agricultural association is likely to be positively associated with technical efficiency.

6.2 Policy Recommendations

The study's implication is that farmers' technical efficiency can be increased by better allocating available inputs, particularly land, fertilizer, and seed varieties, and it identifies a number of factors that affect the level of technical efficiency (gender, educational level, farming experience, farm income, and plant protection, amount of credit, extension services, training, and membership in agricultural associations).

To increase paddy output, not only paddy production area growth but also upgrades such as land reclamation and farm consolidation are required. Land reclamation projects should include the establishment of new villages for landless workers in remote and underdeveloped locations; irrigation and drainage programs; credit schemes; and communication and transportation services. Farm consolidation is promoted as one of the most effective methods of increasing output because low farm income is caused by small farm sizes or a lack of consolidation. To achieve a more effective farm, farmers must establish well-organized agricultural land management programs. The majority of paddy farmers plant their seeds using seeds from the previous growing season. As a result, paddy farmers must be aware of the need for seed preservation in order to improve output and product quality in subsequent years. Furthermore, agro-inputs such as chemical fertilizers, organic manure, pesticides, and small-scale agricultural equipment were required to improve paddy production.

The following policy implications should be examined to improve the technical efficiency of paddy production: Farming experience is strongly related to technical efficiency, which is why the local agricultural development office should provide an opportunity for farmers to share their experiences with one another. It is also critical to enhance agrochemical supplies and instruction on how to use agrochemicals on paddy fields. Because education is strongly related to technical efficiency, it is critical to provide adult education and vocational education to farmers. It is essential to enhance paddy yields. Hence, local governments must improve farmers' access to education by either expanding a farmer training center or other educational expansion. Training determines technical efficiency, which positively and significantly affects paddy-producing farmers. The provision of training for farmers to improve their skills, resource management, post-harvest handling and general farm management capabilities will increase their farm productivity. In addition to strengthening the practical training provided to farmers, for a relatively longer period of time, using the already constructed farmer's training centers and agriculture research demonstration centers. Weed control in paddy fields and disease prevention are both ways to improve production efficiency. Hence, policymakers and non-governmental groups should provide weed management and disease prevention services to paddy farmers. The amount of credit received was found to have a positive and significant effect on output. However, smallholder paddy framers have financial challenges. It would indicate that farmers required outside funding solving their own financial restrictions. MADB should be mandated to give a reasonably high quantity of credit to farmers and should be encouraged and strengthened to deliver more, as well as to align loan delivery with time input requirements and loan payment plans with harvesting seasons. Extension service delivery should be intensified by the training and deployment of qualified extension agents to the township. These extension agents should provide farmers with information on efficient input use, especially land, fertilizer, and pesticides, since these inputs promote paddy output. Extension officers should advise farmers' plant protection technology, such as row-planting, because plant protection has improved farmers' technical efficiency. Membership in an agricultural association increases technical efficiency. Policymakers should consider these factors when creating incentives for smallholder farmers to join agricultural associations, farmers have received the most benefits from such associations. The provision of a training program to inform farmers about the benefits of membership is complemented by effective extension services to deliver technical capacity building.

There are numerous obstacles mentioned above such as educational, extension services, training, membership in agricultural associations, and financial status, which have a transition to a modernized, mechanized farming system. Decision-makers should place a priority on supporting farming infrastructure, human resource development programs for farmers, and a modernized farming system rather than the current situation.

6.2.1 Suggestion for Further Study

The current study only examined one-year cross-sectional data for paddy technical efficiency analysis. Panel data for paddy production should be required to estimate long-term technical change. For several reasons, this study cannot predict technological change and allocation efficiency. However, panel data should be utilized to examine technological changes. In addition, future studies for technological change analysis can provide more solid and specific requirements for the paddy firm's short- and long-term development. Furthermore, future studies should compare the conditions of production efficiency with Myanmar and neighboring paddy-producing nations that have similar climate conditions and paddy-growing patterns and find out if the comparison can reveal the strong and weak aspects of efficient production conditions.

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APPENDIX – 1

QUESTIONNAIRE

SECTION (A): SOCIOECONOMIC CHARACTERISTICS

1	Gender (HH)		1	Male
			2	Female
2	Age (HH)			Years
3	Marital Status (HH)		1	Single
			2	Married
			3	Divorced
			4	Widowed
4	Educational Level (HH)		1	None
			2	Write and Read
			3	Primary
			4	Middle
			5	Higher
			6	Undergraduate
			7	Graduated
5	Year of Schooling HH			Years
6	Year of farming experiences of HH			Years
7	Total farm size in acres			Acres
8	Total area under paddy production			Acres
9	HH members	Under 18		
		18 to 45		
		46 to 60		
		Above 60		
	Total Number of HH members			
10	Non-Farm Activities		1	Yes
			2	No
11	Types of Non-Farm Activities		1	Trading
			2	Teaching
			3	Government Staff
			4	Company Staff
			5	Livestock Rearing
			6	Others, Specify
12	Average annual farm income from the paddy production			Kyats
13	Average annual non- farm income			Kyats

SECTION (B): FACTORS OF PRODUCTION AND FARM CHARACTERSTICS

1	Types of Land preparation	1	Tractor
		2	Animal
		3	Manual
2	Ownership Status	1	Outright Ownership
		2	Rented in
3	Do you have any rented land?	1	Yes
		2	No
4	What type of land do you have rent?	1	Owned land
		2	Fixed-rent
		3	Sharecropping
5	Mode of Payment	1	In cash
		2	In kind
6	Rotation of Crop	1	Once
		2	Twice
		3	Three time
7	Planting Method	1	Broadcasting
		2	Row Planting
8	Land Fragmentation	1	Greater plot size
		2	Smaller plot size
9	Plant Protection	1	Weeding of crop fields
		2	Diseases
		3	Both Diseases and Weeding
		4	Others, specify
10	How many days did they use for planting activity in completing the planning activities?		days
11	How long does it take for the paddy crop you plant to reach maturity?	1	90 days
		2	120 days
		3	150 days
		4	Others, specify
12	What method do you use for control weeding on your farm?	1	Hand weeding
		2	Machine
		3	Chemical
13	Which crop do you cultivate in the dry season after harvesting paddy?	1	Paddy
		2	Mung Bean
		3	Vegetables
		4	Sunflower
		5	Fallow
		6	Other, specify

14	Do you have irrigation supplied for your paddy production?	1	Yes
		2	No
15	Sources of Irrigation	1	Own Well
		2	Creek/River
		3	Private dam/canal
		4	Government irrigation facilities
		5	Others, specify
16	Total Acre		Acres
17	Price per Acre		Kyats
18	Total Cost		Kyats

2. Labor Input Used in Paddy Production

1.	**Land Preparation**	**Plantin g**	**Fertilizer Applicatio n**	**Weedin g**	**Harvesting**	**Othe r**
Hire Labor (Per Acre)						
Number						
Days						
Costs						
Family Labor (Per Acre)						
Male (>18ys)						
Number						
Days						
Cost						
Female (>18ys)						
Number						
Days						
Cost						
Children (<18ys)						
Number						
Days						
Cost						

2	How many laborers did you use in the 2019 growing season?		

1. **Farm Assets**

Machines and Equipment	Number	Total Cost
Tractor (Heavy)		
Tractor (Small)		
Harvester		
Thresher		

Quantity Use (per acre)

Machines and Equipment	Quantity Used (per acre) / (Per hour)	Per unit Cost	Total Cost
Tractor (Heavy)			
Tractor (Small)			
Harvester			
Thresher			

2. **Seed Usage**

Types of Seed	Quantity Use (per acre)	Per Basket price	Total Cost
High Yield Seed			

3. **Fertilizer Usage**

Types of Fertilizer (Kg)	Quantity Use (per acre)	Per Kg price	Total Cost
Organic			
Phosphate			
Urea			
Compound			

4. **Pesticides Usage**

Types of Pesticides (Litre)	Quantity Use (per acre)	Per Litre price	Total Cost
Herbicides			
Insecticides			

5. **Output of Paddy and Marketing**

Total Paddy Cultivated Acres		
Yield Per Acre		
Total Output of Paddy		
Price Per Basket		
Total Revenue		
Consumption		
In Stock		

8	Where did you sell your produce last year?	1	Traders/Middle
		2	Millers/Processors
		3	Wholesale dealers
		4	Taken to town market your self
		5	Others, specify

9	Summary of unit cost/price and quantity of key production variables (Per Acre)			
No	**Production Variables**	**Total Quantity Use**	**Price**	**Total Cost**
1	Number of labor (Man-day)			
2	Compound (Kg)			
3	Urea (Kg)			
4	Phosphate (Kg)			
5	Organic (Kg)			
6	Herbicides (Liter)			
7	Insecticides (Liter)			
8	Seed (Basket)			
9	Farm Tools (Unit)			

SECTION (C): INSTITUTIONAL FACTOR IN PADDY PRODUCTION

1	Did you have access to farm credit last year?	1	Yes
		2	No

2	If you had access to farm credit last year, which of the following was your source of credit.		
	Sources	**Types of Credit**		**Amount**
		Cash	**Farm Inputs**	
	MADB			
	Micro-Finance			
	Cooperative			
	Money Lenders			
	Millers			
	Traders in agribusiness			
	Friend and related			
	Local Shop Owners			

3	Did you have access to extension services last year?	1	Yes
		2	No

4	If you had access to extension services last year, which of the following was your source of services							
	Sources	**Delivery**		**Frequency of visits**		**Types of services**		
		Individual	Group	1-3	3-5	Agri; Practice	Credit	Marketing
	MOLIA							
	Agronomist							
	NGO's							
	Agr; Company							

5	Have you had any training for farm management practices last year?	1	Yes
		2	No

6	Have you had any involvement in agricultural association last year?	Yes	
		No	

SECTION (D): GENERAL QUESTIONS

1	What are the advantages of Fertilizer?	1	Increase grain yield
		2	Increase straw yield
		3	Improve the quality of the crop
		4	Others (Specify)

2	From where do you source your technical information about farming?	1	Newspaper
		2	Journals/periodicals
		3	Radio
		4	Television
		5	Mobile Phone

3	Was there ready market for your product?	1	Yes
		2	No

4	Did you have access to paddy storage facilities after harvesting your paddy last year?	1	Yes
		2	No

5	What are the main reasons for land degradation?	1	Yes
		2	No

6	Does lack of credit affect your use of produced inputs (seed, fertilizer, water) use?	1	Yes
		2	No

7	Please tell us if you have any desire to purchase crop-insurance? (Explain what it is and the different forms) If yes, from whom or which organization can you get it?

Thank you so much for your kind patience in help communicating the questions inquired

APPENDIX - II

Sample Villages

စဉ်	ကျေးရွာအမည်	စုစုပေါင်းစပါးစိုက်လယ်သမားအရေအတွက်	ရွေးချယ်ထားသောလယ်သမားအရေအတွက်
၁	ဆင်မြေစား	၇၅	၂၀
၂	ကျွဲတလင်း	၈၉	၂၃
၃	ဒေါင်းစု	၁၅	၄
၄	ချမ်းသာ	၁၅	၄
၅	သုံးခွ	၉	၂
၆	သာအေးဒေါင့်	၃၉	၁၀
၇	ကျုံတုံး	၈၆	၂၃
၈	အုန်းပင်စု	၃၁	၈
၉	ဗီးဖြူကုန်း	၁၀၇	၂၈
၁၀	အလမျိုးချောင်းဖျား	၂၄	၆
၁၁	ပေါ်ဦးစု	၂၂	၆
၁၂	ဝါးတန်း	၁၀	၃
၁၃	လယ်ပြင်စု	၁၆	၄
၁၄	ကျားခေါင်း	၁၇	၄
၁၅	သရောကနက်	၁၇	၄
၁၆	မိုးသပြု	၈၉	၂၃
၁၇	ဖုန်းဆိုး	၇၀	၁၈
၁၈	ရေကြည်	၅၂	၁၄
၁၉	ကြံခင်းစု	၃၁	၈
၂၀	လှည်းဆိပ်	၄၂	၁၁
၂၁	ကျုံသမျှင်	၄၂	၁၁
၂၂	ရွှေဘိုစု	၂၇	၇
၂၃	တော်ဝ	၃၀	၈
၂၄	ထောက်ရှာရိုး	၃၇	၁၀
၂၅	တင်းကုတ်စု	၁၄	၄
၂၆	ကဇင်းတော	၁၅	၄
၂၇	ကင်ပွန်းချောင်း	၃၆	၉
၂၈	မြင်းစု	၁၂	၃
၂၉	ထောက်ရှာရိုး (ညောင်ချောင်း)	၅၄	၁၄

စဉ်	ကျေးရွာအမည်	စုစုပေါင်းစပါးစိုက်လယ်သမားအရေအတွက်	ရွေးချယ်ထားသောလယ်သမားအရေအတွက်
၃၀	ဖိုတေစု	၁၈	၅
၃၁	စာဖြူစု	၈၂	၂၁
၃၂	အုန်တော	၂၉	၈
၃၃	ရေကန်ကုန်း	၂၅	၇
၃၄	နတ်စဉ်ကုန်း	၁၀၂	၂၇
၃၅	ကျောင်းစု	၁၂	၃
၃၆	ကင်မွန်းခြံ	၁၄	၄
၃၇	မြဟန်ကုန်း	၁၀	၃
၃၈	တောလေး	၂၁	၆
၃၉	ပေါက်ကုန်း	၄၂	၁၁
၄၀	ဇလုတ်ကြီး	၂၃	၆
၄၁	အညာစု	၁၂	၃
၄၂	ရွှေကညင်ပင်	၇၄	၁၉
၄၃	လှေကြီးတန်း	၄၉	၁၃
၄၄	ပျဉ်မကုန်း	၄၆	၁၂
၄၅	အလယ်စု	၂၄	၆
	စုစုပေါင်း	၁၇၀၆	၄၄၇

APPENDIX - III

Map of Danubyu Township

Source: Tsp Profies_GAD_Danubyu_2019_MMR

```
  ___  ____  ____  ____  ____(R)
 /__    /   ____/   /   ____/
___/   /   /___/   /   /___/
  Statistics/Data Analysis
```

```
1 . do "C:\Users\lenovo\AppData\Local\Temp\STD2cbc_000000.tmp"

2 . frontier lnyield lnlabour lnland lncapital lnfertilizer lnpesticide lnseed

Iteration 0:   log likelihood =  523.40097
Iteration 1:   log likelihood =  523.72719
Iteration 2:   log likelihood =  524.30795
Iteration 3:   log likelihood =  524.31106
Iteration 4:   log likelihood =  524.31106

Stoc. frontier normal/half-normal model         Number of obs     =        400
                                                Wald chi2(6)      =    7702.19
Log likelihood =  524.31106                     Prob > chi2       =     0.0000
```

lnyield	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnlabour	.005805	.0412364	0.14	0.888	-.0750169	.0866268
lnland	.7139284	.0633113	11.28	0.000	.5898405	.8380164
lncapital	.001292	.0188606	0.07	0.945	-.0356742	.0382581
lnfertilizer	.1920214	.02106	9.12	0.000	.1507446	.2332983
lnpesticide	-.013762	.0132452	-1.04	0.299	-.0397222	.0121982
lnseed	.0915386	.0403964	2.27	0.023	.0123631	.1707141
_cons	1.491265	.1160259	12.85	0.000	1.263859	1.718672
/lnsig2v	-6.200364	.274549	-22.58	0.000	-6.73847	-5.662258
/lnsig2u	-5.051317	.2802674	-18.02	0.000	-5.600632	-4.502003
sigma_v	.045041	.006183			.0344159	.0589463
sigma_u	.0800056	.0112115			.0607909	.1052937
sigma2	.0084296	.0013427			.005798	.0110612
lambda	1.776284	.016842			1.743274	1.809293

```
LR test of sigma_u=0: chibar2(01) = 5.60               Prob >= chibar2 = 0.009

3 .
end of do-file

4 . drop TEfficiency-Edu1_01

5 . do "C:\Users\lenovo\AppData\Local\Temp\STD2cbc_000000.tmp"

6 . tab te
```

te	Freq.	Percent	Cum.
.5070769	1	0.25	0.25
.5246646	1	0.25	0.50
.5321322	1	0.25	0.75
.541475	1	0.25	1.00
.5432914	1	0.25	1.25
.5447784	1	0.25	1.50
.5525063	1	0.25	1.75
.5543134	1	0.25	2.00
.5598388	1	0.25	2.25
.5698144	1	0.25	2.50
.5700145	1	0.25	2.75
.5778113	1	0.25	3.00
.5818352	1	0.25	3.25
.5906612	1	0.25	3.50
.6009485	1	0.25	3.75
.6058344	1	0.25	4.00
.6062245	1	0.25	4.25
.6195766	1	0.25	4.50
.6220279	1	0.25	4.75
.6225686	1	0.25	5.00
.6338812	1	0.25	5.25
.6399058	1	0.25	5.50
.6400702	1	0.25	5.75
.6425007	1	0.25	6.00
.645316	1	0.25	6.25

.648293	1	0.25	6.50
.6562609	1	0.25	6.75
.6573093	1	0.25	7.00
.6586039	1	0.25	7.25
.6652138	1	0.25	7.50
.668984	1	0.25	7.75
.6729368	1	0.25	8.00
.673635	1	0.25	8.25
.6741785	1	0.25	8.50
.6855358	1	0.25	8.75
.6936634	1	0.25	9.00
.6966812	1	0.25	9.25
.6979386	1	0.25	9.50
.7006867	1	0.25	9.75
.7056616	1	0.25	10.00
.7106046	1	0.25	10.25
.7108481	1	0.25	10.50
.7117744	1	0.25	10.75
.7133637	1	0.25	11.00
.7151719	1	0.25	11.25
.7171189	1	0.25	11.50
.7208495	1	0.25	11.75
.7225147	1	0.25	12.00
.7227737	1	0.25	12.25
.7348788	1	0.25	12.50
.7386838	1	0.25	12.75
.7398091	1	0.25	13.00
.7446458	1	0.25	13.25
.7541911	1	0.25	13.50
.7551009	1	0.25	13.75
.7555893	1	0.25	14.00
.7565147	1	0.25	14.25
.757394	1	0.25	14.50
.7641911	1	0.25	14.75
.7649312	1	0.25	15.00
.7731088	1	0.25	15.25
.7733289	1	0.25	15.50
.7777957	1	0.25	15.75
.7844301	1	0.25	16.00
.788853	1	0.25	16.25
.7953809	1	0.25	16.50
.79982	1	0.25	16.75
.8163295	1	0.25	17.00
.817771	1	0.25	17.25
.817837	1	0.25	17.50
.8245969	1	0.25	17.75
.8255809	1	0.25	18.00
.8279887	1	0.25	18.25
.8342188	1	0.25	18.50
.8349899	1	0.25	18.75
.8458716	1	0.25	19.00
.8496213	1	0.25	19.25
.8510742	1	0.25	19.50
.8512813	1	0.25	19.75
.8526018	1	0.25	20.00
.8535797	1	0.25	20.25
.8548699	1	0.25	20.50
.8553873	1	0.25	20.75
.8569367	1	0.25	21.00
.8584329	1	0.25	21.25
.8594878	1	0.25	21.50
.8603757	1	0.25	21.75
.8692852	1	0.25	22.00
.8698337	1	0.25	22.25
.8706523	1	0.25	22.50
.8738317	1	0.25	22.75
.8754983	1	0.25	23.00
.8766146	1	0.25	23.25
.8776684	1	0.25	23.50
.8781069	1	0.25	23.75
.8787569	1	0.25	24.00
.8798316	1	0.25	24.25

.8820879	1	0.25	24.50
.8835236	1	0.25	24.75
.8863461	1	0.25	25.00
.8869952	1	0.25	25.25
.8875732	1	0.25	25.50
.8879316	1	0.25	25.75
.8884377	1	0.25	26.00
.8887346	1	0.25	26.25
.8887502	1	0.25	26.50
.8894257	1	0.25	26.75
.8898047	1	0.25	27.00
.8930069	1	0.25	27.25
.8941523	1	0.25	27.50
.8957696	1	0.25	27.75
.8965526	1	0.25	28.00
.8965901	1	0.25	28.25
.8981061	1	0.25	28.50
.8983086	1	0.25	28.75
.8984171	1	0.25	29.00
.8985974	1	0.25	29.25
.8992705	2	0.50	29.75
.8994864	1	0.25	30.00
.900094	1	0.25	30.25
.9008532	1	0.25	30.50
.9010934	1	0.25	30.75
.9011058	1	0.25	31.00
.9041699	1	0.25	31.25
.904503	1	0.25	31.50
.9057085	1	0.25	31.75
.9059766	1	0.25	32.00
.9065144	1	0.25	32.25
.9082906	1	0.25	32.50
.9083807	1	0.25	32.75
.9085308	1	0.25	33.00
.9106027	1	0.25	33.25
.9107541	1	0.25	33.50
.9113178	1	0.25	33.75
.9120453	1	0.25	34.00
.9120529	1	0.25	34.25
.9124857	1	0.25	34.50
.9127035	1	0.25	34.75
.9159232	1	0.25	35.00
.9177966	1	0.25	35.25
.917981	1	0.25	35.50
.9184609	1	0.25	35.75
.9190415	1	0.25	36.00
.9196746	1	0.25	36.25
.9206339	1	0.25	36.50
.9206471	1	0.25	36.75
.9206705	1	0.25	37.00
.9207139	1	0.25	37.25
.920925	1	0.25	37.50
.9211625	1	0.25	37.75
.9212903	1	0.25	38.00
.9220368	1	0.25	38.25
.9225708	1	0.25	38.50
.9225774	1	0.25	38.75
.9226151	1	0.25	39.00
.9226567	1	0.25	39.25
.9227546	1	0.25	39.50
.9229761	1	0.25	39.75
.9230837	1	0.25	40.00
.9237056	1	0.25	40.25
.924067	1	0.25	40.50
.9243359	1	0.25	40.75
.9245238	1	0.25	41.00
.9249205	1	0.25	41.25
.9258021	1	0.25	41.50
.9258053	1	0.25	41.75
.9262158	1	0.25	42.00
.92874	1	0.25	42.25
.9297289	1	0.25	42.50

.929783	1	0.25	42.75
.9303138	1	0.25	43.00
.9307928	1	0.25	43.25
.9313406	1	0.25	43.50
.9330091	2	0.50	44.00
.9337866	1	0.25	44.25
.9342408	1	0.25	44.50
.9345034	1	0.25	44.75
.9349165	1	0.25	45.00
.9350969	1	0.25	45.25
.9351184	1	0.25	45.50
.935371	1	0.25	45.75
.9355057	1	0.25	46.00
.9358154	1	0.25	46.25
.9358712	2	0.50	46.75
.9359866	1	0.25	47.00
.9361859	1	0.25	47.25
.9363921	1	0.25	47.50
.9364108	1	0.25	47.75
.9366717	1	0.25	48.00
.9369587	1	0.25	48.25
.9369965	1	0.25	48.50
.9370623	1	0.25	48.75
.9374279	1	0.25	49.00
.9374648	1	0.25	49.25
.9374697	1	0.25	49.50
.9375677	1	0.25	49.75
.9376225	1	0.25	50.00
.9377336	1	0.25	50.25
.9384608	2	0.50	50.75
.9385166	1	0.25	51.00
.9385224	1	0.25	51.25
.93862	1	0.25	51.50
.9387415	1	0.25	51.75
.939109	1	0.25	52.00
.9391449	1	0.25	52.25
.9394497	1	0.25	52.50
.9395549	1	0.25	52.75
.9397777	1	0.25	53.00
.9398708	1	0.25	53.25
.9404549	1	0.25	53.50
.9406505	1	0.25	53.75
.9407008	1	0.25	54.00
.9407367	1	0.25	54.25
.9407445	1	0.25	54.50
.9410312	1	0.25	54.75
.9412158	1	0.25	55.00
.9412468	1	0.25	55.25
.9413705	1	0.25	55.50
.9418274	1	0.25	55.75
.9421571	1	0.25	56.00
.9424133	1	0.25	56.25
.9424857	1	0.25	56.50
.9433479	1	0.25	56.75
.9434889	1	0.25	57.00
.9438694	1	0.25	57.25
.944155	2	0.50	57.75
.9441665	1	0.25	58.00
.9442679	1	0.25	58.25
.9444115	1	0.25	58.50
.9447712	1	0.25	58.75
.9460546	1	0.25	59.00
.9463508	1	0.25	59.25
.9464351	1	0.25	59.50
.946875	1	0.25	59.75
.9473434	1	0.25	60.00
.9490758	1	0.25	60.25
.9494355	1	0.25	60.50
.9494769	1	0.25	60.75
.9496143	1	0.25	61.00
.9496757	1	0.25	61.25
.9498658	1	0.25	61.50

.950876	1	0.25	61.75
.9513973	1	0.25	62.00
.9514213	1	0.25	62.25
.9516441	1	0.25	62.50
.9520682	1	0.25	62.75
.9521469	1	0.25	63.00
.9524051	1	0.25	63.25
.9524717	1	0.25	63.50
.9526649	1	0.25	63.75
.9532636	1	0.25	64.00
.9532914	1	0.25	64.25
.9535679	1	0.25	64.50
.9538851	1	0.25	64.75
.9540817	1	0.25	65.00
.9544228	1	0.25	65.25
.9546497	1	0.25	65.50
.9547671	1	0.25	65.75
.9547938	1	0.25	66.00
.9551447	1	0.25	66.25
.9551963	1	0.25	66.50
.9553044	1	0.25	66.75
.9554269	1	0.25	67.00
.9558853	1	0.25	67.25
.955987	1	0.25	67.50
.9562095	1	0.25	67.75
.9569806	1	0.25	68.00
.9570145	1	0.25	68.25
.9570196	1	0.25	68.50
.9570777	1	0.25	68.75
.9572064	1	0.25	69.00
.9574527	1	0.25	69.25
.9576399	1	0.25	69.50
.9576414	1	0.25	69.75
.9576958	1	0.25	70.00
.9578101	1	0.25	70.25
.9579808	1	0.25	70.50
.9581065	1	0.25	70.75
.9584255	1	0.25	71.00
.9585389	1	0.25	71.25
.9590783	1	0.25	71.50
.9592676	1	0.25	71.75
.9594139	1	0.25	72.00
.9602619	1	0.25	72.25
.9604779	1	0.25	72.50
.9608372	1	0.25	72.75
.9609157	1	0.25	73.00
.961379	1	0.25	73.25
.9621167	1	0.25	73.50
.9624707	1	0.25	73.75
.9624738	1	0.25	74.00
.9629138	1	0.25	74.25
.9629284	1	0.25	74.50
.963057	1	0.25	74.75
.9632733	1	0.25	75.00
.9635651	1	0.25	75.25
.9637769	1	0.25	75.50
.9639478	1	0.25	75.75
.9639592	1	0.25	76.00
.9640021	1	0.25	76.25
.9641566	1	0.25	76.50
.9642729	1	0.25	76.75
.9644983	1	0.25	77.00
.9649309	1	0.25	77.25
.9650538	1	0.25	77.50
.9651924	1	0.25	77.75
.9653392	1	0.25	78.00
.9653452	1	0.25	78.25
.9656469	1	0.25	78.50
.9659055	1	0.25	78.75
.9659057	1	0.25	79.00
.9659276	1	0.25	79.25
.9661019	1	0.25	79.50

.9661325	1	0.25	79.75
.9663981	1	0.25	80.00
.9664135	1	0.25	80.25
.96644	1	0.25	80.50
.9665431	1	0.25	80.75
.9668794	1	0.25	81.00
.9669037	1	0.25	81.25
.9669877	1	0.25	81.50
.9670919	1	0.25	81.75
.9676456	1	0.25	82.00
.9678179	1	0.25	82.25
.9680222	1	0.25	82.50
.9684548	1	0.25	82.75
.9684795	1	0.25	83.00
.9688784	1	0.25	83.25
.9688931	1	0.25	83.50
.9689371	1	0.25	83.75
.9690593	1	0.25	84.00
.9691086	1	0.25	84.25
.969243	1	0.25	84.50
.9692578	1	0.25	84.75
.9693079	1	0.25	85.00
.9693868	1	0.25	85.25
.9694298	1	0.25	85.50
.9694572	1	0.25	85.75
.9694757	1	0.25	86.00
.9696908	1	0.25	86.25
.9697548	1	0.25	86.50
.9698488	1	0.25	86.75
.9700179	1	0.25	87.00
.970036	1	0.25	87.25
.9700627	1	0.25	87.50
.9703854	1	0.25	87.75
.9703961	1	0.25	88.00
.9707046	1	0.25	88.25
.9707547	1	0.25	88.50
.9708128	1	0.25	88.75
.970859	1	0.25	89.00
.971051	1	0.25	89.25
.9712468	1	0.25	89.50
.9712694	1	0.25	89.75
.9712695	1	0.25	90.00
.9715598	1	0.25	90.25
.9717081	1	0.25	90.50
.9718005	1	0.25	90.75
.9718932	1	0.25	91.00
.9719093	2	0.50	91.50
.9726382	1	0.25	91.75
.9728204	1	0.25	92.00
.9729368	1	0.25	92.25
.973043	1	0.25	92.50
.9731401	1	0.25	92.75
.9732754	1	0.25	93.00
.9733378	1	0.25	93.25
.9733547	1	0.25	93.50
.973423	1	0.25	93.75
.9735171	1	0.25	94.00
.9735357	1	0.25	94.25
.9736292	1	0.25	94.50
.9736965	1	0.25	94.75
.9737334	2	0.50	95.25
.9739504	1	0.25	95.50
.9739776	1	0.25	95.75
.97401	1	0.25	96.00
.9744564	1	0.25	96.25
.9744711	1	0.25	96.50
.9744978	1	0.25	96.75
.9745336	1	0.25	97.00
.9746085	1	0.25	97.25
.9748795	1	0.25	97.50
.9758793	1	0.25	97.75
.9770749	1	0.25	98.00

.9777159	1	0.25	98.25
.9778083	1	0.25	98.50
.9779023	1	0.25	98.75
.9779131	1	0.25	99.00
.979467	1	0.25	99.25
.979576	1	0.25	99.50
.9798651	1	0.25	99.75
.9799961	1	0.25	100.00
Total	400	100.00	

```
 7 .
   end of do-file

 8 . do "C:\Users\lenovo\AppData\Local\Temp\STD2cbc_000000.tmp"

 9 . tobit te i.gender Age Edu Farmexp HHsize Farmincome credit i.Extension i.Training i.Membershi
   > antprotection i.Irrigation, ll(0.78)

   Refining starting values:

   Grid node 0:   log likelihood =  417.32576

   Fitting full model:

   Iteration 0:   log likelihood =  417.32576
   Iteration 1:   log likelihood =  431.51755
   Iteration 2:   log likelihood =  431.95327
   Iteration 3:   log likelihood =  431.95352
   Iteration 4:   log likelihood =  431.95352

   Tobit regression                                Number of obs     =        400
                                                      Uncensored     =        337
   Limits: lower = 0.78                               Left-censored  =         63
           upper = +inf                               Right-censored =          0

                                                   LR chi2(15)       =     266.45
                                                   Prob > chi2       =     0.0000
   Log likelihood =  431.95352                     Pseudo R2         =    -0.4460
```

te	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
2.gender	.0845393	.0140055	6.04	0.000	.0570025	.112076
Age	.0006595	.0004219	1.56	0.119	-.0001699	.001489
Edu	.004157	.0009295	4.47	0.000	.0023295	.0059846
Farmexp	.0011729	.0003274	3.58	0.000	.0005292	.0018165
HHsize	.0006904	.0021146	0.33	0.744	-.0034672	.0048479
Farmincome	2.64e-09	1.43e-09	1.85	0.066	-1.73e-10	5.46e-09
credit	1.77e-08	8.12e-09	2.18	0.030	1.72e-09	3.36e-08
2.Extension	.0417273	.0065372	6.38	0.000	.0288743	.0545803
2.Training	.0325836	.008203	3.97	0.000	.0164553	.0487119
2.Membership	.0171154	.0092059	1.86	0.064	-.0009848	.0352156
2.Plantsys	.0052873	.0078462	0.67	0.501	-.0101395	.020714
2.Landfrag	.0094053	.0064105	1.47	0.143	-.0031987	.0220093
Plantprotection						
2	.0279788	.0142355	1.97	0.050	-.0000102	.0559678
3	.035263	.0125083	2.82	0.005	.0106699	.059856
2.Irrigation	.008546	.0070058	1.22	0.223	-.0052284	.0223204
_cons	.6234745	.0276035	22.59	0.000	.5692019	.677747
var(e.te)	.0031767	.0002552			.0027126	.0037202

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10 .
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   end of do-file

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