Profit Efficiencies in Smallholder Rain-Fed Rice Farmers in Bench Sheko Zone: A Case of Guraferda District

A thesis Submitted to the School Graduate Studies of Jimma University for Partial Fulfillment for the award of Masters of Science Degree in Development Economics

BY:

AGERITU YIBIKA

JIMMA UNIVERSITY

COLLEGE OF BUSINESS AND ECONOMICS

DEPARTMENTS OF ECONOMICS

AUGUST, 2020

JIMMA, ETHIOPIA

Profit Efficiencies in Smallholder Rain-fed Rice Farmer in Bench Sheko Zone: A Case of Guraferda District

BY:

Ageritu Yibika

Under The Supervision Of

Main Advisor: Alemu Ayele (Phd Follow)

Co-Advisor: Mohammedsani Ali (Msc)

A thesis submitted to the School Graduate Studies of Jimma University for Partial Fulfillment Masters of Science Degree in development economics

JIMMA UNIVERSITY

COLLEGE OF BUSINESS AND ECONOMICS

DEPARTMENTS OF ECONOMICS

AUGUST, 2020

JIMMA, ETHIOPIA

DECLARATION

I hereby declare that this thesis entitled "Profit Efficiencies in Smallholder Rain-Fed Rice Farmers in Bench Sheko Zone: A Case of Guraferda District", has been Carried out by me under the guidance and supervision of Mr. Alemu Ayele and Mr. Mohammedsani Ali.

The thesis is original and has not been submitted for the award of degree of diploma any university or instructions.

Researchers Name Date Signature

____________________ _______________ __________________

CERTIFICATE

This is to certify that the thesis entities “Profit Efficiencies in Smallholder Rain-Fed Rice Farmers in Bench Sheko Zone: A Case of Guraferda District”, submitted to Jimma University for the partial fulfillment masters of Science degree in development economics. Therefore, we hereby declare that no part of this thesis has been submitted to any other university or institutions for the award of any degree of diploma.

Main Adviser’s Name	Date	Signature
____________________	___________	__________
Co-Advisor’s Name	Date	Signature
____________________	_________	_________

ACKNOWLEDGEMENT

First specifically, the author would love to thank her almighty God for everything done to her throughout her career. The author greatly acknowledges her main advisor Mr. Alemu Ayele for his unmatched assistance, unlimited encouragement and provision of study materials ranging from the beginning of the research career, as without his encouragement the thesis work would not complete. The author would really like to be thankful for her co-advisor Mr. Mohammedsani Ali whose contributions through critical and constructive comments have improved the standard of this thesis.

The author would also like express special appreciation to Mizan-Tepi University for conceding me the fund and different services during the research work. I would also like express heartfelt thanks to Jimma University and Guraferda District Administrative Office and Agriculture Office. She would also extend her deep appreciation to all the respondent farmers and the enumerators for their patience throughout the challenging data collection process and provide all the necessary and relevant information, without which this document could not have been realized. The last, but not the least, she would like to extend her appreciation to her parents, for their remarkable moral as well as material support throughout her work.

LIST OF ABBREVIATIONS

AE	Allocative efficiency
COLS	Corrected ordinary least squares
CSA	Central statistical Agency
DEA	Data envelop analysis
EE	Economic efficiency
FAO	Food and Agricultural Organization
GM	Gross margin
GDANRDO	Guraferda district agricultural and natural resource development office
LR	Likelihood ratio
MLE	Maximum likelihood estimation
OLS	Ordinary least squares
PF	Profit frontier
SNNPR	South nation nationality people region
SFAM	Stochastic frontier analysis model
SFPF	Stochastic frontier profit function
TE	Technical efficiency
TR	Total revenue
TVC	Total variable cost
VIF	variance inflation factor
WLS	Weighted list square

ABSTRACT

In many parts of Ethiopia, rice could grow suitably including guraferda district. Thus, the aim of this study was to measure the level of profit efficiency and to identify factors affecting profit efficiency level in Guraferda district. The two-stage random sampling technique was used to select 410 sample household heads and interviewed using a structured questionnaire during 2018/19 production year. Cobb-Douglas profit function was fitted using a stochastic profit frontier approach to estimate the efficiency level, whereas OLS estimation method was used to identify determinants that affect efficiency levels of the sample farmers. The results showed existence of high level of inefficiency in rice farming because the gamma ratio was comparatively large (γ = 0.89). Cobb-Douglas profit function result indicated that, rice profit was positively and significantly influenced by Seed price, fertilizer price, labour wage, land size and value of fixed capital. The profit efficiencies varied widely between 11.38% and 90.74%. On average, farmers realized 60.34% of their frontier profit, with an estimated 39.66% of the profit lost due to inefficiency. Similarly, the result of OLS exposed that profit efficiency was positively and significantly affected by farming experience, extension access, row planting, market access and non-farm income and variables like, distance to the main road, age of the household head, and social responsibility affected it negatively. It is therefore, recommended that there is potential for farmers to extend rice profit by adopting projects or programs that will support non-farm income activities, strengthening awareness creation on row planting technology, strengthen the existing agricultural extension system and development of market and road infrastructures requirements to improve profit efficiency of rice producers.

Keywords: *Profit efficiency, stochastic frontier, Cobb-Douglas, Ordinary least square, Rice, Guraferda, Ethiopia*

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURE

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

Rice is planted in all the continents of the globe where field crop production is practiced leaving only the frozen continent of Antarctica, where no crops are grown. Rice is among the three most important grain crops in the world, and it is the major contribution to fulfill the food needs across the globe. The role of the rice crop is necessary in the current and future worldwide food security (Chauhan *et al.*, 2017). Rice is the main staple food for 17 countries in Asia and the Pacific, 9 countries in North and South America and 8 in Africa. Rice provides 20 percent of the world's supply of dietary oil, while wheat supplies 19 percent and 5 percent of maize. It is also rich in genetic diversity, with thousands of varieties cultivated worldwide (FAO, 2004).

South and East Asia produces more than 90 percent of the world's total rice production. China is the world's leading country in region and development. Africa represents 3 percent of world production. Rice is the only major crop that can be grown in standing water in vast areas of level, low-lying humid soils and is suitably suited for growth under submerged conditions. Rice is grown in the tropical regions. It is cultivated under broadly differing conditions because of the great variety. For more than 10,000 years, rice has been cultivated, gathered, and, consumed by women and men international longer than any other crop. It is the most important food crop for about half of the human race in the globe (EUCORD, 2012).

Rice production was introduced in Ethiopia at the particular part of Fogera in the 1970s. The introduction of rice in Ethiopia was to ensuring food security and positive agrarian changes through increases domestic consumption of rice and to raising domestic production at national level. Rice is important due to the existence of production potential, the capability of the crop with the traditional production system, the benefits related to higher productivity and prices and the seek for import substitution to decrease the burden of foreign currency (Alemu *et al*., 2018). The expected potential areas of Ethiopia for rice production is about 30 million hectares of upland and 3.7 million hectare of irrigated are suitable for rice production, so Ethiopia has tremendous potential to increase rice area (Alemu, 2015).

Rice is the new crop in Ethiopia that is becoming a staple in some parts, especially where Teffe is not grown in large scale and rice producing areas. In the main season of Ethiopia, rice is the seventh cereal crops in terms of area coverage and the second cereals next to Maize in terms of productivity. In 2017/2018 production year, about 161,106.79 private peasants hold about 53,106.79 hectares of land and produced 1,510,183.30 quintals of rice. Moreover, it was also reported that the productivity of rice is 28.44 quintals per hectare (CSA, 2018).

In many parts of Ethiopia, rice could grow suitably. The major potential areas are the western central highlands of the Amhara region (Fogera, Gonder Zuria, Dembia, Takusa and Achefer); the north-western lowlands of the Amhara and Benshangul regions (Jawi, Pawi, Metema and Dangur); the Gameblla tribal state (Abobo and Etang); the southern and south-western lowlands of the SNNPR region (Beralee, Weyito, Omorate, Guraferda and others) (Alemu, 2015).

Rice could suitably grow in the study area of Guraferda district, southwest lowlands of SNNPR. The potential of the district was 260,000 hectares in Belg season; which covers 20 Kebeles out of 27 Kebeles of the district. Rice is the major food and it takes the lion's share in terms of extent of production, food consumption, number of producers and area coverage relative to other major cereals grown in the district and its production was dominated by smallholder farmers. During the 2017/18 production year, 13,315 hectares of land were covered by rice. The productive capacity of this area is about 28-36 quintals per hectare (GDANRDO, 2018). Therefore, it is crucial to increase volume of production and efficiency. Hence, this study focus on analyzing the profit efficiency of smallholder rain-fed rice producers and identify factors that cause efficiencies variation among farmers in Guraferda district.

1.2. Statement of the Problem

Efficient use of scarce resources has long been recognized in fostering agricultural production and has motivated significant research into the scope and sources of efficiency differentials in smallholder Agriculturists. Technically efficient farmers are highly productive because they can use a minimum level of input to produce a given output level, or produce maximum output from a given input level. Similarly, allocatively productive farmers prefer to operate more competitive farming undertakings because they can achieve a certain amount of production from the minimum costs (Bravo-Ureta and Evenson 1994)

In addition to this, Chakwera,(2015) has highlighted the point that only efficient farmers are able to realize productivity gain. It is also argue that the attention of policy makers to improve food security and to maintain agricultural growth by raising the productivity of smallholder farmer should not stick only on the use of improved agriculture technologies, but they should also give due attention on towards the existing level of efficiencies of farmers.

Rice farming has increased from time to time due to the introduction of upland and irrigated rice varieties in the country. However, rice sector in Ethiopian still faces remaining challenges such as insufficient mechanization and post-harvest processing technologies, poor infrastructure, lack of experienced manpower and study facilities, poor marketing infrastructure, and channels (Belayneh and Tekle, 2017). Lema and Tessema, (2017) argue that considerable possibility to increase rice yield is done by improving resource use efficiency. And also Assaye *et al.,* (2020) indicated that the future direction of growing rice production per hectare should be triggered by improving efficiency at farm level, in addition to technological progress.

High productivity and efficacy in rice production are vital for enhancing food security, reduce poverty levels and to maintain agricultural growth. However, socio-economic and institutional factors affect the possibility of the increasing efficiency of the rice production (Tsegaye *et al.*, 2019). And also Saysay *et al.,* (2016) argue that the best and most effective way of improving efficiency and competitiveness is using scare resources more efficiently.

Tsegaye *et al*., (2019) showed that a room for improve economic efficiency was 36.82%, when these farmers operate at full efficiency levels. In order to improve the productivity gains from existing technologies, efficiency is essential. Thus, an approach that can be used to solve the problem of efficient use of scarce resources focuses on whether farmers are economically efficient in production and, second, on what factors determine their efficiency level. Not only do farmers need to be more productive in their production activities, but they also need to be sensitive to market indicators, so that scarce resources are used effectively to improve productivity and profitability.

Empirical studies on rice has shown the existence of potential for improve rice production through improving the farmers technical efficiency by using the available resource and technology. These studies were, (Akintayo and Rahji, 2017; Bäckman, 2018; Bamiro *et al.*, 2013; Dang, 2017), and (State and Adamu, 2015). But In Ethiopia majority of efficiency studies in rice and other crops were focus on technical efficiency, For instance (Assaye *et al.,* 2020; Tsegaye *et al.*, 2019; and Lema and Tessema, 2017). The existing studies not give attention to measuring farmers profit efficiency even when the output and input prices are known in an attempt to examine the farmers' allocative efficiency. Technical Efficiency considerations are important improvements in production efficiency; however profit efficiency result in greater benefits for agricultural products. Estimating firm-specific efficiency through a profit frontier approach is a theoretical improvement over the previous production frontier approach, as it takes farmer-specific price into account.

Additionally, the use production function approach in evaluating efficiency is criticized because it is suffering from simultaneous equation bias since input levels are determined endogenously. The method therefore fails to capture inefficiencies associated with various factor endowments and diverse inputs. In addition to this the profit function, unlike the production approach, it combines technical and allocative concepts together in a profit relationship (Ali and Parikh, 1994). The more recent developments in modeling farm specific profit function efficiency, have overcome the earlier criticism on its suitability in less developed countries (Saleem, 1988). Therefore, computing profit efficiency is a more important source of information for policy-makers than the partial vision offered by cost or technical efficiency analysis. On the other hand, profit efficiency takes care of the input costs and output prices in profit measure (Ali and Flinn, 1989). This obvious lack of empirical research on the profit-efficiency of smallholder farmers in the agricultural sector in Ethiopia drives the core of this research.

Rice is the major crop in terms of volume of the production and area cultivated in Guraferda district. Production of rice is therefore motivated by earning profits. Meeting this objective requires efficient utilization of scarce resources. Thus, this study was carried out to analyze profit efficiency in small-scale rice producers and identify factors that influence efficiency in the study area. By taking into account those problems, this study was trying to answer the following research questions.

1. What are farm and farmer characteristics in the study area?
2. What are the existing levels of profit efficiencies of small-scale rice producers?
3. What are the major determinates of profit efficiencies for small-scale rain fed rice producer in the study area?

1.3. Objective of the Study

The general objective of this study is to analyze profit efficiencies of small-scale rain-fed rice producers in the case of Guraferda district, SNNPR, Ethiopia.

The specific objectives of the study are:

1. To describe farm and farmer characteristics in the study area.
2. To estimate the mean level of profit efficiencies of small-scale rain-fed rice farmers in the study area.
3. To find out factors affecting profit efficiencies of small-scale rain-fed rice farmers in the study area.

1.4. Significance of the Study

Rice production has a huge advantage in Ethiopia. Since production of rice by smallholder farmers gives increased direct access to food in their livelihoods, rice gains importance in enabling food security, income generation and poverty reduction. However the measurement of efficiencies to evaluate the profit efficiencies of the farmers has remained an area of important research in developing countries. So Profit efficiency study plays a significant role in providing useful information with regarding to profit efficiencies in rice production and helps to identify those factors, which are associated with efficiencies that exist. There are not enough documents and materials related to rice profit efficiency like other crops, particularly in the district and in Ethiopia at a large. As a result this study can provide important information for all concerned bodies.

So, adequate understandings of the factors that affect the efficiencies of farmers are important. Firstly, for farmers to understand the main factors affect profit efficiency and made knowledgeable decision to reduce profit inefficiency. Secondly, the information also shall assist researchers in developing appropriate technologies that best fit the needs of smallholder farmers to improve their use of resources and this study contributes to further researchers as a starting point and used as a reference. Thirdly, policymakers also benefiting from this information to formulate appropriate policies, strategies, programs, and interventions that helps to increase profit and productivity of rice. Finally, this paper is very important to increase academic knowledge for the author.

1.5. Scope of the Study

Geographically this study was limited to Guraferda district, which is found in Bench-Sheko zone of SNNPR, Ethiopia. The study focused on the analysis of profit efficiencies of small-scale rice producing farmers using stochastic frontier approach and focused only on rice and other crops are not included. Conceptually, this study has estimated profit efficiency scores and inefficiency of rice crop production for selected sample farmers. Methodologically, this study was intended to use one production year for cross-sectional data and its generalization is made to Smallholder rice producers in the study area. In addition, this study has been concerned with demographic, socioeconomic and institutional factors affecting profit efficiencies in rice production among rice producers.

1.6. Limitation of the Study

Guraferda District is one of large-household populated areas. The study was conducted by taking samples from a district which was selected randomly that allow making generalization about the whole district. The study has also taken cross-sectional data from one year of production. Consequently, the effects of those factors that vary over time are not incorporated into the study.

1.7. Organization of the Study

This thesis encompasses five major chapters from which the first chapter discusses the background, statement of the problem, research questions, and objectives of the study, significance of the study, scope and limitation of the study. The second chapter deals with review of literature which includes theoretical, conceptual and analytical framework of profit efficiency and empirical studies made on efficiencies in both in Ethiopia and outside Ethiopia. Chapter three presents the methodologies adopted for this study together with brief description of the study area related issues. Moreover, this section gives some highlights about the Design of the study, type and source of data, sampling technique and sample size drawn for the study, methods of data analysis, and definition of variables and hypothesized effects of each determinant on profit efficiency. In chapter four both the descriptive and econometric results are presented and are discussed in detail. In the first section descriptive results obtained from the study were presented. The second section presents empirical results from of estimates of the SPF and the inefficiency model. It also discusses the results of determinants of socio-economic and farm-specific inefficiency factors. The fifth and last chapter gives summery, conclusion, recommendation and suggestion for future research based on the result and it provides some possible indications for future researcher.

CHAPTER TWO

REVIEW OF RELATED LITERATURES

In this chapter gives a review of theoretical and empirical studies on efficiency and measurement of efficiency in the field of agriculture. It is intended to provide a proper understanding of the specific area of the researcher in establishing a clear framework to employ for the analysis in this study. Based on the literature reviewed, the possible methods that can be used for the study was identified. There were large amounts of empirical and theoretical literatures in the field of efficiency measurement, but this review was focused specifically on studies in the agricultural sector.

2.1. Theoretical Literature Review

2.1.1. Production Function, Profit Function and Profit Efficiency

Process of converting inputs into outputs is called Production. The fundamental reality firms must contend with in this process is technological feasibility. The state of technology determines and restricts what is possible way in combining inputs to produce output (Reny, 2011). Whereas Production function is a technical and mathematical relationship that tells how much a particular product depends upon the quantity of inputs or services of inputs, used at a given level of technology and over a given period. It shows the quantity of output which can be produced using various levels of input (Koutsoyiannis, 1979).

Profit function is an extension and formalization of the production decisions taken by a farmer. According to production theory, a farmer is assumed to choose a combination of variable inputs and outputs that maximize profit subject to technology constraint (Ali and Flinn, 1989). Profit efficiency is defined as the ability of a firm to make the highest possible profit, given the prices and levels of fixed factors of that firm (Vivas Ana Lozano, 1997).

2.1.2. The concept of Efficiency

Farrell (1957) categorized efficiency in to technical and allocative efficiency in production, by using a frontier production. Technical efficiency is the ability of a certain technology to achieve a specified production level under such technology, with a minimum of inputs. The ability of the farmer makes optimum use of inputs for given factor a price is known as allocative efficiency. Cost-effective efficiency is the result of good performance in both technical and allocative efficiency. If a firm has achieved both technically and allocatively efficient levels of production, it is also economically efficient. The same is true for Coelli *et al*. (1998), technical and allocative efficiency in production jointly comprises the economic efficiency.

Additionally Fried *et al*., (1993) define allocative efficiency and broken down into cost efficiency and scale efficiency. At a certain input prices, cost efficiency minimizes cost and the cost frontier identifies the cost-minimizing surface for all possible output. Once when cost efficiency is achieved, profit is maximized by the size efficiency.

Either measures a producer's efficiency in terms of quantities (inputs and outputs) or values (cost, revenue, and profit) are three basic causes of private inefficiency in relation to any behavioral target, which are technical, economic and allocative inefficiency. The producer is said to be technically productive if output takes place within the limits of the production possibility set. A technically efficient producer is said to be structurally efficient if output occurs within the boundary of the defined production possibilities zone (Fare *et al.*, 1985).

The objective of the farmer to be Efficient is in order to minimum cost and maximum revenue or profit (Fride *et al*., 1993). Efficiency of a production unit means a comparison between actual and optimal values of its output and input. The comparison can take the form of the ratio of observed to maximum potential output obtained from the given input. In these two comparisons, the optimum is defined in terms of production possibilities, and efficiency is technical. Whereas Economic efficiency is measured by comparing actual and optimum cost, revenue, profit.

Technical efficiency means producing the maximum level of output given inputs or as using the minimum level of inputs given output, whereas allocative efficiency occurs when the marginal substitution rate between any of the inputs is equal to the equivalent price input ratio. If this equality is not satisfied, it means that a firm is not using its inputs in the optimal proportions (Mastromarco, 2008). Efficiency measurement is estimated separately by estimating technical and allocative efficiency from a production frontier. Nonetheless, this may fail to capture inefficiencies associated with various endowments and input and output prices across farms (Abdulai and Huffman, 2000). This is because the farmers face different endowments and different optimum points of activity.

Unlike the production function approach, the profit function, incorporate both technical and allocative concepts in a profit relationship, and Any production decision mistakes are converted into lower incomes for the producer (Ali and Parikh, 1994) and, for this reason, lower profit efficiency. The profit function approach has received limited functional forms in contrast to the production function approach in developing countries. It has the advantage of avoiding the simultaneity bias that usually occurs in the estimation of production functions (Saleem, 1988). The latest developments in modeling farm specific profit function efficiency, have addressed the earlier criticism of suitability in less developed countries. Sevilla-Siero (1991) argues that, it is not necessary to maintain competitive input and output markets to identify the profit role of a farmer. What is necessary is for all the output and input prices to be exogenous to the given farm.

Currently, cost efficiency is only one part of a two-part reaction to deregulation. A more comprehensive picture of the effects of deregulation is obtained from a profit function that reflects both the joint impact of revenue and the cost effects of deregulation. Cost frontier analysis determines cost or input efficiency whereas a revenue frontier determines revenue or production efficiency. A profit frontier determines together. Importantly, the efficiencies calculated using cost and revenue limits may not suit the cost and revenue effects obtained from a profit function if the yield (input) quantities taken as given in the expenditure (revenue) function differ from the quantities consistent with profit maximization. Consequently, the input and output inefficiencies from a profit function were more accurate than those obtained from either a cost or a revenue function alone (Vivas Ana Lozano, 1997).

Interaction between farm-specific prices (pi) and levels of fixed factors (zi) allows the profit frontier to be farm specific. Profit inefficiency in this context is defined as profit loss from not operating on the profit frontier, again recognizing farm-specific prices and resource base. Given a farm operating at point F, comparative profit efficiency is defined as FP/MP and profit inefficiency as 1 - (FP/MP) (Figure 2.1).

If the stochastic profit function is estimated by ordinary least squares (OLS), an average, as opposed to the best-performance frontier, is derived. The estimation shows the average profit curve which does not include the profit inefficiency (Figure 2.1). The upper bounded frontier curve in Figure 2.1 generated by maximum likelihood estimates (MLE) is estimated by postulating that the error term contains two independent components: a one- sided error term representing profit inefficiency and a random error with normal properties (Ali and Flinn, 1989).

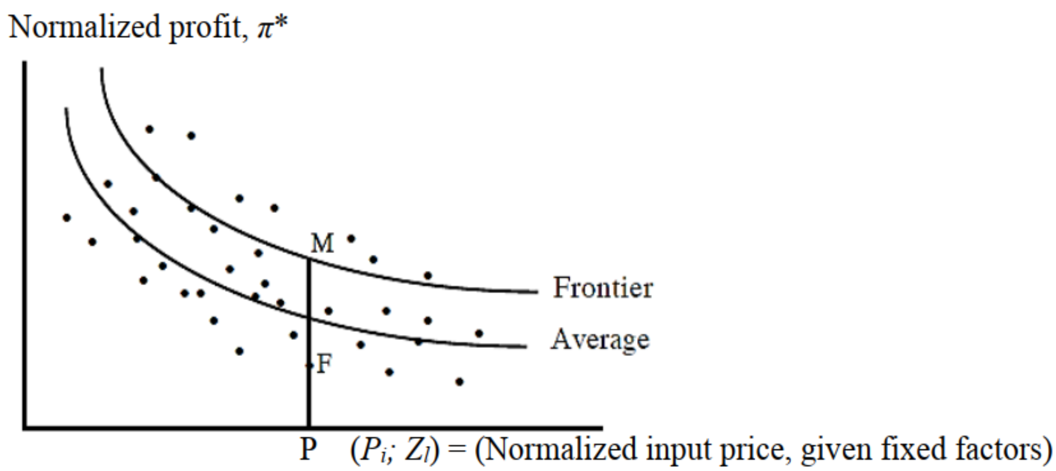


Figure 2. 1: Frontier (MLE) and average (OLS) stochastic profit functions

Source: Ali and Flinn (1989).

2.1.3. Models of Efficiency Measurements

Efficiency measurements are mostly performed using frontier methodologies, which shift the average response functions to the maximum yield or the efficient firm. Under two frontier methodologies these frontier methodologies are broadly categorized; parametric and non-parametric frontier models. The parametric frontier model can also be categorized into a stochastic and deterministic frontier. The parametric models are basically estimated based on econometric methods and the non-parametric technical efficiency model, often referred to as

Data Envelopment Analysis (DEA), involves the use of linear programming method to construct a nonparametric' piece-wise' surface or (frontier) over the data (Coelli *et al*, 1998).

Many empirical efficacy studies have been devoted to analyzing the impact on efficiency measurements of a given model specification. Different concerns concerning product parameters continue to be discussed. Specific frontier model selection depends on many considerations such as data type, cross-sectional or panel data, underlying company behavioral assumptions, the relevance and extent of noise in the data, and study objective. The following reviews focus mainly on these two broad frontier model categories (Coelli *et al*, 1998).

2.1.3.1. Parametric Frontier Models

Parametric frontier models can be categorized further into deterministic and stochastic frontier methods. The deterministic model assumes that any movement away from the frontier is due to inefficiency, while the stochastic approach allows for statistical noise.

The significances of stochastic frontier model initially proposed by Aigner *et al*., (1977). Stochastic frontier models enable the analysis of technical efficiency in the production function framework. Inefficiencies can be due to structural problems or market imperfections and other factors which cause countries to produce below their maximum attainable output. The stochastic frontier method allows decomposing growth into changes in input use, changes in technology and changes in efficiency, thus extending the widely used growth accounting method (Mastromarco, 2008). This point is significant for studies of farm level data in developing economy as data generally consist of measurement errors (Ogundari, 2006). Nevertheless, there is no consensus among researchers as to the best method for measuring efficiency.

Generally, it is assumed that producers aim to maximize profits or outputs and minimize costs or inefficiency; however, this is not normally achieved due to random statistical noise, such as rain failure. Due to differences in resource endowment, skills or knowledge, some farmers tend to be more efficient than others in production; therefore, SFA can be used to model these deviations (Aigner *et al*., 1977). This approach was applied in this study as it provided an efficiency score for every individual farmer so as to identify who needed what intervention. It is also useful in identifying the enter sources of inefficiency, based on the farmer characteristics.

2.1.3.2. Non-Parametric Frontier Models

An alternative method of analyzing efficiency, which has been used in empirical studies, is non-parametric method. Any non-parametric model as opposed to parametric models doesn't require assumption as to the distributional behavior of the population. Data Envelopment Analysis (DEA) is an example of the non-parametric approach that compares every producer with the seemingly most efficient producer, that is, it is based on comparative analysis of the examined producers to their counterparts (Greene, 2007). DEA is an extension of Farrell's measure to multiple-input multiple-output scenarios. The multiple input and output measures were then be transformed into specific estimates of efficiency (Cooper *et al*., 2007). According to Lovell (1994), DEA is popular in studies in the field of agriculture, and it uses mathematical programming to come up with the efficient frontiers.

2.2. Empirical Literature Review

Literature suggests many factors which affects the efficiency of smallholder farmers. There is large number of studies dealing with technical efficiency of farmers in developing countries. Yet, very few studies have addressed profit efficiency of producers.

2.2.1. Empirical Studies on Efficiency Abroad

Table 2. 1: Empirical studies on profit efficiency measurement of farm production

Author(s)	Country	Farming	Function	Model type	Data sat	Main result
Adesina and Djato, (2008)	Cote d'Ivoire	Total farm	Translog	SPFM	A sample of 347 men and 63 women rice farmers	Average profit efficiency (58%)
Ali *et al.*,(2016)	Malaysia	Rice		DEA	survey data of 70 rice farmers	Average profit efficiency (53%)
Dang, (2017)	Vietnam	Rice	Cobb-Dogulas	SPFM	A sample of 302 rice farmers	Average profit efficiency (77.46%)
Galawat and Yabe, (2012)	Brunei	Rice	Translog	SPFM	A sample of 82 farmers	Average profit efficiency (80.7%)
Gershon and Ansah, (2015)	Ghana	maize and cowpea	Cobb-Douglas	SPFM	Sample data from 199 respondents	Average profit efficiency (89%) and (95%) for maize and cowpea respectively
Idiong and Iko, (2019)	Nigeria	Rice	Cobb-Douglas	SPFM	A sample of total of 213 farmer	Average profit efficiency (73%)
Imran, (2015)	Pakstan	Sugarcane	Cobb-Douglas	SPFM	A sample of 120 sugarcane farmers of	Average profit efficiency (93%)
Ogunniyi, (2016)	Nigeria	Maize	Tran slog	SPFM	A sample of 240 maize, producers	Average profit efficiency (41.4%)
Sanusi, (2015)	Nigeria	Maize	Cobb-Douglas	SPFM	A sample of 120 respondents	Average profit efficiency (71%)
Saysay *et.al*., (2016)	Liberia	rice	Translog	SPFM	A sample of 400 rice farmers	Average profit efficiency (67%)
State and Adamu (2015)	Nigeria	Rice	Cobb-Douglas	SPFM	A sample of 156 respondents	Average profit efficiency (59%)

Source: own sketch from literature review, 2020

Galawat and Yabe, (2012) are attempt to study production efficiency amongst rice farmers in Brunei using a stochastic profit frontier model and inefficiency effects studied from its three components technical, allocative and scale efficiency. Empirical results indicate that the average return on profit is 80.7 percent and 19.3% of the profit is lost due to a combination of allocative, technical and scale inefficiency

Dang, (2017) identify profit, profit quality as well as production output determinants among rice farmers in Vietnam based on data from 196 sample rice farmers in two districts in the province of Tra-Vinh. The Cobb-Douglas stochastic profit frontier function integrating the effects of profit inefficiency was used to analyze the data. The results showed that the profit performance ranged from 33.87% to 97.22%, with an average of 75.61%. Important factors found to have a negative effect on rice farm income include fertilizer and pesticide rates, whereas positive effects came from seed price, wage rate and land area.

Farm-specific profit inefficiency was calculated from a variable-coefficient production frontier among Basmati rice producers. The mean amount of farm resource and price inefficiency was 28%, with a wide range of 5% -87%. Socioeconomic factors contributing to the loss of profit were the schooling of the farm family, non-agricultural jobs and a credit limit. And also Corporate determinants of profit loss (Ali and Flinn, 1989).

Saysay *et al*., (2016) also analyze profit efficiency of rice in Liberian farmer using farm level data from 400 rice producers by utilized stochastic translog production frontier model. This study revealed that smallholder rice farmers do not work at maximum benefit capacity. Smallholder rice farmers ' income output in the study area varies from 13% to 93%, with mean profit efficiency level of 67%. This indicates that there are strong opportunities to increase the efficiency of farmers by an average of 33 percent across their technical, allocative and scale efficiencies. In order to operate at maximum profit efficiency level, the sample rice farmers would have to reduce their costs by about 28 per cent on average. Experience in rice farming, household size, access to credit and extension services, membership of a farmer's community and access to market information are among those factors that have a significant influence on profit performance. Lowland rice farmers are more productive than upland rice farmers, and incur less profit loss.

This study examined the profitability of rice farming and explored some socio-economic factors affecting the profitability of rice farming in Bangkok, Thailand's peri-urban area by using the sample of 60 rice farmers in 2015. The gross margin and cost-benefit analysis were conducted to analyze the viability of the rice production. Data were analyzed using multiple tests of regression, and descriptive statistics. Results showed that gender, social status, number of family labour, factors that significantly affected the profitability of rice farming (Fakkhong, 2016).

Duraisamy, (2020) examined the role of education on technical and allocative efficiency on farm production. Profit function method is used to measure separately relative technical efficiency and allocative efficiency between educated and uneducated farmers. Profit function method to examine the differences in resource efficiency between educated and uneducated paddy farmers. As a result educated farmers are technically and allocatively more efficient than uneducated farmers.

Ouedraogo, (2015) deal with the issue of technical and economic efficiency of rice producers in Burkina Faso. He employs stochastic frontier approach to estimate the production function. His results show that the farm size, fertilizer used, years of experience and literacy are the explanatory factors for Kou Valley rice production. The mean technical, allocative and economic efficiencies of the producers are 80.16%, 92.7% and 74.4% respectively.

Mburu *et al.*, (2014) Examine the effect of farm size on economic efficiency among wheat producers and to suggest ways to improve wheat production in the country. They attempts to estimate the levels of technical, allocative, and economic efficiencies among the sampled 130 large and small scale wheat producers in Kenya. Their results point out that small-scale wheat farmers' mean technical, allocative, and economic efficiency indices are 85%, 96%, and 84%, respectively. The corresponding figures are 91 percent, 94 percent, and 88 percent respectively for large-scale farmers. Education level, distance to extension advice, and the size of the farm have strong influence on the efficiency levels. The relatively high levels of technical efficiency among small scale farmers resist the notion that only large scale farmers can produce wheat efficiently.

Addison *et al*., (2016) discussed on gender role, input use and technical efficiency between male and female rice farmers. They employs stochastic frontier model to estimate the technical efficiency levels among male and female rice farmers. They finds that labour, land and fertilizer significant contributors to higher output and yield, and that male labour input tends to promote higher rice output than that of their female counterparts. They also show that males produce rice more efficiently than their female counterparts. Yet studies by Timothy and Adeoti, (2006) give evident from their study that agricultural productivity for a given level of inputs may not be affected by the farmer’s gender. The difference may come in the level of inputs that are actually used. It is because women have less access to household resources and other productivity augmenting resources, they seem to use fewer resources on their plots than their male counterparts. It is clear that these unequal allocations of productive resources by gender are inefficient.

Ayaz and Hussain, (2019) although studies the effects of credit on technical efficiency by Stochastic Frontier Analysis (SFA) technique. They utilized at farm level survey data of 300 farmers for the year 2019. The economic mean efficiency score was 0.84 indicating 16 percent inefficiency of the sample farmers. They use stochastic frontier analysis estimation method to show the parameters for inefficiency being experience, education, access to farming credit, herd size and number of cultivation practices showed positive and significant effects on technical efficiency. The main explanatory variable, credit showed the highest coefficient value (-0.14) indicating the importance of the agricultural credit much more important than any other factor.

In additions to this Duy, (2014) focuses in particular on the effects on production and production efficiency of both formal and informal credits through the use of stochastic frontier analysis and quintile regression. His results verify the credit’s positive influence on the efficiency of production and production. There must be both formal and informal credits to improve farm efficiency. The same is true to Asghar and Chughtai, (2012), credit and farm size has significant factor on technical efficiency of smallholder farmers in Pakistan. The stochastic production frontier technique was employed to investigate the survey data. The results of Maximum Likelihood Estimation (MLE) showed that credit, farm size, fertilizer, and labor significantly affect the rice productivity in Pakistan.

2.2.2. Empirical Studies on Efficiency in Ethiopia

Kitila and Alemu, (2014) Examine the level of technical efficiency of smallholder maize producers and identify its determinants in Ethiopia. They used a Cobb-Douglass stochastic production function model for their analysis. The results tell that farm size under maize cultivation; chemical fertilizer and maize seed are the major factors that are related with changes in the maize yield. The average technical efficiency for smallholder maize producers ranges from 0.06 to 0.92 with a mean technical efficiency of 66%. Their analysis also show that the educational level, age of household head, land fragmentation, extension services, engagement in non-farm activities, and land size of the farmer are the major socio- economic factors affecting farmers' technical efficiency and maize output.

Mekonnen *et al*., (2015) estimate technical, allocative and economic efficiency levels of sesame production, by employ stochastic production frontier model whereas Tobit model was used to identify factors influencing efficiency levels. Their results indicated a significant amount of inefficiency in the production of sesame in the study area. In view of that, the mean technical, allocative and economic efficiencies of sample households were 67.1 percent, 67.25 percent and 45.34 percent respectively.

Haile, (2015) investigated the determinants of technical, allocative and economic efficiencies among small-scale onion farmers in Ethiopia. He uses a stochastic production frontier function to fit to the sample households. His findings revealed that land related factors such as land distance, ownership, and fragmentation explained much of the technical inefficiencies in addition to other socio-economic characteristics of farm households (age, market access, training access, and years of experience in onion production, farm income, responsibility and field visit) were found to be significant at different levels of significance for technical efficiency. The variables that influence allocative efficiency were distance, market access, sources of irrigation water, extension, farm income and field visit where, the Major determinants for economic efficiency be age, plot distance, fertility, and supply of irrigation water, extension , and experience in onion production, land fragmentation and farm revenue.

Lema and Tessema, (2017) were apply stochastic frontier approach to analyze the technical efficiency of rice production in Ethiopia. They found that variables in the stochastic frontier model of Cobb-Douglass production function, which includes land, fertilizer, oxen, seed, and labor, were positively related with rice production except for manure. The average technical efficiency score is 77.2 percent, implying that there is a room for rice yield increase by improving the resource use efficiency of the farmers. This study also explain that the accesses of extension services, research on rice product improvement, experience on rice farming, agro-chemicals, and education to be positively related to technical efficiency while household size was negatively and significantly correlated.

2.3. Overview of Rice in Ethiopia

Farming of rice in Ethiopia is generally a recent event it was started first at Fogera Plains in the early 1970's, which is preceded by its utilization as a food crop. Although rice was introduced to the country very recently, it has established to be a crop that can guarantee food security in Ethiopia. It is reported that the potential rice production area in Ethiopia is estimated to be about thirty million hectares. Since 2006, Ethiopian rice production trends demonstrate increases in both area and productivity, taking into account the significance and potential of the crop, it has been recognized by the Government as "the new millennium crop of Ethiopia" to achieve food security (Belayneh and Tekle, 2017).

According to the agricultural sample survey of 2018, there are 161,376 rice farmers in Ethiopia. From these, 104,975 farmers were live in Amhara, 16,494 farmers were live in SNNPR and the remaining 39,904 of rice farmers were live in other regions of Ethiopia. In 2017/2018 production year, about 161,106.79 private peasants hold about 53,106.79 hectares of land and produced 1,510,183.30 quintals of rice. Moreover, it was also reported that the productivity of rice is 28.44 quintals per hectare. These yields were showed a progress compared to 2016/17 production season by 11.04% relative to area coverage (9.68%) (CSA, 2018).

Guraferda district has a total of 17,462 household heads; from them 12,699 of household heads were rice producers in the year 2017/18. The major cereals grow in the district were, rice, maize and sorghum. Among those cereals, rice production takes the lion share in terms of area coverage and total production. In 2017/18 production season, the total production of rice was 433,181.875 quintals, for maize 88,841.6 quintals and 62,698 quintals for that of sorghum while its yield were 35, 33 and 23 quintals respectively (GDANRDO, 2018). However, the aggregate and farm level productivity and profit efficiency of rice remain in question for the country as a whole and in Guraferda district in particular.

2.4. Research Gaps Based on Literature Review

The existing studies on efficiency (Haile, 2015; Mekonnen *et al*., 2015; Kitila and Alemu, 2014 ; Hailemichael, 2014; Asrat, 2019), did not focus on rice. Additionally studies on rice efficiency (Assaye *et al*., 2020; Tsegaye *et al*., 2019 and Lema and Tessema, 2017) who discussed on the determinants of rice production efficiency however, limited application of the profit frontier function in the study of efficiency in Ethiopia as none of the existing studies combined both technical and allocative efficiency measures into a single estimation procedure. This shows that the existing awareness on efficiency in crop production, especially rice, is inadequate. The profit function approach enables more reliable and efficient estimates to be obtained as profits and variable inputs are determined at the same time through simultaneous estimation of the system (Ali and Parikh, 1994; Saleem, 1988 and Ali and Flinn, 1989).

Measuring profit efficiency level of farmers helps to determine the extent to which it is possible to raise profitability by improving the neglected sources of efficiency under the existing prices, resource base and available technology. So far no study was done using the profit function method to evaluate efficiency of small scale rice farmers in Guraferda, Ethiopia. Studies done in other countries on rice (Dang, 2017; Idiong and Iko, 2019; Saysay *et.al*., 2016 and State and Adamu, 2015) may not be applicable in all aspects to the local perspective due to differences in institutional provision to governing different markets in the economy as well as the economic environments. Moreover, our study introduces row planting, social responsibility, land preparation and time of sowing as an explanatory variable result to determine the profit efficiencies of the farmers in the area.

2.5. Summary of the Reviewed Literatures

From the literature reviewed, it is evident that the most used methods of measuring efficiency were the stochastic frontier profit function and the data envelop analysis. However, the advantages associated with SFPF (its ability to deal with statistical noise) make it a widely used method to determine efficiency, such that majority of studies on efficiency of rice and other crops production used this method. This advantage also makes the SFPF the most approach in measuring the efficiency of the agricultural production.

Although the focus has been on studies concerned with crop and rice production, it is acknowledged that the studies differ significantly from one another in terms of location, climatic conditions and technological backgrounds of the area. The variables identified do, however, serve as a starting point for the decision on which factors to examine as determinants of rice production efficiency, in order to improve the understanding of each of these variables literature beyond rice production profit efficiency studies have been taken in to account.

2.6. Conceptual Framework of the Study

Raising agricultural productivity depends critically on improvement of efficiency in production, development and dissemination of cost effective productivity-enhancing technologies, which leads to directly by raising production levels and profitability. Profit Efficiency is assumed to be affected by a wide range of factors. Profit Efficiency of was determined by the host of socio-economic, demographic and institutional factors. These factors directly/indirectly affect the quality of management of the farm’s operator and, as a result supposed to have effect on the level of profit efficiencies of farms.

From the general reviews, the various factors are grouped into the following three broad categories: (1) Demographic (2) Socio-economic and (3) Institutional factors. The factors related to demographic include age, family size and gender. The factors related to the socio-economic include livestock holding, family size, time of sowing, non-farm income and distance to the main road. The institutional factors include use of market access, credit access and extension access. In addition to this there are six main input variables that affect the profit efficiency of the farmer. This includes fixed capital, land size, labour wage, price of seed, the price fertilizer and the price of agro-chemicals.

The figure presented below shows the conceptual frameworks.

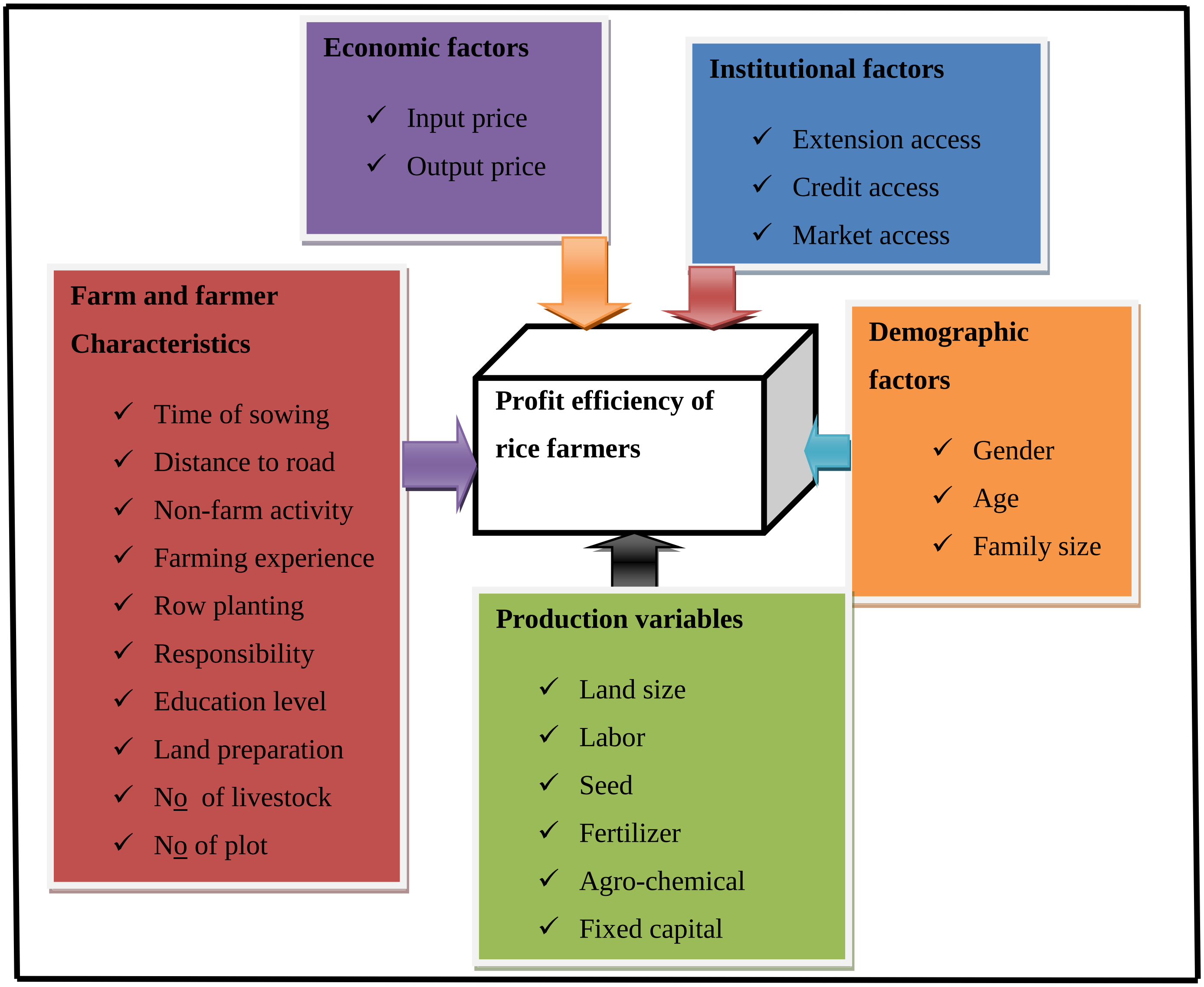


Figure 2. 2 : Conceptual framework of factors influencing profit efficiency

Source: own sketch from literature review, 2020

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter deals with the study methodology appropriate for the given objective in chapter one. It discusses the data sources and sample design, sampling technique and sample size determination, description of variables and expected sign. The chapter also looks at the description of the study area and the empirical model used in data analysis.

3.1. Description of the Study Area

Guraferda is found in southwestern a part of the Federal Democratic Republic of Ethiopia, within the Bench Sheko Zone of the Southern Nations, Nationalities and Peoples Regional (SNNPR) government at regarding 630 kilometers southwest of the national capital city. It's placed between 35°00' E (Latitude) and to 7°00' N (Longitude). It's bordered on the south by Bero-district, on the west and north by the Gambella Region, on the northeast by Sheko, on the east by South Bench, and on the southeast by Menit-Shasha. An estimated area of Guraferda district is regarding 2565.42 km^2. The elevation ranges of the district lays between 559 and 2389 meters on top of the water level. Agro-climatic zones of Guraferda are low land (Moist Qolla) and medium (Woynadega), which constitute 78.25% and 21.75% respectively, of the total area of the district. The annual rainfall of the Guraferda district varies from 1600-2000 mm whereas the mean annual rainfall is about 1332 mm. The mean annual minimum and maximum temperature of the area ranges between 21°C and 29°C, respectively (GDANRDO, 2018).

According to the Guraferda district agricultural and natural resource development office, the population of the Guraferda district was 45,028 in 2018 (GDANRDO, 2018). In Guraferda district there are twenty-seven kebeles with the administrative town of Biftu from this, twenty kebeles are rice producers. The main rainy season, Meher, is considered as important for rain-feed agriculture in the area. As the economy of the Zone, Guraferda is predominantly plow-based agriculture dominantly of cash crops, like coffee and rice. The first four major products of the district are coffee, rice, maize, and sorghum. Besides crop production, farmers of the district rear livestock.

The topography of Guraferda district is highly variable. A number of hills and mountains characterize the landform of the area.

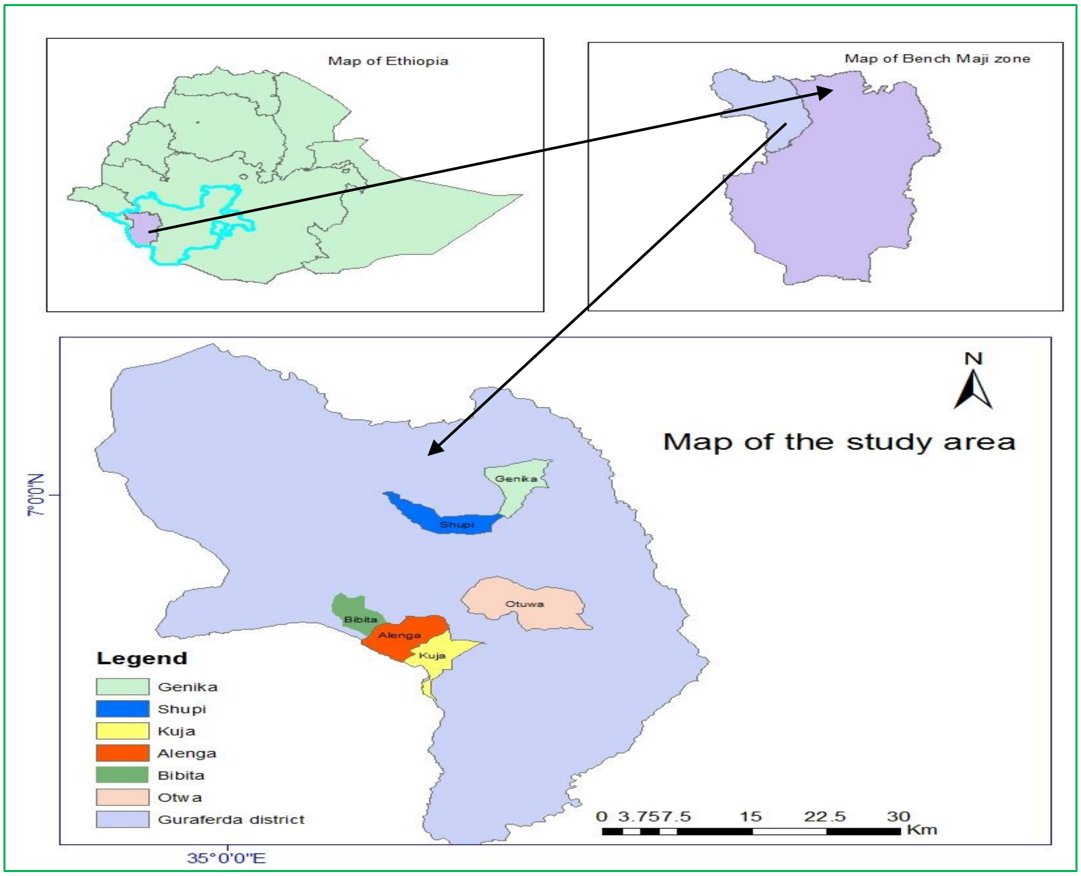


Figure 3. 1: location map of the study area

Source: GIS arc map software

3.2. Design of the study

Research design is regarded as the blue print and cornerstone of any study, as it facilitates different research operations. The nature and objectives to be achieved and the means to obtain information are the most important factors to be considered in choosing the appropriate design for research. To achieve the stated goals, quantitative data was used to obtain accurate and more complete information. A cross-sectional survey was performed to collect the quantitative data used for the analysis. The study was completed in less than one year; thus, the most suitable cross-sectional sample design used for this report was appropriate.

3.3. Data Types and Sources

The study used both primary and secondary data to attain the stated objectives. The secondary data were collected from different sources including research papers, books, internet, CSA, and from Zone and Guraferda district sector offices, and unpublished materials. The primary data were collected through household survey and main informant interviews with sample households using standardized questionnaires. And information on issues related to factors affecting profit efficiency in rice production in the study area was gathered.

The questionnaire in this study was also structured to obtain answers from the selected farmers on farming activities of their households. These include information on the size of the farm, material inputs and prices, labor supply and wages, and so on, as well as the amount of rice output and its price. This was expected to increase the explanatory power of the analysis significantly. Socioeconomic, demographic and institutional data of the farmers such as age of the household head, level of education, farming experience, family size, number of plots, land preparation, time of sowing, row planting, responsibility, extension access, market access, number of livestock and about credit service also have been collected.

3.3.1. Data Reliability and Validity

To control for data reliability and validity of measurement and sampling errors some measurements were concluded. The first action taken was to pretest the questionnaire from non-sample kebeles. The structured questionnaire was pre-tested by using twenty farm households in both Bereji and Kometa kebeles in the Districts; enabling to correct mistakes, evaluate the relevance of a given question, add relevant information, exclude irrelevant information and to make overall improvement on the standard of the questionnaire in line with the objectives of the survey. Then the corrected version of questionnaire was used for interviewing rice farmers in the study area. Secondly, In order to administer the questionnaire to the farmers, the six enumerators, who are believed to have good experience in terms of relaying the relevant information to the respondents and had good communication ability, were hired. A three day of intensive training was given to the enumerators to make them familiar with the questionnaire. All the enumerators had previous working experience in the study area and were able to understand the language, culture and tradition of the study area. This enabled them to overcome the barrier of communication with the households. Thirdly, the author was interested in data collection while in the area, as well as supervising the field team, till all data were collected. Data were entered in the STATA computer software to obtain descriptive and necessary transformation such as log linearization conducted, and finally, the Variables needed for efficiency measurement were then used for analysis.

3.4. Sample Size and Sampling Techniques

3.4.1. Sample Size Determination

The target population for our sample were rice producer households in selected sample kebele (5,602) (GDANRDO, 2018). The sample size of farmers was determined by applying Kothari, (2004) formula of calculating sample size with confidence interval of 95%.

$$n = \frac{z^2.p.q.N}{e^2(N-1)+z^2.p.q} \quad n = \frac{(1.96)^2 * 0.5 * 0.5 * 5602}{(0.05)^2(5602-1)+(1.96)^2 * 0.5 * 0.5} \quad \text{n=360}$$

Where: n= the sample size, N= number of rice producer households in selected sample kebeles in 2018/19 production season (which is 5,602), e is precision level (which equals with 5%), P is the estimated proportion of an attribute that is present in the population (p=0.5, we do not know variability) and q is 1-p. whereas z is the abscissa of the normal curve that cuts off an area at the tails (1-α, at 95%). By adding 14% non-response rate, the final sample size was 410.

Therefore the total of 410 households was selected for the study. These households were selected from six kebeles by using simple random methods. The sample size was then proportionately disaggregated as follows below table for the six kebeles, based on the proportion of rice growers in each kebeles. The target households of the study are obtained from Guraferda district agriculture and natural resource development office.

Table 3. 1: Selected kebeles and their sample size

Cluster	Selected Kebeles, number of farmer household and their sample size		Sample household Numbers	%
High producer	Shupi, N=984	and n=72	138	33%
	Genika, N =896	and n=66		
Medium producer	Kuja, N =1,086	and n=79	146	36%
	Alenga, N=909	and n=67		
Low producer	Bibita, N =886	and n=65	126	31%
	Otuwa, N=841	and n=61		
Total	5,602	and n=410	410	100%

Source: Guraferda district agricultural office and own computation, 2019

3.4.2. Sampling Techniques

The sampling method employed two-stage sampling techniques to draw an appropriate sample household. Even though Guraferda district consists of 27 kebeles, only 20 kebeles were engaged in the production of rice. In order to avoid sampling biased these kebeles were clustered into three groups; depending up on their productive potential, namely high producer (greater and equal to 40 quintal/ha) which includes 7 kebele, medium producer (between 28 and 39 quintal/ha) which includes 7 kebele and low producer kebeles (less than and equal to 28 quintal/ha) which includes 6 kebele (GDANRDO, 2018). In the first stage, two kebeles from each category and a total of six rice producer kebeles in the district were selected randomly. In the second stage, 410 sample farmers were selected by using simple random sampling technique from selected kebeles based on probability proportional to their population size.

3.5. Method of Data Analysis

The study employed both descriptive statistics and econometric models for analyzing the data. The data collected on socioeconomic, institutional and demographic characteristics of the sample households were analyzed by using descriptive statistics such as mean, standard deviation, minimum, maximum, frequency and percentage. The qualitative and quantitative data were tabulated in the way that can enable to understand or compute the view of factors that affect profit efficiency in rice production. And STATA software was used for estimation of farm specific profit efficiency scores of rice producers in the study area.

The aim of using econometric method is to estimate the effects of factors on the efficiency of rice benefit by using the maximum likelihood estimation of stochastic frontier profit function. Whereas, OLS estimation technique was applied to showed variation in the source of profit inefficiencies among the farmers. The OLS estimation technique was applied because the available data set on hand was more suitable for OLS estimation technique than other models, such as the Tobit model.

3.6. Analytical Frame Work and Empirical Model Specification

3.6.1. Approaches to measuring efficiency

Following Farrell's (1957) study, researchers in the field of calculating efficiencies in all fields have increased. But the model and estimation of stochastic frontier function initially proposed by Aigneir *et al*. (1977) in the field of agriculture.

A critical analysis of the frontier literature on farm-level efficiency in developing countries conducted by (Bravo-Ureta and Penheiro, 1993; Coelli, 1995) suggested that specific theoretical issues had to be addressed in the calculation of frontier efficiency, including the selection of functional types and appropriate approaches. These frontier methodologies are broadly categorized; parametric and non-parametric frontier models. Parametric and non-parametric models differ from one another in two ways. First, the two models differ on assumptions of an inefficiency representing error term distribution. Secondly, they differ in the way the data is imposed on the functional form. Parametric methods impose functional and distributional forms on the term error, while the non-parametric methods do not impose.

However, parametric models suffer from the same criticism as border deterministic models, in a sense that they do not take into account the possible influence of measurement errors and other noises in the data as do stochastic border models. The results may also be misleading because as in stochastic parametric approaches they do not allow for random error. So the economic estimation of the production or profit functions falls under the stochastic parametric approaches (Aigneir *et al*., 1977). Thus a stochastic frontier model is preferred because of its capable of capturing measurement error and other statistical noise manipulating the shape and position of the production and profit frontier.

A stochastic frontier production model anticipated by (Battese, 2017) in accordance with the original models (Aigner *et al*., 1977). Crop production in the study area is rain-fed which is affected by random shock such as drought and erratic rainfall. Not only because of measurement error, statistical noise or some other effect, but also because of inefficiency, the farmer may deviate from the boundary. The effect of stochastic noises can clearly be observed. To assess such conditions, stochastic frontier model analysis is the best approach to estimate profit efficiency of rice producer in the study area. For this reason, this study adopts the stochastic parametric model and profit function frontier for rice farmers.

3.6.2. Empirical Model Selection Criteria

An advantage of using stochastic frontier analysis to estimate profit efficiency is that various hypotheses concerning modeling the technology and characteristics of firm-specific efficiency measures can be statistically tested. Modeling profit functions following SFA is in conformity with profit theory. SFA offers flexibility in modeling various specific aspects of production and profit such as production risk and marketing risk. Further, it facilitates decomposition of profit efficiency into technical and allocative efficiencies (Kalirajan and Shand, 1999).

Throughout the literature, there are a variety of functional models for estimating the profit function, including the Cobb-Douglas and versatile functional forms such as standardized quadratic, standardized translog and generalized Leontief. From these, Cobb-Douglas and Translog forms are the two common functional forms used in most literature.

The Cobb-Douglas functional form is popular and is frequently used to estimate farm efficiency (Dang, 2017; Gershon and Ansah, 2015; Idiong and Iko, 2019; Sanusi, 2015; Saleem, 1988 and Imran, 2015). The translog model has also its own weaknesses as well, but it has also been used by (Ali and Flinn, 1989). The main drawbacks of the translog model are its potential problems of insufficient degrees of freedom due to the presence of interaction terms. The interaction terms of the translog also don’t have economic meaning (Abdulai and Huffman, 2000) and the attempt to use a translog profit function method is failed because of the high multicolinearity between the interaction and the individual variables (Coelli *et al.,* 2001). In addition, the functional form of the translog is fraught with the issue that theoretical consistency cannot be imposed globally (Sauer *et al.*, 2019). This means that theoretical specifications of translog functional type are missing. As a result in this study a Cobb-Douglas profit function was allowed.

An econometric estimation analysis was done first by specifying profit frontier using Cobb-Douglas stochastic model. The model has estimate parameters of profit frontier, level of efficiency, and significant level of the different variables in the determination of efficiency of farmers. The various null hypotheses for parameters in the frontier profit efficiency model was tested by using likelihood ratio test (LR) given by Coelli *et al*., (1998)

3.6.3. Cobb-Douglas Stochastic Frontier Profit Function Model

Econometric models are widely applied in measuring efficiency. According to Yotopoulos *et al***.**, (1973), a production function approach to measure efficiency is not appropriate if farmers face different prices and have different factor endowments. This led to using stochastic profit function models to estimate farm specific efficiency directly (Ali and Flinn, 1989; Rahman, 2003; Ogundari, 2006). A profit function is superior to a production function because: it permits straight forward derivation of own-price and cross-price and output supply and input demand functions; it avoids simultaneity bias problems because input prices are exogenously determined. Thus, problems of Endogenity can be avoided by estimating a profit function instead of a production function (Ogunniyi, 2011).

Additionally, cost efficiency measures derived from a profit function can differ from those obtained from a cost function if the output quantities are observationally contradictory with profit maximization, so that revenue inefficiency exists. That means that, a cost function deals with only inefficiencies in input use whereas a profit function deals with both input and output inefficiencies. The same is true, input inefficiency measured in a profit function may be different from that resulting from a cost function (Vivas Ana Lozano, 1997).

In measuring efficiency based on the stochastic profit frontier, two key assumptions are made which results in two types of the functions. Depending on whether market forces are taken into account or not, the standard and the alternative profit functions. The standard profit function assumes that markets for outputs and inputs are perfectly competitive. While the alternative profit function assumes that outputs and inputs markets imperfectly competitive (Berger and Mester, 1997). Following the work of Asrat (2019), this thesis used Cobb-Dogulas functional form of the alternative profit efficiency model. As presented above the reasons for choice of this function in the study area, rice output markets are not perfectly competitive in the Guraferda district. As in most rural Ethiopia, markets for crop produce are seasonal and prices that farmers receive depend on their negotiation power and skills with assemblers. Therefore, the alternative profit function is better fit to this situation than the standard profit function.

This study adopted the models developed by Battese and Coelli, (1995). In smallholder farms it is not easy to isolate fixed factor costs. The practice is to use gross margin as a proxy for profit (Rahman, 2003 and Abdulai and Huffman, 1998) by postulating a profit function that is supposed to comply with the stochastic frontier framework. Gross margin is defined as revenue per hectare planted to rice minus costs incurred over the growing season (Burke *et al.,* 2011). Profit efficiency is characterized as profit from operating a frontier, taking in to account the farm-specific price and factors of the farmers. And, considering a rice farm that operates to maximize its profit subject to imperfectly competitive input and output markets and a singular output technology that is quasi-concave in the (n x 1) vector of variable inputs, and the (m x 1) vector of unchanging factors, Z, the actual normalized profit function which is expected to be well behaved can then be resulting as follows:-

Rice farm profit is measured in terms of gross margin (GM) which equals the difference between the total revenue (TR) and total variable cost (TVC) and is determined in terms of

$GM(\pi) = \varepsilon(TR - TVC) = \varepsilon(PQ - WX_i)$ -- (3.1)

To normalize the profit function, gross margin (π) is divided by P (the market price of rice per kg) to obtain:

$\frac{\pi}{P}(P, Z) = \frac{\varepsilon(PQ - WX_i)}{P} = Q - \frac{WX_i}{P} = f(X_i, Z) - \Sigma P_i X_i$ ---------------------------- (3.2)

Where TR is the total revenue from rice farming activity, TVC are total variable costs (seed, pesticides, hired labor, fertilizer etc.); Q is rice output; X represents the (optimal) quantity of input used; Z represents fixed inputs, P_i = W/P which represents normalize price of input X_i while f (X_i, Z) represents the production function.

The profit function of the Cobb-Douglas was employed and is expressed as:

Π (p, Z) = Y(X*, F) – Σ pi Xi* --- (3.3)

Where

Y (X*, F) is production function; refers to optimized values. Pi is the normalized price of input i, p = W/P, where P and W are the output and input prices, respectively.

The stochastic profit function can then be expressed as:

π_i= f (P_{ji},F_{ji}) $\exp(v_i - u_i)$) -- (3.4)

Where

π_i is normalized profit of the i^{th} farm, measured as gross revenue less variable expense, divided by farm specific output price P_y; P_{ji} is the normalized price of input j for the i^{th}farm, calculated as input price divided by farm specific output price P_y; $F_{ji}$is the amount of the j^{th} fixed factor for the i^{th} farm Vi is the symmetric error term and ui, is a one-sided error term. v_i is normally, independently and identically distributed as two-sided error term representing various random shocks, and effects of measurement error of variables. U_i , is the non– negative or one-sided residual instead of farm-specific profit inefficiency. Hence if U_i= 0, the farm's profit inefficiency is non-existent, i.e., the farm makes maximum possible profit (being on the frontier) given its input prices and fixed factors. On the other hand, U_i> 0 indicates that the farm forgoes profit due to inefficiency (Ali and Flinn, 1989). The profit efficiency (PE) in relation to the stochastic profit frontier is given by

$$\text{PE} = \frac{\pi_i}{\pi_i^*} = \frac{f(P_{ji},F_{ji}) exp(v_i - u_i)}{f(P_{ji},F_{ji}) exp(v_i)} = exp(-u_i) \text{ -- } (3.5)$$

PE takes values between 0 and 1 and is inversely related to the level of profit inefficiency. π_i is an observed profit and π_i^* is the frontier profit. The P_{ji} , F_{ji}, U_i and have been defined earlier. In this case, π_i achieve its maximum value of *f (P_{ji}, F_{ji}) exp (V_i)* if and only if PE =1. Otherwise, PE< 1 provides a measure of the shortfall of observed profit from maximum feasible profit.

The Cobb-Douglas functional form for estimation is specified as:

$$\ln\pi i = \ln\beta_0 + \beta_1 lnp_{1i} + \beta_2 lnp_{2i} + \beta_3 lnp_{3i} + \beta_4 lnp_{4i} + \beta_5 lnZ_1 + \beta_6 lnZ_2 + (V_i - U_i) \text{ -- } (3.6)$$

Where:

lnπi = normalized profit of rice computed as the total revenue less variable cost per output price for i^{th}farmer,

ln = natural log

p_1= price of seed (birr/kg) normalized by price of rice output,

p_2= price of fertilizer (birr/kg) normalized by price of rice output,

p_3= price of labour (birr/man day) normalized by price of rice output,

p_4= price of agro-chemical (birr/lit) normalized by price of rice output,

Z_1= area of land cultivated (ha),

Z_2=total fixed capital used in rice production

β_0 to β_6 are parameters to be estimated and V_i represents statistical disturbance term and U_i = represents profit inefficiency effects of i^{th} farmer.

The stochastic profit frontier model seeing that in equation (3.6) above could be calculated using maximum likelihood method, which is asymptotically more efficient than the other alternative, such as Corrected Ordinary Least Squares (COLS) method (Battese and Coelli, 1995). Mean profit efficiency could be easily predicted using the mathematical expectation of profit efficiency. A natural predictor of mean profit efficiency would be the arithmetic mean of the farm specific efficiencies in the sample. By applying maximum likelihood estimation, the variance of the random errors and that of the profit inefficiency effect and overall variance of the model are also obtained and are related as follows:

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \text{ and } \gamma = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2} = \frac{\sigma_u^2}{\sigma^2} \text{---} (3.7)$$

Where, σ^2 is the total variance for the combined error term ε_i; σ_v^2 is the constant variance for the symmetric error term v_i; σ_u^2 is variance for the non-negative error term u_i, and; γ is ratio of farm - specific efficiency effects to the total variance. The overall variance of the model (σ^2) measures the total variation of profit from the frontier which can be attributed to profit inefficiency. Gamma (γ) represents the share of inefficiency in the overall residual variance with values between 0 and 1. If γ = 1, profit inefficiency is the dominant source of error and there is no effect of random errors in the data, denoting existence of a deterministic frontier. On the other hand, if γ = 0, it shows that the dominant source of error could be attributed to random factors alone and thus no inefficiency effect, and is evidence in favour of OLS estimation (Battese and Corra, 1977; Ali and Flinn, 1989; Battese and Coelli, 1995).

3.7. Determinants of Inefficiency

Sources of inefficiency are determined through assumption on the inefficiency error component. The inefficiency error component is assumed to follow a half- normal distribution with a mean as a function of the hypothesized sources of inefficiency in production (Coelli, 1995). Many empirical studies showed that a range of farmer-specific characteristics, socioeconomic and institutional factors cause profit inefficiencies. The farm-specific profit inefficiency is equal to 1-exp (-u). In other word of inefficiency of a given farmers = 1- efficiency score of the farmers. The specific profit inefficiency effects on rice producer are described as:

$$\begin{aligned} U_i &= \delta_0 + \delta_1 \text{age} + \delta_2 \text{gender} + \delta_3 \text{education} + \delta_4 \text{ expriance} + \delta_5 \text{family size} + \\ &\delta_6 \text{nub of plot} + \delta_7 \text{land preparation} + \delta_8 \text{time of sowing} + \delta_9 \text{rowplanting} + \\ &\delta_{10} \text{extenstion} + \delta_{11} \text{ credit} + \delta_{12} \text{responsibility} + \delta_{13} \text{nonfarm income} + \\ &\delta_{14} \text{market access} + \delta_{15} \text{distance to road} + \delta_{16} \text{number of livestock} + \text{e} \text{ ....} \quad (3.8) \end{aligned}$$

e Is error terms, assumed to be independently and identically distributed with mean = 0 and constant variance. OLS is also used to analyze the inefficiency determinant variables to identify important explanatory variables that could decide variations in profit inefficiency among farmers. For the reason that the available data sets on hand were more suitable for OLS estimation technique than models like Tobit, OLS was applied because the dependent variables (inefficiency) are continuous.

Estimation of OLS is mainly used when the inefficiency scores are not truncated or censored for a particular value. If the observation tends to be grouped near the border with only a relatively small number in the extreme range, the distribution of errors will be highly skewed and we should expect the maximum estimator of likelihood to be highly efficient than OLS (Greene, 1980). There was no efficiency score one value for some observations in the available data set showing the farmers are fully efficient or zero value for some observation showing they are inefficient. So the Tobit model cannot apply efficiency scores for some observation without censored or truncated values, rather than the usual least square estimation technique.

3.8. Hypothesis Testing

To assess the suitability and significance of the adopted model statistical tests are required. Log likelihood ratio test is an appropriate testing procedure, which permit the assessment of a restricted model with respect to the adopted model (Coelli *et al*., 1998). So the generalized likelihood ratio test statistics was used to test the various null hypotheses for the parameters in the frontier profit function and in the inefficiency models. The test statistics is defined by:

$$\mathrm{LR}\lambda = -2\{\log[\mathrm{l}(\mathrm{H}_0) - \log[\mathrm{l}(\mathrm{H}_1)]]\},$$

Where (H_0) and $\mathrm{l}(\mathrm{H}_1)$ represents likelihood function values under the null $(H0)$ and the alternative hypothesis(H_1), respectively. The statistic test LRλ has approximately a chi-square ($\chi 2$) distribution with the number of degrees of freedom equal to the number of parameters (restrictions), assumed to be zero in the null hypothesis. When LR_λ is lower than the correspondent critical value (for a given significance level), is not to reject the null hypothesis (Ali and Flinn, 1989).

The first hypothesis (H_0: $\gamma = \beta 1 = \cdots \beta 6 = 0$) is to test whether farmers are profit efficient and there is no room for, improved efficiency growth. The $\beta's$ represent the parameters in the profit function.

The second hypothesis ($H_1: \gamma = \delta 1 = \cdots \delta 16 \neq 0$) is to test whether the socioeconomic and institutional variables effect on farm level profit efficiencies. The $\delta's$ represent the parameters of variables related to inefficiency factors.

3.9. Descriptions of Variables and Expected Signs

3.9.1. Descriptions of Production and Economic Factor and Expected Signs

Rice output: It is refers to the physical amount of rice produced in quintals per hectare in 2018/19 production season.

Price of rice: is the sailing price of rice Birr per quintal or per kg.

Land size: is one of the major factors used in agricultural production. This continuous variable referred to the total arable farmland that a farmer owned measured in hectares. A Larger farms in addition to good management practices translate into increased outputs and income. According to Rahman (2003), Sanusi (2015), Abu and Asember, (2011) and Sunday *et al*., (2012) Farm size had positive effect on profit efficiency.

Price of labour: Wage rate was measured as the total cost of human labour for hired labourers per labour-day. Labour was valued at the agricultural wage rates prevailing in the local area. This variable is expected to have a positive relationship with profit (Dang,2017; and Kolawole, 2006)

Price of fertilizer: It was the payment in Birr/kg for fertilizer applied by each farmer in rice production in the study area. Hong and Yabe (2012) reported positive relationship between price of fertilizer and profit efficiency of rice production. Yet Rahman, (2003) was postulated to have a negative relationship with profit efficiency.

Price of seed: It is the price of seed in Birr/kg used for rice production in the study area. Hence, in the study area the local unit of measurement used to measure seed is kilo and has a value of 15 Birr for local seed and 25 Birr/kg for improved seed. Some studies argue that cost of improved seed had positive relation with profit efficiency, like Dang (2017), Abu and Asember, (2011) and Gad *et al*., (2019). while Rahman, (2003) was postulated to have a negative relationship with profit efficiency.

Price of agro-chemicals: it is the price of pesticide in Birr/let used for rice production. Price of chemical had affect profit efficiency negatively (Dang, 2017).

Fixed capital: Among fixed inputs included in the profit frontier was the value of fixed farm capital, a continuous variable measured in Birr. This was computed as the total value of capital assets or implements owned by the household including ox-drawn plough, Sickle, weeder and Dibber used in rice production. Fixed capital affects productivity and was hypothesized to have a positive relationship with profit (Rahman, 2003 and Asrat, 2019).

3.9.2. Descriptions of Variables Determinants inefficiency and Expected Signs

There are so many variables that affect or determine the inefficiency of rice producers in the study area. But, this study mainly focused on the major factors that causes variation among rice producers in Guraferda district are hypothesized as given below;

Farming Experience: It is a continuous variable which refers to years of the household head which mainly exercise rice production measured in years. As the farmers got more experience, he/she learn from his/her past lessons, adopt the real situation and accumulate optimal combination of resource (Idiong and Iko, 2019 and Dang, 2017).

Education Level: This is a continuous variable which represents educational level of the household head measured in years of schooling and it is used as a proxy variable for managerial ability of farmers. Educated farmers are more responsive to improved farming techniques and they have a higher level of efficiency than farmers with less education (Duraisamy, 2020).

Extension access: It is nominal variable which was measured as 1 if there was a contact between extensions agents and household head and 0 otherwise. Extension contact increase efficiency by disseminating of new technologies to farmers. In addition, households who get more extension services by extension workers appear to be more efficient than those who not get extension service (Saysay *et al.*, 2016). So, this study expected the inverse relationship between inefficiency of farmers and extension access.

Credit availability: It is dummy variable which is measured as 1 the household head borrows from different lending institutions measured in Ethiopian birr and 0 other wise. Because the availability of credit moves the cash constraint outwards and enables farmers to make timely purchases of the necessary inputs they cannot supply from their own sources (Duy, 2014 and Sanusi, 2015). Therefore, it is hypothesized that farmers who get credit have to less inefficient, and then it had a negative relation.

Non-farm income: This is also a nominal variable which is measured as 1if one of the household members participates in non-farm activity in the 2018/19 rice production season or 0 otherwise. Non- farm income is affect efficiency negatively (Tsegaye *et al*., 2019). However Haile *et al*., (2018) argue that non-farm income decrease the level of inefficiency.

No Livestock: Livestock support crop production in many ways. Dang, (2017), Tsegaye *et al.*, (2019) and Akpan *et al*., (2012) argue that livestock had positive impact on farm efficiency.

Distance to the all-weather road: It is also the distance of farmers located from the main road, in kilometers. Distance have negative impact on profit efficiency of the farmer (Dang, 2017).

Gender: It is a dummy variable that is 1 if the household head is male headed and 0 other wise. Addison *et al*., (2016) show that males are more efficient in rice production than their female counterparts. Yet studies by Timothy and Adeoti, (2006) give evident from their study that agricultural productivity for a given level of inputs may not be affected by the farmer's gender.

Family size: Family is an important source of labor supply in the area. Family size could have positive effect in raising the farmers' production efficiency, if actually the members are in the working force (Tsegaye *et al.*, 2019 and Akpan *et al*., 2012). while family labour exerts negative effect on efficiency (Bamiro and Aloro , 2013).

Time of sowing: time sowing is a nominal variable where 1 indicates early sowing and 0, otherwise. Early sowing starts from mid to end of March and late sowing is in end of July in the study area.

Row planting: It is also a nominal variable which represents whether the farmer adopted row planting practice or not during the 2018/2019 production season. It takes the value of one if the farmer adopted it and zero, otherwise. Row planting has positive and significant effect on efficiency (Lema and Tessema, 2017).

Market access: the access where the farmers sales their output and buy their input and 1 if the farmer has any accesses and 0 otherwise. Wongnaa and Mensah,(2018) and Ahmed *et al*., (2013) showed that the market access have positive relation with profit efficiency of the farmer.

Social Responsibility: the stages of fact of having a duty to deal with some think or of having control over some one. Social status had negative relationship with efficiency (Ahmed *et al*., 2013). Responsibility was nominal variable, 1 if the farmers have any responsibility in the community and 0 otherwise.

Table 3. 2: Key Variables incorporated in the Frontier Profit Function Models and their expected signs.

Variable	Description	Expected sign	Source
dependent variable (π)	Normalized profit of the i^{th} farm defined as gross revenue less variable cost divided by farm specific price (dependent).		
P_1	Normalized price of Seed divided by price of rice output.	+ve	Dang (2017), Abu and Asember, (2011) and Gad *et al*., (2019)
P_2	Normalized price of fertilizer divided by price of rice output.	+ve	Hoang and Yabe (2012) and (Gad *et al*., 2019)
P_3	Normalized price of agro-chemical divided by price of rice output	-ve	Gad *et al*., (2019)
P_4	Normalized price of labour divided by price of rice output	+ve	Dang(2017) and (Kolawole, (2006)
Z_1	Land under rice in hectares on farm	+ve	Rahman(2003), Sanusi (2015), Abu and Asember, (2011) and Sunday *et al*., (2012)
Z_2	Fixed capital (hoes, ploughs and sickles) used in the farm	+ve	Dang, (2017)

Source: own sketch from literature review, 2020

Table 3. 3: Description of Variables Included in the Inefficiency Model and their expected sign

Variables	Description	Expected sign	Source
Age	Age is a variable that describe number of years of the rice producing farmer.	**+ve**	Hoang and Yabe, (2012)
Gender (male)	Gender is a dummy variable that is 1 if the household is male headed and 0 other wise.	**-ve**	Hoang and Yabe, (2012) andAddison *et al*., (2016)
Education	Education is a continuous variable which represents educational level of the household head measured in years of schooling and it is used as a proxy variable for managerial ability of farmers	**-ve**	Hailemichael , (2014) and Duraisamy, (2020).
Experience	Experience is a continuous variable which refers to years of the household head which mainly exercise rice production measured in years.	**-ve**	Idiong and Iko, (2019), Galawat and Yabe, (2012) Kaka, (2016),and Saysay *et al*., (2016) .
Family size	Family size is an important source of labor supply in the area.	**-/+ve**	Lema and Tessema, (2017)
Number of plot	Number of plot is the continuous variable that describes number of land the farmer have.	**+ve**	Lema and Tessema, (2017)
Land preparation	Land preparation is continuous that explains the starting and finishing time of land preparation before starting sowing.	**-ve**	Galawat and Yabe,(2012),
Time of sowing	Time of sowing is a dummy variable where 0 indicates late sowing and 1, otherwise.	**-ve**	(Kaka, 2016) and (Saysay et al.,2016)
Row planting	Row planting is also a dummy variable which represents 1 if the farmer adopted row planting practice and 0 otherwise.	**-ve**	Lema and Tessema, (2017) and Kaka, (2016)
Extension access	Extension access is dummy variable which was measured as 1 if there was a contact between extensions agents and household head and 0 otherwise.	**-ve**	Galawat and Yabe, (2012), Kaka, (2016) and Saysay et al., (2016)
	Credit access is dummy variable which is measured as 1 the household head borrows from different lending institutions measured in Ethiopian birr and 0		

	other wise.		
Credit access	Non-farm income is a dummy variable which is measured as 0 if one of the household members participates in non-farm activity in the 2018/19 rice production season or 1 otherwise.	**-ve**	Sanusi, (2015)and Duy, (2014).
Non-farm income	Responsibility is the stages of fact of having a duty to deal with some think or of having control over some one.	**-/+ve**	Haile *et al*., (2018) and Tsegaye *et al*., (2019) respectively
Responsibility	Distance is also the distance of farms located from the main road, in kilometers	**+ve**	Fakkhong,(2016)
Distance	Market access is the place where the farmers sales their output and buy their input and attached a dummy of 1 if the farmer has any accesses and 0 otherwise	**+ve**	Rahman, (2003)
Market access	Number Livestock are important to support crop production in many ways; it can be source of cash, draft power and manure that will be used to maintain soil fertility.	-ve	Wongnaa and Mensah,(2018) Ahmed *et al*., (2013)
Number Livestock		-ve	Dang, (2017) Tsegaye *et al.*, (2019) and Akpan *et al*., (2012)

Source: own sketch from literature review, 2020

3.10. Model Diagnostic Tests

A test of the appropriateness of the model and the explanatory variables included in the model is critical step before analysis and drawing implications. Taking into account the varying nature of the cross sectional data was used, multicolinearity, normality, Endogenity and heteroscedasticity problems were checked.

3.10.1. Multicolinearity Test

The presence of multicolinearity among the explaining variables is one of the serious problems with the identification of variables to be used in the model. If one explaining variable is exactly in line with the other explaining variable, the standard error is equal to infinity. Multicolinearity refers to a condition with a strong correlation between the describing variables and other explanatory variable. Multicolinearity refers to a situation with a high correlation between the explanatory variables with multiple regressions, which is a sample question and a state of nature resulting in fairly large standard errors for the measured regression coefficients, but not biased estimates. Multicolinearity checks were carried out on data (Andren, 2007).

One can presume that every single explanatory variable is a linear function of another. The tests provided no proof of any issues with multicolinearity. This can be analyzed by measuring for each of the explanatory variables using the Variance inflation factor (VIF). If a mean value of VIF is greater than 10; there is proof of multicolinearity that calls for serious problems.

3.10.2. Heteroscedasticity Test

Heteroscedasticity is a violation of one of the requirements of ordinary least squares (OLS) in which the error variance is not constant. The consequences of heteroscedasticity are that the estimated coefficients are unbiased but inefficient. Andren, (2007) Showed that regression maximum likelihood estimators are inconsistent when there is a question of heteroscedasticity. Heteroscedasticity is prevalent in cross-sectional data set like the one used in this analysis. Some of the main causes are: variance of dependent variable increase with increase in the level of dependent variable, variance of dependent variables increases or decreases with changes in independent variables and outliers in the data set. The first step in solving the heteroscedasticity problem is to determine whether or not there really is heteroscedasticity. Hence, following the techniques used to identify the heteroscedasticity problem, the Breusch-Pagan is a common t est procedure presented in most textbooks on econometrics. And it's slightly more general than the Goldfeld-Qaunt test, as it makes the chi-squ test.

Some of the approaches used to correct heteroscedasticity include data transformation into natural logarithms, Weighted Least Squares (WLS) and standard error weighted robustness (Andren, 2007). Heteroscedasticity-robust methods are valid in large samples at least, whether or not there is constant variance in the errors. Therefore, the variance matrix estimator should be robust when heter is present(Wooldridge, 2009).

3.10.3. Endogenity Test

Endogenity problem exists when an independent variable in the model is explained by other variables and correlated with error terms with in the equation. Neglecting the problem of Endogenity in the equation introduces a simultaneity bias. A more difficult problem arises when a model excludes a key variable, because of data unavailability. One possibility is to obtain a proxy variable for the omitted variable. Loosely speaking a proxy variable is something that is related to unobserved variable (Wooldridge, 2009).

3.10.4. Normality Test

It is important to note that profit efficiency can only be estimated if the effects of inefficiency are stochastic and have a specific distributional specification (Battese and Coelli, 1996). The estimator is inconsistent if the underlying disturbances are not normally distributed. And unifying treatment includes various distributions, such as exponential, lognormal and Weibull (Greene 2003). One of the assumptions made in this study is that the inefficiency component (u) is a half-normal distribution or one-sided non-negative distribution of which is independent from v, which represents factors external to the farmer and is assumed to be distributed independently.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents and discusses the results by dividing the section into two main subsections; descriptive statistics and econometric results. The descriptive statistics present in the form of; farm and farmer characteristics, institutional factors and, production and economic factors. The purpose is to offer a general background about the farmers and their situation. This is necessary to understand how socioeconomic situations influence farming decisions. While, the second sub-section were all about the econometric results of the study describing the mean level of profit.

4.1. Descriptive Statistics

4.1.1. Farm and Farmer Characteristics

Table 4.1 exhibits, farm characteristics (distance to road, number of plots, household size, time of sowing, and land preparation) and farmer characteristics (farming experience, education level, and age of family head) of the selected household. The mean age of the household heads was nearly once 42 years. This indicates majorities of the farmer in the study area is an economically productive age group. The oldest rice farmer in the sample was 70 years while the youngest was 24 years. Education is an instrument to enhance the first-rate of labor to improving the managerial skill and the tendency to undertake new technologies. The mean years of formal education was found to be 4 years with minimum 0 and maximum of 10 years, this indication that the majority of the household heads from the pattern had at least no longer attained primary education.

The mean years of experience in rice farming was 4 years. The farmer with the least experience had practiced crop farm for two years, while the one with the best experiences was in the exercise for 17 years. More experienced farmers were proven to have a higher chance of the use of better farm practices. The family size, defined by way of the number of humans that were living in the family the previous 12 months, implies mean nearly 4 people. Some households did now not have any household member in the household; instead, there have been familiar laborers' who had been in-charge of the things to do on the farm. The household with the highest number of members was found to have 11 people and least of 2 people in the household.

The average farm size for both owned and rented was 2.24 hectares with a standard deviation of 0.95 hectares; this indicates that most farmers in the study area were small-scale farmers. The farm sizes ranged between 0.5 and 7 hectares. On average 1.3 hectares of the land were covered by rice crop. This means, more of the land of the households in the study area was covered by rice crop.

Table 4. 1: summary statistics of farm and farmer characteristics

Variable	Mean	Standard deviation	Minimum	Maximum
Age (year)	41.93	10.03237	24	70
Education level (year)	3.5796	2.9745	0	10
Rice farming experience(year)	10.9328	4.2229	2	17
Family number (number)	4.4378	3.0412	2	11
Number of plot (number)	1.1293	0.3619	1	3
Land size (hectare)	2.2486	0.9536	0.5	7
1and size of rice (hectare)	1.2960	0.5476	0.5	4
Time of sowing (month)	7.6492	1.0658	6	10
Land preparation (month)	6.6417	1.1282	5	10
Distance to road (km)	2.627662	2.343986	0.1	10
Number of livestock (number)	6.7039	5.3088	1	28
Sample size	402			

Source: own computation, 2020

The livestock subsystem is highly interrelated with the crop production subsystem. It provides draught power and means of transportation. The mean number of livestock is 6 that are ranging from 1 to 28. The mean month of land preparation is 6 ranging from 5^{th} mouth to tenth 10^{th}month. The same true for time of sowing the mean 7 ranging from 6^{th} to 10^{th} month. The mean of number of plot is 1 ranging from 1 to 3. This indicates that most of the farmer in the study area single land plot. The mean of distance to road is 2.6 ranging from 0.01 to 10 km.

Sample respondents were composed of both male and female household heads. Out of the total sampled household head farmers about 90.5% were male headed and the remaining 9.5% were female headed households. From the total of 402 sample farmers only 28.6 percent farmers follow row planting technology. Some studies explain that social responsibility had a negative impact on efficiency. From 402 samples, household only 15.7 percent had social responsibility and 9 percent of the respondents received non-farm income.

Table 4. 2: summary statistics of Nominal variable of farm and farmer characteristics

Nominal Variable	Response	Frequency	Percentage
Gender	Male	364	90.6
	Female	38	9.4
Adopt Row planting	Yes	199	49.5
	No	203	50.5
Social responsibility	Yes	167	42
	No	216	58
Nonfarm income	Yes	36	9
	No	366	91
Sample size		402	

Source: own computation, 2020

4.1.2. Institutional Factors

Institutional factors are important determinants of profit efficiency in crop production. On average, 47% of the farmers had access to extension services (Table 4.3). The results show that there is less than 50% coverage of extension services in the study area. The proportion of farmers that had access to credit to support agricultural production was approximately 6% (Table 4.3). This credit was mainly accessed through OMO-micro-finance and informal money lenders. This shows that credit access in the study area is very low and also only 16.7 percent of the respondents get market access.

Table 4. 3: summary statistics of institutional factors

Nominal Variables	Response	Frequency	Percentage
Extension access	Yes	190	47
	No	212	53
Credit access	Yes	24	6
	No	378	94
Market accesses	Yes	235	46
	No	186	54
Sample size		402	

Source: own computation, 2020

4.1.3. Production and Economic Factors

The summary statistics for production and economic factors are reported in Table (4.4). Seeds are an important input in determining productivity of a farm activity. The demand for seed does not only concern quantity, but more importantly the quality and profitability. The results in Table (4.4) show that the average price of seed estimated at 2,776 Birr ranging from 300 to 9,000 Birr. The average price of fertilizer reported among the sampled farm households was 2,020.62 Birr reneges from 750 to 4,900 Birr. The estimated average wage of labour was 996.62 Birr ranges from 100 to 4,100 Birr. Farming activities were conducted using mostly family labor and, in some cases, hired labor was used especially during peak periods such as land preparation and weeding. The mean level of agrochemical price was 817.33 Birr ranges from 300 to 1,600 Birr.

The average value of fixed capital among the households was 30,091 Birr with the maximum of 72,000 and the minimum of 1,000. On average, farmers had required to invest 5,748.7 amounts of birr for the production of 29 quintals of rice output with a minimum of 750 birr up to a maximum of 20,780 birr.

Table 4. 4 : summary statistics for production and economic factor

Variables	Mean	Std. deviation	Minimum	Maximum
Seed price	2776.035	1354.57	300	9000
Fertilizer price	2021.627	859.23	750	4900
Labour wage	996.627	553.7535	100	4100
Agro-chemical price	817.3383	295.2021	300	1600
Fixed capital(in birr)	30091.94	11693.66	1000	72000
Yield(quintal/ha)	29.28856	6.118637	15	41
Total yield(quintal)	38.51244	18.14955	15	120
Output price(birr/quintal)	953.7313	88.12826	700	1200
Revenue from rice(birr)	32779.1	18275.54	3000	98000
cost of rice output(birr)	5748.744	3315.241	750	20780
Gross profit(birr)	27030.36	16630.42	100	83500
Sample size	402			

Source: own computation, 2020

The mean level of output per hectare is 29 quintals ranging from 15 to 41 quintals. An average rice output price was 953.7 Birr. Prices in Guraferda vary from 700 to 1200 Birr within one season, depending on when the selling is done due to information access and distance to markets. The average revenue received from rice sale was 32,779.1 Birr with minimum of 3,000 Birr and maximum of 98,000 Birr. Table (4.4) shows that households obtained varied gross margins with an average of 27,030 Birr from rice sales after deducting the total costs from rice sale revenue. The profit was ranging from 100 Birr to 83,500 Birr. This means that rice production provides positive returns.

4.1.4. The Correlation and partial correlation of dependent variable (profit) with explanatory variable

There are three possible results of a correlational study: a positive correlation, a negative correlation, and no correlation. Table (4.5) showed that the explanatory variable like land size, the price of seed, and the price of fertilizer, wage and value of fixed capital were positively correlated with profit of rice farmers. The price of agro-chemical was negatively correlated with profit of the rice producer. Additionally this result shows that there is no strong correlation between the explanatory variables. These indicate that there is no collinearity problem in the data.

Table 4.5: the Correlation and partial correlation of explanatory variable with the dependent variable (profit).

	Profit	Fixed capital	Price of seed	Price Fertilizer	Lobour wage	Land size
Profit	1.0000					
Fixed capital	0.3497	1.0000				
Price of seed	0.6030	0.2617	1.0000			
P of fertilizer	0.3951	0.1739	0.2198	1.0000		
Lobour wage	0.0248	-0.1354	0.0661	-0.0035	1.0000	
Land size	0.3168	0.1964	0.3825	0.0090	-0.0179	1.0000

Variable	**Partial Corr.**	**Semi partial Corr.**	**Significance Value**
Land size	0.1268	0.0925	0.0114
Price of seed	0.4765	0.3922	0.0000
Price of fertilizer	0.3381	0.2600	0.0000
Labour Wage	0.0326	0.0236	0.5168
Price of chemical	-0.0727	-0.0527	0.1482
Fixed capital	0.2206	0.1636	0.0000

Source: own computation, 2020

Partial correlation measures the strength of a relationship between two variables, while controlling for the effect of one or more other variables. As a result land size was positive association with profit and significant at the 5% level. Where price of seed, price of fertilizer, and the value of fixed capital were positively associated with profit and significant at the 1% level. The result indicates that these factors have significant impact on profitability and able to increase the level of profit differential among farmers.

4.1.4. Correlation and Partial correlation of profit Inefficiency (U) with explanatory variable

Table (4.6) showed that the explanatory variable like education level, experience, row planting, extension access, credit access, market access, number of livestock, and family size were negatively correlated with inefficiency. While the variables like responsibility, distance, and age of the household were positively correlated with inefficiency. Additionally this result showed that there is no strong correlation between the explanatory variables. These indicated that there is no collinearity problem in the data.

Table 4.6: correlation and Partial correlation of explanatory variable with dependent variable (inefficiency)

	U	Extension	Credit	Responsibility	Market access	Distance to road	Number livestock
U	1.0000						
Extension	-0.3271	1.0000					
Credit	-0.1205	0.1596	1.0000				
Responsible	0.6650	-0.3314	-0.1485	1.0000			
Market access	-0.6801	0.2620	0.1663	-0.5393	1.0000		
Distance to road	0.6141	-0.2436	-0.0761	0.5810	-0.4352	1.0000	
Number livestock	-0.7078	0.2259	0.0022	-0.4347	0.5110	0.4368	1.0000

	U	Age	Educ	Farm experience	Family No	Row planting
U	1.0000					
Age	0.2087	1.0000				
Gender(male)	0.0520	0.0292				
Education	-0.5774	-.2234	1.0000			
Farmexprianc	-0.5348	0.0558	0.3983	1.0000		
FamilyNo	-0.3721	0.0093	-.1899	0.3013	1.0000	
Row planting	-0.6356	-.1143	0.4248	0.3924	0.2570	1.0000

Source: own computation, 2020

Table (10) showed that the age of household head, distance to the main road and responsibilities were positively associated with inefficiency and significant at the 1% level. The result indicates that these factors have significant impact on inefficiency and increase the level of inefficiency differential among farmers. While the coefficient of education level showed a negative correlation and significant at the 10% level. The remaining explanatory variables like farming experience, row planting, extension, nonfarm income, and market access showed negative association with inefficiency and significant at the 1% level. This implies that, these explanatory variables were an important role to reduce inefficiency and increases profit efficiency of the given farmer and have the potential to create inefficiency differential among farmers in the area.

Variable	**Partial Corr.**	**Semi partial Corr.**	**Significance Value**
Age	0.1865	0.1163	0.0002
Gender	0.0669	0.0411	0.1871
Education	-0.0873	0.0537	0.0849
Ricefarmexp	-0.2263	-0.1424	0.0000
Family number	0.0008	0.0005	0.9871
Row planting	-0.2143	-0.1345	0.0000
Extension access	-0.1469	-0.0911	0.0036
Credit access	0.0366	0.0225	0.4705
Nonfarm income	-0.1628	-0.1012	0.0013
Responsible	0.1730	0.1077	0.0006
Market access	-0.2098	-0.1315	0.0000
Distance to road	0.1841	0.1148	0.0003
Number of livestock	-0.0615	-0.0378	0.2257

Source: own computation, 2020

4.2. Result of the Econometric Model

4.2.1. Hypothesis Testing

In this section econometric results of the study are presented and discussed. The profit function, efficiency scores and determinants of efficiency are presented and discussed. Before starting on discussions of the output of the model, different essential hypothesis testing was conducted to identify appropriateness of the model, distributions and for the existence of a profit inefficiency component of the composed error terms of the stochastic profit frontier function. The generalized likelihood-ratio test statistics was employed to check the null hypothesis for the parameters within the profit frontier and inefficiency models.

Table 4. 7 : Generalized likelihood ratio test of hypotheses for parameters of SPF

Null hypothesis	Degree of freedom	χ2 Test Statistic	Prob> χ2 statistic	Decision
$H_0 : \gamma = 0$	6	21.9	0.0000	Reject H_0; Inefficiency effects are present in the model
$H_0 : \gamma = \delta_0 = \delta_1 \ldots \delta_{16} = 0$	16	41.1	0.0000	Reject H_0; Explanatory variables determine the U_i
Gamma (γ) coefficient		0.89	0.0000	Indicates the presence of inefficiency and appropriateness of the model

** 1% significant level; source own computation, 2020

The first hypothesis tested was that farmers were profit efficient and there's no room for improving efficiency, which is H_0: $\gamma = \beta_0 = \beta_1 = \ldots \beta_6 = 0$. The system of log likelihood ratio test used to find out the presence of inefficiency rejected the null hypothesis at the 1% level of significance (LR statistic 21.9, $p = 0.000 < 0.01$) in favor of the presence of inefficiency effects. Additionally the null hypothesis is rejected as the γ parameter is 0.89 and significant at the 1% level. This means that about 89% the variation in rice output profit is caused by inefficiency factor other than statistical noise. The estimated gamma or variance ratio parameter

(γ) is statistically greater than zero at the 1% level and comparatively large (0.89) given the (0, 1) interval within which γ lies. The value of γ shows that 89% the of disturbance in the system is due to profit inefficiency (u), with one sided error and 11% is due to stochastic disturbance with two sided error which makes the profit frontier stochastic (Rahman, 2003).

The second hypotheses tested is whether the farm socio-economic and institutional variables, as identified in chapter three, affect farm level profit efficiencies, that is $H_0 : \delta_0 = \dots \delta_{16} = 0$. The null hypothesis is rejected at the 1 % level (F-statistic 41.1, $p = 0.000 < 0.01$). These results confirm that the joint effect of socioeconomic and institutional indicators of profit inefficiency is statistically significant. Therefore, variables included in the inefficiency effects model can explain the inefficiency term U_i.

In addition, a sigma square (σ^2) coefficient of 0.6112 is statistically significant at 5% probability level denoting that the equation has a good fit and confirms the correctness of the specified distribution assumption of the composite error term for the model. The implication is that the inefficiency equation (u_i) can explain the differences between each farm's profit and the profit on the frontier function.

Before going to econometric analysis, the data were tested against different econometric problems. Accordingly, the data was checked for heteroscedasticity using Breusch Pagan test, and the result showed that there was no problem of heteroscedasticity. According to the Breusch-Pagan, the chi-square was 0.64 with probe>chi2 equals 0.425 at the 10 percent level of confidence. Since the probe>chi2 was 0.425 which greater than 10 percent level of confidence the null hypothesis of homoskedasticity is accepted and researcher conclude that there is no heteroscedasticity in the data (Appendix- 2).

Multicolinearity test for independent variables was done using Variance Inflation Factor (VIF). Test for multicolinearity was made using STATA 14 computer program for the values of variance inflation factor for input variables. VIF values were computed for all variables and they were ranging between 1.05 and 1.51. Moreover, the mean value of the factors (VIF) was 1.27 as shown on (Appendix-2). Hence mullticollireaty was not a problem among the explanatory variables.

In order to confirm the assumed distribution, kurtosis test is one of used method in the state (kurtosis). According to kurtosis, the joint chi-square was 1.066 with probe>chi2 equals 0.3017 at the 10 percent level of confidence (Appendix 2). Since the probe>chi2 was 0.3017 which is greater than 10 percent level of confidence, the null hypothesis of normality in the distribution of inefficiency is accepted and the researcher concluded that this was an indication of assumption that u is non-negative half normal distribution at least 10 percent level of significance. The result of the stata on omitted variable test showed that Prob > F = 0.5802 which is greater than 10 percent level of confidence. This leads to accept the null hypothesis model has no omitted variables. Independent variables and the error are not linearly related, ensuring that variables measuring efficiency are independent from the variables in the error term.

4.2.2. Estimation of Frontier Profit Function: Cobb- Douglas

The stochastic Cobb- Douglas frontier profit function model was adopted for analysis in this study. The study identified key factors that influence the profit of rice. The results of the maximum likelihood estimates (MLE) are presented in (Table 4.8).

Table 4. 8: Maximum Likelihood Estimates of parameters of Cobb-Douglas stochastic frontier profit function for rice farmer in Guraferda district

Variables	Parameter	Coefficient	SE	Z Value	P value
lnprice of seed	β_1	0.4605***	0.0541611	8.50	0.000
lnprice of fertilizer	β_2	0.25453***	0.0557589	4.56	0.000
Lnwage	β_3	0.0718387*	0.0435754	1.65	0.099
lnprice of agro chemical	β_4	-.0573458	0.0720143	-0.80	0.426
lnland size	β_5	0.26622***	0.0779818	3.41	0.001
lnfixed capital	β_6	0.2083058 ***	0.0421564	4.94	0.000
Constant	β_0	0.7615968 ***	0.4390006	1.73	0.002
Sigma – squared	σ^2	0.611***			0.0000
Gamma	γ	0.89***			0.0000
Log likelihood		-290.26			
Wald chi2 (6)		253.26			
Mean VIF		1.27			

Breusch Pagan	0.64	0.4250
Sample size	402	

Note: *, **and *** indicate levels of significance at 10% ($p<0.10$), 5% ($p<0.05$), and 1% ($p<0.01$) respectively. Source: own computation from survey data, 2020

The result shows that the coefficient of farm size was positive and significant at the 1% level. This indicates that increasing land size by 1%, holding other variables constant, and farm profit will increase by 0.27%. This result similar with the findings of Abdulai and Huffman (1998), Rahman (2003), and Sanusi (2015) who found a positive relationship between farm size and profit efficiency.

The coefficient on fixed capital showed a significant positive relationship with farm profit at the 1% level. This indicates that increasing fixed capital by 1%, holding other variables constant, and farm profit will increase by 0.21%. This shows that fixed capital is an important factor in explaining changes in profit. The implication is that an increase in the value of fixed capital assets owned by a farmer will bring about an increase in farm profit. Thus, expansion in farm capital, in the form of necessary tools, implements and equipment contributes positively to rice supply and significantly increases farm profit. Increased in capital facilitates increased output, which in turn leads to increased profit (Rahman, 2003).

Variable related to price of seed had positive sign and significant at the 1% level. This indicates that increasing price of seed by 1%, holding other variables constant, and farm profit will increase by 0.46%. It follows that, using high quality seed which is relatively expensive than local variety will increase farm profit. Thus, farmers believe that the more expensive the seed, the better it is for rice production. This shows that the marginal value production of improved seed was greater than its price, making it rational to obtain a higher profit with increased price and quality. This result shares the contradictory version of the law of profits in production but it agrees with (Gad *et al.*, 2019) in order to increase the profit efficiencies the farmers must use improved seed varieties (more expensive than local seed). Similarly study by Dang (2017) showed positive relation between price of improved seed and profit efficiency. Yet this result contradict with the finding of Ogunniyi, (2011) and Rahman, (2003) who discussed the negative impacts of price of seed on profit efficiency. Hence this difference is occurred may be due to the functional forms difference they used or due to different in agricultural policy and location differences.

Similarly, the result shows that the coefficient of fertilizers was positive and significant at the 1 % level. The result revealed that 1% increase in the price of fertilizer leads to increase the profit efficiency of the rice farmers by 0.25%, given others variables constant. However, decreasing return to scale was established since increasing the price of fertilizers by 1% will result to an increase in farm Profit by only 0.25%. The positive relationship between price of fertilizers and farm profit indicates that the marginal value productivity of the farmers was increased when they used high quality fertilizer. As a result, it follows that when appropriately and well-timed applied of fertilizers increases yield per area planted and subsequently increases farm profit; all other variables were given constant. This finding is in line with that of Galawat and Yabe, (2012) and Gad *et al*., (2019) who reported positive relationship between high price of fertilizer and profit efficiency of rice production.

Variable related to price of labour showed positive sign and significant at the 10% level. This indicates that increasing the labour wage by 10%, holding other variables constant, and farm profit will increase by 0.071%. However, decreasing return to scale was established since increasing the labour wage by 10% will result to an increase in farm profit by only 0.07%. It can be inferred from this result that engaging hired labour supposed to give up profit to farmers than using agro-chemical. The positive coefficient of price of labour is contrary to the law of profits in production. This may be because rice production is labour intensive. As more labour is applied (till reach at maximum) in small-scale rice production, output will increase ceteris paribus, will increase profit. This finding is in line with the finding of Dang (2017) and Nwauwa *et al*., (2013) who discussed the positive relation between wage and profit efficiency.

The results of agro-chemical was the expected signs but were not significant. This is may be due to the use of agro-chemical in rice production is low in the study area. This result shares the law of profits in production. Therefore, the profit efficiency levels of the farmers could be adversely affected by agro-chemical price.

4.2.3. Profit Efficiency Score in Rice Farmers

The distribution of profit efficiency in rice production is presented in Table 4.9. The farmers reveal a wide range of profit efficiency from 11.38% to 90.74% of the farmers. The result revealed that few farmers are close to the profit efficiency frontier while most of them are very far from the efficient frontier. It is observed that even the most efficient rice farmer did not achieve the optimal resource allocation and needed improvements to attain the frontier profit. This progress can be achieved if the determinants of inefficiency are minimized. Similarly, study by Kolawole (2006) reported that the average measure of profit efficiency of 60.1%. Furthermore Asrat (2019) who obtained a minimum of 24.6% and a maximum of 99% efficiency scores for maize farmers in Ethiopia. Additionally Kaka (2016) also documented similar findings, where profit efficiency estimates ranged from 33% to 94% among Paddy farmers in Malaysia.

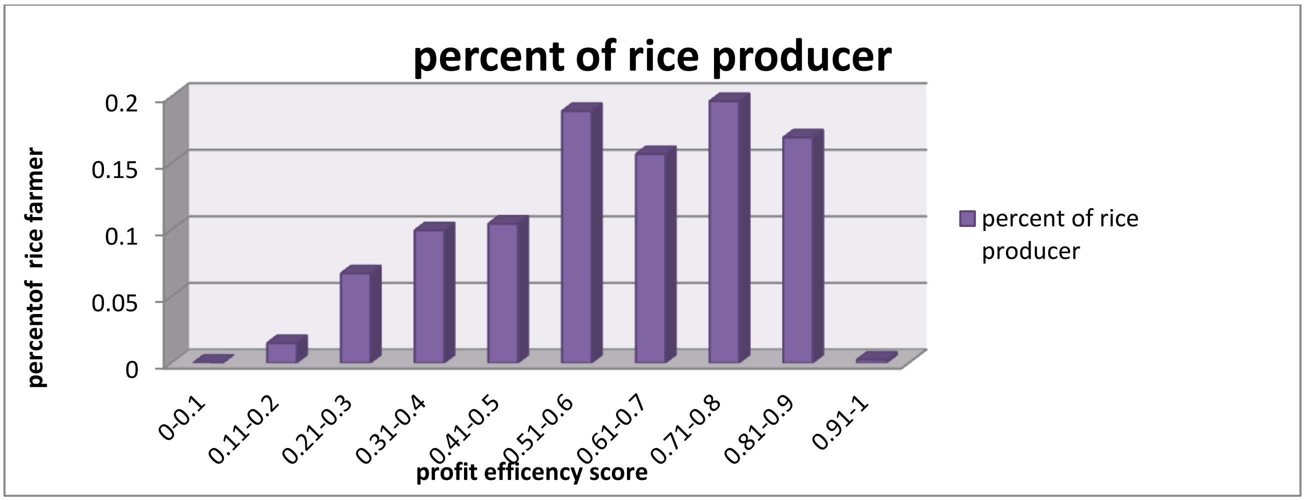
Table 4. 9: Distribution of profit efficiencies scores among rice farmers.

profit Efficiency Score	Frequency	Percentage
0-0.1	0	0
0.11-0.2	6	1.49%
0.21-0.3	27	6.72%
0.31-0.4	40	9.95%
0.41-0.5	42	10.45%
0.51-0.6	76	18.91%
0.61-0.7	63	15.67%
0.71-0.8	79	19.65%
0.81-0.9	68	16.92%
0.91-1	1	0.24%
Minimum profit efficiency	0.1138	11%
Maximum profit efficiency	0.9074	90%
Mean profit efficiency	0.6034	60%
standard deviation	0.1884	18.84
sample size	402	100%

Source: own computation, 2020

The result had revealed that the average profit efficiency score of rice farmer in the area was 0.6034. This Show that rice farmers achieved, on average, 60.34% level of efficiency. This implies that significant or important amount of profit (about 39.66%) is lost from rice profit in the Guraferda district because of the existence of profit inefficiency at the given input prices, output price and technology. The producers can increase their profits by 39.66%, on average, to build up their competitiveness in the short run through the adoption of best farm practices that reduce inefficiencies and improving their technical and allocative efficiency (e.g. row planting) to attain the frontier.

Figure 4. 1: Percentage distributions of farmers by profit efficiency score



Source: own computation from (2020) survey data

4.2.4. Determinants of profit inefficiency for rice farmers: Inefficiency model

Before going to econometric analysis of the inefficiency model, the data were tested against different econometric problems. Accordingly, the data was checked for heteroscedasticity using Breusch Pagan test, and the result showed that there was no problem of heteroscedasticity. Heteroskedasticity-robust methods are valid at least in large samples whether or not the errors have constant variance. So, the variance matrix estimator should be robust in the presence of heteroskedastiy of unknown form (Wooldridge, 2009). According to the Breusch-Pagan, the chi-square was 29.29 with prob>chi2 equals 0.000 at the 1 percent level of confidence (Appendix-2). Since the prob>chi2 was 0.000 which less than 1 percent level of confidence the null hypothesis of homoskedasticity is rejected and researcher conclude that there is heteroscedasticity in the data even though as such not problematic in this case. For this study, robust standard error methods were used to address Heteroskedasticity.

Multicolinearity test for independent variables was done using Variance Inflation Factor (VIF). Test for multicolinearity was made using STATA 14 computer program for the values of variance inflation factor for input variables. VIF values were computed for all variables and they were ranging between 1.02 and 5.17. Moreover, the mean value of the factors (VIF) was 1.95 as shown on (Appendix-2). Hence mullticollireaty was not a problem among the explanatory variables.

In order to confirm the assumed distribution, Henze-Zirkler test is one of used method in stats (hzirkler). According to Henze-Zirkler, the joint chi-square was 1.1435755 with prob>chi2 equals 0.2841 at the 10 percent level of confidence (Appendix 2). Since the prob>chi2 was 0.2841 which is greater than 10 percent level of confidence, the null hypothesis is accepted and the researcher concluded that this was an indication of assumption that e is normal distribution at least 10 percent level of significance. Similarly the result of the stata on omitted variable test showed that Prob > F = 0.5802 which is greater than 10 percent level of confidence. This leads to accept the null hypothesis model has no omitted variables. Independent variables and the error are not linearly related, ensuring that variables measuring efficiency are independent from the variables in the error term.

A number of major socio-economic and institutional variables were hypothesized to affect the level of profit efficiencies of rice producers in Guraferda. The coefficients of these variables included in the model were estimated by multiple linear regressions. The outcome of the inefficiency coefficients shows either a negative or positive sign that indicates the effect of the variable on efficiency. Hence, a negative sign indicates that the presence of the variable has a decreasing effect on inefficiency whereas a positive sign indicates an increasing effect on inefficiency.

Table (4.10) showed that the R squared is 0.6309. This means that 63.09% of the total variation of the dependent variable (inefficiency) that can be explained by the changes in the explanatory variables included in the model. The remaining 36.91% variation is explained by the error term (e).

Table 4. 10: Determinants of profit inefficiency for rice farmers: Inefficiency model

Source	SS	DF	MS		
				Number of obs	= 402
				F (16, 385)	= 41.13
Model	8.98884596	16	.561802873	Prob > F	= 0.0000
Residual	5.25861149	385	.013658731	R-squared	= 0.6309
				Adj R-squared	= 0.6156
Total	14.2474575	401	.035529819	Root MSE	= 0.11687

U	Parameter	Coef.	Std. Err.	T	P>t
Age	δ_1	.00227***	.0006247	3.64	0.000
Gender	δ_2	.0270125	.0201363	1.34	0.181
Educ	δ_3	-.0034422	.0026218	-1.31	0.190
Ricefarmexp	δ_4	-.00835***	.0018135	-4.61	0.000
Familyno	δ_5	-.000066	.002109	-0.03	0.975
No of plot	δ_6	.0023551	.0171999	0.14	0.891
Land pre	δ_7	.0025996	.0115007	0.23	0.821
Time of sowing	δ_8	.0153541	.0124542	1.23	0.218
Row planting	δ_9	-.05911***	.0157301	-3.76	0.000
Extension	δ_{10}	-.022358**	.0093487	-2.39	0.017
Credit	δ_{11}	.017121	.0260453	0.66	0.511
Nonfarm	δ_{12}	-.07475***	.0211274	-3.54	0.000
Responsible	δ_{13}	.0499377***	.0174973	2.85	0.005
Mkt access	δ_{14}	-.079831***	.0169381	-4.71	0.000
D to road	δ_{15}	.01178***	.0034221	3.44	0.001
No live stock	δ_{16}	-.00121	.0014252	-0.85	0.395
_cons	δ_0	.27751***	.0658398	4.21	0.000

Note: ** and * ** indicate levels of significance at 5% (p<0.05) and 1% (p<0.01) respectively.

Source: own computation from (2020) survey data

Age of the household head had a positive coefficient and significant at the 1% level. This indicating that there was a positive relationship between age of the farmer and profit inefficiency. This implies that young farmers were able to decrease their inefficiency thus increase their efficiency more than the old farmers.

Farming involves a lot of risks and uncertainties, hence, to be competent enough to handle all the vagaries of farming a farmer must have stayed on the farm for quite some time. The results this research revealed that the estimated coefficient on experience is negative and statistically significant at 1% level, indicating reduction in profit inefficiency. This result is expected, because experience is gained through learning by doing which enables farmers to correct past mistakes and adopt better practices in the farm. This result is in line with that of Rahman (2003) who concluded that farmers in his study area with more than three years of experience in growing modern varieties earn a significantly higher profit, operate at significantly higher level of profit efficiency. Additionally Galawat and Yabe, (2012), Kaka, (2016), and Saysay *et a*l.,(2016) shows that the profit efficiencies of the farmer were positively related with the experience of the farmers.

The analysis indicates that the appliance of recent farming technology like row planting in rice production has significant functional on elevating profit efficiency of farmers. The coefficient of row planting was negative and significant at the 1% level. This means, efficiency is improved if the farmers follow row planting technology. Similar study reported by Kaka,(2016) with land cultivation method, harvesting method possess a negative relationship with profit inefficiency and positive with profit efficiency.

The estimated coefficient with related to the extension services was showed negative sign and significant at the 1% level. The outcome examines that the farmers who have access to extension services achieve a better level of efficiency. This is due to that development agents have had a critical role to distribute new product information, technologies and inputs from the research field to the actual farmers on the ground. This result's also in line with findings obtained by (Galawat and Yabe,2012 ; Kaka, 2016), and (Saysay *et al*.,2016). This result so would serve to emphasize the importance of extension services in rice production to reducing profit inefficiency.

The end result of non-farm employment variable integrated into the profit inefficiency impact model indicated that the variable affect the level of profit inefficiency negatively and significant at the 1% level. In other words, these farmers occupied in some non-farm employment to do were not as much of earnings inefficient compared to farmers who had been no longer engaged in non-farm activities. Abdulai and Huffman (2000) reported similar results for farmers in Northern Ghana. Additionally study by Ali and Flinn, (1989) and Rahman, (2003) reported parallel outcomes in Pakistan and Bangladesh rice farmer, respectively. The effect indicated that having non-farm employment provides the earnings to buy inputs wished to increase productivity, and as a result decreasing inefficiency.

The regression coefficient of the social responsibility was positively signed and statistically significant at the 1 % level. This indicates that social responsibilities had increased inefficiency and reduced profitability of rice farmers. This finding was consistent with Fakkhong, (2016) showed that social status had a negative impact on profit efficiency.

Manipulate of road infrastructure on the profit efficiency of rice farmers is positive and statistically significant at the 1% for rice farmers in the area. This means that rice farmers with farms close to high-quality roads are more profit efficient than those whose farms are located in areas with disappeared roads. This is because good road network in producing areas enhances the inflows and outflows of production inputs and outputs respectively, which increases rice production and avoid postharvest losses. This result is in line with that of Rahman (2003) that identified poor rural infrastructure as one of the main obstacles to the improvement of agriculture in Bangladesh.

The estimated coefficient related with market access, in this study conveys the expected negative sign and is statistically significant at the 1% level. Access to output and input markets tend to help farmers to purchase inputs at the right quantity, time, and sell their output at a higher price. This enhanced access to input and output markets and services enables farmers to regulate their resources relatively more effective, such as timely availability of fertilizers and seed at competitive prices, thereby positively influencing profitability. Purchasing input correctly leads to an increase in input utilization efficiency similarly, high output price essential to motivate farmer to use the given input wisely and properly. Therefore, an access to improved input and output market is predicted to affect farming profit efficiency. This research proves that access to input market has a significant effect on profit efficiency. Other studies support this conclusion, such as (Wongnaa and Mensah, 2018)

However, the explanatory variables in inefficiency model; gender, education level, household size, number of plot, land preparation, time of sowing, credit access and number of livestock were no significant influences on rice profit efficiency in the study area. This does not mean that the above variables did not have any consequence on inefficiency, but the level of their significance fell below the level of confidence limits tested and this is may be due to the explaining power of the above variable decline as a result of low accessibility.

For example, the result of credit access is expected sign but insignificant, this may be due to the access of credit in the study area is very low (about 6% of the household head were received credit from both formal and informal money lender). So in order to reduce inefficiencies in rice farmer, governments give consideration to develop a sustainable rural credit institution or introduce appropriate legislation that encourages financial institutions to accommodate smallholder farmers to access loans at affordable interest rates.

The same is true for education level of the household head, the result is the expected sign but insignificant, this may be due to that the majority of the household heads had at least no longer attained primary education. This implies that greater education of the household head brings about a decrease in inefficiency (increase in profit efficiency) in rice production even if the result is insignificant. This indicates that the more educated farmers are more likely to adopt best farm practices to move toward producing the frontier output using the least cost combination of productive inputs.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter begins with the study summary, conclusion and recommendation where the objectives, postulated hypotheses, method of examination and results are summarized. Based on empirical results, conclusion and recommendations were made for policy makers and stakeholders in the rice production and crop agriculture sector.

5.1. Summary

Rice is the recently grown crop in Ethiopia that is becoming a staple in some parts, especially where Teffe is not grown in large scale. Rice should ensure food security and positive agrarian changes through increases domestic consumption of rice and to raising domestic production at the national level. This study analyzed the profit efficiencies and factors that explain the variation in efficiency among small-scale rice farmers in the Guraferda district, Bench-Sheko zone, Southern Nation Nationalities and Peoples Regional State. The study area was preferred purposively based on the potential of rice production in the zone. A two-stage random sampling process was employed for the selection of 410 sample respondents from six kebeles administration. The required Cross-sectional data were collected through interviews of farm household heads using a structured questionnaire.

This study set out to determine profit efficiency in rice production and the determinants of profit efficiency among the smallholder rice farmers in Guraferda district. The study made two null hypotheses: (i) smallholder farmers are profit efficient in rice production; and (ii) socio-economic and institutional factors do not significantly influence profit efficiency of smallholder rice farmers. The SFA approach was preferred as it best suits a single output and multiple-input production programs and as it simply disaggregates inefficiency effects in production into non-random and random error components. The survey data were analyzed using both descriptive statistics and econometric model for the estimation of profit efficiency and efficiency differentials. The Cobb-Douglas stochastic profit frontier and an inefficient model were employed to evaluate profit efficiency using farm level data obtained from 402 farm households of Guraferda district.

Descriptive statistics indicated that the mean age of all the sampled farmers was about 42 years. This indicates that farmers in the study area were economically productive. The respondents had about 10 years of rice growing experience on average in the study area. This showed that rice production has been in existence for a number of years as the majority of smallholder rice producers. An experience for farmers in production helped to capture the knowledge of the production practices. Additionally, farmers depend primarily on family labour. The average family size of respondents was found to be about 4 members per household. This shows that farmers needed access to additional labor from the labour market.

The results showed that there is high inefficiency in rice farming for the reason that the gamma ratio was closer to one ($\gamma = 0.89$), meaning profit inefficiency at the given level of inputs and prices is more prominent than the pure noise effect. This result led to the reject of the first hypothesis that smallholder farmers are profit efficient in rice production. The presence of inefficiency supports the suggestion that models that assumes complete efficiency could lead to misleading conclusions. This was shown by the log likelihood test which rejected the model without inefficiency in favor of the one that included inefficiency. Seed price, price fertilizer, land size and value of fixed capital were positive and significant at the 1% and labour wage also positive and significant at the 10% level, in the profit function. This estimation revealed that changes in seed input prices, the price of fertilizer, land size; labour wage and level of fixed capital factors affect the farmer's profit positively in the area.

With respect to profit efficiency levels of the rice farmer in Guraferda, the difference in actual profit from maximum profit (profit frontier) between households, ranged from 11.38% to 90.74%. This mainly arose from variation in farmers' practices rather than from random variation. The least profit efficient farmer needs an efficiency gain of 88.62% to attain the profit efficiency of the best farmer in the district. An average efficient of a rice farmer needs an efficiency gain of 39.66% to attain the level of the most profit efficient rice farmer, while the most profit efficient rice farmer needs only 9.26% gains in profit efficiency to be on the frontier. These findings entail that farmers were not using production resources efficiently to achieve higher profits in Guraferda district.

The study showed that the estimated average efficiency value was 60.34% among the sample farmers. This implies that, on average, profit is 39.66% below the efficient frontier. The estimated average profit efficiency was correspondingly low this showed that there existed a chance to increase efficiency given the present state of technology. Profit efficiency realized from rice production can increase by 39.66% if producers adopted the best farm practices and used the least cost combination of inputs.

In analyzing the sources of inefficiency of rice farmers, 16 variables were identified. These were gender, non-farm employment, education, experience, access to credit, access to extension service, row planting, time of sowing, access to market, age of respondents, distance to the road, responsibility, land preparation, number of family, the number of plot and number of livestock. As a result, rice Farming experience, row planting, market access, access to market and nonfarm income showed negative sign and significant at (at the 1% level) and access of extension (at the 5% level) of significant and create variation among rice farmer. This indicates that the variables had positively related to profit efficiency and negatively with inefficiency of the rice farmer in the study area.

While, the variables like Social responsibility, age of the household head and distance to all weather roads showed positive sign and significant at the 1% level. This means that these variables increase the inefficiency level of the given farmer and reduce efficiency score. These were the major determinants of profit efficiency in rice productivity and profitability, which led to the rejection of the second hypothesis that socio-economic and institutional factors do not significantly influence profit efficiency of smallholder rice farmers.

5.2. Conclusions

Rice is among the three most important grain crops in the world, and it is the major contribution to fulfill the food needs across the globe. The role of the rice crop is necessary in the current and future worldwide food security. In many parts of Ethiopia, rice could grow suitably including guraferda district. The main objective of the study was to analyze profit efficiency of rice production among smallholder rice farmers and to evaluate the effects of socio-economic and institutional variables on the profit inefficiency in the study area. This study employed Cobb-Dogulas stochastic profit frontier function model to analyze profit efficiency among smallholder rice farmers in the district of guraferda, Bench-Sheko zone, SNNPRS using farm level data obtained from 402 rice farmers.

The study results from the frontier profit function showed that the major farm specific production factors affecting profit efficiency were, land size, fixed capital, labour wage, the price of seed, and the price of fertilizer had a positive influence on profits. This indicates that, Production inputs were made available to farmers at appropriate time the farmers get better profit with regardless of input price. This may be due to that the inputs price were related to the productivity of the inputs (The use of high yielding improved rice varieties, fertilizer, and skilled labour) enhances efficiency, increases actual profit and reduces profit loss.

The study also has shown that profit efficiency varied widely among the sampled farmers with ranged from 11.38% to 90.74% with a mean of 60.34%. These findings entail that farmers were not using production resources efficiently to achieve higher profits in Guraferda district. Most of the parameters of variables incorporated in the inefficiency model have significant impacts on profit efficiency. The result of OLS revealed that profit efficiency was positively influenced by extension services, Experience of the farmer, access to markets, non-farm employment, and row planting. While the profit efficiencies were negatively influenced by the ages of farmers, responsibility and distance to road.

5.3. Recommendation

The study provides information with important policy implication in promoting profit efficiency and improving farm incomes among rice farmers in Guraferda district in particular and in Ethiopia in general. The presence of inefficiency established in rice production entails that, trying to introduce new technologies without addressing the causes of inefficiency may not yield the expected impact. The study therefore makes the following recommendations:

- ✓ The study recommends that policies and interventions in the rice sub sector ought to focus on the development of appropriate rice production technologies such as the use of improved high yielding varieties. It is recommended that improved seed be made available to farmers at appropriate time by the stakeholders.
- ✓ Also, improvement in efficiency would require focused policies and programs increasing and improving access to market. Road and market availability are essential efficiency factors. So Stakeholders ought to be developing a better roads and market infrastructure in the rural areas to reduce transport costs and the distance farmers have to cover to access markets. In order to increase rice productivity it is better to focus on improvement on the road and market access infrastructure.
- ✓ In addition, governments have to also have policies to promote row planting technology to improve yields per unit area. This result shows that policy measures be supposed to be considered to educate smallholder farmers about the row planting and its involvement to improve their profit efficiency.
- ✓ Development agents have had a critical role to distribute new product information, technologies and inputs from the research field to the actual farmers on the ground. Therefore, special emphasis and motivation had better to given to those persons so as to improve the efficiency level. This is possible by upgrading the extension personnel by providing practical attachment training with the current agricultural production.
- ✓ The positive impact of non-farm activities of the household on the level of profit efficiencies indicates its supplementary nature with the activities that did not compete with time of rice production. It contributes to income diversification. As a result, farmers engaged in the non-farm activities were operating at the highest level of profit efficiencies. Therefore, project or program that would support non-farm income activities ought to be adopted, which in turn will enhance rice production and farm profitability.

5.4. Future Research

This study focused only on the analysis of farmers profit efficiency in the rice production. In these regards future research in the area is needed to investigate the level of farmers profit efficiency in the overall crop production activities. Since this study used cross-sectional data, it would be interesting to estimate profit efficiency using time series data to assess changes in efficiency over time. The study analyses the profit efficiency of small scale rice farmers. The study analyses the efficiency of large scale farmers is also recommended. This is important for to compare the efficiency difference between large and small-scale rice farmers. In future studies, variables showing the effects of soil conditions and membership in smallholder farmer’s organization on efficiency could be considered. The study considered only the SFPF model, given the developments in the statistical DEA model, an extension of this work using DEA model can add the profit efficiency literature, and also compare the findings with SFPF.

REFERENCES

Abdulai, A. and Huffman, W., (2000) 'Structural Adjustment and Economic Efficiency of Rice Farmers in Northern Ghana'. Economic Development and Cultural Change, 48(3): 503-520. DOI: 10.1086/452608 [Accessed on 06/06/15]

Abdulai, A. and Huffman, W., (1998) 'An Examination of Profit Inefficiency of Rice Farmers in Northern Ghana. Staff Paper No. 296. Iowa State University, Ames, IA 50011. Available at: http://ageconsearch.umn.edu/bitstream/18271/1/isu296.pdf [Accessed on 06/06/15].

Abu, O. and Asember, D. J. (2011) 'Opportunities for Smallholder Spinach Farmers in Nigeria : A Profit Efficiency Analysis', 2(2), pp. 75–79.

Addison, M., Ohene-yankyera, K. and Fredua-antoh, E. (2016) 'Gender Role , Input Use and Technical Efficiency among Rice Farmers at Ahafo Ano North District in Ashanti Region of Ghana', 4(2), pp. 27–35. doi: 10.12691/jfs-4-2-1.

Adesina, A. A. and Djato, K. K. (2008) 'Relative efficiency of women as farm managers : Profit function analysis in Cote d Ivoire', 16(1997), pp. 47–53.

Ahmed, B., Haji, J. and Geta, E. (2013) 'Analysis of farm households' technical efficiency in production of smallholder farmers: the case of Girawa district, Ethiopia.', American-Eurasian Journal of Agricultural & Environmental Sciences, 13(12), pp. 1615–1621. doi: 10.5829/idosi.aejaes.2013.13.12.12310.

Aigner, D., Lovell, C. A. K. And Schmidt, P. (1977) 'Formulation And Estimation Of Stochastic Frontier Production Function', Journal Of Econometrics, 6, Pp. 21–37.

Akintayo, O. I. and Rahji, M. A. Y. (2017) 'Technical efficiency in rice ecologies of north central Nigeria: Implications for national self-sufficiency', Uganda Journal of Agricultural Sciences, 17(1), p. 99. doi: 10.4314/ujas.v17i1.9.

Alemu, D. (2015) 'Rice in Ethiopia: Progress in Production Increase and Success Factors 6', in *6th CARD General Meeting*.

Alemu, Dawit Assaye, Abebaw Tadesse, Tilahun (2018) A Historical Analysis Of Rice Commercialisation In Ethiopia : The Case Of The Fogera Plain. Publication at https://www.researchgate.net/publication/338394896.

Ali, F., Parikh, A., and Shah, M.K. (1994) Measurement of Profit Efficiency Using Behavioral and Stochastic Frontier Approaches. Applied Economics, 26: 181-188. DOI: 10.1080/00036849400000074 [Accessed on 13/02/16].

Ali, M. and Flinn, J. C. (1989) 'Profit Efficiency among Basmati Rice Producers in Pakistan Punjab. American Journal of Agricultural Economics, 71(2): 303-310. Available at: https://www.jstor.org/stable/1241587 [Accessed on 13/02/16].

Andren (2007) Econometrics Book. 4 Ed. Thomas Andren And Ventus Publishing APS ISBM 978-87-7681-235-5.141 P.

Asghar, N. and Chughtai, M. W. (2012) 'Impact of Agricultural Credit on Production of Wheat Crop : A Case Study of District Faisalabad-Pakistan', 4(2), pp. 43–51.

Asrat Anye Aka (2019) 'Analysis of Profit Efficiency Among Smallholder Maize Producers', Zambrut Journal, 4(1), pp. 60–107, ISSN: 2717-3151.

Assaye, A., Yami, M. and Abera, S. (2020) 'Technical Efficiency of Lowland Rice Production in Northwest of Ethiopia', 30(1), pp. 99–111.

Ayaz, S. and Hussain, Z. (2019) 'Impact Of Institutional Credit On Production Efficiency Of Farming Sector : A Case Study of District Faisalabad', 49(2), pp. 149–162. Available at: https://www.jstor.org/stable/23622108 [Accessed on: 12-11-2019 06:15].

Bamiro, O. M. and Aloro and Janet O (2013) 'Technical Efficiency in Swamp and Upland Rice Production in Osun State', Scholarly Journal of Agricultural Science, 3(1), pp. 31–37.

Battese, G. (2017) 'Prediction of firm-level technical efficiencies with a generalized frontier production function and panel data', 4076(October). doi: 10.1016/0304-4076(88)90053-X.

Battese, G.E., and Coelli, T.J. (1995) A Model for Technical Inefficiency Effects in Stochastic Frontier Production for Panel Data. Empirical Economics, 20: 325- 345. Available at:

http://link.springer.com/article/10.1007/BF01205442 [Accessed on 22/11/15]

Battese, G. E. and Corra, G. S. (1977) 'Estimation of a production frontier model', Australian Journal of Agricultural Economics, pp. 169–179. Available at: http://ageconsearch.umn.edu/handle/22266.

Berger, A.N. And Master, L.J. (1997) In Side The Black Box: What Explains Difference In The Efficencies Of Financial Institutions? Journales Of Banking And Finance, 21(7) , 895-947.

Belayneh, T. And Tekle, J. (2017) "Review on Adoption, Trend, Potential, and Constraints Of Rice Production To Livelihood In Ethiopia." International Journal of Research - Granthaalayah, 5(6), 644-658. Https://Doi.Org/10.5281/Zenodo.824116

Bravo-Ureta, B,E., And Evenson, R.E., (1994) Efficiency in agricultural production: the case of peasent farmers in eastern paaguay. agriccultural economics, 10(1), 27-37.

Bravo-Ureta, B,E., And Pinheiro, A.E., (1993) Efficiency Analeysis Of Developing Country Agriculture: Areview Of The Frontier Function, Agricultur and Resource Economics Review, 22, 88-11.

Chakwera, S. J. (2015) 'Full Length Research Paper A survey on Technical , allocative , and economic efficiency of maize production using the Parametric stochastic frontier production function', 3(6), pp. 237–245.

Chauhan, B. S., Jabran, K. and Mahajan, G. (2017) 'Rice Production Worldwide Citation : International Publishing AG , Switzerland .', (February 2018). doi: 10.1007/978-3-319-47516-5.

Coelli, Tim ; Grifell-Tatje, Emili ; Perelman, Sergio , (2001) Capacity utilisation and profitability: a decomposition of short run profit efficiency. CORE Discussion Papers ; 2001/52http://hdl.handle.net/2078.1/4208

Coelli, Tim, D.S. Prasada Rao Christopher J.O Donnell, George E. Battese (1998) An Introduction To Efficiency. Second Edi. Edited By G. E. B. Timothy J. Coelli, D.S. Prasada Rao Christopher J.O Donnell. New York University.

Cooper, William W. Lawrence M. Seifordkaoru Tone, (2007) Data Envelopment Analysis.

Second Edi, Isbn-13: 978-0387-45283-8 (E-Book).

CSA, (2018) The Federal Democratic Republic Of Ethiopia Report On Area And Production Of Major Cropes, Agricultural Sample Surve. Adiss Abeba Ethiopia.

Dang, N. H. (2017) ‘Profitability and Profit Efficiency of Rice Farming in Tra Vinh Province , Vietnam’, Review of Integrative Business and Economics Research, 6(1), pp. 191–201.

Duraisamy, P. (2020) ‘Technical And Allocative Efficiency Of Education In Agricultural Production : A Profit Function Approach’, Indian Journal Of Agricultural Economics, 25(1), Pp. 17–32.

Duy, V. Q. (2014) ‘The role of access to credit in rice production efficiency of rural households in the Mekong Delta, Vietnam’.

EUCORD, (2012) ‘Rice Sector Development In East Africa’.

Fakkhong, S. (2016) ‘Determinants of Profitability of Rice Farming in Peri-Urban Area, Bangkok, Thailand’, in The Asian Conference on the Social Sciences 2016 Official Conference Proceedings Abstract.

FAO (2004) ‘Rice and Human Situation’, In International Year Of Rice.

Fare. R., Grosskopf, S. and Lovell. C. A. K. (1985) The Measurement of Efficiency of Production. 1 st editi. Edited by A. Dogramaci. Kluwer-Nijhoff, ISBN 978-90-481-5813-3 or ISBN 978-94-015-7721-2 (eBook) DOI 10. 1007/978-94-015-7721-2.

Farrell, M. J. (1957) ‘The Measurement of Productive Efficiency’, Journal of the Royal Statistical Society, 120(3), pp. 253–290. Available at: https://www.jstor.org/stable/2343100.

Fried, Harold O. C.A. Knox Lovell, S. (1993) ‘The Measurement Of Productive Efficiency’. Edited By S. S. S. Harold O. Fried, C.A. Knox Lovell. New York: Oxford University Press.

Gad, A. S, Opoku-Kwanowa Yaa and Jianmin Cao (2019) ‘A Profit Analysis Of Small-Scale Maize Farmers: A Case Study In The Brong Ahafo Region Of Ghana’, 12, Pp. 18–26. Doi: 10.18551/Rjoas.2019-12.03.

Galawat, F. And Yabe, M. (2012) ‘Profit Efficiency In Rice Production In Brunei Darussalam ’, 18(1), Pp. 100–112.

GDANRDO (Guraferda District Agricultural and Natural Resource Development Office) (2018) The Annual Report Bench-Sheko, Ethiopia. Unpublished.

Gershon, I. and Ansah, K. (2015) ‘A Comparative Analysis of Profit Efficiency in Maize and Cowpea Production in the Ejura Sekyedumase District of the Ashanti Region , Ghana’, (December 2014). doi: 10.5296/rae.v6i4.6320.

Greene, W.H. (2003) ‘Econometrics Analysis’. 5th edition. New York University, New York.

Greene, W.H. (2007) ‘Econometric Analysis’. Library of Congress Cataloging-In-Publication Data

Greene, W. H. (1980) ‘Maximum Likelihood Estimation Of Econometric Frontier Function’, Journal Of Econometrics, 13(162), Pp. 27–56.

Haile, B. T. (2015) ‘Determinants of technical , allocative and economic efficiencies among onion producing farmers in irrigated agriculture : Empirical evidence from Kobo district , Amhara region , Ethiopia’, 10(20), pp. 2180–2189. doi: 10.5897/AJAR2015.9564.

Haile, K., Haji, J. and Tegegne, B. (2018) ‘Technical Efficiency of Sorghum Production: The Case of Smallholder Farmers in Konso District, Southern Ethiopia’, Agricultural Development, 3(1), pp. 1–15. doi: 10.20448/journal.523.2018.31.1.15.

Hailemichael Mulie, (2014) ‘The Determinants of Profit Efficiency of Coffee Producing and Marketing Cooperatives (The Case Study of Sidama Coffee Farmers ’ Union)’, Journal of Economics and Sustainable Developmen, 5(7), pp. 125–138.

Hoang and Yabe (2012) ‘Impact of Environmental Factors on Profit Efficiency of Rice Production : A Study in Vietnam ’ s Red River Delta’, 6(6), pp. 330–337.

Idiong, I. C. and Iko, M. A. (2019) ‘Profit Efficiency and Poverty Status of Farmers in Selected Rice Growing Communities in Cross River’, 30(1), pp. 1–12. doi: 10.9734/AJAEES/2019/v30i130098.

Imran, M. A. (2015) ‘Under Creative Common Analysis Of Profit Efficiency In Sugarcane Analysis Of Profit Efficiency In Sugarcane Production In District Sargodha , Punjab , Pakistan’, International Journal Of Economics, Commerce And Management, iii(9).

Kaka (2016) ‘Profit Efficiency Among Paddy Farmers : A Cobb-Douglas Stochastic’, 6(4), pp. 66–75. doi: 10.18488/journal.2/2016.6.4/2.4.66.75.

Kalirajan, K. P. And Shand, R. T. (1999) ‘Frontier Production Functions and Technical Efficiency Measures’, 13(2), Pp. 149–172.

Kitila, G. and Alemu, B. (2014) ‘Analysis of Technical Efficiency of Small Holder Maize Growing Farmers of Horo Guduru Wollega Zone, Ethiopia: A Stochastic Frontier Approach’, Science, Technology and Arts Research Journal, 3(3), p. 204. doi: 10.4314/star.v3i3.33.

Kolawole (2006) ‘Determinants Of Profit Effciency Among Small Scale Rice Farmers In Nigeria: A Profit Function Approach’, In International Association Of Agricultural Economists Conference.

Kothari, C. R. (2004) Research Methodology. Second Edi. Edited By Kothari. New Age International (P) Limited, Publishers 4835/24,. ISBN (13) : 978-81-224-2488-1

Koutsoyiannis, A. (1979) Modern Microeconomics. Second Edi. New York: St. Martin’s Press, Inc. Doi: Dol 10.1007/9781349160778.

Lema, T. Z. and Tessema, S. A. (2017) ‘Analysis of the Technical Efficiency of Rice Production in Fogera District of Ethiopia : A Stochastic Frontier Approach’.

Lovell, C. A. K. (1994) ‘Linear Programming Approaches to the Measurement and Analysis of Productive Efficiency’, 2(2), pp. 175–248.

Mastromarco, C. (2008) ‘Stochastic frontier models’, pp. 1–49.

Mburu, S., Ackello-ogutu, C. and Mulwa, R. (2014) ‘Analysis of Economic Efficiency and Farm Size : A Case Study of Wheat Farmers in Nakuru District , Kenya’, 2014.

Mekonnen, E., Geta, E. And Legesse, B. (2015) ‘Current Research In Agricultural Sciences Production Efficiency Of Sesame In Selamago District Of South Omo Zone , Southern Ethiopia

Contribution / Originality', 2(1), Pp. 8–21. Doi: 10.18488/Journal.68/2015.2.1/68.1.8.21.

Nguyen Huu Dang (2017) 'Determinants of Profit Efficiency among Rice Farmers in Kien Giang', in Proceedings of the 11th Asia-Pacific Conference on Global Business, Economics, Finance and Business Management (AP17Thai Conference), pp. 1–14.

Nwauwa, (2013) 'Determinates of profit efficiency of small-Scale Dray Season Fluted Pumpkin Farmers : A Profit Function Approach', International Journal of Vegetable Science. doi: 10.1080/19315260.2012.662582.

Ogunniyi, L.T. (2011) Profit Efficiency among Maize Producers in Oyo State, Nigeria. Journal of Agricultural and Biological Science, 6(11): 11-17. Available at: http://www.arpnjournals.com/jabs/research_papers/rp_2011/jabs_1111_330.pdf [Accessed on 02/09/2015].

Ogundari, K., (2006) Determinants of Profit Efficiency among Small Scale Rice Farmers in Nigeria. A Profit Function Approach. Research Journal of Applied Sciences, 1(1-4): 116-122. Available at: http://ageconsearch.umn.edu/bitstream/25238/1/pp060688.pdf [Accessed on 13/02/16].

Ouedraogo, S. (2015) 'Asian Journal Of Agriculture and Rural Development Technical And Economic Efficiency Of Rice Production In The Kou Valley (Burkina Faso): Stochastic Frontier Approach', 5(2), Pp. 53–63.

Rahman, S. (2003) Profit Efficiency among Bangladeshi Rice Farmers. Contributed Paper For The 25th Conference Of The International Association Of Agricultural Economists, Durban, South Africa, August, 2003. Available At: Http://Ecsocman.Hse.Ru/Data/072/661/1219/040.Pdf [Accessed On 17/12/2015]

Reny, G. A. J. And P. J. (2011) Advanced Microeconomic Theory. Third Edit.

Sahubar Ali Bin Mohamed Nadhar Khan, Md. Azizul Baten, And R. R. (2016) 'Technical , Allocative , Cost , Profit And Scale Efficiencies In Kedah , Malaysia Rice Production : A Data Envelopment Analysis', Journal Of Agricultural And Biological Science, 11(8), Pp. 322–335. Available At: Issn 1990-6145%0atechnical,.

Saleem, S. T. (1988) ‘Relative Efficiency of Cotton Farms in Sudanese Irrigated Agriculture’, World Development, 16(8), pp. 975–984.

Sanusi, M. (2015) ‘Application of stochastic frontier function in measuring profit efficiency of small-scale maize farmers in Niger State , Nigeria’, 3(1), pp. 229–239.

Sauer, J., Frohberg, K. and Hockmann, H. (2019) ‘Stochastic Efficiency Measurement : The Curse of Theoretical Consistency’, Journal of Applied Economics ISSN:, 326. doi: 10.1080/15140326.2006.12040642.

Saysay, J. L., Gabagambi, D. M. and Mlay, G. I. (2016) ‘Profit loss per hectare according to profit efficiency level among smallholder rice farmers in Central Liberia’, 11(32), pp. 3012–3019. doi: 10.5897/AJAR2016.11366.

Sevilla (1991) ‘The Journal of On the use and misuse of profit functions for measuring the price responsiveness of peasant farmers : A comment’, The Journal of Development Studies, 27(4), pp. 123–136. doi: 10.1080/00220389108422216.

Tsegaye Melese , Mebratu Alemu , Amsalu Mitiku and Nesre Kedirconomics, A. (2019) ‘Economic Efficiency of Smallholder Farmers in Rice Production : The Case of Guraferda Woreda , Southern Nations Nationalities People ’ s Region ’, International Journal of Agriculture Innovations and Research, 8(2), pp. 151–167.

State, T. and Adamu, T. (2015) ‘Profit Efficiency among Rain-Fed Rice Farmers in Northern’, Journal of Biology, Agriculture and Healthcare, 5(8), pp. 113–120.

Sunday, B.A., Inimfon, V.P., and Samuel, J.U. (2012) Stochastic Profit Efficiency of Homestead based Cassava Farmers in Southern Nigeria. Asian Journal of Agriculture and Rural Development, 2(3): 498-505. Available at: http://ageconsearch.umn.edu/bitstream/197995/2/20-127-AJARD-498-505.pdf [Accessed on 02/09/2015]

Timothy, A. T. and Adeoti, A. I. (2006) ‘Gender Inequalities and Economic Efficiency : New Evidence from Cassava-based Farm Holdings in Rural South-western Nigeria’, pp. 428–443.

Vivas Ana Lozano (1997) ‘Profit efficiency for Spanish savings banks’, European Journal of Operational Research, 2217, pp. 381–394.

Wongnaa and Mensah (2018) ‘Profit Efficiency of Ghana Maize Farmers’, Agricultural Economics.

Wooldridge, J. M. (2009) Introductory Econometrics. 4 edition ISBN 10: 0-324-66054-5.

Yotopoulos, P.A., and Lau, L.J. (1973) A Test for Relative Economic Efficiency: Some Further Results. The American Economic Review, 63(1): 214-223. Available at: https://www.jstor.org/stable/1803137 [Accessed on 17/12/2015].

APPENDIX 1: QUESTIONNAIRES

COLLEGE OF BUSINESS AND ECONOMICS

DEPARTMENTS OF ECONOMICS

Household questioner on: Profit efficiency of rain-feed rice producers: In the case of small-scale rice farmers in Guraferda district, Bench Sheko, SNNPR Ethiopia.

General Instruction:

This questioner is mainly focus on obtaining important information only on 2011/2012 production years.

- ✓ Tell the purpose of the study and introduce yourself before starting the interview.
- ✓ For all closed questions encircle the appropriate you are interested in and use the space provided for open ended questions.

Name of Enumerator____________________ date of interview_________________________

Identification Number __________________________ Kebele _________________________

A. General information about the sample household

1. Household Head Age_________
2. Sex of the respondent: 1. Male 2. Female
3. Education level of the head: 1. Illiterate 2. Only read and write 3. If attend school grad____4. Certificate 5. Diploma 6. Degree
4. Farming experience to cultivate rice in year. _________________ Years
5. How many people are living in your household during the last 12 months? Fill the following table accordingly.

No.	Age in year	Sex 1=male 2=female	Relation to household head Head=1,Spouse=2,Son/Daughter=3 Father/Mother=4,Grandson/daughter=5 Other relatives=6, Not related=7	Education level(write the exact education status)
1.				
2.				
3.				
4.				
5.				
6.				
7.				

B. Input-output information of Rice production. Land holding

1. What is the total size of your own land holding _______________Hectares?
2. Total size of land covered by rice in 2011 E.C________________ Hectares
3. Total size of land covered by other crop in 2011 E.C ____________ Hectares
4. Total size of own land left uncultivated in 2011 E.C _____________Hectares
5. Total size of land rented in, in 2011 E.C ______________________Hectares
6. Total size of own land rented out, in 2011 E.C ________________ Hectares
7. Total size of land shared out in 2011 E.C _____________________ Hectares
8. Total size of land shared in, in 2011E.C______________________________Hectares
9. Number of plot you have__________________________
10. .feature of plot

Rol. No	Plot code	Size in hectare	Distance from home in Km	Production in quintals
1				
2				
3				
4				

11. What is your primary source of draft power you use? 1. Oxen 2. Any other-----
12. Do you have oxen? 1. Yes 2. No
13. If yes for Q10, how many oxen do you have? ________________.

14. Did you use fertilizer in rice farm? 1. Yes 2. No

15. If yes Q13, what types of fertilizer? 1. DAP 2. Urea 3. Both 4. Other

16. How many kg of Urea per hectare do you use for rice? ___________________.

17. How many kg of DAP per hectare do you use for rice? ____________________

18. If you do not use fertilizer, why?

1. Too expensive 4. Not available

2. Inconvenient to transport 5. Other_________________

3. Not timely available

19. Do you use improved rice seed varieties in this year? 1. Yes 2. No

20. If no Q18, why?

1. Too expensive 3. It is not easily accessible

2. Not high yielding 4. Other ______________

21. If yes Q18, what are the major varieties of rice seed you are growing?

Name of variety	Area in ha	Yield per ha	Total yield	Unit price of seed	Total price of seed
Local seed					
NERICA- 4					
Suparica-1					

22. Do use hired labor? 1. Yes 2. No

23. If yes Q20, how much hired labor did you used in producing rice? ____men

24. Is weeding rice is a common practice? 1. Yes 2. No

25. What method do you use for weeding?

1. Hand weeding 3. Use chemical

2. Hoeing 4. Other

26. Do you use agro chemical for weeding? 1. Yes 2. No

27. **Price paid for the input used for rice production**

Input types	Unit of measurement	Amount of used	Unit cost	total cost incurred in 2011/12 production year
DAP	Birr/kg			
Urea	Birr/kg			
Pesticide	Birr/lit			
Seed	Birr/kg			
Land rent	Birr/ha			
Labour for Land preparation	Birr/day			
Oxen power Land for preparation	Birr/day			
Labour for Sowing	Birr/ day			
Oxen power for sowing	Birr/day			
Weeding	Birr /day			
Harvesting	Birr/day			
Threshing	Birr/ days			
Labour to Transporting	Birr/km			
Animal to power transporting	Birr/km			

28. Yield

28.1.How much quintal of rice did you get in 2011/2012 E.C per hectare? -----------

28.2.What is the total yield of rice did you get in 2011/2012 E.C in quintal________.

28.3.What is the sailing price of rice per quintal? __________________

28.4.What is the total revenue received from rice output. ______________birr.

28.5.What is the total cost of rice produced in 2011/2012 E.C in birr-------

29. How much fixed capital (like, plough, sickle, oxen, pole and dibber) do you have?

____

30. How much money did you spent to perches this fixed capital? ___________________

31. What is the expected current total price of fixed capital do you have? ______________

C. Factors related to inefficiencies

1. What is the earliest date of land preparation for rice? ______month

2. What is the last date of land preparation for rice? __________month

3. At what time did you start land preparation last year (2011)? ____month.

4. What is the earliest date of sowing rice? ____________ Month.

5. What is the last date of sowing rice? _____________ Month.

6. At what time did you sow rice last year (2011)? ________ Month.

7. Is you adopted row planting practice in your farm activities? 1. Yes 2. No

8. **Extension service:** Do you get agricultural extension service? 1. Yes 2. No

9. How many days did he/ she come to see you per month? --------------day

10. **Credit service:** Have you borrowed the last two years (2010/2011)? 1. Yes 2. No

11. If yes Q10, how much do you borrowed in this years, for

    1. Fertilizer --------Birr
    2. Seed and chemical-----Birr
    3. Any other

12. What source of credit do you have? 1. Formal source 2. Informal source 3. Both

13. What types of credit do you have? 1. in kind 2. In money 3. Any other specify---

14. What are the formal sources of credit institution?

    1. Commercial banks
    2. OMO-micro finance
    3. Others specify

15. What collateral was requested for the credit?

    1. Animal 2. Land 3. Durable goods 4. Friends and relatives 5. Others specify

16. What are the informal sources of credit? 1. Trader 2. Friends 3. Relatives 4. Other –

17. What collateral was requested for this informal credit?

    1. Animal 2. Land 3. Durable goods 4. Friends and relatives 5. Others specify

18. What time frame is foreseen for the credit repayment? _____________ month?

19. How much is the interest rate per month? ____________________ %.

20. Of the total amount you borrowed over the last two years, how much proportion did you repay? _________________

21. In your view, what problems did face in processing credit? _____________________

    ____.

22. **Non-farm activities:** do you spent time in non- farm activity? 1. Yes 2. No

23. Are there any family members who are engaged in non-farm activity? 1. Yes 2. No

24. If yes Q23, how many of your family members are engaged in non-farm activities? ___

25. What are the main sources of non-farm income for you and your family? ____ ____ ___

26. How much money do you received from non- farm activity. ____________Birr/year

27. For what purpose do you use the income you get from non-farm?

1. For primary basic goods   2. For medicine   3. For school   4. For input purchase

28. If you use for input purchase which types of input?

1. Improved seed   2. Fertilizer   3. Hiring labor   4. Rented land

29. **Social Responsibility:** Do you have any responsibility in the community? 1. Yes   2. No

30. If yes Q28, what is your responsibility in the community?

1. Social   2. Religious   3. Other specify-------

31. Do you think this responsibility have negative impact in your farming activities?

1. Yes   2.No

32. **Marketing access:** Do you have access to market and price information   1. Yes   2. No

33. If yes Q35, what types of access do you have? 1. Input market   2. Output market 3.price information

34. What was the average selling price of rice in this year? ___________ Birr per quintal

35. Do you have unsold rice waiting for good market season? 1. Yes   2. No

36. If yes Q38, how many quintal? ______

37. In which month do you expect to sell__________ and at what price _______birr/quintal

38. Is there any market problem   1. Yes   2. no

39. If yes Q41, what marketing problems are you facing? 1. Low price   2. High seasonal price fluctuation   3. Inadequate demand   4. High market cost   5. Lack of market information

40. And what you think will be the solution? _____________________________________

41. How many kilometers you are far from the main market? _______________

42. **Constraints in rice production:** What are the major constraints of rice production?   1. Crop disease   2. Seed shortage   3. Shortage of draft animals   4. Shortage of labors   5. Any other

43. What were some of the constraints you faced in rice farming?

i. during sowing ____

ii. during harvesting ____

iii. during marketing and selling ____

44. How much is the distance from your home to main road in kilometers ____________km

45. How many livestock do you have? ________________________________

46. What is the total income received from livestock sale? ________________Birr

THANK YOU IN ADVANCE!

APPENDIX 2

Table 1: Regression result of profit efficiency by OLS

Lnnp	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]
lnnormalps	.4351479	.0633606	6.87	0.000	.3105818 .5597141
lnnormalferti	.3212445	.0571615	5.62	0.000	.2088657 .4336233
Lnnormw	.0692333	.0472057	1.47	0.143	-.0235726 .1620392
lnnormch	-.0849302	.0771492	-1.10	0.272	-.2366045 .0667441
Lnland	.2381747	.0853986	2.79	0.006	.0702822 .4060673
Lncapital	.2525013	.0483046	5.23	0.000	.1575351 .3474676
_cons	-.2821847	.477937	-0.59	0.555	-1.221803 .6574336

Table 2. Variance Inflation Factor for input variables used in the model

Variable	VIF	1/VIF
Lnnormalps	1.51	0.662554
Lnnormch	1.50	0.667293
Lnland	1.23	0.810652
Lncapital	1.22	0.818843
Lnnormalferti	1.11	0.904442
Lnnormw	1.05	0.955187
Mean VIF	1.27	

Heteroscedasticity test for profit efficiencies (estat hettest)

Breusch-Pagan / Cook-Weisberg test for Heteroskedasticity

Ho: Constant variance

Variables: fitted values of lnnp

chi2 (1) = 0.64

Prob > chi 2 = 0.4250

Test for multivariate normality

Mvtest normality e, stats (kurtosis)

Mardia kurtosis = 3.252331 chi2 (1) = 1.066 Prob>chi2 = 0.3017

Table 31: Variance Inflation Factor for explanatory variables used in the model

Variable	VIF	1/VIF
Time of sowing	5.17	0.193308
Land pre	4.94	0.202317
Responsible	2.19	0.456991
Mkt access	2.10	0.476363
D to road	1.89	0.529398
Row planting	1.82	0.549317
Educ	1.79	0.560059
No livestock	1.68	0.594986
Ricefarmexp	1.62	0.617349
Extension	1.35	0.742435
Familyno	1.21	0.827944
Age	1.15	0.867288
Credit	1.12	0.892224
No of plot	1.11	0.900460
Nonfarm	1.07	0.933603
Sex	1.02	0.979024
Mean VIF	1.95	

Ramsey RESET test using powers of the fitted values of u

Ho: model has no omitted variables

F (3, 382) = 0.66

Prob > F = 0.5802

Test for multivariate normality

Mvtest normality e, stats (hzirkler)

Henze-Zirkler = .7435755 chi2 (1) = 1.147 Prob>chi2 = 0.2841

Table 2: Efficiency scores of the sample farmers

No	Effic	No	Effic	No	Effic	No	Effic	No	Effic	No	Effic	No	Effic	No	Effic
1	0.2507	51	0.54433	101	0.2327	151	0.2629	201	0.423	251	0.625	301	0.481	352	0.5057
2	00.6703	52	0.70106	102	0.8147	152	0.8785	202	0.542	252	0.404	302	0.793	353	0.7481
3	0.3117	53	0.50645	103	0.8722	153	0.4411	203	0.852	253	0.114	303	0.588	354	0.4546
4	0.8232	54	0.40679	104	0.4385	154	0.515	204	0.53	254	0.466	304	0.83	355	0.723
5	0.5163	55	0.30352	105	0.4603	155	0.3048	205	0.801	255	0.5	305	0.801	356	0.5664
6	0.7091	56	0.81468	106	0.3359	156	0.8575	206	0.472	256	0.813	306	0.523	357	0.612
7	0.7581	57	0.85809	107	0.5414	157	0.6633	207	0.774	257	0.406	307	0.81	358	0.4763
8	0.6051	58	0.41336	108	0.3043	158	0.7433	208	0.83	258	0.447	308	0.744	359	0.7912
9	0.7273	59	0.41357	109	0.6741	159	0.3926	209	0.861	259	0.876	309	0.572	360	0.5832
10	0.7955	60	0.30376	110	0.5469	160	0.2925	210	0.722	260	0.528	310	0.708	361	0.8286
11	0.4633	61	0.50933	111	0.7401	161	0.3803	211	0.863	261	0.856	311	0.861	362	0.6751
12	0.8429	62	0.28284	112	0.5484	162	0.4192	212	0.764	262	0.448	312	0.836	363	0.7834
13	0.5	63	0.27909	113	0.621	163	0.8018	213	0.783	263	0.762	313	0.864	364	0.904
14	0.8216	64	0.1612	114	0.5409	164	0.2662	214	0.702	264	0.824	314	0.741	365	0.8841
15	0.8242	65	0.34693	115	0.751	165	0.2882	215	0.57	265	0.85	315	0.578	366	0.8387
16	0.6888	66	0.31741	116	0.3895	166	0.6681	216	0.401	266	0.722	316	0.756	367	0.8113
17	0.6568	67	0.61989	117	0.8456	167	0.802	217	0.873	267	0.864	317	0.725	368	0.8816
18	0.6914	68	0.89567	118	0.4161	168	0.8201	218	0.789	268	0.751	318	0.541	369	0.8312
19	0.6546	69	0.59881	119	0.8223	169	0.77	219	0.491	269	0.869	319	0.507	370	0.8398
20	0.5181	70	0.71164	120	0.7431	170	0.6041	220	0.797	270	0.74	320	0.555	371	0.8165
21	0.1953	71	0.78587	121	0.5241	171	0.5073	221	0.793	271	0.583	321	0.723	372	0.7615
22	0.488	72	0.78402	122	0.1884	172	0.342	222	0.77	272	0.619	322	0.516	373	0.8172
23	0.4776	73	0.78355	123	0.6209	173	0.3224	223	0.688	273	0.551	323	0.579	374	0.665
24	0.455	74	0.61017	124	0.2546	174	0.3137	224	0.638	274	0.696	324	0.626	375	0.7873
25	0.5515	75	0.63796	125	0.3578	175	0.2458	225	0.65	275	0.546	325	0.8	376	0.8702
26	0.4583	76	0.85891	126	0.7724	176	0.6635	226	0.609	276	0.558	326	0.779	377	0.8841
27	0.5159	77	0.50084	127	0.3362	177	0.6425	227	0.599	277	0.866	327	0.77	378	0.8387
28	0.4761	78	0.75068	128	0.7287	178	0.483	228	0.551	278	0.596	328	0.738	379	0.8461
29	0.6215	79	0.37229	129	0.716	179	0.5097	229	0.71	279	0.599	329	0.691	380	0.8816
30	0.6225	80	0.75336	130	0.2018	180	0.5224	230	0.587	280	0.52	330	0.701	381	0.8312
31	0.7543	81	0.70547	131	0.7996	181	0.5174	231	0.571	281	0.365	331	0.665	382	0.8398
32	0.5434	82	0.57498	132	0.3439	182	0.4928	232	0.867	282	0.776	332	0.599	383	0.8165
33	0.2712	83	0.67495	133	0.3679	183	0.5552	233	0.609	283	0.688	333	0.551	384	0.8037

34	0.4603	84	0.61017	134	0.8164	184	0.4759	234	0.632	284	0.294	334	0.715	385	0.792
35	0.5828	85	0.63796	135	0.3723	185	0.7161	235	0.572	285	0.671	335	0.591	386	0.5074
36	0.3006	86	0.79041	136	0.7379	186	0.5434	236	0.332	286	0.373	336	0.568	387	0.7323
37	0.1726	87	0.48603	137	0.5834	187	0.3438	237	0.742	287	0.751	337	0.868	388	0.7389
38	0.6217	88	0.63166	138	0.3423	188	0.3831	238	0.583	288	0.576	338	0.624	389	0.5671
39	0.6012	89	0.3492	139	0.3	189	0.4642	239	0.327	289	0.618	339	0.636	390	0.7028
40	0.668	90	0.72114	140	0.3233	190	0.2106	240	0.283	290	0.648	340	0.594	391	0.8588
41	0.8763	91	0.52397	141	0.3191	191	0.1154	241	0.347	291	0.818	341	0.416	392	0.8935
42	0.4163	92	0.35718	142	0.6627	192	0.6456	242	0.74	292	0.676	342	0.83	393	0.9074
43	0.3322	93	0.60719	143	0.6489	193	0.6595	243	0.526	293	0.76	343	0.731	394	0.8419
44	0.3918	94	0.41758	144	0.7007	194	0.8127	244	0.605	294	0.808	344	0.428	395	0.749
45	0.2217	95	0.25706	145	0.6038	195	0.8763	245	0.541	295	0.51	345	0.342	396	0.8506
46	0.4231	96	0.27746	146	0.4129	196	0.4865	246	0.628	296	0.751	346	0.601	397	0.8327
47	0.3778	97	0.54433	147	0.7275	197	0.7887	247	0.27	297	0.459	347	0.632	398	0.7506
48	0.4176	98	0.56009	148	0.543	198	0.7659	248	0.785	298	0.602	348	0.81	399	0.7203
49	0.335	99	0.50645	149	0.3765	199	0.3272	249	0.332	299	0.571	349	0.659	400	0.8361
50	0.2775	100	0.31565	150	0.275	200	0.3884	250	0.705	300	0.616	350	0.747	401	0.6466
												351	0.805	402	0.5753

Table 5: Summary of profit efficiency score

Variable	Obs	Mean	Std. Dev.	Min	Max
efficiency	402	.6034957	.1884936	.1138595	.9074258

Table 6: Inefficiency scores (u) of the sample farmers

No	Ineffic	No	Ineffic	No	Ineffic	No	Ineffic	No	Ineffic	No	Ineffic	No	Ineffic	No	Ineffic
1	0.7493	51	0.4557	101	0.76727	151	0.7371	201	0.5765	251	0.3753	301	0.5194	351	0.1946
2	0.3297	52	0.2989	102	0.18532	152	0.1215	202	0.4584	252	0.5964	302	0.2066	352	0.4943
3	0.6883	53	0.4936	103	0.12785	153	0.5589	203	0.1481	253	0.8861	303	0.4123	353	0.2519
4	0.1768	54	0.5932	104	0.56148	154	0.485	204	0.47	254	0.5345	304	0.1696	354	0.5454
5	0.4837	55	0.6965	105	0.53966	155	0.6952	205	0.1986	255	0.5001	305	0.1985	355	0.277
6	0.2909	56	0.1853	106	0.66407	156	0.1425	206	0.5276	256	0.1868	306	0.4773	356	0.4336
7	0.2419	57	0.1419	107	0.45858	157	0.3367	207	0.2264	257	0.5945	307	0.1904	357	0.388
8	0.3949	58	0.5866	108	0.69575	158	0.2567	208	0.1704	258	0.5532	308	0.2565	358	0.5237
9	0.2727	59	0.5864	109	0.32593	159	0.6074	209	0.1387	259	0.1236	309	0.4277	359	0.2088
10	0.2045	60	0.6962	110	0.45315	160	0.7075	210	0.2784	260	0.4721	310	0.2921	360	0.4168
11	0.5367	61	0.4907	111	0.25987	161	0.6197	211	0.1369	261	0.1445	311	0.1388	361	0.1714
12	0.1571	62	0.7172	112	0.45164	162	0.5808	212	0.2356	262	0.5516	312	0.1635	362	0.3249
13	0.5	63	0.7209	113	0.37901	163	0.1982	213	0.2168	263	0.238	313	0.1359	363	0.2166

14	0.1784	64	0.8388	114	0.45905	164	0.7338	214	0.2975	264	0.1756	314	0.2593	364	0.096
15	0.1758	65	0.6531	115	0.24896	165	0.7118	215	0.4305	265	0.1502	315	0.4224	365	0.1159
16	0.3112	66	0.6826	116	0.61052	166	0.3319	216	0.5993	266	0.2784	316	0.2437	366	0.1613
17	0.3432	67	0.3801	117	0.15443	167	0.198	217	0.1271	267	0.1364	317	0.275	367	0.1887
18	0.3086	68	0.1043	118	0.58388	168	0.1799	218	0.2109	268	0.2489	318	0.4592	368	0.1184
19	0.3454	69	0.4012	119	0.17772	169	0.23	219	0.5089	269	0.1312	319	0.4932	369	0.1688
20	0.4819	70	0.2884	120	0.25693	170	0.3959	220	0.203	270	0.2605	320	0.4449	370	0.1602
21	0.8047	71	0.2141	121	0.47591	171	0.4927	221	0.2073	271	0.4172	321	0.2774	371	0.1835
22	0.512	72	0.216	122	0.81163	172	0.658	222	0.2302	272	0.381	322	0.4842	372	0.2385
23	0.5224	73	0.2165	123	0.37906	173	0.6776	223	0.3118	273	0.4492	323	0.4215	373	0.1828
24	0.545	74	0.3898	124	0.74542	174	0.6863	224	0.3621	274	0.3036	324	0.3744	374	0.335
25	0.4485	75	0.362	125	0.64215	175	0.7542	225	0.3505	275	0.4541	325	0.1997	375	0.2127
26	0.5417	76	0.1411	126	0.22756	176	0.3365	226	0.3914	276	0.442	326	0.2205	376	0.1298
27	0.4841	77	0.4992	127	0.66382	177	0.3575	227	0.4012	277	0.134	327	0.2302	377	0.1159
28	0.5239	78	0.2493	128	0.27126	178	0.517	228	0.4492	278	0.4042	328	0.2621	378	0.1613
29	0.3785	79	0.6277	129	0.28395	179	0.4903	229	0.2904	279	0.4011	329	0.3086	379	0.1539
30	0.3775	80	0.2466	130	0.79819	180	0.4776	230	0.4134	280	0.4799	330	0.2993	380	0.1184
31	0.2457	81	0.2945	131	0.20038	181	0.4826	231	0.4295	281	0.6346	331	0.3354	381	0.1688
32	0.4566	82	0.425	132	0.65614	182	0.5072	232	0.1335	282	0.224	332	0.4012	382	0.1602
33	0.7288	83	0.325	133	0.63207	183	0.4448	233	0.3914	283	0.3118	333	0.4492	383	0.1835
34	0.5397	84	0.3898	134	0.18359	184	0.5241	234	0.368	284	0.7062	334	0.2847	384	0.1963
35	0.4172	85	0.362	135	0.62767	185	0.2839	235	0.4281	285	0.329	335	0.4092	385	0.208
36	0.6994	86	0.2096	136	0.26211	186	0.4566	236	0.6675	286	0.6267	336	0.4323	386	0.4926
37	0.8274	87	0.514	137	0.4166	187	0.6562	237	0.2584	287	0.249	337	0.1322	387	0.2677
38	0.3783	88	0.3683	138	0.65769	188	0.6169	238	0.4166	288	0.4238	338	0.3761	388	0.2611
39	0.3988	89	0.6508	139	0.7	189	0.5358	239	0.6728	289	0.3815	339	0.3639	389	0.4329
40	0.332	90	0.2789	140	0.67672	190	0.7894	240	0.7166	290	0.3516	340	0.4061	390	0.2972
41	0.1237	91	0.476	141	0.6809	191	0.8846	241	0.6529	291	0.1818	341	0.5841	391	0.1412
42	0.5837	92	0.6428	142	0.33725	192	0.3544	242	0.2599	292	0.3237	342	0.17	392	0.1065
43	0.6678	93	0.3928	143	0.35106	193	0.3405	243	0.4741	293	0.2399	343	0.2687	393	0.0926
44	0.6082	94	0.5824	144	0.2993	194	0.1873	244	0.3949	294	0.1922	344	0.5722	394	0.1581
45	0.7783	95	0.7429	145	0.39623	195	0.1237	245	0.4591	295	0.4899	345	0.6582	395	0.251
46	0.5769	96	0.7225	146	0.58714	196	0.5135	246	0.3718	296	0.2491	346	0.3992	396	0.1494
47	0.6222	97	0.4557	147	0.27254	197	0.2113	247	0.7304	297	0.5413	347	0.368	397	0.1673
48	0.5824	98	0.4399	148	0.45695	198	0.2341	248	0.2149	298	0.3984	348	0.1901	398	0.2494
49	0.665	99	0.4936	149	0.62346	199	0.6728	249	0.668	299	0.4291	349	0.3406	399	0.2797
50	0.7225	100	0.6843	150	0.72504	200	0.6116	250	0.2951	300	0.3838	350	0.2533	400	0.1639
														401	0.3534
														402	0.4247