ANALYSIS OF TECHNICAL EFFICIENCY OF TEFF PRODUCTION AMONG SMALLEHOLDER FARMER′S: IN WOLAYTA ZONE, SOUTHERN ETHIOPIA REGIONAL STATE.

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DECLARATION

The work presented in this thesis, is to the best of my knowledge and belief, original except as acknowledged in the text. I declare that I have not submitted this material, either in full or in part, for a degree in this or any other institution. No part of this work should be copied, either in part or full, without my permission and that of Addis Ababa University.

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ACRONYMS AND ABBREVATIONS

ATA	Agricultural Transformation Agency
CSA	Central Statistical Agency
DA	Development Agent
DAP	Di- Ammonium Phosphate
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
MOA	Ministry of Agriculture
NPS	Nitrogen, Phosphorus and Sulfur
NPSZ	Nitrogen, Phosphorus, Sulfur and zinc
PE	Productive Efficiency
SEPRS	Southern Ethiopia Peoples Regional State
SFP	Stochastic Frontier Production
TE	Technical Efficiency
UN	United Nation
USD	United State Dollar

ABSTRACT

In Ethiopia increasing agricultural production of staple crops is necessary for economic growth, the alleviation of poverty as well as improvement of the security of food and nutrition. In the wolayta zone, teff is one of the staples crops which regions with utilization of resource and improvement of efficiency of production is as to obtain greater output in the production system. The aim of this study was to analyze the level of the technical efficiency of teff production among smallholder farmers and its determinants in Wolayta zone. A multi-stage sampling technique was employed to select 286 sample farmers. Quantitative data were collected through individual survey based structured questionnaires. The questionnaires were designed and formulated to collect information about socio-economic and demographic determinants of technical efficiency of teff production from sampled farm house holds to obtain data pertaining to teff production during 2023/2024 production year. A Cobb-Douglas trans log production model was used to estimate technical efficiency and probit model was used to identify the determinants of technical inefficiency of teff production. The parameter estimation technical efficiency showed that teff output was positively and significantly influenced by 27%, by Urea 7%, NPS 8%, pesticide 16% oxen days 8%, labour days 8% improved seed 8% and local seed affect negatively by 11%. The technical efficiency teff production is positively and negatively affected by education 4.8%, training 3.4%, experience 0.2%, age 0.2%, family size -0.7, extension contact -0.2% and non-farm income -5.5% affected technical inefficiency of teff production in the study area. This would mean that there is a room to increase technical efficiency of teff production. From this result I recommended to increase the farmers technical efficiency in teff production such as urea NPS and pesticides. Because of education variable affect technical inefficiency negatively the zonal administrator needs to improve education status of the farmers.

Key words: Approach, Technical efficiency, stochastic frontier approach, wolayta zone, Ethiopia.

CHAPTER ONE

1. INTRODUCTION

1.1 Background of the study

Growth in agriculture is a primary factor in Ethiopia's impressive economic growth over the past ten years (Moges et al., (2018). By 2040, more than 40 percent of people are expected to live in rural areas than in urban areas (UN, 2014), with smallholder farming households accounting for 94% of the country cropped land (CSA, 2014a). With this, nearly 70% of Ethiopia's population is expected to live in rural areas. Smallholders' landholding decreased from an average of one hectare between 2004/2005 and 2013/2014, but the number and size of households rose (CSA, 2005a–2014a). Since the introduction of the Agricultural Development Led Industrialization strategy in 1993, the Ethiopian government has prioritized smallholder agriculture through major agricultural and rural development policy initiatives. This is due in part to the fact that the majority of Ethiopians, including the impoverished, work in the agricultural sector (Government of Ethiopia, 1993).

With more than 50% of GDP and more than 85% of the labor force employed, agriculture is the main economic sector in Ethiopia (Welteji,2018). A sizable section of Ethiopia's population, income, foreign exchange, and employment generation are derived from agriculture (Anbes,2020; CSA,2018; Mekonen, 2015). This agriculture plays a key role in the economy, which is defined

by a sophisticated agricultural expansion strategy that leads to industrialization. As a result, agriculture provides 72.7% of the raw materials used by national industries, over 50% of GDP, 90% of export revenue and 85% of the labour force (Anbes, 2020; CIA, 2018; CSA, 2018; Teklu and Tefera, 2005). Because of the inadequate attention paid to the agricultural sector, the yield, productivity, and efficiency levels of the agriculture is typically below the global norm.

The sector's output, productivity, and efficiency levels are significantly lower than the global average. The teff crop is the second most commonly produced and consumed cereal in Ethiopia, Alemu et al., (2018). Between 2004/05 and 2013/14, about half of smallholder farmers in the country farmed teff, which made up around 5% of the total agricultural area (CSA, 2014). In comparison to other staple crops, it has historically received less attention while being one of the most widely consumed cereals in Ethiopia. In addition, teff is grown by around 6 million families and is the main cereal crop in more than 30 of the 83 high-potential agricultural regions. Teff is the most widely cultivated cereal in terms of production area and is surpassed only by maize in terms of consumption. However, the amount of grain available to consumers is reduced by up to 50% due to low yields (around 1.4 tons/ha) and significant loss rates (25–30% before and after harvest) (CSA, 2014).

In the country, improving the total yield and productivity is a necessity and the most important concern in their plan and policies. output and productivity can be enhanced by using recommended inputs and advancements in technology and efficiency of growers (CSA, 2019; Thiam et al., 2001). Improving technical efficiency in output allows growers to improve their output without any additional inputs and advanced yield technologies (CSA, 2017; FAO, 2015; Fischer et al., 2014). That means using new improved technologies is less cost-effective than applying existing technologies.

A large number of teff growers face low use of existing technologies and inputs due to socio-economic and socio-cultural constraints. The average national productivity of teff in Ethiopia is 1.75 ton per hectare at the cultivators' level which is very low. However, through research and applying improved agricultural technologies, teff productivity can be raised to 5 tons.

The technical efficiency of teff growing was not consistently found in these many empirical researches, but overall teff growth, productivity, and technical efficiency were relatively low. (Beyan et al., 2013; Idiong, 2007, Alemu et al., 2018; Mamo et al., 2018; Solomon, 2014; Toma et al., 2017). Developing on the existing studies, this research expands the analysis by looking into important set of poverty and food insecurity measures. Improving overall output and productivity is the top objective in most developing nations' program (Wassie, 2014).

1.2. Statements of the Problem

Improving overall output and productivity is the top objective in most developing nation's program; it is not an alternative (Wassie, 2014). Efficiency measurement has continued to be a major field of study, particularly in developing nations where resources are limited and chances to advance through the creation or adoption of new technologies are disappearing (Hagoes, 2014). With 40% of GDP, 65% of employment, and more than 80% of the nation's export values, agriculture dominates the Ethiopian economy (World Bank, 2019; Central Statistics Agency, 2017/18, see Agricultural Transformation Agency (ATA), 2018/2019). Ethiopia and other emerging nations have poor levels of agricultural productivity and output, and the rise of agricultural output has not kept pace with population growth. High potential areas in Ethiopia have the capacity to produce enough grains to meet the demands of the areas experiencing deficits. But inefficient agricultural systems prevent farmers from producing as much as is anticipated (Yimenu, 2017).

Some research concerning new and improved agricultural technology is highly focused on factors that influence agricultural technology adoption, but it is not complementary to its determinants of technical efficiency implementation (Ahmed et al., 2013; Kebede et al., 2017; Arega et al., 2010; Biftu et al., 2016). Therefore, it is very difficult to have a clear understanding of the adoption of improved new agricultural technology and its technical efficiency.

Mekonnen et al., (2015) developed their study employing stochastic frontier production function to estimate cereal crop efficiency in South Omo Zone, Southern Ethiopia. The findings presented that average technical efficiency was found to be 67.11%. Also, the findings of the inefficiency model presented that education and credit use were positively related to technical inefficiencies. Understanding the determinants underlying growers of technical efficiency is important to improve teff yield through enhanced participation of such technical efficiency. There is different literature focusing on factors affecting technical efficiency (Bamiro and Janet, 2013; Danso-Abbeam et al., 2012; Gebrehaweria et al., 2012; Geta et al., 2013; Kadiri et al., 2014; Tefera et al., 2014; Tolga et al., 2009). Their research indicates that the following factors have an impact on technical efficiency: age, sex, educational attainment, oxen, area, pesticide costs, family size, landholding, land ownerships, experience, revenue from sources other than farming, credit, extension, infrastructure, seed, training, distance from the land, and fertilizer. The technical efficiency of teff growing was not consistently found in these many empirical research, but overall teff growth, productivity, and technical efficiency were relatively low. (Beyan et al., 2013; Idiong, 2007, Alemu et al., 2018; Mamo et al., 2018; Solomon, 2014; Toma et al., 2017).

According to a study of Crymes (2015) by 25–30% of the teff crop would be lost both before and after harvest, and lodging could account for up to 30% of the output loss (CSA, 2019). However, teff production can be increased to 5 tone per hectaret by conducting research and implementing new agricultural methods (Wassie, 2014). It is necessary to understand the current levels of resource allocation if smallholder farmers are to become more efficient.

To the best of the author's knowledge, there are no similar studies undertaken on technical efficiency of teff producing household in wolayta zone, southern Ethiopia. However, the productivity of teff in the study area is very low. This study was mainly concerned on increasing productivity through enhancing the technical efficiency among smallholder farmer's teff production in Wolayta zone.

1.3.Objective of the study

The general objective of this study was to analyze the level of the technical efficiency of teff producing farmers and its determinants in Wolayta zone.

1.3.1. Specific objectives

The specific objectives of the study were;

i. To estimate the level of technical efficiency.
ii. To identify the key factors affecting technical efficiency of teff production among farmers in the Wolayta zone.
iii. To find out key constraint of technical inefficiency of teff production of small farmers in Wolayta zone.

1.4.Research Questions

i. What are the factors affecting the level of technical efficiency in teff production smallholder farmers: in Wolayta zone?
ii. How can improve production and productivity of teff in Wolayta zone?
iii. what are the key determinants of technical inefficiency of teff production among smallholder farmers: in Wolayta zone?

1.5.Significance of the Study

The study was focused on the analysis of technical efficiency of teff among smallholder farmer's Teff production in wolayta zone of southern region. Like any other developing nations of the world, one of the goals of the government of Ethiopia is, to raise agricultural production and productivity, by providing possible assistance, to assert the economic sustainability of rural small-scale peasants and to avoid or at least reduce the rampant poverty. Hence, this paper could be significant because it attempts to analyze the technical efficiency of Teff production among smallholder farmers. In addition, it could also enable to have some guide lines on what type of inputs should the government give emphasis to provide for farmers and what type of input the farmers should use to improve productivity based on the findings, conclusions, and recommendations. It helps policy makers to easily identify the determinants of technical efficiency of teff production. In addition, it may be used as a source of information for those researchers who want to conduct a deeper study in the area.

1.6. Scope and Limitations of the study

This study was focused on technical efficiency of teff among smallholder farmer's Teff production in the wolayta zone, using cross-sectional data of the of 2023/24G.C production year and data was collected from 286 sampled teff producing farmers. Transportation cost and distance of the study area was one of the examinant challenges to collect data from the farm house holds and to accomplish the study. The other limitation was the study is limited to analysis of technical efficiency of teff production without regard to other crops. The budget and time constraints and the study was limited to only wolayta zone, Southern Ethiopia regional state.

1.7. **Organization of the Thesis**

This paper was organized in to five chapters. Chapter one constituted the introduction, which focused mainly on the background, statement of the problem, objectives, research question, significance of the study, the scope and its limitation. Chapter two was deal with the review of the theoretical and empirical literature pertinent to the concern of the study. Chapter three was described the research methodology that included a brief description of data collection method, procedures, analytical model and techniques of estimation method. Chapter four was dealt on results and discussion of the study. Finally, summary and recommendation were be presented in Chapter five.

CHAPTER TWO

2. LITERATURE REVIEW

2.3.The concepts and definition of Technical Efficiency.

Derived from the production function, technical efficiency is a part of productive efficiency. Technical efficiency and allocative or factor price efficiency make up productive efficiency (Joseph, 2014). According to Adedeji et al., (2019), technical efficiency can be expressed as the ratio of the observed output to the maximum output or, conversely, as the ratio of the observed input to the minimal input when operating under the premise of fixed output. The term "production frontier," also known as "technical efficiency," refers to the lowest level of input bundles needed to generate a certain level of output or the highest level of output that can be produced from a given level of inputs (Wassie, 2014). Although the phrases technical efficiency and production efficiency have certain similarities, they are not the same (Dessale, 2020-).

Technical efficiency (TE) is output maximization from a given mix of inputs, whereas productive efficiency (PE) is cost minimization through input mix adjustments (Palmer and Torgerson, 1999). This is the simplest approach to distinguish between TE and production efficiency. Technical efficiency, which describes a company's physical performance, gauges a farmer's relative capacity to produce the most at a given input, or collection of inputs, as feasible (Asefa, 2011).

A producer's technical efficiency is determined by comparing its input and output values at optimal and observed levels. It describes the capacity to prevent waste by either using as little input as necessary for output production and technology-enabled output generation, or by producing as much output as possible. Farmers who operate on the production frontier, which denotes the highest output possible from each input level, are considered technically efficient. The amount that a company falls short of its profit or production frontier is known as technical inefficiency. The further out from the frontier the firm is, the less efficient it is (Farrell, 1957).

Ethiopia is the centre of teff's diversity and origin; according to Vavilov (1951), teff, scientifically known as Eragrostistef (Zucc.), is said to have originated in Ethiopia; teff is a small, spherical, khaki-colored grain that resembles millet quite a bit; the Amharic term for "lost," "teffa," gets its name from the small size of teff; the world's tiniest grain, its small size often causes it to be overlooked during the threshing and harvesting process. From teff, the preferred staple diet made in the Ethiopian and Eritrean people is injera, a flat, sour-like fermented pancake that is used with “wot,” a stew made with spices, meats, and pulses, like lentils, beans, and split peas (Piccinin, 2002).

Teff output the least of all cereal crops, with a meager 1.3 tons per hectare. In addition, teff has been aggressively sold for many years and is cultivated solely by smallholders (FAO, 2015). Up until recently, Ethiopia's (and formerly Eritrea's) market was nearly entirely domestic; nevertheless, a potential niche export market is currently emerging in Europe and Americ a (Samuel and Sharp, 2008). Teff Longer storage times without significant effects are possible (Bekabil et al., 2011).

2.2. Concepts and Definition of Teff Production System.

In Ethiopia and Eritrea, teff is a staple crop that is mostly used to make injera, a spongy flatbread that is typically consumed with meals. The most significant grain crop in Ethiopia, teff products made up 12% of the nation's food expenditures in 2011. Teff makes approximately to 20% of Ethiopia's total cultivated land. Approximately 48% of the nation's teff is produced in Oromia, with 39% coming from Amhara. Over the past few decades, there has been a rise in teff production, which has been linked to an increase in the area of land planted with the crop. Because teff costs more per kilogram than other grains, it is prized for use at home and as a cash crop.

Teff is prized for its fine straw, which is utilized in building and as animal feed. Teff is a hardy crop in contrast to other cereals. It is resilient to floods and droughts. It may be produced in various agro-ecological zones and elevations, and it can be readily interplanted with other crops. Furthermore, due to the low entry of storage insect pests, it attracts few illnesses and insect pests, and post-harvest loss is negligible. Compared to wheat, maize, or rice, teff is considered a "orphan crop" and is not as well-researched, despite its significance in Ethiopia. This is most likely a result of the worldwide agricultural research and governmental organizations' research agendas, which favor studies on high-yield cereal crops farmed elsewhere. Teff has not yet profited from decades of research aimed at raising its yields, and much more needs to be discovered on each link in the value chain.

Nutritional value of Teff: Teff resembles what in terms of protein content and is composed primarly of complex carbohydrats. Teff is a good source of fatty acids, fiber, calcium, and iron when compared to other cereals. Outside of Ethiopia, there is a developing market for teff, an ingredient devoid of gluten. Although teff has long been believed to be high in iron, new research indicates that this is actually the result of soil combined with the grain rather than the crop itself (Baya, 2014)

Traditional agricultural practices of teff farm: teff is typically grown by ethiopia farmers on several pieces of land in a rotation with other crops. According to one study, teff is grown on an average of four plots. Teff is not typically planted by farmers two years in arow; instead, onions, chickpeas, common beans, and lentils are frequently planted in its place. The main labor utilized to produce teff is family labour (63%), followed by hired labour (11%), and reciprocal labor (22%). Because teff costs more per kilogram than other grains, it is prized for use at home and as a cash crop. Teff is prized for its fine straw, which is utilized in building and animal feed. Teff is a hardy crop in contrast to other cereals. It is resilient to floods and droughts (Temesgen, 2018).

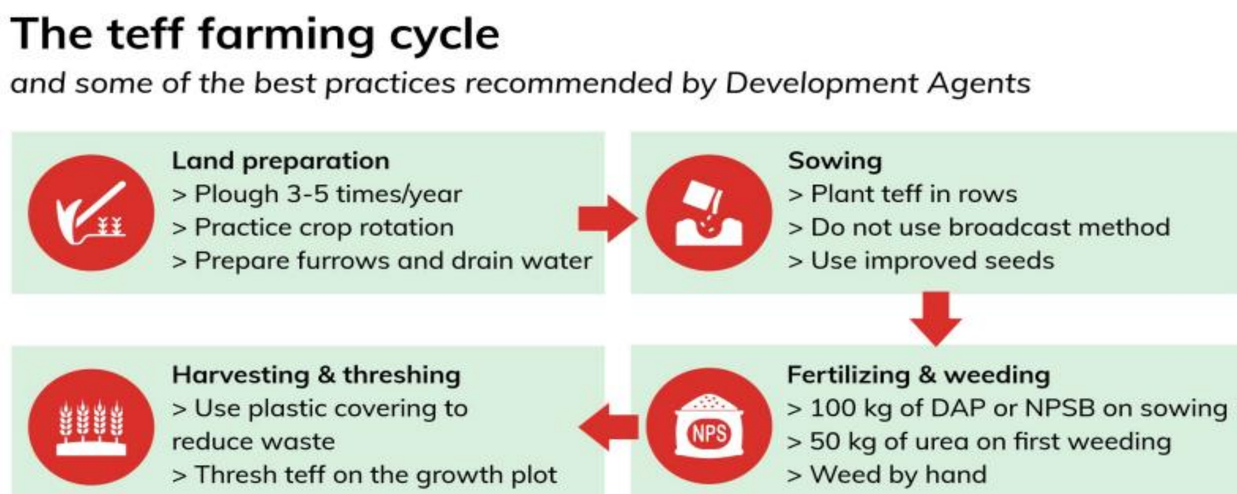


Figure 1 the teff farming cycle.

2.4. Approaches of Measuring Efficiency

The output-oriented approach and the input-oriented approach are the two methods used to quantify technical efficiency (Shumet, 2011). The question with the output-oriented approach is how much more output could be produced at a given level of inputs. Whereas in the second method the interest is the amount by which inputs could be minimized to attain technically efficient level of production (Murillo-Zamorano, 2004). These methods are also known as input-overuse and output shortfall, respectively.

2.4.1. Input oriented measure

In his seminal work on efficiency, Farrell (1957) used the following graphic to demonstrate his concept of assessing efficiency. The technically efficient combinations of inputs, X1 and X2, that are employed to produce output Q are represented by the isoquant SS'. The best practice production frontier is another name for SS'. An isocost line, denoted as AA', displays every possible combination of inputs X1 and X2 that should be employed to ensure that the total cost of inputs remains constant throughout. To maximize earnings, a farmer must, nonetheless, produce at Q', a tangency point that denotes the least expensive combination of X1 and X2 in the creation of Q. The producer is economically efficient at point Q' (International Institute of Science,2018).

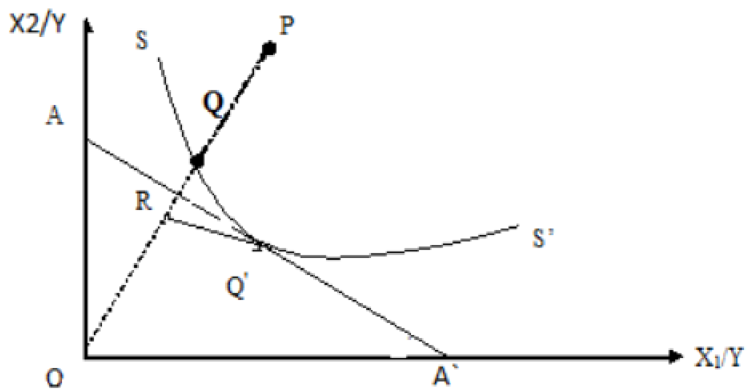
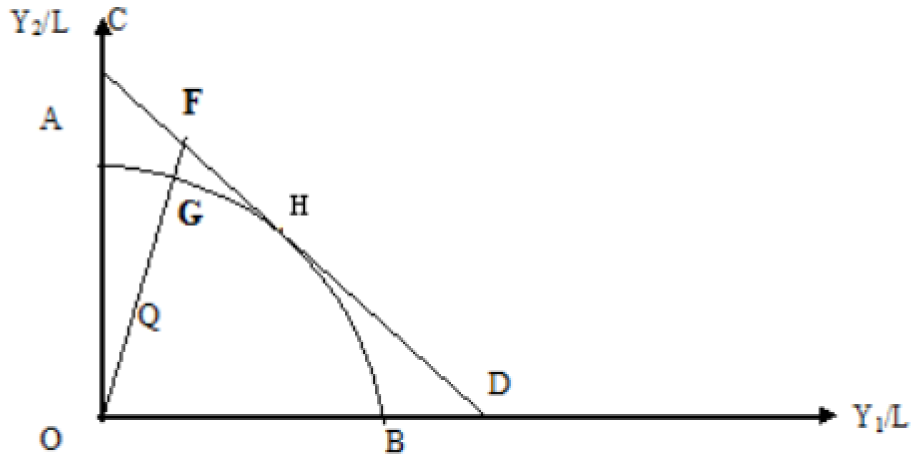


Figure 2 Input oriented measures of technical efficiency

In Figure 1, let's imagine a farmer who is using the input combination (X1 and X2) shown on the iso-quant SS′ to produce his output. The production at point P is not technically efficient because a lower amount of inputs (Q) is needed to produce the same quantity on iso-quant SS′. Essentially, the farmer could achieve the same level of production with less inputs (X1 and X2) at point Q on the input-input space SS. The technical efficiency of a farm is measured by the ratio of the observed output (OQ) to the maximum potential output (OP) that could be achieved with the same level of inputs. This ratio represents the degree to which the farm is able to maximize its output without increasing the use of any inputs. Farmers who operate along the isoquant curve, which represents the maximum possible output for a given set of inputs, are considered to be 100% technically efficient.

2.4.2. Output oriented measure

Efficiency is calculated from an output-oriented perspective while maintaining constant inputs. Farrell (1957) asserts that the scenario in which production comprises two outputs (Y1 and Y2) and a single input (L) can be used to explain output-oriented measurements. A two-dimensional production possibility curve can represent the technology as follows, provided that the input amount is held constant at a given level.



(Source: Coelli, Rao, and Battese (1998).

Figure 3 Output oriented measures for technical efficiency

The production possibility curve, represented by the curve AB in Figure 4, depicts the technically efficient combinations of producing outputs Y1/L and Y2/L given the same level of input L. A firm operating at point Q on the graph is not technically efficient, as the technical efficiency can be calculated as the ratio of the observed output OQ to the maximum potential output OG. Conversely, all farmers producing along the production possibility curve are considered to be 100% technically efficient. Based on this, the researcher will use an output-oriented measure of technical efficiency to assess the farms.

2.4.3. Approaches of efficiency measurement

In frontier models, technical efficiency is measured by comparing an individual producer's performance to that of the most efficient producer in the industry. There are two main methodological approaches used to measure technical efficiency: the econometric (parametric) approach and the mathematical (non-parametric) approach. The parametric models use econometric methods to estimate the production function, while the non-parametric methods, such as Data Envelopment Analysis, rely on categorizing quantitative and qualitative variables.

This study will use the parametric (econometric) approach. Parametric efficiency measures assume the production function of the fully efficient firm is known, but in reality, this is not the case, so the efficient isoquant must be estimated from the sample data using the best performing firms as the reference. There are two main types of parametric frontier models - deterministic and stochastic frontier production (SFP) models. The key difference is how they treat the error term. The deterministic model assumes any deviation from the frontier is due to inefficiency, while the stochastic approach allows for statistical noise. The deterministic frontier model is defined as: $\ln (Y_i) = F (X_i; \beta_i) - U_i$

Where Yi is output, Xi are inputs, β are parameters, and Ui is the inefficiency term.

The stochastic frontier production (SFP) function addresses limitations of the deterministic approach by incorporating a two-part error term - a random error component (v) and the inefficiency component (u). The SFP can be estimated via maximum likelihood (ML) or corrected ordinary least squares (COLS), with ML being the preferred and more efficient method.

2.5. Empirical Literature Review

This subchapter examines recent studies on technical efficiency (TE) in different parts of the world, with a focus on TE of single crop production. This particular study also concentrates on single crop teff production using an output-oriented approach.

Dawit et al. (2012) conducted a stochastic frontier analysis to estimate the level of TE in agriculture for 29 developing countries in Africa and Asia from 1994-2000. Their findings revealed the mean TE was around 86%, suggesting there is potential to increase production through better allocation of existing resources. Factors like agricultural R&D, education, and irrigation were found to enhance TE, while foreign aid and investment were associated with lower TE.

Isaac et al. (2011) applied a stochastic frontier production model to estimate the TE of maize production in Nigeria, and determined that farm size and seed positively influenced efficiency.

Abdi et al. (2012) analyzed the TE in wheat production in Punjab, India using a Cobb-Douglas frontier. The mean TE was 47.1%, indicating there is scope to increase productivity through improved seed quality and irrigation.

Hailemaraim (2015) estimated a mean TE of 72% for teff production in Ethiopia, with factors like fertility, off-farm work, education, and extension affecting efficiency levels. Teffera et al. (2014) also found potential to raise teff yields through efficiency gains and better input use.

Essa et al. (2011) assessed resource use efficiency for teff, wheat, and chickpea in Ethiopia. They identified inefficiencies that could be addressed through integrated crop-livestock systems, off-farm activities, community leadership involvement, and market infrastructure development to enhance productivity

Teffera et al. (2014) conducted a study on the technical efficiency of teff production in the Raya Alamata woreda using a Cobb-Douglas stochastic production frontier approach. The results showed that farmers in the Raya Alamata region have the potential to increase teff productivity by improving technical efficiency under the existing input use and technology. The study found that teff yields can be increased through the adoption of better production practices and technologies. Fertilizer application rate was found to have a positive and significant contribution to teff production, indicating that increasing fertilizer use could help boost teff output. Additionally, the education level of farming households had a significant positive impact on teff production, suggesting improvements in farmer education could lead to efficiency gains and higher teff yields. The study also identified sources of inefficiency in teff production, including the use of poor-quality seeds year after year and large farm sizes.

Essa et al. (2011) assessed farm-level resource use efficiency in the production of teff, wheat and chickpea using a cross-sectional data obtained from 700 rural households in the central highland of Ethiopia. The data envelopment analysis results showed that smallholder farmers were resource use inefficient and the regression results on the determinants of inefficiency revealed that livestock ownership and participation in off-farm activities were significantly associated with reduced level of resource use inefficiency. It was also found that those households whose decision makers have roles in their community activities show improve resource use efficiency. The study also suggested that resource use efficiency would be significantly improved through a better integrated livestock and crop production systems; off farm activities and integrating community leadership in various community activities and programs. Moreover, market infrastructure development would likely increase efficiency and agricultural productivity.

Beyan et al. (2013) analyzed the technical efficiency of smallholder farmers in Girawa through a Cobb-Douglas stochastic production frontier. The results from the production function showed that fertilizer, inorganic inputs, labor, oxen power, and seed were statistically significant factors. The study also found that technical efficiency of farmers is positively associated with education, extension services, and livestock holdings. Thus, education and extension services increase efficiency by enhancing farmers' awareness and ability in properly using farm inputs, controlling pests and crop diseases, and overall farm management. Livestock ownership enhances efficiency directly through use in farming operations, and indirectly by providing financial support in poor production years.

Similarly, Asefa Solomon (2012) confirmed the importance of education and extension services in improving technical efficiency of Ethiopian smallholder farmers.

Solomon (2014) used the stochastic production frontier model to identify factors affecting technical efficiency of crop production, finding that the age of the household head was a negative and significant determinant of technical inefficiency. Conversely, age had a positive and significant effect on the technical efficiency of teff production. Teff has significant potential for growth, as it has received limited research, development, and public support despite being the second most widely produced and consumed cereal in Ethiopia. Teff remains an important crop for Ethiopian farmers due to its higher grain and straw prices compared to other cereals, better performance under moisture stress and waterlogged conditions, and longer storability without pest damage

Getahun (2014) conducted a study on the relationship between off-farm income and technical efficiency of smallholder farmers in Ethiopia. The study used a stochastic frontier model to derive individual efficiency scores and estimate the factors determining technical efficiency in smallholder farming. The Cobb-Douglas production function was found to be more appropriate in representing the data than the translog. The estimation results show that farm land size, household size, off-farm income, and education of the household head are the most significant variables determining the value of farm output. The average technical efficiency of farmers is only 53 percent, indicating a wide scope for improving their efficiency.

Additionally, the maximum likelihood estimation results indicate that household size, education of the head, extension services, and off-farm income are major factors influencing differences in technical efficiency among farmers.

Endrias et al. (2013) applied a Data Envelopment Analysis (DEA) model and found that the average technical efficiency of maize production in the Wolaita and Gamo Gofa zones of the

Southern Nations, Nationalities and Peoples Region of Ethiopia was around 0.40. This implies that if the average farmer achieved the technical efficiency level of the most efficient counterpart, they could realize a 60 percent cost savings. This indicates a substantial amount of technical inefficiency in maize production. However, about 7.26 percent of the decision-making units (DMUs) operated at greater than 90 percent technical efficiency level in maize production. The study also used a Tobit model to show that farm size and oxen holding were highly significant factors affecting the technical efficiency of smallholder maize producers.

A study on the technical effectiveness of haricot bean seed production in the southern Ethiopian region of Boricha woreda in Sidama zone was conducted by Abebayehu (2011). It was predicated on cross-sectional data gathered from 120 farmers who multiplied haricot bean seeds in the 2010–11 growing season. The area's haricot bean seed growers were evaluated for efficiency using the Cobb-Douglas production function. Based on the calculated SPF model, he found that the production level was significantly influenced by the plot area, DAP fertiliser, seed, oxen, and amount of pre-harvest labour. The findings also showed that the research area's haricot bean seed production was inefficient, with a 74 percent relative divergence from the frontier as a result of this inefficiency. The estimated Cobb-Douglas SPF with inefficiency variables showed that the mean TE of farmers in the production of haricot bean seed was 69.5 percent. His result implied that education, livestock holding, and membership in seed multiplying cooperative were important factors in determining the existing efficiency of farmers.

Mohammed et al., (2010) assessed the Asasa woreda in southeast Ethiopia's scarcely production's technical efficiency. By fitting a translog stochastic production function, they were able to determine the level and determinants of the efficiency differential across farmers in a one-stage estimation approach. According to the study, farmers in the region were only using, on average, 55% of the technology available to them, which prevented them from reaching their full potential. Livestock holding, contact with extension, the field's intrinsic fertility condition, weed control, and rotation were found to be significant in determining inefficiency out of the eleven variables included in the inefficiency model. Coefficients of livestock holding and rotation practice representing fallow/pulse was negative indicating complimentary effect of livestock on barely production and plots that followed pulse or fallow were more efficient than plots which followed linseed. Besides, coefficients of contact with extension, inherent fertility status of the field and weed management were found positive which is beyond expectations made.

A study on the factors influencing smallholder farmers' technical efficiency in producing maize in Dhidhessa Woreda, Illubabor zone, Ethiopia, was conducted by Wondimu (2013). The Stochastic Production Frontier (SPF) result showed that the amount of land planted to maize and the use of chemical fertilizers seemed to have a major impact on the yield of maize. While return to scale was 0.96 percent, the average technical efficiency was 86 percent. The findings indicated that there was potential for a 14% increase in maize yield by making effective use of the resources already in place. Hence if the experience and knowledge of farm household heads that attained higher technical efficiency were shared among other farmers in the woreda, an additional output of 2060 quintals of maize could have been produced given 7550 hectares of land allocated to maize production during the study period in the woreda. As a result, there was plenty of room to increase maize output given the resources already available and the state of production technology. The socioeconomic factors of age, education, better seed, training in maize production, and labour availability in the home all played significant roles in the variances in technical efficiency.

In the South Wollo Zone of Ethiopia, smallholder farmers plant wheat crops. Hassen (2016) assessed the technical efficiency of these crops and determined the factors influencing it. The Stochastic production Frontier (SPF) analysis results indicated that the amount of fertilizer applied, the type of seed used, the number of man-days of labor, and the area planted to wheat appeared to be significantly influencing wheat production at a probability level of less than 1%. The average technical efficiency was 78 percent, indicating that farmers are operating at an increasing return to scale, even if the return to scale was 1.17 percent. Variations in technical efficiency were significantly influenced by the socioeconomic parameters of age, education, size of farm, number of oxen retained, and livestock holding in the Tropical Livestock Unit. However, it was discovered that farm households' efficiency was greatly reduced when they participated in off-farm income. This suggests that farm households have room to improve their technical efficiency.

Ethiopia's central and northwest highlands have historically been the country's primary teff-producing regions. The Oromia region is the nation's most significant teff-producing region; according to estimates, it accounts for up to 48% of the nation's overall production (Ibrahim et al., 2018). As per the Central Statistical Agency data for the 4 2018/2019 crop year, teff accounts for 29.46 percent of the total acreage allotted for cereal crops in the Oromia region, placing it at the top of the list. During the production year, 2.56 million tons of teff were produced on 1.43 million hectares of land, yielding 1.79 t/ha from 2.57 million holders (CSA, 2019). In Jimma zone, 0.55 million private peasant holders cultivated wheat on 0.18 million hectares, yielding a total of 0.26 million tons of teff produced in 2016–17. 1.51 t/ha was the average productivity reported (CSA, 2017).

The aforementioned empirical research, conducted in various agroclimatic and socioeconomic environments throughout Ethiopia, revealed the presence of efficiency disparities among smallholder farmers.

Moreover, this study also will show that there will considerable variations of factors of inefficiency which are responsible for efficiency differentials. Though production efficiency of different crops has been investigated in wolayta zone, production efficiency of teff in the study area is not been covered as far as the knowledge of the author of thesis goes.

2.6.Conceptual Framework of the study

The majority of empirical studies on productivity and efficiency assessment have used the analytical framework offered by the economic theory of production. The production function, which assumes a clear link between output and factor inputs, is the cornerstone of the theory. Productivity can be obtained in two ways: first, by pushing the production frontier upward through technological advancements in the use of improved production practices like ploughs, fertilizers, pesticides, improved seeds, etc.; second, by increasing farmer proficiency with the use of current production techniques (Ayele et al, 2006). The majority of empirical studies on efficiency are theoretically underpinned by the microeconomic theory of production, which defines production as the conversion of inputs into outputs (Tabe-Ojong and Molua, 2017). Conversely, productivity is merely a measure of how much an output is worth in relation to the inputs used in agricultural production.

The production of teff requires inputs including manpower, oxen power (quantity), acreage, and fertilizers. The policy framework in existence may have an impact on the distribution and availability of these inputs, which ultimately impacts teff production. It is anticipated that increased teff productivity results from farmers using more inputs up to the suggested level. Technical efficiency also has an impact on teff productivity because efficient utilization of available inputs is essential to a successful production. However, other factors that affect farmers' productivity include their traits, the traits of their cultivated land, crop-specific factors, institutional factors, and their socioeconomic background. Therefore, a technically proficient farmer should have increased teff productivity as opposed to a less proficient one in teff farming. Consequently, this benefits the farmers who grow teff, which benefits their welfare. Policy makers learn pertinent lessons and have more access to production inputs as a result of improved farmer wellbeing. To conduct this study, both demographic and socioeconomic Variables are taken as independent variables while the teff production of the farm household is the dependent variable.

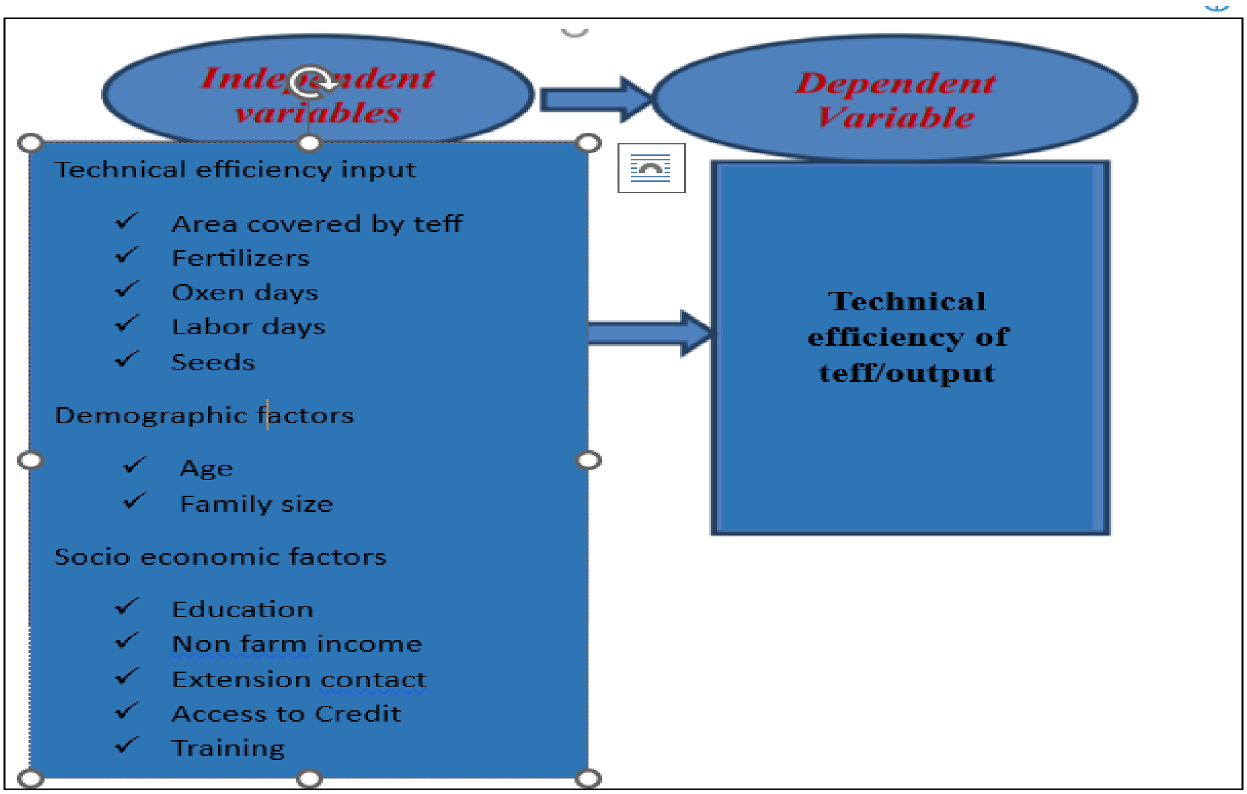


Figure 4 Conceptual framework (Source; Literature Reviews (2021))

CHAPTER THREE

3. RESEARCH METHEDOLOGY

3.1.Description of the Study Area

Wolayta zone, with a total land area of 4537.5 square kilometers, is located between 6º4´N to 7º1´N and 37º4´E to 38º2´E and inhabited by the Wolyta speaking people. Wolyta was formally incorporated into the old Ethiopian empire in 1894 (Dea, 1998). At present, Wolaita forms one of the zonal administrations in the Southern Ethiopia Peoples Regional state (SEPRS). The altitude in the zone varies between 900 and 2600 meters above sea level.

Wolayta is roughly divided into two altitudinal zones: the lowlands with hot and semi-dry conditions and the highlands with relatively cooler and sub-humid conditions. Rainfall occurs in two distinct rainy seasons: the main rains (called 'kremt' rains) occur in summer (roughly June, July and August) and a shorter rainy season (called the 'belg' rains) occurs in spring (roughly from mid-February to mid-May). Average annual rainfall varies between 803 mm at Abela Faracho in the lowlands and 1189 mm at Soddo in the highlands. However, the rainfall regime shows high variability, especially in its distribution in all areas over Crop production is the major means of livelihood, but livestock is also kept as a source of food, cash income, draught power and insurance against uncertainty. In the highlands, cereals, root crops and perennials are widely grown, while the hot and semi-dry conditions in the lowlands allow the cultivation of only limited types of crops (Tessema, 2008).

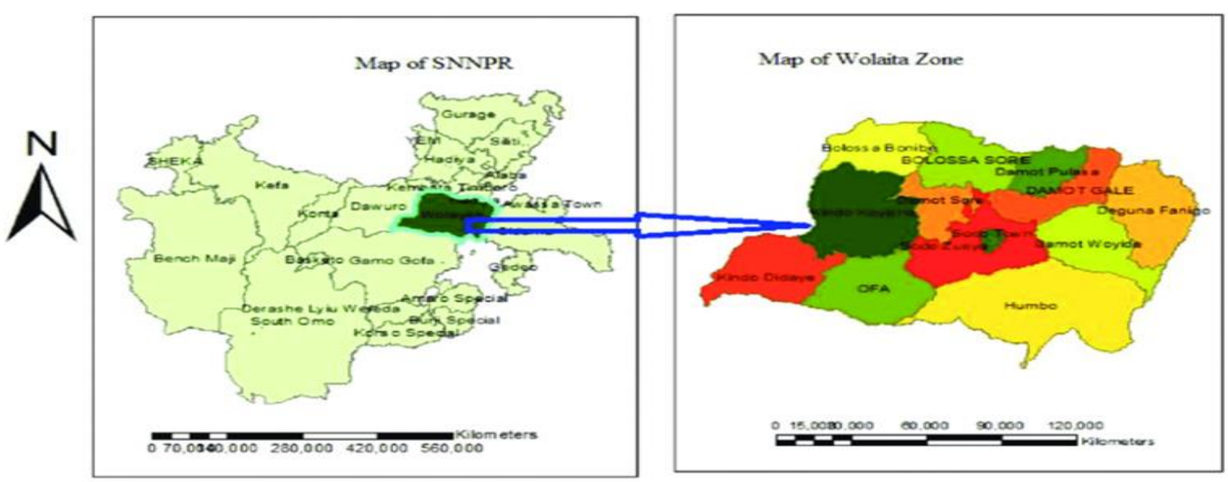


Figure 5 Map of the Study area (Source: zonal finance and economy office)

3.2 Data type and Method of Data Collection.

Both primary and secondary data as well as quantitative and qualitative data were employed for this study. In the study cross-sectional household data of 2023/2024 main harvest cropping season would be used. Data for input (such as land, human labor, oxen labor, fertilizer, and seed amount) were used and output of teff production was collected from the specified period of time. Data on input use and outputs was collected in local units and converting into standard units. In addition, primary data was collected by interviewing the selected teff producing farmers and variables that cause variation in production efficiency like age, education, household size, extension contact, gender, and the like. On the other hand, data related to teff production trend, input supply and extension services was collected to clarify and support analysis and interpretation of primary data.

3.3 Sampling Design

In order to select sampled households, multi-stage sampling techniques were employed. In the first stage, woredas stratified in to teff producing and non- producing woredas, out of 16 woreda 10 woredas are teff producing and six woredas are not producing. Then five known by teff producing woredas namely damot gale, sodo zuriya, Boloso sore, Damot sore and Humbo are randomly selected from ten (10) teff producing woreda. Secondly, five kebeles selected by using simple random sampling technique.

In order to determine a representative sample size from the selected kebeles, the researcher used a sample size determination formula given by Yamane (1967) as cited by (Abugamea, 2018). The relation was given as below. The sample size for the study was determined based on Yamane (1967) since the population was homogenous in agro-ecology and production system. The simplified formula provided by Yamane is used to determine the required sample size at 95% confidence level and 5% level of precision. The simplified formula used to determine the sample size of the study was specified as follows.

$n=N/1+N(e)^{2,}$ Where: n = sample size;

N = total number of teff producing farmers in five kebeles (1,000); e = level of precision (0.05).

n = 286. Based on the formula the total sample size of the study was 286 farmers. In order to determine the number of sample respondents from each five kebeles, the researcher applied the proportional sample determination technique as follow;

ni= Ni/N*n, where ni is the proportional sample taken from each sample kebele.

Ni is the total farmer population of each respective sampled kebele,

N is the sum of the total teff producer population of the five kebeles and n is the total sample size taken.

Therefore, the distribution of samples in to five kebele is shown in the table below;

Table 1 Distribution of Samples across Five woredas

NO	Sampled kebeles	Number of teff producer	Proportional sample	% of Total
1	Buge	250	250*286/1000=71	25%
2	Quxo sorphela	200	200*286/1000=57	20%
3	Admacho	300	300*286/1000=86	30%
4	Fisho Naqe	150	150*286/1000=43	15%
5	Tiyo Himbicho	100	100*286/1000=29	10%
	Total	1000	286	100%

3.4 Methods of Data analysis

The analysis basically was employed both descriptive and Econometric methods. Descriptive statistics (mean, percentage, frequency, etc.) was used to summarize the variables which are used in the model and describe the study area. Econometric model, SPF model, is employed to estimate the elasticity of production function, determine the determinants of efficiency and estimate the level of efficiency.

3.5 Econometric Model Specification

For efficiency studies where there was a chance that variables outside the control of the decision-making unit had an impact, the stochastic production frontier technique was the most suitable. This was due to the fact that this method takes into consideration the inefficiencies that arise from these factors as well as technological faults that may occur during observation and measurement. The output of teff in the study region is probably going to be impacted by unforeseen weather patterns, insect and disease outbreaks, and natural dangers that are out of the farmers' control. Errors in measurement and observation may also arise when gathering data. This study used a stochastic frontier model to describe the effects of these errors. At the same time, Aigner et al., (1977) and Meeusen and Van der Broeck (1977) present stochastic frontier analysis. and Meeusen and Van der Broeck (1977). The stochastic frontier approach splits the deviation (error term) into two parts to accommodate factors which are purely random and are out of the control of the farm. One component is the technical inefficiency of a firm and the other component is random shocks (white noise) such as bad weather, measurement error, and omission of variables and so on. The model was expressed as:

$$\ln Yi = \beta o + \Sigma \beta i \ln Xij + eij \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where: ln = denotes the natural logarithm; i = represent the i^{th} farmer in the sample, Yi = represents output of the i^{th} farmer (Qt), Xij = refers to the farm inputs of the ith farmer, ei = vi-ui which is the residual random term composed of two elements vi and ui.

The vi is a symmetric component and permits a random variation in output due to factors such as weather, omitted variables and other exogenous shocks.

3.6 Selection of the Functional Form

The choice of functional form is another problem with parametric boundaries. The translog and Cobb-Douglas functions have been the most often utilized functional forms among all available algebraic forms in the majority of empirical production analysis studies. Every functional form has benefits and drawbacks of its own. According to some academics, the Cobb-Douglas functional form compares computational feasibility with an appropriate fit to the data, giving it an edge over the other functional forms. It is also highly frugal when it comes to degrees of freedom and convenient for interpreting elasticity of production. It is therefore frequently employed in studies of the frontier production function, as noted by Hazarika and Subramanian (1999). Furthermore, the Cobb-Douglas functional form has been widely employed in the majority of empirical estimations of frontier models because of its qualities of simplicity. Nevertheless, this simplicity comes with certain limitations because it makes the assumptions that elasticity of substitution is equal to one, constant elasticity, and a constant return to scale for all businesses and farms (Coelli et al., 1998). In addition, the Cobb-Douglas functional form is also handy in interpreting the elasticity of production and it is quite parsimonious concerning degrees of freedom. For this reason, the Cobb-Douglas functional form is employed in this investigation. The technical efficiency of teff production in the wolayta will be measured by taking the output gained per household head as the dependent variable. Quintals are will used to represent the amount of teff produced in the 2023–2024 production year. The production inputs (factors) utilized in the same manufacturing year served as the independent variables. Consequently, the following pertinent inputs were be taken into consideration.

Y = the total amount of teff produced in quintal by the i^{th} farmer;

X1= the total number of oxen-power used for teff production in oxen-days by the i^{th} farmer;

X2=the total labor in man-days used for teff production by the i^{th} farmer;

X3=the total quantity of teff in quantal used for teff production by the i^{th} farmer;

X4 = the total amount of fertilizer urea in quantal used for teff production by the i^{th} farmer;

X5= pesticide in liter applied for teff production by the i^{th} farmer;

X6= the total area covered by teff in hectares of the i^{th} farmer and etc.; The Cobb-Douglas form of stochastic frontier production is stated as follows;

$\ln Y = \beta o + \sum_{j=1}^{12} \beta j \ln Xij + V - U$………………………………………… (2)

Where: For ith farmer, Y is the total quantity of teff produced, x is the quantity of input j used in the production process including Oxen, labor, land, quantity of seed and quantity of fertilizer; Vj is the two-sided error term and Uj is the one-sided error term (technical inefficiency effects). The inefficiency model was estimated as the equation given below.

$\ln Y = \delta o + \sum_{n=1}^{12} \delta Zni$………………………………………………………… (3)

Zi is the variable in the inefficiency model. The technical inefficiency (ui) could be estimated by subtracting TE from unity. The function determining the technical inefficiency effect is defined in its general form as a linear function of socio-economic and management factors. It can be defined in the following equation:

$Ui = \delta o + \sum_{k=1}^{12} \delta KZjk$………………………………………………………… (4)

Where, μi is the technical inefficiency effect, δk is the coefficient of explanatory variables, The Zi variables represent the socio-economic characteristics of the farm explaining inefficiency of the ith farmer.

Zil = Age of the household head (years); Zi2 = family size; Zi3 = Education (who can write and read or cannot write and read of the farmer); Zi3 = Number of livestock measured by TLU; Zi4 = Training (A dummy variable. It takes a value of 1 if yes, 0 otherwise); Zi5 = credit (A dummy variable. It takes a value of 1 if yes, 0 otherwise); Zi6 = Experience is a continuous variable that indicated years 0f experience; Zi7 = distance to development center; Zi8 = soil and water conservation; Zi9 = extension contact to improve technical efficiency the farmers should contact extension workers and it dummy variable it takes 0 if extension workers not contact and 1 if they contact; Zi10 = non-farm income it support farmers to improve their productivity by purchasing input from the income of non-farm; Zi11 = Experience is used to improve farmers technical efficiency by correcting the mistakes from 2023/24 production year to 2024/25 and Zi12 = sex is female and male if the respondent male 1, 0 others wise. As a result, the technical inefficiency was explained by the following determinants: The inefficiency function can be specified as:

μi = $\delta 0$ + $\beta 1$Age + $\beta 2$Edu + $\beta 3$Number of livestock + $\beta 4$Training+ $\beta 5$Credit + $\beta 6$ experience + $\beta 7$nonfamin+ $\beta 8$ extension contact + $\beta 9$ sex + $\beta 10$ distance to development center + $\beta 11$family size + $\beta 12$ soil and water conservation + εi. Where, $\boldsymbol{\mu i}$ is the technical inefficiency score; $\boldsymbol{\delta i}$ is a vector of parameter to be estimated; $\boldsymbol{\varepsilon i}$ is error term.

3.7 Variable Definition, Measure and Hypothesis

Teff Output: Output, which was the dependent viable in the estimation of production functions, is measured in quintal.

3.7.1. The independent variables and their hypothesis

Fertilizer: The two fertilizers that are most frequently used in Ethiopia are urea and NPS, and they are crucial production inputs. Ethiopia is using and requiring these fertilizers more than it did in the past (Kefyalew, 2011). Therefore, the study was used the total amount of urea administered per quantal of land. The results of Abebe Dagnew's 2009 study demonstrate that urea raises the production level. Then, it is postulated to boost the production of teff's technical efficiency.

Oxen power: The total number of oxen days that the sample farmer head utilized to complete various plowing tasks, expressed as a numerical value. After that, the production frontier model incorporates it. Oxen power and production level have a favorable link, according to Bamlaku et al. (2009)'s findings.

Labor: A vital component of agricultural productivity is labor. The entire labor force family used by the i^{th} farmer to produce teff in man-days; it was hypothesized that this labor force is positively correlated with technical efficiency. Since labor is the primary input in crop production, a farmer with a larger household could complete crucial crop husbandry procedures on time (Hasssen Beshir, 2011). Then, it was expected to increase technical efficiency of teff production.

Land size(area): is defined as the total area under cultivation, including shared and rented land, by the farmer. The present analysis posits a positive relationship between inefficiency and farm size. Given the amount of technology, a farmer's ability to manage his or her farm will decline as it grows in size, which will lower the farmer's efficiency. As a result, the estimated outcome matches the prediction, and the inefficiency variable's coefficients were determined to be positive and statistically significant. Sultan and Ahmed (2014) and Mwajombe1 and Mlozi (2015).

Seed: This is the quantity of teff that the sampled farmer sowed on the teff patch. By converting the local unit into the standard unit, the quantal, it is included in the production function frontier in physical quantity. Using a stochastic frontier production model, Isaac (2011) discovered that seeds had a positive and large impact on production levels. Therefore, in this research the effect of improved seed on technical efficiency and the effect of local seed on technical efficiency of teff production was analyzed. According to the result improved seed is positively affected technical efficiency of teff production and local seed is negatively affected the technical efficiency of teff production.

Inefficiency variables: These biological and social factors were selected based on prior research and sound rationale, and they were utilized to determine the factors that contribute to inefficiency. The majority of studies examined factors that influence efficiency as opposed to inefficiency. But their interpretations are the only thing that separates them.

♣Age (AGE): This is the head of the household's age expressed in years. According to empirical research, older households have greater experience than younger ones (Addai and Owusu, 2014). However, elderly household heads are less likely than younger ones to adopt new technology, which makes them more inefficient overall (Bekele Alemayehu, 2013). This makes it difficult to determine how this variable affects technical efficiency. Therefore, in this study age was affect technical efficiency of teff producers positively.

♣Education (EDUCATION): This is the household head's educational attainment expressed in can write and read and cannot write read; illiteracy (cannot write and read) is assigned a value of zero. This serves as a stand-in variable for the household head's managerial proficiency. It is believed that education raises labor quality and makes people more willing to use new technology. Higher educated farmers are more likely to be able to perceive and understand professional agricultural guidance. (Dlamini et al., 2010). In this study it is affected technical efficiency positively.

♣Extension contact (EXTFREQ): This is a dummy variable measured as 1 if Extension contact and 0 otherwise. extension experts are deal with helping farmers in adopting new technologies and enhancing productivity in the study areas and it is affected technical efficiency positively.

training: This is a dummy variable that represents the providing training to the farmers concerned to technical use of teff producing system. If the farmer has taken training, the variable takes a value of 1 and 0 otherwise.

Experience: - is one of the important factors which determine management and productivity of teff. So, it is plausible to discuss farming experience of farmers within the sample is affected technical efficiency of teff production positively.

Table 2 Definition of Variables, Measurements and Hypothesis

No	Input Variables	Types	Hypothesis by sign
1	Area	Continuous	+
2	Urea	Continuous	+
3	Oxen power	Continuous	+
4	Labor	Continuous	+
5	Improved seed	Continuous	+
6	Local seed	Continuous	-
7	Pesticide	Continuous	+
8	NPS	Continuous	+
Inefficiency variable			
1	Age	Continuous	+
2	Education	Dummy	+
3	No of livestock	Continuous	+
4	Training	Dummy	+
5	Farm size	Dummy	+

6	Experience	Continuous	+
7	Tot TLU	Continuous	+
8	Extension contacts	Dummy	+

Source: Own Computation.

CHAPTER FOUR

4 RESULT AND DISCUSSION

The results of the econometric analysis and descriptive statistics comprised the two main portions of this chapter. The first section discusses the findings of a descriptive study that employed survey data to characterize the socioeconomic characteristics of sample farmers. The second segment covered the topic of econometric results.

4.1 Descriptive Statistics Result

4.1.1 Descriptive statistics of inefficiency variables

Age: - Age is one of the important factors which determine management experience of farmers. So, it is plausible to discuss age structure of farmers within the sample. The survey result shows that, the average age of the farmers is about 45.7 with min 37 and max 65 and all farmers are economically active. Age of the sample farmer also has implication on farm economy and agricultural productivity. Because availability of work force and other socio-economic factors in the agricultural society might be determined by age of the household.

Livestock holding (LIVH): The Tropical Livestock Unit (TLU) is a key player in boosting teff production, which directly impacts farmers' capacity to supply significant quantities of teff to the market. According to Table 3, tropical livestock ranges from a minimum of 2.08 to a maximum of 7.4, with an average of 3.5.

Farming experience: - is among the key elements that affect teff technical efficiency and management. It is therefore reasonable to talk about the farmers' farming experiences within the sample. According to the study results, the minimum and greatest levels of farming experience are 18 and 35, respectively. The average experience level in farming is 25.

Family size: - is the total number of family members in the sampled respondents mean is 5.5 and minimum and maximum is 3 an10 respectively

Table 3 summery of descriptive statistics of inefficiency continuous variables

Variable	Mean	Std.	Min	Max
Age	45.7	5.4	37	65
Total livestock	3.5	.97	2.08	7.4
Experience	25	5.5	18	35
Family size	5.46	1.8	3	10

Variables		Freq.	Percent
Education	write and read (0)	187	65
	Not read and write (1)	99	35
Training	Not get	52	18
	Get	234	82
Extension contacts	Not get	137	48
	Get	149	52
Non-farm income	Have not	60	20.98
	Have	226	79.02

Source: Survey result, 2024

Education: enhances the will to accept new technology and managerial abilities. A knowledgeable farmer is also open to trying new things on their plots. Production in agriculture is impacted by the educational attainment of the farming community. Due to a drive to eradicate adult illiteracy that has been carried out in recent years, around 34.62 percent of the sample farmer farmers were able to read and write, whereas 65.38 percent of the household heads were illiterate.

Extension contacts: uses to improved technical efficiency and to get new production system. 52 percent of the respondent get contact with extension workers and 48 percent is not get contact with those who are extension workers.

Training: - Table4 shows that 18 percent of the total sample farmers are not get training and 82 percent of the total sample farmers are get training.

Non-farm income: - For farmers, having sufficient funding sources available for credit is essential. Farmers purchase inputs like better seed, fertilizers, weed killers, and animals with the money they get from other sources, which immediately increases the amount of teff products produced and allows farmers to increase the amount of teff given to the market. Only 20 percent of smallholder farmers used have no non-farm income and about 80 percent of the respondents have non-farm income according to the survey results.

4.1.2 Descriptive Statics of Efficiency Variables

Area (size) of farm: - The primary factor in production is land. The sample farmers in the research area covered by teff an average of 0.76 hectares of land. A land holding could be as small as 0.25 hectares or as large as 3 hectares.

Fertilizer: - In order to produce teff, farmers in the research area utilize UREA, NPS and pesticides fertilizer. Private dealers and cooperatives/unions provide these inputs to farmers. Producers in the study area primarily obtain their fertilizer from cooperatives. Fertilizers, like urea, NPS are supplied by the government (zonal input supply enterprise) to unions, who can then sell them to primary cooperatives, which in turn distribute them to farmers and other private input suppliers. The average of Urea used for teff production was .64 quantal and the minimum and maximum amount of Urea applied for the teff production is .25 and 2 quantal per hectare. NPS is other type of fertilizer currently substituted DAP and it was used .53 average and minimum amount applied in the production and maximum amount is .25 and 2 respectively. The third fertilizer applied to kill any disease from the teff production is pesticide. The amount applied in the production average .64 and the minimum and maximum amount of pesticide applied in production is .25 and 2 respectively. All of the smallholder farmers in the sample applied fertilizers; however, 51.4 percent of the farmers applied less urea than the standard amount, and 48.6 percent of the farmers applied the needed amount. 34% of farmers used pesticides, compared to 66% of farmers who did not. Farmers buy those inputs from individual dealers as well as cooperatives, with each sample household purchasing some of them. But because cooperatives offer input at lower prices and their members produce smaller amounts of teff with fewer inputs, farmers prefer to purchase from them rather than from individual traders.

Oxen: -The research area's average number of oxen days of farm participation for teff production during the 2023–2024 production season is approximately 6.9, with a minimum of 1 and a maximum of 20 oxen days. Lack of oxen power results in inadequate land preparation and postpones operation completion. Inadequate preparation of the land results in low yields, severe weed infestation, and poor plant establishment. The sample farmers' ox power consumption was calculated on the assumption that each pair of oxen worked eight hours a day.

Labor: - Human labor is one of the primary production variables and is needed for crop management and production. Over the course of the 2023–2024 production season, an average of 32 man-days per hectare were employed in all agricultural operations related to the production of teff, with a minimum of 15 and a maximum of 88-man days.

Improved Seed: - The average of roughly.19 tested farmers employed improved seed the minimum and maximum amount of improved seed used for teff production is .025 and .5 quantal per hectare. This suggests that a variety of factors, including the lack of improved seed, its high cost, and the poor guidance provided by input providers and extension officials, were at play. The local market, the extension market, and stock from the previous harvest are the main suppliers of seeds. The farmers also used local seed for teff production in the study area. The average of local seed used for production is .21quantal., The minimum and maximum amount of local seed applied for the production is .025 and .7 per hectare.

Table 5 descriptive Summary of efficiency variables for analysis

Source: Survey result, 2024

4.2 Econometric Results

Table 6 displays the maximum likelihood (ML) estimates of the parameter of the stochastic frontier Cobb Douglas production function. The two stages of the estimation of the stochastic frontier model are intended to investigate whether or not the farmers are technically efficient. For comparison, the typical ordinary least square (OLS) estimate is also provided. There are sixteen (16) variables in the data set that was used for this research. fifteen (15) of these variables have coefficient estimates that are significant at the five percent significance level and have the predicted sign, indicating the technical efficiency of teff production in the southern Ethiopian region of Wolayta.

With the use of the program Frontier version 4.1, the maximum likelihood (ML) estimations of the SPF's parameters were determined. The estimated coefficient of area was found to have a positive and negative significant impact on teff productivity at the five percent significance level, according to the MLE data displayed in Table 6. This suggests that a 1% increase in area consumption will result in a 27% increase in teff output. Farmers utilized a considerably lower area rate than the recommended rate. Similarly, at the five percent significance level, the application of chemical fertilizers, specifically urea, had a highly significant and favorable effect on teff productivity. That means if the farmers increased use of urea at 1% the output of teff will increase 7%, citrus paribus.

The effect of NPS usage level on total technical efficiency of teff production of smallholder farm household is positive and statistically significant at 5% statistically significance level. The result states one percent increase in the NPS usage level increase technical efficiency of teff production by 8% keeping other factors constant. This illustrates that farmers that use lower chemical fertilizer at greater rates than the model result. The effect of pesticide usage level on total technical efficiency of teff production of smallholder farm household is positive and statistically significant at 5% statistically significance level. The result shows that one percent increase in the pesticide usage level increase technical efficiency of teff production by 16% keeping other factors constant. The effect of oxen day on total technical efficiency of teff production of smallholder farm household is positive and statistically significant at 5% statistically significance level. This indicates that one percent increase in the oxen day usage level increase technical efficiency of teff production by 8% keeping other factors constant.

The effect of labour day usage level on total technical efficiency of teff production of smallholder farm household is positive and statistically significant at 5% statistically significance level. The result states one percent increase in the lobour usage level increase technical efficiency of teff production by 8% keeping other factors constant. This suggests that improving manpower utilization in procedures like land preparation, fertilizer application, and weeding will greatly enhance teff productivity.

The effect of improved seed usage level on total technical efficiency of teff production of smallholder farm household is positive and statistically significant at 5% statistically significance level. The result states one percent increase in the improved seed usage level increase technical efficiency of teff production by 8% keeping other factors constant. This illustrates that farmers that use lower the lower usage of improved seed in the study area than the model result. The effect of local seed usage level on total technical efficiency of teff production of smallholder farm household is negative and statistically significant at 5% statistically significance level. The result states one percent increase in the local seed usage level decrease technical efficiency of teff production by 11% keeping other factors constant. This illustrates that farmer that higher usage of local seed in the study area than the model result.

Table 6 The ML and OLS estimates of the parametric stochastic production frontier.

ML estimate						OLS estimate			
Variables	para	Coef	Std.Err	Z	p>|z|	Coef	Std.Err	t	p>|t|
Constant	δ	1.78**	.137	13.01	0.000	1.46**	.18	5.13	0.000
Logareahe	$\beta 1$	.27**	.34	7.68	0.026	.21**	.04	2.75	0.006
Logurea	$\beta 2$	.07**	.03	2.22	0.015	.096	.03	1.42	0.158
logNPS	$\beta 3$	.08**	.03	2.43	0.000	.06**	.04	5.17	0.000
Logpesti	$\beta 4$	.16**	.038	7.15	0.000	.25**	.048	6.20	0.000
Logoxenday	$\beta 5$	.08**	.024	7.39	0.000	.20**	.03	4.88	0.000
Loglaborday	$\beta 6$	.08**	.03	5.05	0.000	.20**	.04	2.96	0.003
Logimprov	$\beta 7$	.08**	.03	2.69	0.007	.12**	.039	-3.52	0.000
Loglocal	$\beta 8$	-.11**	.03	-3.65	0.000	-.111**	.037	11.88	0.000

Source; model result; Note: ** indicates significant at 5%

According to the study, the sampled farmers technical efficiency ranges from a minimum of 0.46 to a maximum of 0.97, with an average of 89. The average technical efficiency level also indicates that, with the right steps it is possible to raise the technical efficiency of teff product in the study area. The sample respondents' teff output might rise by approximately 11% on average.

Table 7 The level of technical efficiency

Variable	Mean	Std.Err	Min	Max
Te	.89	.08	.46	.97

Source: - regression result

4.2.1 Determinants technical inefficiency of teff

In order to improve smallholders' agricultural productivity and efficiencies, reduce resource waste, and enhance farmers' livelihoods, it is more crucial to evaluate the factors that influence agricultural production efficiencies than it is to simply present a set of efficiency indices (Tenaye, 2020). The socioeconomic, demographic, agricultural, and institutional aspects that impact teff production efficiency are shown in Table 8. To determine the variables influencing the efficiency levels of the sampled farmers, the Tobit regression model was employed.

The household head's education level, which can be used as a stand-in for a farmer's managerial aptitude, positively and significantly affected the technical efficiencies of teff production at the five percent significance level. The effect of education on total technical efficiency of teff production of smallholder farm household is positive and statistically significant at 5% statistical significance level. The result states that a one percent increase in the education level increase technical efficiency of teff production by 4.8%, keeping other factors constant. This suggests that farmers with higher levels of education are more technically proficient than those who are not educated. Therefore, farmers with greater levels of education are more likely to have better access to agricultural information and to adopt and use improved inputs (such as crop varieties and fertilizers) in a more optimal and effective manner, implying that more educated household heads have an easier time understanding agricultural instructions, are more likely to embrace enhanced production technology, have better access to information, and are capable of putting newly acquired technical abilities to work. Thus, improving the efficiency of teff production in the study areas appears to depend in large part on the education level of the family head. This finding is consistent with other studies of a similar nature, including those by Arega and Reshid (2005), Elibariki et al. (2008), Otitoju and Arene (2010), Shehu et al. (2010), and Shumet (2011), which discovered that farmers who have completed education typically produce crops more efficiently.

The effect of experience level of the household head on total technical efficiency of teff production of smallholder farm household is positive and statistically significant at 5% statistical significance level. The result of the model indicates that a one percent increase in the experience level increases technical efficiency of teff production by 0.24%, other factors remaining constant. This implied that experienced farmers who were older, were more productive than their less experienced or young farmers. This was most likely caused by the farmers' increasing skill level as they grew older from their combined farming experiences. The outcome is consistent with the outcomes of the following studies: Wassun et al. (2019); Dessie et al. (2019); Abate et al. (2019).

The model result shows the effect of total livestock of the household head on total technical inefficiency of teff production of smallholder farm household is negative and statistically significant at 10% statistical significance level. The result of the model indicates that a one percent increase in the total livestock decreases the technical efficiency of teff production by 0.9%, other factors remaining constant. This result indicates that they use income from selling livestock for the purpose of consumption and again to increase the number of livestock rather than buying production inputs.

Table 8 model result also showed that training had a positive and substantial impact on technical efficiencies. The effect of training of the household head on total technical efficiency of teff production of smallholder farm household is positive and statistically significant at 5% statistical significance level. This indicates that a one percent increase in the training level increases technical efficiency of teff production by 3.4%, other factors remaining constant. This suggests that farmers who received instruction are more technically proficient than those who did not. The findings of this study are consistent with those of Mamo et al. (2017) and Asfaw et al. (2019).

Extension contacts are used to improve technical efficiency and to get a new production system. The model result shows the effect of extension contact of the household head on total technical inefficiency of teff production of smallholder farm household is negative and statistically significant at 5% statistical significance level. The result of the model indicates that a one percent increase in the extension contact decreases the technical efficiency of teff production by 2%, other factors remaining constant. But according to the researcher's conclusion, the extension contact should not affect the technical efficiency, therefore this result needs further research for the future. The effect of age of the household head on total technical inefficiency of teff production of smallholder farm household is positive and statistically significant at 5% statistical significance level. The result of the model indicates that a one percent increase in the age increases technical efficiency of teff production by 0.2%, other factors remaining constant. This indicates that the older farmers were more efficient than the younger farmers.

The model result shows a negative relationship of family size of the household head on total technical inefficiency of teff production. It indicates that a one percent increase in family size decreases technical inefficiency by 0.7%. This is because of the high number of young families who cannot contribute to the production process in the study area.

The model result shows the effect of non-farm income of the household head on total technical inefficiency of teff production of smallholder farm household is negative and statistically significant at 5% statistical significance level. The result of the model indicates that a one percent increase in the non-farm income decreases the technical efficiency of teff production by 5.5%, other factors remaining constant. This result indicates that they use income from non-farm for the purpose of consumption rather than buying inputs. The findings of this study are different from those of Essa et al. (2011) by using the SPF model, where off-farm activities supplement the agricultural activities in terms of providing cash income, thereby allowing the purchase of necessary inputs in a timely manner.

Table 8 Marginal Effect After Tobit regression results.

Variables	Coef	Std. Error	t	p>|t|	[95%conf. inter]	
Age	.002**	.0011	2.35	0.019	.0004	.005
Famsze	-.007**	.0031	-2.29	0.023	-.013	-.00009
Edu	.048**	.0096	5	0.000	.029	0.067
Ditastadev	-.005	.0065	-0.72	0.47	-.0177	.008
Solwa	-.01	.013	-0.77	0.44	-.036	.016
TotTLU	-.009	.005	-1.92	0.056	-.018	.0002
Tain	.034**	.012	2.8	0.006	.01	0.06
Sex	.03	.02	1.3	0.19	-.016	.079
Extcont	-.02**	.0097	-2.18	0.030	-.04	-.002
Nonfarin	-.055**	.014	-3.99	0.000	-.08	-.028
Ctedit	-.008	.013	-0.67	0.5	-.035	.017
Exp	0.0024**	.0008	3.09	0.002	.0009	.004
Conist	0.866**	0.06	13.25	0.000	.68	.92

Number of obs =286 LR chi^2 (12) =58.24

Prob > chi^2	=0.000	Pseud R^2	= -.118

Source: Model result (2024); Note: ** indicate the level of significance at 5%; Marginal effects computed only for significant variables. Source; model result.

CHAPTER FIVE

5 SUMMARY, CONCLUSION AND RECOMANDATION

5.1 Summary

This study was carried out to analyze the technical efficiency of teff production using cross-sectional data. The primary objective of this study was to analyze the level of technical efficiency of teff-producing farmers and its determinants in the Wolayta zone. A standardized questionnaire covering questions about institutional, farm-specific, and demographic features as well as inputs and outputs was used to gather data from 286 sample farmers who produced teff. A multi-stage sampling procedure was utilized to choose the participants. Both descriptive statistics and an econometric model were used to analyze the data.

The research revealed that significant variables affect technical inefficiencies in the production of teff within the studied zone. It is estimated that the technical efficiency level is 89% on average. This suggests an 11% increase in teff production on average through full technical efficiency improvement, indicating a significant potential for teff productivity enhancement in the zone.

The results of the stochastic frontier analysis suggest that there is significant potential to improve the technical efficiency and productivity of teff production through improved management practices that make use of currently available inputs and technology. The area (farm size) covered by teff, fertilizer (Urea, NPS and pesticides), labor days, oxen days, improved seed and local seed were shown to be significant and favorably impacted the technical efficiency of teff production in the research area, according to the second-stage estimated stochastic production frontier model. Hence, the increase in these inputs would increase the technical efficiency of teff production, except for local seed.

Similarly, the OLS regression result indicated that technical efficiency was positively and significantly affected at the 5% significance level by education, training, experience, age, family size, non-farm income, and extension contact. The positive significance of production inputs indicates the importance of these inputs in the technical efficiency of teff production. This implies that enhanced access and better use of these production inputs could lead to higher technical efficiency of teff production in the study area. The negative impact of production inputs indicates that they affect the efficiency of teff production negatively. This implies that for the future, the local administrator should concentrate on enhancing access and better use of these production inputs, which would then lead to higher technical efficiency of teff production in the study area.

5.2 Conclusions

Generally, increasing the size of the farm, the use of fertilizers such as urea, NPS and pesticides, receiving training, making extension contacts with extension workers, and using improved seeds were used to increase the technical efficiency of teff production in the Wolayta zone. In the study, using local seed negatively affected the technical efficiency of teff production. However, the price and supply shortage of improved seed is a basic problem. In the study area, some farmers preferred not to produce teff even though their livestock holdings are high. They do not buy inputs for the production of teff using the income they obtained from selling their livestock. Consequently, this has negatively affected the technical efficiency of teff production in the Wolayta zone. The extension contacts, providing training for the farmers related to the use of agriculture, and providing formal and informal education, are used to increase the farmers' awareness, and this affected the technical inefficiency.

According to the information given from the zonal agricultural office, the fertilizer DAP was substituted by NPS during the 2023/24 production season. Farmers bought those inputs from individual dealers as well as cooperatives, with each sample household purchasing some of them. However, because cooperatives offer inputs at lower prices and their members produce smaller amounts of teff with fewer inputs, farmers prefer to purchase from them rather than from individual traders. Therefore, the shortage of input supply was high, and it led to high prices for the farmers in the study area, which brought a negative impact on the technical efficiency of teff production in the Wolayta zone.

5.3 Recommendations

The researcher put the following recommendations based on the findings of the study. In order to increase farmer productivity in the research area, the local government or other relevant entities should focus on boosting farmer productivity by placing a special emphasis on important production aspects.

i. To increase farmers' technical efficiency in producing teff, fertilizers such as urea, NPS, and pesticides should be available on schedule and at a fair price. It is important to work toward educating rural households about the proper use of fertilizers and pesticides.

In the research area, farmers with higher levels of education tend to be more productive than those with lower levels of education. As a result,

ii. The regional governments must improve farmers' access to education. This can be done by expanding the farmers' training centers or the amount of formal and informal education offered in the research area. Using the manpower and resources at its disposal, such as extension agents and farmer training centers, the zonal administration should offer official and informal farmer education.
iii. To impart expertise from older farmers to younger farmers, the zonal administrators should organize field days, cross-visits, forums for elder households to discuss their experiences, and short-term training programs. Development initiatives must support better land management techniques in order to preserve and enhance agricultural soil fertility and boost farmer productivity.
iv. To increase farmers' technical efficiency in producing teff, improved seed should be available on schedule and at a fair price. It is important to reduce the use of local seed, which negatively affected technical efficiency.
v. To decrease farmers' technical inefficiency in producing teff, extension contact and training should be available on schedule. It is important to reduce the technical inefficiency of teff production.

Given that the largest percentage of respondents claimed that most of the time, input costs are higher than product prices, the government should support more innovation and originality in the construction of productivities in the agricultural sectors by funding research institutes and offering research courses on these topics to raise the level of teff output.

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APPENDIX

Apendix1

```
Stoc. frontier normal/tnormal model              Number of obs =       286
                                                 Wald chi2(8)  =   6308.94
                                                 Prob > chi2   =    0.0000

Log likelihood =   190.4209
```

logoutput	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Frontier						
logAreahe	.2657157	.0345886	7.68	0.000	.1979233	.333508
logUrea	.0655273	.029518	2.22	0.026	.0076731	.1233815
logNPS	.0832578	.0342734	2.43	0.015	.0160832	.1504324
logPesti	.2704003	.0378198	7.15	0.000	.1962749	.3445257
logOxenday	.1784413	.0241355	7.39	0.000	.1311365	.2257461
logLaborday	.1645046	.0325545	5.05	0.000	.1006989	.2283102
logImproved	.0841552	.0313225	2.69	0.007	.0227642	.1455462
logLocal	-.1084289	.0297309	-3.65	0.000	-.1667004	-.0501574
_cons	1.786976	.1374028	13.01	0.000	1.517671	2.05628
Mu						
_cons	-163.6443	589.919	-0.28	0.781	-1319.864	992.5757
Usigma						
_cons	2.948253	3.598932	0.82	0.413	-4.105524	10.00203
Vsigma						
_cons	-5.283315	.2095439	-25.21	0.000	-5.694014	-4.872617
sigma_u	4.367218	7.858661	0.56	0.578	.1283798	148.5638
sigma_v	.0712431	.0074643	9.54	0.000	.0580177	.0874832
lambda	61.30026	7.858676	7.80	0.000	45.89753	76.70298

```
H0: No inefficiency component:           z =  -7.622          Prob<=z = 0.000
```

Appendix2

Source	SS	df	MS
Model	77.1647292	8	9.64559115
Residual	5.29885207	277	.01912943
Total	82.4635813	285	.289345899

Number of obs = 286
F(8, 277) = 504.23
Prob > F = 0.0000
R-squared = 0.9357
Adj R-squared = 0.9339
Root MSE = .13831

logoutput	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
logAreahe	.2079072	.0405275	5.13	0.000	.1281261	.2876882
logUrea	.0963671	.0350941	2.75	0.006	.027282	.1654521
logNPS	.0600841	.0424226	1.42	0.158	-.0234275	.1435956
logPesti	.2488958	.0481693	5.17	0.000	.1540715	.3437202
logOxenday	.2010025	.0324165	6.20	0.000	.1371884	.2648166
logLaborday	.2078413	.0425674	4.88	0.000	.1240446	.2916379
logImproved	.1169432	.0394801	2.96	0.003	.0392241	.1946624
logLocal	-.1336454	.0379314	-3.52	0.000	-.2083157	-.058975
_cons	1.459263	.1759184	8.30	0.000	1.112956	1.805569

Apendix3

. sum te

Variable	Obs	Mean	Std. Dev.	Min	Max
te	286	.8946961	.0833431	.4550933	.9798403

Apendix4

```
Tobit regression                                  Number of obs   =        286
                                                  LR chi2(12)     =      71.32
                                                  Prob > chi2     =     0.0000
Log likelihood =  336.81481                       Pseudo R2       =    -0.1184
```

te	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Age	.0026528	.0011283	2.35	0.019	.0004316	.004874
Famsze	-.0071167	.0031118	-2.29	0.023	-.0132428	-.0009907
Edu	.0481544	.0096222	5.00	0.000	.0292116	.0670973
Distadeve	-.0047736	.0065916	-0.72	0.470	-.0177502	.008203
TotTLU	-.0089131	.0046527	-1.92	0.056	-.0180726	.0002465
Sex	.0316888	.024417	1.30	0.195	-.01638	.0797576
SolWa	-.0103069	.0133353	-0.77	0.440	-.0365595	.0159456
Train	.0345216	.012347	2.80	0.006	.0102144	.0588287
Extcont	-.0213868	.00979	-2.18	0.030	-.0406601	-.0021136
Nonfarin	-.055317	.0138506	-3.99	0.000	-.082584	-.02805
Credit	-.0087955	.0132196	-0.67	0.506	-.0348203	.0172294
Expr	.0024959	.0008067	3.09	0.002	.0009079	.004084
_cons	.800416	.0604255	13.25	0.000	.6814588	.9193732
/sigma	.0736643	.0030903			.0675806	.0797479

Appendix5

```
. mfx

Marginal effects after tobit
      y  = Linear prediction (predict)
         =  .89464978
```

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
Age	.0026528	.00113	2.35	0.019	.000441	.004864	45.7028
Famsze	-.0071167	.00311	-2.29	0.022	-.013216	-.001018	5.46503
Edu*	.0481544	.00962	5.00	0.000	.029295	.067014	.653846
Distad~e	-.0047736	.00659	-0.72	0.469	-.017693	.008146	4.79371
TotTLU	-.0089131	.00465	-1.92	0.055	-.018032	.000206	3.5258
Sex*	.0316888	.02442	1.30	0.194	-.016168	.079545	.958042
SolWa*	-.0103069	.01334	-0.77	0.440	-.036444	.01583	.402098
Train*	.0345216	.01235	2.80	0.005	.010322	.058721	.181818
Extcont*	-.0213868	.00979	-2.18	0.029	-.040575	-.002199	.479021
Nonfarin*	-.055317	.01385	-3.99	0.000	-.082464	-.02817	.79021
Credit*	-.0087955	.01322	-0.67	0.506	-.034705	.017114	.828671
Expr	.0024959	.00081	3.09	0.002	.000915	.004077	25.4266

(*) dy/dx is for discrete change of dummy variable from 0 to 1