2024-03

Economic Efficiency of Onion Production in Mecha and Fogera Districts of Amhara Region, North West Ethiopia

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By

Amarech Yitayih Wassie

A thesis is submitted in Partial Fulfillment of the Requirements for the Masters of Science in In Agriculture (Agricultural Economics)

Principal Advisor's Name: Solomon Bizuayehu (PHD)

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March, 2024

Bahir Dar

DECLARATION

This is to certify that the thesis entitled “Economic Efficiency of Onion Production in Mecha and Fogera Districts of Amhara Region, North West Ethiopia”, submitted in partial fulfillment of the requirements for the Master of science in Agriculture of Department of Agricultural Economics, Bahir Dar University, is a record of original work carried out by me and has never been submitted to this or any other institution to get any other degree or certificates. The assistance and help I received during the course of this investigation have been duly acknowledged.

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Approval of Thesis for Defense

As members of the board of examiners, we examined this thesis entitled "Economic Efficiency of Onion Production in Mecha and Fogera Districts of Amhara Region, Ethiopia" by Amarech Yitayih. We hereby certify that the thesis is accepted for fulfilling the requirements for the award of the degree of "Master of Science in Agricultural Economics"Board of Examiners

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DEDICATION

I dedicate this piece of work for my aunt WORKAYEHU BIRRU whom I know what real love is while living in this world and the memories of my father YITAYIH WASSIE whom I lost in January 11, 2011.

BIOGRAPHIES OF THE AUTHOR

The author, Amarech Yitayih, was born in Finot Selam on September 11/ 1997. She attended her elementary and junior school education at Finot Selam Elementary school, and Damot Junior Secondary School, Finot Selam, respectively. She has completed her high school education at Damot Secondary School, Finot Selam. After completion of his high school education, she joined Bahir Dar University in November 2017 and graduated with Bachelor of Science Degree in Agricultural Economics in February 2021.

Soon after graduation, she joined Bahir Dar University as graduate I assistance in April 2021.After that she joined the School of Graduate Studies of Bahir Dar University, Department of Agricultural Economics gave a chance for her MSc degree in agricultural economics

ACKNOWLEDGEMENTS

First and for most, I would like to be grateful for the loving, kindness, and faithfulness of the Almighty God and His Mother St. Merry in bestowing health, strength, patience and protection throughout the study period.

I express my sincere gratitude and heartfelt appreciation to my advisor Dr. Solomon Bizuayehu as without his consistent advice, understanding, guidance and supervision the completion of this work would not have been possible. He was so helpful and I had full freedom to communicate him any time and in any place, which was so nice of him. He deserves big respect and thanks. I must thank and heartfelt appreciation to my co-advisor Dr. Ermias Tesfaye for his advice and supervision.

I am greatly indebted to my mom Ms. Yengusie Birru (Tata) for her special love and prayer throughout my life. My gratitude also goes for all my sisters and my brothers for their moral and support during my study time. My sincere appreciation and thanks also go to my colleagues, Tigist, for the remarkable memories and constant moral support during the study period. I must thank my husband Robel Dagnaw, for supporting me by everything, for his critical comments in improving this work. I also thank Birara Endalew for their valuable comments.

I am very grateful to TOMATO project of Bahir Dar University for recognizing the importance of this study and providing financial assistance, which led to the implementation and finalization of this study.

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ABSTRACT

This research aimed to assess the economic, allocative, and technical efficiency levels and their determinants among small-scale onion farmers in the Mecha and Fogra districts of Amhara region, Ethiopia. The data was collected from a total of 374 onion farmers. The study employed a stochastic frontier model to estimate the technical, allocative, and economic efficiency of smallholder onion producers and a Two-Limit Tobit model to identify the causes of inefficiencies. The specification test result shows that the Cobb-Douglas (CD) production function best fits the data. The study revealed that land, labor, urea, NPS, and insecticide and herbicide significantly and positively influenced onion production, as expected. The technical, allocative, and economic efficiencies of the sampled onion farmers were estimated to be 69.2%, 75.6%, and 52.6%, respectively. The results further show that the age, livestock ownership, family size, technology (pump) adoption, improved seed, extension services on seed, extension service on harvest, and total income of the household were associated with higher levels of onion production efficiency in the study area. With the current inputs and technology, onion producers in the study area can potentially increase their output by 30.8% and/or lower their average cost of production by 24.4%, given the current level of production. Therefore, government policies and initiatives should support onion growers by improving access to agricultural inputs (seed and fertilizer) and quality of extension services.

Keywords/phrases: Efficiency, Stochastic Frontier Model, Ethiopia

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ACRONYMS

AE	Allocative Efficiency
COLS	Corrected Ordinary Least Squares
DEA	Data Envelopment Analysis
EE	Economic Efficiency
FAO	Food and Agriculture Organization
ML	Maximum Likelihood
OLS	Ordinary Least Squares
SFA	Stochastic Frontier Analysis
SPF	Stochastic Production Frontier
TE	Technical Efficiency
TLU	Tropical Livestock Unit

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1. INTRODUCTION

1.1 Background of the study

Ethiopia has a comparative advantage in producing different types of horticultural crops due to its favorable climate, proximity to European and Middle East markets, and relatively cheap labor force. It produces different types of vegetable crops under rain-fed and irrigation systems. Onion is one of the horticultural crop produced in Ethiopia, which has become increasingly popular in Ethiopia, contributing significantly to the overall vegetable production (Tafesse *et al*., 2023). Onion dominantly used for enhancing the flavor of Ethiopian cuisine (CSA, 2021; Alemu *et al*., 2022; Shura *et al*., 2022).

Small-holder farmers and commercial producers currently cultivate it year-round for both local consumption and export (Esmael & Negesse, 2023). Specifically, 3,460,480.88 tons was harvested from the total area allocated for onion production (38,952.58 ha) in 2020/21 in Ethiopia (CSA, 2021). Amhara region is one of the major onions producing areas in Ethiopia, and has seen an increase in onion production in recent years. The region contributed 54% of the annual production about 143,195.6 tons in the 2015-16 main seasons. In Mecha district the total area covered by onions increased from 70 ha in 2011/12 to 943.75 ha in 2017/18. In Fogera woreda, the land used for onion production has increased from 6,133 hectare in 2011/12 to 11,880.5 ha in 2017/18 (Getu & Ibrahim, 2018).

In Ethiopia, between 2019/20 to 2020/21 production period the area coverage and production of onion increased by 7.4% and 34% respectively (CSA, 2022). However, its productivity in Ethiopia (122.8 qt ha-1) is far below the world average productivity of 211.2 qt ha-1 (FAOSTAT, 2022).

Various factors contribute to this lagging productivity, including suboptimal farming practices, lack of improved seed varieties, the prevalence of insect pests and diseases, inadequate extension services, and high costs of agricultural chemicals (Shura *et al*., 2022).

The majority of farmers possessing identical resources are yielding disparate yields per hectare due to ineffective management practices, restricted utilization of contemporary agricultural technologies, conventional farming methods, inadequate provision of supportive and infrastructural services like marketing, credit, extension, and roads, and inadequate agricultural policies (Abate *et al*., 2019). Productivity can be raised by implementing new technologies or by making current technologies work better by optimizing inputs like labor and management (Restuccia, 2016).

1.2 Statement of the problem

In the context of developing countries where resources are scanty, improving efficiency using the existing technologies is more important (Tadesse & Krishnamoorthy, 1997).Therefore, the measurement of efficiency has remained an important area of research, especially in developing countries like Ethiopia.

Efficiency in agricultural production is a critical factor that can influence the productivity and profitability of farmers. It refers to how effectively farmers use their resources—such as land, labor, and capital—to produce outputs. Evidence shows that even farmers with similar resources end up getting different amounts of production per hectare (Abate *et al*., 2019).

While there is a substantial body of research on the efficiency of agricultural production in Ethiopia, most previous studies are limited to estimation of technical efficiency (e.g. Koye *et al*., 2022; Makombe *et al*., 2017; Tafesse *et al*., 2023). While there are few studies (Esmael & Negesse, 2023; Tafesse *et al.*, 2023) on Economic efficiency of onion production in Ethiopia, their findings might not be applicable to the case of Mecha and Fogera districts due to differences in the know-how and experience of the farmers, and differences in technology and means of production. Therefore, building on previous studies, the current research aims to estimate the level and determinants of technical, allocative, and economic efficiency of onion producers in Fogera and Mecha districts of Amhara region.

1.3 Objectives of the study

1.3.1 General objective

The main objective of this study was to examine the production of onion determinants of technical, allocative and economic efficiency of onion in Mecha and Fogera districts.

1.3.2 Specific objectives

Specifically these studies had two objectives

- To estimate the level of technical, allocative and economic efficiency of onion producers in the study area.
- To examine the determinants of technical, allocative and economic efficiencies in onion production study area.

1.4 Research questions

1 What were the levels of technical, allocative and economic efficiencies of onion producers in the study area?

2 What were the determinants of technical, allocative and economic inefficiencies in onion production study area?

1.5 Significances of the study

Analysis of efficiency status and related factors was a beneficial study because it yielded information that would allow for the successful implementation of efficient methods to raise productivity status and ensure the success of onion efficiency improvement projects in the study area. Additionally, it would have made it possible for policymakers and development professionals to assist more effectively in rural regions by knowing where and how to reduce inefficiencies or increase efficiency. Further the effective performance of this study would essential to provide secondary data to other researchers to conduct further research on issue of efficiency of onion in the Woreda and elsewhere in similar scenario.

1.6 Scope and Limitations of the Study

Research work requires a lot of resources. The necessary geographic, financial and technical requirements must be met. There were only two woredas where the study was done. It concentrated especially on the Sociodemographic and economic factors of household efficiency. It was unable to explore the onion efficiency's broader environmental implications. The study was also cross-sectional in nature because the time span of the investigation is too short to detect any trends that could influence a household's efficiency at different times of the year.

1.7 Organization of the Thesis

The subsequent chapters are structured so that, in chapter two, numerous methodological aspects pertaining to efficiency measurements are briefly examined, and concepts of efficiency in general are covered. The study's approach is the focus of Chapter 3. It comprises the research area, data sources, and sampling strategy. Additionally, a quick illustration of the variable definition and the econometric model is provided. The results and discussion of this study are presented at the beginning of Chapter 4. The conclusion and policy implications of this result are continued in Chapter 5. Chapter 6 is the reference part. Chapter 7 is the appendix part of this study, which includes the model result that is not part of main body and the questioners.

2. LITERATURE REVIEW

In this chapter, a review of performance of the Ethiopian agriculture, concepts of efficiency and efficiency measurements and empirical studies on efficiency are discussed.

2.1 Theoretical literature review

2.1.1 Definition and Concepts of Efficiency

The concept of productive efficiency was first introduced by Farrell in 1957 in his seminal publication (Farrell, 1957), wherein he claimed that efficiency had two parts: technical efficiency (TE) and allocative efficiency (AE). Economic efficiency (EE) is defined by Farrell's technique as the product of two variables, TE and AE, where TE is the capacity to create on the frontier isoquant and AE is the capacity to produce at a specific output level using the cost-minimizing input ratios. In other words, allocative inefficiency is associated with deviations from the minimum cost input ratios, whereas technical inefficiency reflects departures from the frontier isoquant. Thus, EE is defined as the capacity of a firm to produce a predetermined quantity of output at the minimum cost for the given level of technology ((Farrell, 1957); (Diewert, 1982)). An economically efficient firm is the one which is technically as well as allocatively efficient.

According to (Coelli, 1995) Empirical work in all fields of economics, including agricultural economics, has been dominated by ordinary least squares (OLS) regression and its variants, which fit a line of best fit through the sample data rather than over the data, as would be appropriate for a production or profit function, or under the data, as would be appropriate for a cost function. The two main benefits of estimating frontier functions, rather than average (e.g., OLS) functions, are that: Estimation of an average function will provide a picture of the shape of technology of an average firm. While the estimation of a frontier function will be most heavily influenced by the best performing firms and hence reflect the technology they are using, and the frontier function represents a best-practice technology against which the efficiency of firms within the industry can be measured. It is this second use of frontiers which has provided the greatest impetus for the estimation of frontier functions in recent years.

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

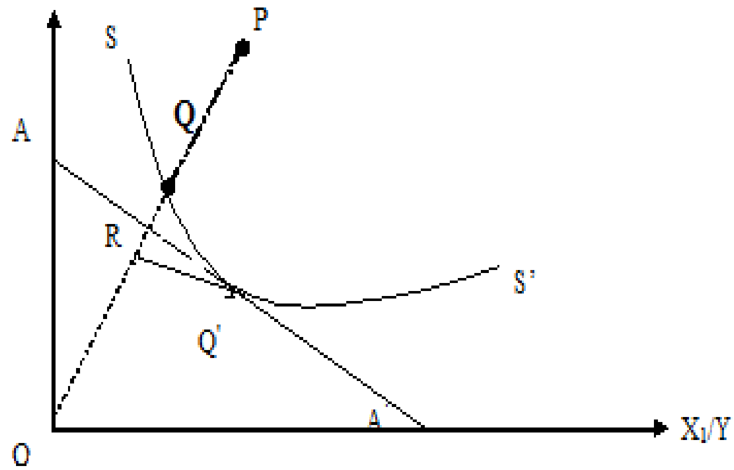
According to TJ Coelli (2005),Efficiency can be measured using either the input- or output-oriented method (often referred to as the primal approach) (referred as dual approach). In the primal method, the output shortfall—or potential expansion of output from a given amount of inputs is what is of interest. The difficulty with the input-oriented strategy, known as input over use, is how much all inputs may be proportionately lowered to attain an efficient level of production. When the technology displays constant returns to scale, both measures will be equal, but they are likely to differ in other situations.

2.1.2 Input oriented measures

(Farrell, 1957)), illustrated his idea about measuring efficiency using a simple example involving firms, which use two inputs (X_1 and X_2) to produce a single output (Y). In figure 1 bellow SS" is an isoquant, representing technically efficient combinations of inputs, X_1 and $X_{2,}$ used in producing output Q. SS" is also known as the best practice production frontier. AA' is an isocost line, which shows all combinations of inputs X_1 and X_2 to be used in such a way that the total cost of inputs is equal at all points. However, any firm intending to maximize profits has to produce at Q', which is a point of tangency and representing the least cost combination of X_1 and X_2 in production of Q. At point Q' the producer is economically efficient. The same figure (Figure 1) is employed to measure the technical, allocative and economic efficiency. Suppose a farmer is producing his output depicted by isoquant SS" with input combination level of (X_1 and X_2).

Figure1 Input-oriented measure of technical and allocative efficiency

Suppose a farmer is producing his output depicted by isoquant SS" with input combination



level of (X_1 and X_2). Production at input combination of point (P) is not technically efficient because the level of inputs needed to produce the same quantity is Q on isoquant SS". In other words, the farmer can produce at any point on SS" with fewer inputs (X_1 and X_2), in this case at Q in an input-input space. The degree of TE of such a farm is measured as *OQ OP*, which is proportional in all inputs that could theoretically be achieved without reducing the output.

In Figure 1, AA' represents input price ratio or isocost line which gives the minimum expenditure for which a firm intending to maximize profit should adopt. The same firm using (X_1 and X_2) to produce output with input combination at point P would be allocative inefficient in relation to R. Its level of AE is represented by *OR OQ* , since the distance RQ represents the reduction in production costs if the farmer using the combination of input (X_1 and X_2) was to produce at any point on AA', particularly at point R instead of P.

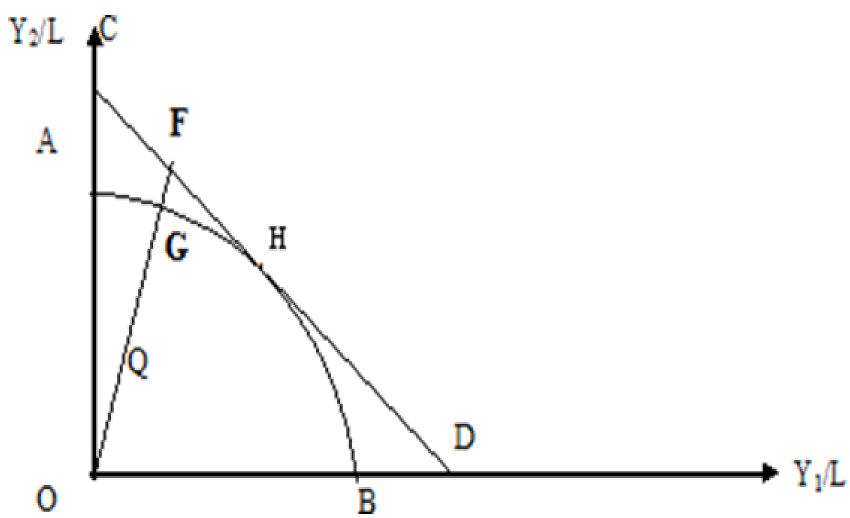
The overall (economic) efficiency is measured as the product of *OQ OP* and *OR OQ*, which is *OROP*. All three measures of efficiency are bounded between zero and one. This follow from interpretation of distance RP as the reduction in costs if a technically and allocative inefficient producer at P were to become efficient (both technically and allocative) at Q' (Coelli, 1995).

2.1.3 Output oriented measure

In the output oriented perspective, efficiency is evaluated keeping inputs constant. Knowledge of the fully efficient production possibility curve as well as the isorevenue line makes it possible to measure and interpret the level of EE.

Output oriented measures can be illustrated by considering the case where production involves two outputs (Y_1 and Y_2) and a single input (L). If the input quantity is held fixed at a particular level, the technology can be represented by a production possibility curve in two dimensions as follows.

Figure2.Output oriented measures for technical and allocative



Source:(T. Coelli, 1998).

The production possibility curve is represented by the curve AB in Figure 2, which represents technically efficient combinations of production of outputs Y_1/L and Y_2/L. The economically efficient point is H where the marginal rate of product transformation equals the slope of the isorevenue line CD. Consider a firm situated at point Q. Its economic output efficiency is OQ/OF. TE is represented by OQ/OG and the AE is OG/OF.

The point of tangency between the isorevenue line CD and the production possibility curve AB (at point H) represents the economically efficient method of production, which is 100% technically and allocatively efficient. Again, all these three measures are between by zero and one.

2.2 Models of Efficiency Measurement

Farrell (1957) suggested the use of either (a) a non-parametric (data envelopment analysis (DEA)) piecewise linear convex isoquant, constructed such that no observed point lies to the left or below it; or (b) a parametric function into (deterministic and stochastic frontier methods), such as the Cobb-Douglas form, fitted to the data, again such that no observed point lies to the left or below it.

The two principal methods that have been used are data envelopment analysis (DEA) and stochastic frontiers, which involve mathematical programming and econometric methods, respectively(T. Coelli, 2005).

2.2.1 Data Envelope Approach (DEA)

According to (TJ Coelli, 2005), DEA is a non-parametric envelopment frontier over the data points such that all observed points lie on or below the production frontier. It has a purpose for the simple example of an industry where one output is produced using two inputs; it can be visualized as a number of intersecting planes forming a tight fitting cover over a scatter of points in three-dimensional space. Only a small percentage of agricultural frontier applications have used the DEA approach to frontier estimation. This is, in one sense, surprising, given the popularity of mathematical programming methods in other areas of agricultural economics research during the 1960s and 1970s. However, DEA has a very large following in other professions, especially in the management science literature, and in applications to service industries where there are multiple outputs, such as banking, health, telecommunications and electricity distribution.

Before finishing with DEA it is important to quickly point out a few of the limitations and possible problems that one may encounter in conducting a DEA. These include: Measurement error and other noise may influence the shape and position of the frontier, Outliers may influence the results, the exclusion of an important input or output can result in biased results, the efficiency scores obtained are only relative to the best firms in the sample. The inclusion of extra firms (e.g., from overseas) may reduce efficiency scores. Be careful when comparing the mean efficiency scores from two studies. They only reflect the dispersion of efficiencies within each sample - they say nothing about the efficiency of one sample relative to the other. In addition of an extra firm in a DEA analysis cannot result in an increase in the TE scores of the existing firms. The addition of an extra input or output in a DEA model cannot result in a reduction in the TE scores. When one has few observations and many inputs and/or outputs many of the firms will appear on the DEA frontier, Treating inputs and/or outputs as homogenous commodities when they are heterogeneous may bias results, it is not accounting for environmental differences may give misleading indications of relative managerial competence. Standard DEA does not account for multi-period optimization nor risk in management decision making.

2.2.2 Stochastic frontier approach

It is an alternative parametric approach to the estimation of frontier functions using econometric techniques. SFA approach considers both an inefficiency component and a random error. Independently proposed the estimation of a stochastic frontier production function, where noise is accounted for by adding a symmetric error term (vi) to the non-negative error. This stochastic model specification not only addressed the noise problem, but also permitted the estimation of standard errors and tests of hypotheses.

Stochastic frontier production functions can be estimated using either the ML method or using a variant of the COLS method suggested by (Richmond, 1974). The COLS approach could be preferred because it is not as computationally demanding as ML which requires numerical solution of the likelihood. The ML estimator is asymptotically more efficient than the COLS estimator, but the properties of the two estimators in finite samples cannot be analytically determined. A more recent study by (TJ Coelli, 2005), involving substantially more replications, finds the ML estimator to significantly outperform the COLS estimator when the contribution of the inefficiency error to the total error term is large.

2.3 Empirical Literature Review

2.3.1 Demographic, Socioeconomic and Intuitional Factors on Efficiency

Age: It is one of a continuous demographic factor which affects efficiency. according to (Koye, 2021)the age of the household influenced technical efficiency negatively and statistically significant. This implies younger households are relatively more efficient than older farmers. The reason might be younger households had more contacts with extension agent services, plot demonstration and agricultural meetings. This is in line with the findings of (Hailu, 2021; Andaregie *et al*., 2020). But this result contradicted with the finding of (Tesema, 2023; Degefa *et al*., 2020). Based on the result of [(Degefa *et al*., 2020), (Esmael & Negesse, 2023),(Tesfaye & Abelieneh, 2020)], this demographic factor affects economic efficiency positively. But it is not in line with the result of(Andaregie *et al*., 2020). Allocative efficiency also affected by age positively (Andaregie *et al*., 2020).

Total income: it is a continuous variable which affects the efficiency. As discussed by(Wassie, 2016) and (Tafesse *et al*., 2023)the total income of the household has a positive and highly significant effect on efficiency (i.e economic allocative and technical efficiency). It is due to if the households are rich they purchase inputs of onion production without income constrained.

Family size: (Tesema, 2023) define family size as the total number of family members had a negative sign demonstrates that farmers with smaller families are more technically and allocatively efficient than those with larger families. This may be the case when a small family can manage challenges with home expenses that are incurred when purchasing inputs for the production. This finding supported by (Hailu, 2021). Whereas the finding of [(Andaregie *et al*., 2020), (Degefa *et al.*, 2020)] disagree with the above study. . According to the (Tesema, 2023) study, there is a negative relationship between family size and economic efficiency.

Ownership of livestock: It represents the total amount of livestock measured by Tropical Livestock Unit and has significance and negative effect on technical efficiency(Asfaw, 2021). This could be because, in the study area, the majority of society was agro-pastoralist and if they owned more livestock, they would shift their practice to animal husbandry rather than vegetable production, and this may be caused a reduction of the efficiency of production. The above finding contradict with (Hailu, 2020; Bati *et al*., 2020; Koye, 2021).

Education: it is a continuous variable which affects efficiency positively. Based on (Bati *et al*., 2020 ; Degefa *et al*., 2020; Tesfaye & Abelieneh, 2020; Hailu, 2021) education level of the household head influence technical and allocative efficiency positively. This variable also affect economic efficiency (Tesema, 2023).

Off/non-farm activities: The result of (Esmael & Negesse, 2023) reveals that off-farm activity has positive and significant on farmers' efficiency. This is because even if farmers may allocate more of their time to off/non- farm activities and thus may lag in agricultural activities. On the other hand, incomes from off/ non-farm activities may be used as extra cash to buy agricultural inputs and can also improve risk management capacity of farmers. Participation of non/off-farm activity would increase Technical and Economic efficiency. This is in line with the findings of (Tesema, 2021; Asfaw, 2021).

Credit service: It is dummy variable which affect efficiency. According to (Tesema, 2021), credit service has positive effect on economic efficiency. This result in line with (Asfaw, 2021; Hailu, 2021)for technical efficiency.

Training: It represents a dummy variable that is 1 if the farmers get training on production, 0 otherwise. Training has a positive and significant effect on technical efficiency[(Asfaw, 2021; Degefa *et al*., 2020). It has also positive effect on allocative and economic efficiency (Tesema, 2023).

Extension service: It represents a dummy variable that is 1 if the farmers get advice from development agents on the production, 0 otherwise. It has a positive and significant effect on technical and allocative efficiency (Bati *et al*., 2020; Tesema, 2021; Hailu, 2020; Degefa *et al*., 2020).

New technology: it is a dummy variable that 1 if the sample household used new technology and 0 if not. This technology has a positive and significant effect on efficiency. Meaning that it reduced labor, time and increase the production due to proper watering of crops(Tamirat & Tadele, 2023).

Improved seed: It is a type of onion seed variety. It have 1 value is the onion producer household use improved onion seed and 0 is the household use local seed. It has a positive and significant effect on onion production(Ermias, 2020).

The summery table of the above review is here in the appendix part of this paper (Appendix1)

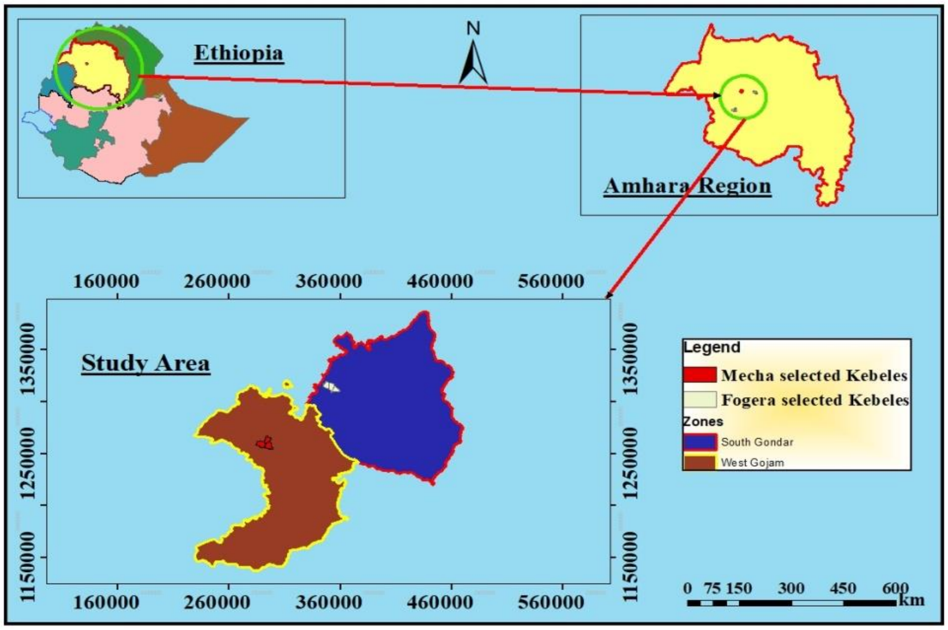
3 METHODOLOGY

3.1. Description of the Study Area

The study was conducted in Mecha and Fogera woredas districts of the Amhara region, Ethiopia (Figure 3). Fogera is one of the woredas in the Amhara Region of northwest Ethiopia. Fogera is part of the south Gondar Zone. Which is located on **11° 57' 59.99" north** latitude and **Longitude: 37° 40' 59.99" Longitude East.** The district is bordered on the south by Dera, on the west by Lake Tana, on the north by the Reb which separates it from Kemekem, on the northeast by Ebenat, and on the east by Farta (Figure 3). Wereta city is the administrative center for this woreda. The altitude of this woreda ranges from 1774 to 2415 meters above sea level. Rivers in Fogera include the Gumara and the Reb, both of which drain into Lake Tana. The land use in Fogera district shows that 44.2% is arable or cultivable, out of which 20% is irrigated (Fogra Agricultural Office, 2021) .

Mecha woreda: which is located, between 11°10’ and 11°25’ North latitude and 37°2’ and 37°17’ East longitude in Blue Nile basin, within the Highland of Ethiopia, and administratively the district is found in West Gojjam Zone of the Amhara National Regional state (figure3). The District is bordered on the south by Sekela, on the southwest by the Agew Awi Zone, on the west by the Gilgel Abay River (Lesser Abay River) which separates it from South Achefer and North Achefer, on the northeast by Bahir Dar Zuria, and on the east by Yilmana Densa District. The mean annual rainfall recorded in the area is 1480 mm with mean monthly temperature of 25.8°C. The elevation ranges between 1885-3131 meters above sea level, and the slope ranges from nearly flat to very steep. It is one of the food secure areas with no history of relief assistance. Surplus vegetable and crop production ensures food self-sufficiency and generates relatively higher cash income specifically for the better-off and middle households. Crop, livestock, and mixed farming are the dominant production system in the District(Ayalew, 2018)

Figure3.Map of the study area



Source: From arc GIS

3.2. Sampling technique and sample size

3.2.1. Sampling techniques

In this study, a combination of both purposive and two stage random sampling techniques were employed to draw an appropriate sample. Mecha and Fogera were selected purposively, based on their onion production capacity. In the first stage, sample onion producer kebeles were selected randomly. In the second stage, sample households were selected from the selected kebeles based on proportionate probabilistic sampling techniques. Sampling unit of this study was the households and the sampling frame was the list of onion producer households in sample kebeles.

3.2.2. Sample size determination

For this study to obtain a representative sample size cross-sectional household survey were employed. Since both districts have a large number of populations, we used (Cochran, 1963) the sample size formula at 5% level of precision p=.5 (maximum variability).

- $$n_0 = \frac{Z^2pq}{e^2} = \frac{1.96^2(0.5*0.5)}{0.05^2} = \frac{4.92}{0.05*0.05} = 385$$

Where n_0 is the sample size, Z^2 is the abscissa of the normal curve that cuts off an area α at the tails (1 – α equals the desired confidence level, e.g., 95%), e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population, and q is 1-p. The value for Z is found in statistical tables which contain the area under the normal curve.

We collected a total of 394 household proportionally to each six kebeles. However from the total of 394 households 20 sample households had a problem of missing variables. Then the sample household that we used for this study was 374 households.

Table 1 kebeles sample size proportion

Kebeles	Numbers of household	Sample household
Kidest Hana	271	45
Quar michaeal	328	52
Shina Teklehaimanot	292	48
Abo mesk	369	59
Kudmin	574	92
Anguti	607	98
Total	2441	394

3.2.3. Data sources and method of data collection

Both primary and secondary data were employed. Primary data was collected through face-to-face interview using questioners and pre-tested interview schedule that filled up by recruited and trained enumerators under the close supervision of the researchers. Whereas secondary data were obtained from various sources such as reports of bureau of agriculture at different levels, previous research findings used for this study.

3.3. Method of data analysis

3.3.1. Descriptive statics

To address the objectives of this study, both descriptive and econometric methods were employed. To get some insight about the characteristics of the sampled farm households, descriptive statistics (such as percentage, frequency and measures of central tendency such as mean and standard deviation) were used.

3.3.2. Econometric model Specification

The study used descriptive statistics to get some insight about the characteristics of the sampled farm households, and a stochastic frontier model to estimate the efficiency of smallholder onion producers. Stochastic frontier analysis and data envelopment analysis (DEA) are widely used efficiency estimation approaches. In the context of developing countries' agriculture where the data is heavily influenced by measurement error and the effects of weather, disease, etc, Stochastic frontiers are likely to be more appropriate than DEA in agricultural applications (T. Coelli, 2005).

The Cobb-Douglas functional form has been most commonly used in the empirical estimation of frontier models (Coelli, 1995). Its most attractive feature is its simplicity. This simplicity, however, is associated with some restrictive properties. Most notably, returns to scale are restricted to take the same value across all firms in the sample, and elasticities of substitution are assumed equal to one. On the other hand, the Translog functional form imposes no restrictions upon returns to scale or substitution possibilities and the Zellner-Revankar form removes the return to scale restriction. However, these functional forms are susceptible to multicollinearity and degree of freedom problems.

Consider the Cobb-Douglas production functional model given by

$$Y_i = f(x_1, x_2, x_3, x_4, x_5, x_6) = (x_{1i}{}^{a} x_{2i}{}^{b} x_{3i}{}^{c} x_{4i}{}^{d} x_{5i}{}^{e} x_{6i}{}^{f}) \qquad (1)$$

By taking the logarithmic transformation on both sides of the model Following (Beattie *et al*., 1985), the logarithmic transformation of the Cobb-Douglas model can be estimated as follows:

$$lnYi = \beta_0 + \beta_1 X1i + \beta_2 X2i + \beta_3 X3i + \beta_4 X4i + \beta_5 X5i + \beta_6 X6i + \varepsilon \qquad (2)$$

where: ln=Natural logarithm; Y_i = onion output (quintal); β_0=constant term; β_i=regression coefficient of the variables; X_1= land used for onion production(ha); X_2= labour used (man-days); X_3=amount of urea; X_4=amount of NPS (kg); X_5= amount of pesticide for onion (lit); X_6= herbicides (lit) used for onion production(ha); ε_i = error term and defined as$(v_i - \mu_i)$ v_i= random effects (measurement errors, omitted explanatory variables) assumed to be independent of μ, identically and normally distributed with zero mean and constant variance. μ_i is a non-negative random error variable which is assumed to account for technical inefficiency in onion farmers.

(Aigner et al., 1977)proposed the log likelihood function for model in equation (2) assuming half normal distribution for the technical inefficiency effects the (u_i). They expressed the likelihood function using λ parameterization, where λ is the ratio of the standard errors of the non-symmetric to symmetric error term (i.e. $\lambda = \sigma_u / \sigma_v$). However, (Battese & Corra, 1977)proposed that the γ parameterization, where $\gamma = \sigma^2{}_u(\sigma^2 + \sigma^2)$, to be used instead of λ . The reason is that λ could be any non-negative value while γ ranges from zero to one and better measures the distance between the frontier output and the observed level of output resulting from technical inefficiency.

Assuming that the production function is self-dual, the dual cost function can be derived algebraically and written in the following form:

$$C(Y^*, W) = kW_1^{\alpha_1}W_2^{\alpha_2}W_3^{\alpha_3}W_4^{\alpha_4}W_5^{\alpha_5}W_6^{\alpha_6}Y^{*\mu} \qquad 3$$

where; $\alpha_j = \mu\hat{\beta}_j$, $\mu = (\sum \hat{\beta}_j)^{-1}$, $H = \frac{1}{\mu}(\hat{A}\prod \hat{\beta}^{\beta_j}{}_j)^{-\mu}$, $Y_i^* = \hat{A}\prod X_j^{\hat{\beta}_j}$ and $\hat{A} = \text{Exp}(\hat{\beta}_o)$, i refers to the ith sample household; C_i is the minimum cost of production; W_i denotes observed mean input prices; Y_i* .refers to farm output which is adjusted for noise $v_{i,}$ x_j refers to the inputs used, β's are the coefficients estimated from the production function and α's are parameters to be estimated.

Following (Sharma *et al.* 1999), Equation 2 above is used to calculate the minimum efficient cost (C*) which was then used as outcome variable in the cost function. The allocative efficiency (AE) is also estimated as the ratio of economic efficiency to technical efficiency. Once efficiency scores are estimated, Two Limit Tobit model was used to identify factors affecting efficiency (TE, AE, and EE). Following Gujarati (2004) the two limit Tobit model can be estimated as follows:

$$E_i^* = \delta o + \delta_k Z_i + v \qquad (4)$$

Where i represent the i th farmer in the sample; k is the number of factors affecting efficiency; Z_i represents farm and household specific factors affecting efficiency; δ is parameter to be estimated; E is efficiency (TE, AE and EE) = max (0, E^*). The observed efficiency E equals one when E*>0, but E equals zero when E*$\leq$ 0.

3.4.Hypothesis and definition of variables

Output: It is a continuous variable. Physical output as a measure of production does not account the differences among the qualities of products.

1. **Land (LAND):** It is a continuous variable. It is the plot allocated for onion production during production season in hectare. It has positive effect on onion production[(Tafesse *et al*., 2023),(Esmael & Negesse, 2023)]
2. **Human labor (LABOR):** It is a continuous variable. It is the total amount of labor (family and hired labor) participated for onion production in the production season measured by man day. Labor has positive and significant effect on efficiency[(Degefa *et al*., 2020), (Al-jubouri & Alihbabi, 2020)].
3. **UREA:** It is a continuous variable. It is the total amount of UREA used for onion production during production season measured in Kg. Urea fertilizer has also a positive and significant effect on efficiency [(Nakana *et al*., 2021), (Bati *et al*., 2020)].
4. **NPS:** It is a continuous variable. It is the total amount of DAP used for onion production during production season measured in Kg. This production input also has appositive and significant effect on efficiency(Abate *et al*., 2019).
5. **Chemicals (insecticide and herbicide)**: It is a continuous variable. It is the total amount of insecticide and herbicide used for onion production during production season measured in litter. It have positive expected sign(Tafesse *et al*., 2023).
6. **Age (AGEHH):** It is a continuous variable. This refers to the age of the household head measured in years. The expected sign for this variable is negative or positive(Tafesse *et al*., 2023; Abate *et al.*, 2019).
7. **Family size (FAMSIZE):** the number of persons the household head administers/supposed to manage as family members, regardless of blood relationship. It has positive and negative expected sign (Hailu, 2021; Tafesse *et al*., 2023).
8. **Total income**: it is a continuous variable. It is the total amount of income for the farm household during the production season. It has a positive expected sign (Wassie, 2016; Tafesse *et al*., 2023).
9. **Number of livestock (LIVSTOCK):** it is a continuous variable. This is the total number of livestock in terms of Tropical Livestock Unit (TLU). It has positive and negative expected sign (Koye, 2020 ;Asfaw, 2021).
10. **Education (EDUCLVL):** It is a dummy variable. This refers to the level of education of the household head measured in 0 did not have formal education and 1 got formal education. Education has positive expected sign(Hailu, 2021; Tamirat & Tadele, 2023).
11. **None and/or off farm activity**: It is the participation of the household member in none and

/or off farm activities such as daily labor, trade, work for food, etc. It is a dummy variable that takes a value 1 if the household is not participant and 0 otherwise. It has negative expected sign (Tesema, 2021; Asfaw, 2021).

12. Extension service on onion (EXTSERV): This is a dummy variable measured as 1 if the farmer has access to extension service about onion production and 0 otherwise. It has a positive and negative expected sign (Bati *et al.*, 2020; Degefa *et al.*, 2020).

13. Credit Access for onion production: it is a dummy variable measured as 1is the farmer take credit for onion production and 0 otherwise. We have expected that credit has a positive expected sign (Tafesse *et al.*, 2023; Tesema, 2021).

14. Seed variety: it is a dummy variable with 1 for improved onion seed and 0 for local onion seed. The expected sign for this variable is positive(Koye *et al*., 2022).

15. .**New technology:** it is a dummy variable with 1 for the farmer who used new technology and 0 for the farmer who didn’t use. The expected sign for this variable is positive(Tamirat & Tadele, 2023).

Table 2 Proposed hypothesis and definitions of the variables

Variable	Definition and measurement	Hypo.	Reference
Output	Total amount of onion produced measured in quintals.		(Tafesse et al., 2023a),(Esmael & Negesse, 2023)
Land	Area of land allocated for onion production measured in hectare	+	Ermias, 2020; Asfaw, 2021; Koye, 2021; Tafesse et al., 2023, Esmael & Negesse, 2023
Labor	Labor (family and hired labor) participated for onion production in the production season measured by man day	+	(Degefa et al., 2020), (Al-jubouri & Alihbabi, 2020)
Urea	Urea used for onion production measured by Kg	+	(Nakana et al., 2021), (Bati et al., 2020)
NPS	NPS used for onion production measured by Kg	+	(Abate et al., 2019)
Insecticide	Insecticide used for onion production measured in litter	+	

Herbicide	Herbicide used for onion production measured in litter	+	
Age	Age of the household head measured in years	-	(Tafesse et al., 2023a), (Abate et al., 2019)
Family size	The number of active labor force in the household [Active labor force]	+/-	(Hailu, 2021),(Tafesse et al., 2023)
Livestock ownership	Total number of livestock in terms of Tropical Livestock Unit (TLU)	-/+	(Asfaw, 2021) (Abebe G, 2020, [(Koye, 2020)
Income	Total income of the household during last 12 months (thousands of Birr)	+	(Wassie, 2016),(Tafesse et al., 2023a)
Education	= 1 if the household head have formal education and 0 otherwise	-	Asfaw, 2021,Koye, 2021, (Hailu, 2021), (Tamirat & Tadele, 2023)
None /off farm activity	= 1 if the household members participate in off/non-farm activities and 0 otherwise	+	(Asfaw, 2021), (Koye, 2021), (Tesema, 2021)
Extension	= 1 if the household	+	(Abebe G, 2020;

services	gets extension service about onion production and 0 otherwise		(Asfaw, 2021), [(Bati et al., 2020), (Degefa et al., 2020)
Credit Access	=1 if the household took credit for onion production during the production season and 0 otherwise	+	(Abebe G, 2020),(Asfaw, 2021),(Wudineh & Endrias, 2016) (Tafesse et al., 2023a), (Tesema, 2021)
Seed variety	=1 if the household used improved onion variety during the production season and 0 otherwise	+	(Tamirat & Tadele, 2023).
Training	=1 if the household got training during the production season and 0 otherwise	+	(Koye *et al*., 2022)
new technology	=1 if the household used new technology during the production season and 0 otherwise	+	(Tamirat & Tadele, 2023).

4 RESULT AND DISCUSSION

In this section the results of the study along with previous research findings are briefly discussed. Before discussing about results obtained from the models, it is important to briefly describe inputs, costs and socioeconomic variables using descriptive statistics. This would help to draw a general picture about the study area and sampled households.

2.1 Descriptive Statistics

2.1.1 Input variables

Table 3 below presents the mean and standard deviation of input variables used to estimate the production function. The production function for this study was estimated using six input variables.

Table 3 Summary statistics of variables used to estimate the production function

Variable	Mecha		Fogra		Total	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Output(Qt)	15.5	16.9	44.6	35.1	31.2	31.7
Land(Hect)	0.4	0.3	1.1	0.8.	0.2	0.2
Urea(kg)	20.7	34.8	64.3	67.2	44.2	58.8
NPS(kg)	8.1	34.7	21.2	66.5	15.2	54.5
Insecticide(Lt)	1.7	1.7	3.4	2.7	2.7	2.4
Herbicide(Lt)	0.1	0.3	0.3	0.6	0.2	0.5
labor(man/day)	61.2	24.3	97.6	43.9	80.8	40.5

Source: Own survey

On average farmers got 31.2 qt of onion, which is an outcome variable in the production function. The average land allocated for onion production by sampled farmers during the survey period was 0.2 ha. Like other inputs human labor inputs was also decisive, given a traditional farming system in the study area. Sampled households, on average, use 80.8 man/day labors for the production of onion during 2021/22 production season. In the study area farmers use both urea and NPS for onion production. Hence, on average farmers used 44.2 Kg and 15.2Kg of urea and NPS respectively. Onion production is affected by serious problem of diseases and pests and herbs. For controlling them during the survey period the sampled farmer used 2.6 liters pesticide and 0.3 liters herbicide on average.

4.1.1. Input cost variables

Table 4 summarizes input costs along with their contribution to the total cost of production. On average the total cost of production to produce 31.22 qt of onion was 54436 birr. Among the factors of production, the cost of land accounted for the highest share (49.84 %) followed by cost of human labor (25.98%). Given the high productivity and greater opportunity cost of land in the area, it is logical to get this result (Wassie, 2016). Among the inputs, cost of herbicide takes the smallest (0.35%) share out of the total cost of onion production.

Table 4 Summary statistics of variables used to estimate the cost function

Variable	Mean	Std.Dev.	Percentage share of costs
Total cost(ETB)	54436.25	47293.25	100
Land cost (ETB)	27135.52	24831.45	49.84
Urea cost (ETB)	1474.58	9317.12	2.72
NPS cost (ETB)	456.22	3253.31	0.84
Insectic cost (ETB)	8102.12	16650.11	14.88
Herbi cost (ETB)	188.25	644.15	0.35
Labor cost (ETB)	14141.87	7087.16	25.98

Source: own survey

4.1.2. Explanatory (efficiency factors) variables

From the total twelve factor variables eight of them were dummy variables and the other four variables were continuous. The mean standard deviation continuous and the percentages of dummy variables would be illustrated in table 5.

Table 5 Summary statistics of variables used to estimate efficiency

Variable	Mean	Std. Dev.	Percentage dummy=1	Percentages dummy=0
Age(years)	43.8	12.1	-	-
Livestock ownership (TLU)	5.8	2.8	-	-
Family size (active labor)	5.7	1.9	-	-
Income (000)	117.8	102.9	-	-
Education(=1 if yes)	-	-	24.6	75.4
Off-farm activity(=1 if yes)			19.5	80.5
Credit access (=1 if yes)	-	-	8 3.9	16.1
Training ((=1 if yes)	-	-	58.3	41.7
Improved seed (=1 if yes)	-	-	21.4	78.6
Pump use (=1 if yes	-	-	42.8	57.2
Extension service(=1 if yes	-	-	81.3	18.7

Source: own survey

The descriptive results presented in Table 4 showed that the average age of the sampled household heads was 43.8 years. The same table shows that the average livestock ownership of the onion producer household heads was 5.8 TLU. It is indicated that the average family size of the sample households was 5.7 persons. Education composition of the respondents indicated that about 24.6 % of the sampled households were literates. The result further revealed that about 83.9% of sample households had an access to credit. In addition, results indicate that about 58.3% of the sampled households had taken training. From the sample household heads 42.8% were used water pump. Moreover, the use of improved seeds and off-farm activity were also expected to affect the resource efficiency of farmers in onion production. Accordingly, about 21.4% of the sampled households in the study area were using improved seed and about 19.5% of sampled households participated in off/non-farm activities. The other factor extension also affects the efficiency of the sample households. The above table indicates that from the total sample households 81.3% were got an extension service on onion production.

4.2. Econometric Analysis

Before running to the econometric analysis, the data was tested against different econometric problems. Accordingly, Multicollinearity test for all variables was done using Variance Inflation Factor (VIF=4.749<10) for continuous variables. Contingency Coefficient (CC=1.169<7.5 was calculated to test for the existence of multicollinearity problem among discrete variables (appendix 2 and appendix 3). Test for multicollinearity using both methodologies confirms that there is no serious linear relation among explanatory variables.

Second, the appropriate functional form was selected using a log likelihood ratio test. The specification tests were computed using the generalized likelihood ratio test (LR = -2L (H0)-L (H1)], where L (H0=) and L (H1=) are the values of log likelihood functions under the null (i.e., all the interaction and square terms equals to zero or Cobb-Douglas best fits the data) and alterative hypothesis, respectively (Greene, 1980). The null hypothesis is rejected when the calculated chi-square is greater than the critical chi-square value. Accordingly, the estimated LR = -2(-250.2468)-(-290.52679) = 38.27999 is less than the calculated chi-squire value (40.115) at 5% level of significance. Hence, the null hypothesis is rejected suggesting that the Cobb-Douglas production function best fits the data. Finally, the diagnostic test for the inefficiency component also shows that sigma squared (δ^2) was statistically significant at 1%. The result therefore suggests that the stochastic frontier model fits the data best compared to the ordinary least square estimation (appendix4).

The hypothesis that shows the appropriateness of employing stochastic frontier model over ordinary least square (whether technical inefficiency effect is present in the model or not) is tested. The test is based on the statistical significance of the parameter gamma. This helps to measure the level of farm specific technical efficiency and whether the farmers in the study area are technically efficient or not. The value of gamma was 2.23 at 10% level of significant (table 7 below)

Table 6 Stochastic frontier normal/half-normal model

Variables	Frontier	St.Err.	t-value	p-value	Sig
ln_Land	0.415	.036	11.80	0	***
ln_Labor	0.667	.075	8.84	0	***
ln_urea	0.0153	.005	3.41	.001	***
ln_NPS	0.0117	.019	3.88	0	***
ln_insecticide	0.0773	.007	2.74	.006	***
ln_herbicide	0.0181	.35	2.60	.009	***
λ	-1.702	.236	-6.69	0	***
σ^2	-1.319	.645	-2.43	.015	**
LR test of sigma_u=0	2.23				*
Observations	374				

Notes: ***, **, and * refer to 1%, 5%, and 10% significance level; Figures in parenthesis represents standard error

Source: Own computation

4.2.1. Empirical Results

Estimation results of the production function (Table 5) show that all input variables have a positive and significant effect on output. The results indicate that a one percent increase in the size of land, number of labor, amount of urea, amount of NPS, amount of insecticide and amount herbicide would increase onion production by 0.415% 0.667%, 0.015%, 0.012%, 0.077% and 0.018% respectively. These findings are consistent with Previous studies (Degefa *et al*., 2020; Koye *et al*., 2022; Tafesse *et al*., 2023; Nakana *et al*., 2021; Abate *et al*., 2019).

The input variable land has a coefficient of 0.42. The elasticity of onion production to land is positive at a 1% level of significance. It indicates that each additional hectare of the land area used for onion production increases onion output by 42%. This result indicates that farmers with larger land sizes exhibit significantly better levels of technical efficiency. Next to human labor land is an important input for onion production. This supports the conclusions of (Koye *et al*., 2022).

The third important input in this study was insecticide chemical. It had a positive and significant effect on technical efficiency of onion production at 1% level of significant. The elasticity of onion production to insecticide chemical was 0.773. That is showing a liter increase in insecticide chemical input would enhance onion yield by 7.73%. The other chemical input herbicide also had a positive and significant effect on onion production at 1% level of significant. The coefficient of chemical herbicide was 0.0181. It implies that as a liter increase in herbicide the onion yield increase by 1.81%.

The other significant production input urea and NPS had positive and significant effect on onion yield at 1% and 5% level of significant. The elasticity of onion production to urea and NPS was 0.0153 and 0.0117 respectively. This meaning that as 1kg increases in urea and NPS the technical efficiency of onion production increase by 1.53% and 1.17% respectively.

The returns to scale were calculated to be 1.204 (increasing returns to scale) suggesting that a percent increase in all inputs proportionally would increase the total production by more than 1%. As a result, they are in the first stage of production, resource usage, and production was below optimal levels, and onion growers can continue expanding their outputs by using the existing inputs. This result is in line with the result of(Tafesse *et al*., 2023), Irrigated Onion Production Efficiency in Humbo.

4.2.2. Efficiency Scores

The results of the efficiency scores indicate that there were wide ranges of differences in TE, AE and EE among onion producer farmers (table 6). The mean TE of sampled households during the survey period was 69.2 %. The TE among farmers ranges from 30.3 to 88.6 %, with standard deviation of 0.11. This in turn implies that farmers can increase their Onion on average by 30.8% at the existing level of inputs and current technology by operating at full technical efficient level. Similarly, the mean AE and EE of farmers were 75.6% and 52.6%, respectively.

Unlike TE there was low average EE score, which was attributed to both allocative and technical efficiency of onion producers. Generally there is a considerable amount of efficiency variation among onion producer farmers in all measures of efficiency. This result, wide variation in farmer specific efficiency levels, is consistent with study of(Esmael & Negesse, 2023) whom Economic Efficiency of Onion Production in East Shewa Zone , Oromia Region , Ethiopia.

Table 7 Descriptive statistics of efficiency measures

Variable	Mean	Std.Dev.	Min	Max
Te	.692	0.110	.303	.886
AE	.756	0.107	.382	.963
EE	.526	0.119	.196	.776

Source: Own computation

The mean TE, AE, and EE of sampled onion farmers were found 69.2%, 75.6%, and 52.6%, respectively. This demonstrates that sample farmers performed better in AE than in TE and EE. This also implies farmers are better at allocating their onion production budget than minimizing onion farm inputs. The onion farmers have the potential to reduce the input required in onion production by 30.8% while maintaining present output levels. If the average farmer in the sample achieved the most efficient counterpart's level of production costs, the average farmer might realize a 24.4% decrease in input costs to create the most efficient output. Similarly, if the technically efficient farmer achieved the TE level of his most efficient, the least efficient farmer might realize a 69.2% decrease in inputs necessary to obtain the most efficient output level. The TE estimate is consistent with the results obtained by (Abdi Zekeriya, 2016).

The sample onion farmer's mean AE was 75.6%, implying that production is 24.4% below the frontier on average (less than the achievable potential output). This suggests that more inputs are being allocated for the same amount of output. A farmer with an average level of AE, for example, would save around 24.4% to reach the level of the most efficient farmer. This result is in line with the findings of (Tafesse *et al.*, 2023).

The sample farmer's mean economic efficiencies were 52.6%, indicating a considerable level of inefficiency in the manufacturing process. That is, a producer with average EE might lower current average production costs by 47.4% to meet the possible minimal cost level without affecting output levels. Farmers would save 47.4% on production costs if they achieved 100% EE. This suggests that lowering the cost of production by removing inefficient resource usage might add 47.4% to their annual revenue. These findings indicate that there is room to enhance farm family productivity and economic advantages in onion production in the research area by boosting all efficiencies(Tafesse *et al*., 2023).

4.2.3. Determinant of Efficiency

Based on the estimated parameter resulted from the Tobit regression model, the influencing factors impact on production onion, and their respective signs were identified. The positive or negative signs indicated the effects of each explanatory variable on the scores' technical, allocative and economic efficiency of onion production (Table 7). Therefore, those variables with a higher impact value should be given an attention in order to improve the existing efficiency level of onion production in Mecha and Fogera districts, and the results of the variables are presented as follows.

Table 8 Tobit results of determinants of efficiencies in Onion production

VARIABLES	TE	TE	TE
Age	**-0.001****	-0.009	**-0.002*****
	(0.001)	(0.0001)	(0.002)
Family size	-0.005	**0.005***	6.23e-05
	(0.003)	(0.003)	(0.003)
Credit service	-0.013	-0.012	-0.012
	(0.012)	(0.010)	(0.011)
Income	**0.001*****	**0.001*****	**0.001*****
	(5.66e-05)	(5.20e-05)	(5.64e-05)
Livestock ownership	0.004	-0.002	0.002
	(0.002)	(0.003)	(0.003)
Extension service	0.001	**0.033****	**0.026***
	(0.014)	(0.013)	(0.014)
Education	0.002	-0.007	-0.006
	(0.013)	(0.012)	(0.013)
off_farm act	0.015	-0.009	0.006

	(0.014)	(0.013)	(0.014)
	0.051* **	**0.074*** **	**0.086*** **
	(0.014)	(0.012)	(0.013)
seed_type	**0.026***	0.004	0.018
	(0.014)	(0.013)	(0.014)
Constant	0.659***	0.654***	0.431***
	(0.037)	(0.034)	(0.037)
Observations	374	374	374

Notes: ***, **, and * refer to 1%, 5%, and 10% significance level; Figures in parenthesis represents standard error

Source: Own computation

The results above showed that the coefficient for age was found to be negative and significant at a 5% level with a coefficient of -0.001 and -0.002 for technical and economic efficiency respectively. This implies that an increase in age of household by 1 year leads to a decrease in technical and economic efficiency by 0.1% and 0.2% respectively; that younger farmers are more technically efficient than their more elderly counterparts. This is because older farmers are less energetic, leading to lower productivity and lower technical efficiency levels. This result is in line with the findings of (Tafesse *et al.*, 2023). But this result not the same to (Abate *et al*., 2019).

The coefficient for household size was positive and significant at a 10% level with coefficient of 0.005, indicating that as the household size increase by 1 person allocative efficiency of onion production increase by 0.5%. The result showed that producers those having large family size are more efficient than those with small family size, because; they manage crop plots on time. This finding in line with the finding of (Degefa *et al*., 2020).

The other important factor for efficiency was total income of the sample household heads. This variable had a positive and highly significant effect for efficiency at 1% level of significant. As total income of the household increase by 1000 Ethiopian birr the technical, allocative and economic efficiency of onion producer farms increase by 0.021, 0.022 0.033% respectively. This is due to household finance having a direct impact on efficiency since farmers with high income will be unable to purchase agricultural inputs (seed, agrochemicals, and fertilizer) and would be able to adopt updated technologies. The result has conformity with(Tafesse *et al*., 2023, Wassie, 2016).

Getting extension service on onion production has also a positive and significant effect on allocative and economic efficiency of onion production. The result suggests that onion producers who got extension service on onion production increase their allocative and economic efficiency by 3.3% 2.6% respectively than their counterparts. This finding in line with a previous study (Tamirat & Tadele, 2023).

The finding indicated that use of improved irrigation technology (pump) has a positive and highly significant effect on production efficiency (i.e., technical, allocative and economic efficiency) with coefficient of 0.052, 0.072 and 0.085. An Increased technical efficiency can be because of the possible improvement in productivity, while the increased the allocative and economic efficiency can be associated with educed cost of production.

Even though we couldn’t include onion seed as an input in the production function, the type of seed was an important explanatory variable. As we know seed is a necessary input in production function. But during the survey period most farmers used onion seedling than onion seed. They bought the seedling fro market or their neighbor or by rowing small amount of seed. So we couldn’t count the amount of seedling and couldn’t measure the amount of seed. This is the reason why we couldn’t include seed as input variable.

This study indicated also types of seed had positive and significant effect on technical efficiency at 10% level of significant with a coefficient of 0.026. This indicated that the farm household who used an improved seed variety would increase their onion production by 2.6% than the farm household who used local seed. This result is similar with the finding of (Ermias, 2020).

5 CONCLUSION AND POLICY IMPLICATIONS

The study looked at the production efficiencies and causes of production efficiency in onion farming in Mecha and Fogera. In this study we can conclude that there is a wide gap in efficiency among smallholder onion farmers. From Cobb-Douglas stochastic frontier functional model we understood the inputs such as land, labor, fertilizer (urea and NPS), and chemicals (herbicide and insecticide) found important factors in determining onion production in the research area. This implies an increased utilization of these resources can increase to a greater extent the onion production level. This model also indicates onion producers are in the first stage of production. From this, we advise the farmers to produce more onion production by using the existing inputs and technologies. From the Two-limit Tobit model results, the study conclude that the onion producer age, extension service on seed, extension service on harvest, family size, and livestock ownership, using technology (pump), seed type and total income of households found significant sources of the efficiency of onion producers. This finding tells as in addition to other important factors, in the study area, farmers can increased their onion production by using new technology and improved seed variety.

The study suggests that increased adoption and distribution of agricultural inputs and new technologies would lead to a significant increase in production levels or reduction in production costs. The elasticity of land and labor shows that land and labor have highest contribution for onion production. Therefor we recommended that the farmers to use much amount of land and labor inputs. The results also show that youth participation in onion production will help increase efficiency. In summary, the coordinated efforts of stakeholders in extension and provision of inputs are crucial to support smallholder onion farmers.

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7 APPENDIX

Appendix1: summer table review of efficiency researches done in different countries

No	**Author/s**	**Year**	**Methodology**	**Determinants of efficiency**	**Significant variables sign (+/-)**		
					TE	**AE**	**EE**
1	(Esmael and Negesse)	2023	SFA &Tobit model	-Age -Off/non-farm activity -Farming Experiance -Land allotted for onion	+ + + +		+ + + -
2	(Tesema)	2021	DEA and Tobit	Credit use Education off/nonfarm activity extension service		+ + +	+ +
3	(Tesema)	2023	SFA and Tobit	-Educational level, -experience -training -family size -distance market,			+ + + - -
4	(Hailu)	2020	SFA and two-limit Tobit	-experience -family size -own farm labor -livestock size, -extension contact -received training	+ + + + + +		
5	(Bati, Tilahun, and Parabathina)	2020	SFA & Tobit	-Land utilization and availability -Education -Land fragmentation -extension contact	+ -	+ -	+ -

				-soil fertility -livestock holding	+	- + +	
6	(Degefa, Biru, and Abebe)	2020	SFA & Tobit	-Age -Education -sex -Experiance -training -extension visit -family size	+ + + + + + +	+ + + + +	+ + +
7	(Tesfaye and Abelieneh)	2020	SFA & Tobit	-age -Dependency-ratio -Household size -Education - market distance - experience	+ + - +		+ +
8	(Hailu)	2021	SFA & Tobit	-Education -land tenure status -extension service -credit service -soil fertility of the farm -sex of HH -age of HH, -farm size -land fragmentation	+ + + + - - - - -		
9	(Andaregie, Worku, and Astatkie)	2020	SFA & Tobit	Sex Age Family size Experience education level, distance to market	+ - + + -	+ + + + -	- + -
10	(Koye)	2021	SFA	Education TLU plot size Labor and	+ + -		

				oxen	+		
11	Ermias	2020	SFA	-SexHH -Frequency of weeding -Disease Incidence -variety	- - + +		
12	Asfaw			-Access to credit -Ownership of livestock -Distance to the market -Pesticides -Training -Off-farm income -extension contact -Household size -Education	+ - - - + + + +/ - +		

Appendix3 Contingency coefficients for discrete explanatory variables

Variables	1	2	3	4	5	6	7
(1) education	1.000						
(2) credit access	-0.072	1.000					
(3) off_farm	0.267	0.013	1.000				
(4) seed_type	0.081	0.015	0.171	1.000			
(5) exten_servic	0.028	0.079	0.058	0.117	1.000		
(6) use_pump	-0.130	-0.049	-0.126	-0.293	-0.152	1.000	
(7) Training	0.030	0.118	0.075	0.124	0.142	-0.112	1.000

Source: Own computation

Appendix4: the model result of Translog function

VARIABLES	Translog
ln_Land_total	0.296(0.422)
ln_Labor_total	0.848(0.958)
ln_urea_onion	0.145**(0.067)
ln_NPS_onion	0.111(0.0764)
ln_insecticide_onion	0.489(0.315)
ln_herbicide_onion	-0.0516(0.0901)
ln_land2	0.0559**(0.0242)
ln_land_labor	0.0234(0.0907)
ln_land_urea	0.0130**(0.00580)
ln_land_NPS	-0.0114*(0.00666)
ln_land_insecticide	0.0448(0.0333)
ln_land_herbicide	-0.0136(0.00895)
ln_labor_urea	-0.0152(0.0134)

ln_labor_NPS	-0.0225(0.0139)
ln_labor_insecticide	-0.0741(0.0654)
ln_labor_herbicide	0.0129(0.0165)
ln_labor2	-0.0488(0.108)
ln_urea2	0.00867**(0.00412)
ln_urea_NPS	0.000311(0.00122)
ln_urea_insecticide	-0.00516(0.00546)
ln_urea_herbicide	0.00114(0.00120)
ln_NPS2	0.00367(0.00720)
ln_NPS_insecticide	0.00602(0.00416)
ln_NPS_herbicide	-0.000739(0.00136)
ln_insecticide2	0.0180***(0.00477)
ln_insecticide_herbi	-0.00836(0.00678)
ln_herbicide2	-0.000149(0.00612)
λ	-2.292***(0.256)
σ^2	-1.030***(0.243)
sigma_u=0:	10.10*
Constant	0.537(2.171)
Likelihood	-290.52679
Observations	374

Source: Own computation

Appendix5: Questioners

Questioner Number **……………………………..** Kebele **( )**

General Household and Farm Characteristics (01)

1 Name of the Respondent (Household head)………………………………………………….

2 Sex of the Household head (M/F) ……………… Age…….years

3 What is the educational status of the household head?

A. Illiterate B. Read and write C. formal education (__grade).

4. Marital status: 1. Single 2. Married 3. Divorced 4. Widow

5 Number of family members and structure

No.	Name	Age	Sex	Kinship

6. How long have you been in farming? .... Years.

Socio economic and institutional factors (02)

1. Do you have access to loan, if you need it? A. Yes B. No

2. Do you have interest to use the loan for your agriculture? A. Yes B. No

3. Did you receive credit for vegetables last cropping season? A. Yes B. No

1 If yes, how much did you take for onion production purpose? ……………In Birr

2 Is anyone in the family a member of any associations? A. Yes B. No

3 Is anyone in the household a member of any of the following organizations?

A Multi-purpose cooperatives

B. Seed producing cooperative

C. saving and credit cooperatives

D. other forms of cooperatives

E. Farmers Research Groups (FRG)

F. Informal groups (Idir, equb etc)

G. Women’s group

H. Youth group

I. Other

J. None of them

4 Did you have extension contact in relation to onion production in the year 2021 cropping season? A. Yes B. No

5 What was the extension advice specifically on onion production?

A. Seed bed preparation

B. Fertilizer (compost) applications

C. Harvesting

D. Transplanting

E. Marketing

F. Post-harvest handling

G. Protection
H. Others (specify)……………………………

6 What is your income at present (in ETB/year)?....................ETB

7 Did you participate in off-farm activities in the last cropping season A. Yes B. No

Livestock, Land, machinery, tools, services (03)

8 Do you own livestock? A. Yes B. No

Class of livestock	Numer	Purpose for maintaining	Remark
Cows			
Oxen			
Heifers			
Bulls			
Calves			
Sheep			
Goat			
Donkey			
Horse			
Mule			
Poultry			
BeeHives			

9 Are you operating any land obtained in any of the following ways?

A. Gift
B. Share tenancy
C. Family land
D. Leased or rented
E. Inherited
F. Own land
G. Other

10 How much land did you operate in the last cropping season?

Unit of land

- Timad/kada/kert/gemed
- hectare (1 ha = 10,000 meter square)
- meter square

Gross margin for onion (04)

1 Total area cultivated for onion in the last cropping season………… (unit)

2 How much onion bulb was harvested in quintal the last cropping season? ....… Quintal.

1 How much of the harvest was wasted after harvest in quintal? .... .Quintal.

2 How much of harvested onion was kept for household consumption in quintal?.......................quintal

3 How much of harvested onion bulb was kept for seed in quintal? …………..quintal.

4 How did you sell your onion?

A. Just on the field before harvest

B. take my product to the market

5 What was the total revenue generated from the sale of onion bulb did in the last cropping season in ETB? ……………birr

When answering the following questions please consider your household's processing practices of onion in this cropping season.

1. What did you do with onion before selling?
   A. Sorting
   B. storing
   C. Packing
   D. Other
   E. Nothing
2. How much quintal of the onion bulb was sold last cropping season?
3. What was the average selling price of onion per kg in the last year (2021/22 EC) (last cropping Season)

Inputs for onion bulb

4 Types of onion seed cultivated last cropping season

   A. Local
   B. Improved

5 sources of seed

   A. Own
   B. Market
   C. Government

D. NGO

E. Neighbor

F. Cooperatives

G. Other

6 How much did you spend on seeds for onion in birr in last cropping season?

7 How much did you spend on seeds for onion in birr in last cropping season? ……….birr.

Did you apply chemical fertilizer for your onion production? A. Yes B. No

8 If yes, what type of chemical fertilizer you used? A. Urea B. NPS

9 How much kg urea did you used?..........kg

10 How much did the urea cost?..................birr

11 How much (in kg) NPS did you use for onion? ...Kg.

12 How much did the NPS cost (birr/kg)?

13 Did you use manure and/or compost for your onion bulb production? A. Yes B. No

14 How much in quintal?

15 How much did it cost in birr? (This refers to total cost of manure for the last cropping season)

16 Did you use insecticides for your onion bulb production? A. Yes B. No

17 If yes, what is the name of the insecticide?

18 How much? (In liters, kg)

19 How much did it cost in Birr? (This refers to total cost for the last cropping season)…………birr

20 Did you use herbicides for your onion bulb production? A. Yes B. No

21 If yes, what is the name of the herbicide you applied

22 How much? (In liter, kg).

23 What did it cost in birr? (This refers to total cost of herbicides for the last cropping season).

24 Did you use fungicides for your onion bulb production? A. Yes B. No

25 if yes, what is the name of the fungicide you used

26 How much?(In liter, kg,)

27 What did it cost in birr? (This refers to total cost for the last cropping season)

28 Did you use plastic bag/wooden-box for your onion production? A. Yes B. No

29 What did it cost in birr? This refers to total cost for the last 12 month

Hired labor

30 Did you hire labor for your onion bulb production in the cropping season? A. Yes B. No

Please indicate the approximate total number of days worked for onion bulb in each

step in the last 12 months.

31 Purchase of inputs for onion-bulb (seeds, fertilizers, pesticides..): Total days worked by hired laborers in the last 12 months

32 Land preparation and plowing for onion bulb: Total days worked by hired laborers in the last 12 months

33 Sowing/Planting for onion bulb: Total days worked by hired laborers in the last 12 months

34 Weeding for onion bulb Total days worked by hired laborers in the last 12 months

35 Chemical fertilizer application: Total days worked by hired laborers in the last 12 months

36 Pest and disease control for onion bulb: Total days worked by hired laborers in the last 12 months

37 Harvesting for onion bulb: Total days worked by hired laborers in the last 12 months

38 Transportation and packaging of harvest for onion bulb: Total days worked by hired laborers in the last 12 months

39 Selling/Marketing for onion bulb: Total days worked by hired laborers in the last 12 months

40 Processing for onion bulb: Total days worked by hired laborers in the last 12 months

41 What was the average daily wage for hired laborers for onion bulb?

Family labor

42 Did any of your household members work on the onion bulb value chain production in the last cropping season? A. Yes B. No

43 How many male youth (up to age 25)?

44 How many female youth (up to age 25)?

45 How many male youth (u> age 25)?

46 How many female youth (> age 25)

Please indicate the approximate number of total days worked in each step I in the last 12 months

47 Purchase of inputs for onion bulb (seeds, fertilizers, pesticides..): Total days worked by household members in the last 12 month

48 Land preparation and plowing for onion bulb : Total days worked by household members in the last 12 months

49 Sowing/Planting for onion bulb : Total days worked by household members in the last 12 months

50 Chemical fertilizer application for onion bulb : Total days worked by household members in the last 12 months

51 Weeding for onion bulb : Total days worked by household members in the last 12 months

52 Pest and disease control for onion bulb : Total days worked by household members in the last 12 months

53 Harvesting for onion bulb : Total days worked by household members in the last 12 months

54 Transportation and packaging of harvest for onion bulbs : Total days worked by household members in the last 12 months

55 Selling/Marketing for onion bulb : Total days worked by household members in the last 12 months

56 Processing for onion bulb : Total days worked by household members in the last 12 months

57 The family labour who worked on onion bulb production is

58 The total estimated cost of family labor is

Mechanization cost onion bulb

59 Did you use rented oxen for onion bulb? A. Yes B. No

60 If yes, how many oxen days you rented for onion bulb……..oxen/day.

61 How much was an average rent price per oxen in birr during the 12 months?

62 Do you use irrigation for your production of onion? A. Yes B. No

63 What is your water source?

63.1 Reservoir D. Spring

63.2 Pond E. River

63.3 Wells F. Others…..specify.

64 Which method are you using to apply irrigation water?

64.1 Flooding D. Sprinkler irrigation

64.2 Furrow irrigation E. Drip irrigation

64.3 Using watering F. Other…specify

65 How is the frequency of watering onion?

65.1 Once in a week D. whenever the soil is dry

65.2 Once in two week E. whenever the plant shows wilting symptoms

65.3 Once in three week F. whenever irrigation is available.

66 Did you use water pumping technologies for watering onion last cropping season? A. Yes B. No

67 Who owns the used pump? A. Own B. Hired C. Borrowed

68 Which technologies did you use?

68.1 Diesel generators C. Manual pumping devices

68.2 Solar pumping D. Electric pumping

69 How much the cost of lifting device?

70 How much the cost of accessories?

71 How much the cost of maintenance and installation?

72 How much the cost of fuel and lubricant?

73 Did you use mechanization for onion bulb? A. Yes B. No

74 If you yes, how much did you pay for mechanization for onion bulb in the last cropping season?

75 Did you rent land for onion-bulb production last cropping season? A. Yes B. No

76 How much you spend for rented land in the last twelve month for onion-bulb cultivation?

77 Did you share land for onion production last cropping season? A. Yes B. No

78 How much did you spend for shared land in the last 12 month for the onion land?

Knowledge Attitude Practice (05)

79 Did you participate in any training? A Yes B. No

80 If you yes, what kind of training did you participate in?

A. Varieties
B. Crop rotation
C. Conservation
D. Compost
E. Tillage
F. Chemicals
G. Other….specify.

THANK YOU