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Research Article

Technical Efficiency of *Teff* Production: The Case of Mareka District in Dawuro Zone, Southwestern Ethiopia

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Abstract

This study examines the technical efficiency of smallholder *teff* producers in Mareka district, revealing significant productivity differences attributed to varying efficiency in resource use. Data from 174 randomly selected farmers during the 2020/21 production season were analyzed using a Cobb-Douglas Stochastic Frontier Production (SFP) function, resulting in a mean technical efficiency level of 70.7%. This indicates a potential for a 29.3% improvement in efficiency with existing resources. The analysis identified key factors influencing technical efficiency, showing that *teff* output was positively affected by the use of fertilizers, labor, oxen days, and land area. The inefficiency discrepancy ratio was approximately 67.16%. Furthermore, maximum likelihood estimation highlighted that factors such as sex, education, soil fertility, livestock ownership, off-farm income, training, credit access, and extension contact significantly influenced technical inefficiency. To enhance technical efficiency among *teff* producers, the study recommends improving education, asset ownership, credit access, and facilitating knowledge exchange between efficient and inefficient farmers. These strategies aim to increase overall teff productivity in the region.

Keywords

Technical Efficiency, Cobb-Douglas, *Teff,* Mareka, Stochastic Frontier

1. Introduction

Teff (Eragrostis teff) is a crucial staple food crop in Ethiopia, thriving in diverse environmental conditions. It is primarily cultivated at altitudes of 1800-2100 meters above sea level, with an annual rainfall of 750-850 mm and temperatures ranging from 10-27°C. Teff is favored by Ethiopian farmers due to its resilience to adverse weather, allowing it to grow in drought and waterlogged conditions, making it a security crop.

Ethiopia is the leading producer of *teff* globally, but productivity remains low at approximately 1.3 tons per hectare, primarily due to limited use of improved seeds, inefficient agronomic practices, and small-scale farming. While *teff* contributes significantly to the economy accounting for about 6.1% of real GDP most farmers rely on unimproved varieties, with only 5% using improved seeds from formal suppliers. Inorganic fertilizer usage is prevalent, yet rates fall below recommended levels due to financial constraints.

The country faces challenges related to weak market linkages, limiting farmers' access to improved inputs and hindering the connection between agricultural outputs and processors. Despite *teff's* potential, it has historically received less research attention than other cereals, resulting in underper-

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formance.

Cereals dominate Ethiopian agriculture, with *teff* being the most widely grown grain, cultivated by nearly half of smallholder farmers. However, yields are low (around 1.4 tons per hectare) and losses can reach up to 50% before and after harvest. The increasing population, projected to exceed 126 million by 2030, will intensify pressure on resources, emphasizing the need for improved productivity.

Research into technical efficiency in *teff* production is critical, as enhancing this efficiency could provide immediate benefits for farmers. Despite recent growth in *teff* production, the factors driving this increase are not well understood, particularly concerning productivity and landholding sizes. Addressing these inefficiencies is vital for sustainable food security in Ethiopia.

1.1. Statement of the Problem

Agricultural production and productivity in Ethiopia are critically low, failing to keep pace with the rapidly growing population. Despite the potential of high-yield areas to produce sufficient grains for deficit regions, inefficiencies within agricultural systems discourage farmers from maximizing output. The reliance on outdated practices and insufficient use of modern inputs, such as fertilizers and improved seeds, has led to stagnation in food production, which is unable to meet the increasing demands of the population.

To address these challenges, enhancing agricultural efficiency is essential. Studies suggest that improving the use of available resources can yield significant gains in productivity, even within existing technological frameworks. However, while localized research has indicated potential benefits, there is a lack of comprehensive studies that can be generalized across Ethiopia. The diverse agricultural conditions across regions further complicate this issue, necessitating targeted research to understand specific production dynamics.

In the Dawuro Zone's Mareka District, *teff* is the predominant cereal crop, yet increasing population pressures limit the feasibility of expanding cultivated land. No prior studies have investigated the technical efficiency of *teff* production in this area, leaving a gap in understanding the factors contributing to inefficiency among smallholder farmers. This study aims to explore the potential for increasing *teff* production by improving technical efficiency and to identify the determinants influencing this efficiency among farmers in Mareka District.

1.2. Objectives of the Study

To measure the level of technical efficiency of *teff* production in the study area.

To identify the determinants of technical efficiency among *teff* producing farmers in the study area.

2. Literature Review

2.1. Concepts of Technical Efficiency

Technical efficiency, as defined by [8] refers to the ability to produce the maximum output from a given set of inputs or achieve a specific output with minimal inputs. In developing countries, where resources are scarce, enhancing technical efficiency is crucial for sustainable production. [16] Utilized stochastic frontier models to estimate technical efficiency, leveraging both cross-sectional and time series data.

The conducted study highlight the role of technical efficiency in poverty alleviation and food security for smallholder farmers, emphasizing improved access to technology and extension services as means to enhance productivity [1]. The stochastic frontier production model has emerged as a key tool in agricultural research for estimating technical efficiency, with significant studies conducted in Ethiopia, such as those by [7, 26]. These studies indicate that factors like irrigation positively influence efficiency, while off-farm participation has a negative effect.

2.2. Stochastic Frontier Production Function

Efficiency, often conflated with productivity, refers to the optimal use of resources to generate outputs relative to a production frontier. According to [4], efficiency is inherently unobservable and typically estimated through the relationship between outputs, inputs, and their prices [13]. Technical efficiency specifically concerns the physical relationship between inputs and outputs, with inefficiency arising when outputs could be increased with fewer inputs [3].

Two primary approaches to measuring efficiency exist: input-oriented and output-oriented methods. The former asks how much input can be reduced without affecting output, while the latter explores potential output increases from a fixed input level [15]. Additionally, stochastic frontier analysis (SFA) can be categorized into these two approaches and a third, directional measure of inefficiency [20].

The stochastic frontier production function, developed by [4, 18, 12], incorporates a disturbance term with two components: an error term and stochastic noise. This model allows for the accommodation of random variations, providing a more nuanced view of production efficiency compared to deterministic models. The maximum likelihood estimation (MLE) method is preferred over corrected ordinary least squares for its efficiency and ability to estimate standard errors [13, 14].

2.3. Empirical Studies of Technical Efficiency

Numerous studies have focused on analyzing technical efficiency (TE) in agriculture, aiming to identify sources of inefficiency and derive policy implications to enhance future development efforts. Most researchers have employed Cobb-

Douglas and Translog production functions, estimating parameters primarily using maximum likelihood estimation (MLE) and methodologies such as Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA).

Several studies utilized bootstrap DEA to analyze TE in crop production, finding an average TE of 77.26%, indicating a 23% production loss attributed to inefficiency [21]. Their two-stage estimation highlighted that factors such as hired labor, farm location, gender, and age of the household head significantly enhanced TE [25]. [24] also employed the SFA model, revealing that the age of the household head negatively impacted TE, highlighting demographic influences on productivity.

A study conducted by [24] focused on wheat production in Pakistan, using a stochastic frontier Cobb-Douglas production function. Their findings indicated that increases in land, labor, fertilizers, and tractor use significantly raised wheat yields. Notably, they found that higher education levels among farmers correlated with reduced technical inefficiency. Similarly, [8] assessed maize production in Zambia and reported a mean TE of 0.796, suggesting a 20.4% potential increase in production through better input use. Factors such as age, cooperative membership, and farm size positively influenced efficiency, while education and seed types negatively affected it [17].

In Ethiopia, [2] examined haricot bean production, using cross-sectional data to reveal a mean TE of 69.5%. Significant determinants included plot size, fertilizer use, and preharvest labor, with education and cooperative membership emerging as critical factors for efficiency. [26] Studied urban agriculture in Tanzania, finding a mean TE index of 0.72, suggesting a 28% potential output increase. Challenges faced by urban farmers included land size and costs, which negatively affected TE [6].

Several studies identified common factors affecting TE among smallholder farmers, such as oxen ownership, farm size, improved seed usage, education level, fertilizer application, and access to extension services [23, 5] noted that the technical inefficiency model utilizes an inefficiency index as a dependent variable, with independent variables explaining inefficiencies.

According to [15] assessed food crop production in Nigeria, identifying farm size, fertilizers, and hired labor as key factors influencing output, with a mean TE index of 68%. They emphasized that improvements in resource utilization could enhance TE by 32%. [7] applied MLE methodology in Oyo State, Nigeria, reporting a mean TE of 70%. His results showed that while farmer age positively affected TE, education and experience had negative implications.

A study by [2] analyzed rice production in Vietnam, finding a mean TE of 81.6%, with labor intensity, irrigation, and education being significant positive factors. [2] determined that household education, literacy, and credit access positively influenced TE among smallholder farmers in Tigray, Ethiopia, while age and off-farm activities negatively affected it.

Many studies evaluated wheat seed production in Ethiopia, finding a mean TE of 79.9% and suggesting that interest in the wheat seed business and total income positively impacted efficiency [21, 19]. A study by[10] focused on Ethiopian subsistence farmers, identifying extension access, off-farm participation, and gender as crucial factors affecting efficiency, with average farmers producing less than 60% of the most efficient counterparts.

A study by [9, 10] in southern Ethiopia found significant inefficiencies among maize farmers, with a mean TE of 40%. They identified labor, fertilizer use, and oxen power as key productivity factors.

3. Research Methodology

3.1. Description of the Study Area

The study was conducted in the Mareka district of the Dawro zone, located in southern Ethiopia, approximately 282 km from Hawassa and 507 km from Addis Ababa. The Dawro zone covers an area of 466,082 hectares, comprising 38% dry land, 41% middle altitude, and 21% highland. Agriculture in this region is predominantly subsistence mixed crop-livestock farming, with perennial Enset (Enset ventricosum) serving as a staple food and income source. Other key crops include coffee (Coffea arabica), various fruit trees such as false banana (Musa species), avocado (Persea americana), and mango (Mangifera indica), as well as vegetables like potatoes, cabbage, onions, carrots, pumpkins, and green peppers, often intercropped with Enset or coffee. Annual crops such as maize, sorghum, barley, wheat, *teff,* beans, and peas are also commonly cultivated [22].

3.2. Data Types, Sources and Methods of Data Collection

The study collected qualitative and quantitative data on households' socioeconomic characteristics, farm characteristics, and output production from smallholder *teff* farmers through structured interviews. Secondary data were also gathered from various sources, including Agricultural Development Offices, government and non-government agencies, and relevant websites, to support the primary findings.

3.3. Sampling Procedures and Sample Size Determination

A multi-stage sampling technique combining purposive and random sampling was used to select sample households, starting with the purposeful selection of Mareka district based on its *teff* production potential. Subsequently, four kebeles were chosen, and 174 *teff* producing farmers were randomly sampled from these kebeles, with the sample size determined using Cochran's formula for a 5% error term at a

95% confidence level.

$$n = \frac{z^2 p(1-p)}{e^2} = \frac{(1.96)^2 \times 0.87(1-0.87)}{(0.05)^2} = 174 \quad (1)$$

3.4. Methods of Data Analysis

The data collected from producers were analyzed using descriptive statistics and econometric models, specifically employing a stochastic frontier model estimated with STATA software version 14 to measure production efficiency levels and their determinants.

Specification of Econometric Model

The assumption in Data Envelopment Analysis that all deviations from the frontier are due to inefficiency is problematic given the inherent variability in agricultural production caused by factors like weather, pests, and diseases. Therefore, a stochastic frontier production function approach, specifically using the Cobb-Douglas model, was deemed most appropriate for this study, as it accounts for inefficiencies resulting from uncontrollable external factors and measurement errors. This methodology allows for a clearer distinction between inefficiency and deviations due to random shocks, making it suitable for assessing the economic efficiency of *teff* farmers in the study area.

Stochastic frontier model: To determine the technical efficiency of *teff* producing farmers in the study area.

$$\ln(Y_i) = \alpha_o + \sum_{j=1}^{n} \beta_j X_{ij} + \varepsilon_i \quad (2)$$

Where, ln=natural logarithm

Y_i=*teff* output in qt; X_{ij}=inputs used per hectare;

$ß_j$= parameters to be estimated (they are elasticity coefficients in the case of cobb-Douglas specification of the production function.

The disturbance term ε_i=v_i-u_i is composed of two components,

V_i= assess the random deviation in output due to factors outside farmer's control,

U_i = are factors that are within the farmer's control responsible for technical inefficiency. and

i=1, 2…… n farms is defined as the ratio of observed output and the corresponding frontier output, given the state of available technology. The technical efficiency level, which is the main focus of this study, is estimated;

$$TE = \frac{y_i}{f(x_i, \beta)\exp(v_{i)}} = \frac{f(x_i, \beta)\exp(\varepsilon_i)}{f(x_{i,}\beta)\exp(v_i)} = \exp(-ui) \quad (3)$$

Where, f (xi;β).exp(vi-ui) is the observed output (Y) and f (xi;β). exp(vi) is the frontier output (Y*)

According to [4] in SPF hypothesis tests can be made using Maximum Likelihood ratio test that are not possible in non-parametric models. A number of tests were made in this study using the Likelihood Ratio (LR) test given by Equation (4).

$$LR = \lambda = -2 \ln [L(H0) / L(H1)] \quad (4)$$

$$\lambda = -2[\ln L(H0) - \ln L(H1)]$$

Where, λ is the likelihood ratio (LR),

L(H0) = the log likelihood value of the null-hypothesis;

L(H1)= the log likelihood value of the alternative hypothesis; and ln is the natural logarithms.

This test statistics is asymptotically distributed as a Chi-square (or mixed Chi-square) random Variable with degree of freedom equal to the number of restrictions involved [4].

3.5. Definition of Variables and Working Hypotheses

Dependent Variable

Output (outp): This was dependent variable of the production function. It is defined as the actual quantity of *teff* produced by each sample household and measured in quintals during the 2018/19 production season.

Independent Variable

Area of Land (ARA): The land used for teff production in the 2021/2022 season by the sample farmer, measured in hectares, including owned, rented, or sharecropped land.

Labor (LAB): The labor force for *teff* production (plowing, weeding, and planting) during 2021/2022, standardized to man-days (MDs) to account for differences in sex and age.

Seed (SE): The amount of *teff* seed used by each farmer in 2021/2022, measured in kilograms.

Oxen Power (OP): The oxen power used for farming *teff,* measured in oxen days during 2021/2022.

Fertilizer (FRT): The total DAP and Urea fertilizers applied to *teff* fields in 2021/2022, measured in kilograms.

Inefficiency variables

Off/Non-far Income Participation (OFARMP): A dummy variable (1 = participates, 0 = does not). Off-farm income can provide cash for timely input purchases, with mixed effects on efficiency.

Family Size (FS): A continuous variable (measured in man equivalents). Larger working family sizes are expected to positively influence production efficiency.

Perception of Soil Fertility Status (PSFS): A dummy variable (1 = fertile, 0 = infertile). Farmers perceiving their land as fertile are expected to be more efficient.

Age of Household Head (AGEHH): A continuous variable (in years). Older farmers may be less efficient as their ability to manage farming declines.

Frequency of Extension Contact (EXCT): Continuous variable (number of visits). Frequent extension agent visits are expected to positively affect efficiency.

Access to Credit (ACSCDT): A dummy variable (1 = access, 0 = no access). Credit availability is expected to improve technical efficiency.

Farm Size (FRMS): Continuous variable (in hectares). Larger farms may be less efficiently managed, with an inverse relationship to efficiency.

Education of Household Head (EDU): Continuous variable (years of formal schooling). Higher education levels are expected to improve managerial ability and efficiency.

Sex of Household Head (Sex): A dummy variable (1 = male, 0 = female). Male-headed households are expected to be more efficient due to fewer constraints in plowing, credit, and inputs.

Number of Livestock (TLU): Continuous variable (measured in Tropical Livestock Units). More livestock is expected to positively correlate with efficiency as it represents wealth and purchasing power.

Table 1. Summary of variables definition and hypothesis.

Variable name	Definition	Variable type	Expected sign
Access to credit	CREDIT	Dummy	+ve
Age of household heads	AGEHH	Continuous	-ve
Educational status of household heads	EDU	Continuous categorical	+ve
Family size	FS	Continuous	+ve
Frequency of extension contact	EXTS	Continuous	+ve
Farmsize	FRMS	Continuous	-ve
Sex of household heads	SEX	Dummy	+ve
Soil fertility	PSFS	Dummy	+ve
Total livestock owned	TLU	Continuous	+ve
Off/non-farm activities	OFARMP	Dummy	+ve

4. Results and Discussion

4.1. Descriptive Statistics of Variables Used to Estimate Production Function

In the 2021/22 production season, on average sample households farmers produce 11.92 quintals per ha of *teff* output with minimum of 4.75 quintals and maximum of 22 quintals which is dependent variable in the production function. The land allocated for *teff* production, by sampled household farmers during the survey period, ranges from 0.125 to 2.25 ha with average of 0.80 ha. The amount of seed that sampled households used a minimum of 3.5 kg and a maximum of 25 kg of seed with a mean of 13.02 kg of *teff* seed was used for production. Like other inputs human and animal labor inputs were also decisive, given a traditional farming system in the study area. The survey result on labor force used for production of *teff* by sample respondents which changed in to man power per day shows that, the mean labor use was 30.81 man-days with minimum of 12.9 and maximum of 54.3 man days. The labor force was assigned for land preparation, cultivation, weeding, mulching and crop management, and harvesting of output. Sampled households, on average 6.37oxen days with minimum of 1 oxen days and maximum of 5 oxen days for the production of *teff* during 2021/22 production season. In the study area farmers use both DAP and UREA for *teff* production. Fertilizer is one of the inputs which help farmers to improve the production and productivity of their farm output. On average farmers used 92.65 Kg per ha and 51 Kg per ha of DAP and UREA respectively.

Table 2. Summary statistics of variables used to estimate the production function.

Variable description	Minimum	Maximum	Mean	Std. deviation
Yield (Qt)/ha	4.75	22	11.92	5.10
Land (ha)	0.125	2.25	0.80	0.46

Variable description	Minimum	Maximum	Mean	Std. deviation
Seed (Kg)	3.5	25	13.02	5.58
Labor (MDs)	12.9	54.3	30.81	10.33
Oxen (Oxen days)	1	5	2.00	1.22
DAP (Kg)	75	100	92.65	6.92
Urea (Kg)	15	100	51.04	11.37

Hypothesis 1: The null hypothesis (Ho) stated that *teff* farmers are technically efficient with no efficiency differences. The alternative (Ha) claimed inefficiency exists. Using the likelihood ratio (LR) test, the calculated value (λ = 43.8) exceeded the critical value (3.84), leading to the rejection of Ho. This indicates that farmers are not fully efficient.

Hypothesis 2: The null hypothesis (Ho) posited that inefficiency variables have no impact on farmer inefficiency. The LR test (λ = 38.08) exceeded the critical value (33.92), rejecting Ho. This suggests that at least one variable significantly explains efficiency differences among farmers.

Both hypotheses were rejected, showing inefficiency and the influence of explanatory variables.

4.2. Estimation of *Teff* Production

The study analyzed *teff* output (in quintals) using six major inputs: land, DAP fertilizer, Urea fertilizer, *teff* seed, human labor, and oxen power. The Maximum Likelihood (ML) estimates were obtained using STATA 14.

Significant Inputs: Land, DAP, Urea, labor, and oxen power had a positive and significant effect on *teff* output, with land, Urea, labor, and oxen power significant at the 1% level, and DAP at the 10% level. Seed was the only input with an insignificant effect.

Elasticity of Production: A 1% increase in each input would increase *teff* output by:

DAP: 0.230%, Urea: 0.159%, Seed: 0.025%, Land: 0.829%, Labor: 0.045%, Oxen power: 0.201%

Table 3. Estimate of Cobb-Douglas frontier production Production.

Ln output	Coefficient	Standard-error
Constant	3.032	0.242
Ln(DAP)	0.230*	0. 126
Ln(UREA)	0.159***	0.045
Ln(Seed)	0.025	0.033
Ln(land)	0.829***	0.030
Ln(labor)	0.045***	0.020
Ln(oxen)	0.201***	0.056
Lambda	1.43***	0.080
Sigma square	0.069***	0.017
Log likelihood	36.305	36.305

Source: Own computation, (2022/23)
Note: *, ** and *** significant at 10%, 5% and 1% significance level, respectively.

The study found that the ratio of the standard error of inefficiency (λ) is 1.43, and sigma squared (σ^2) was statistically significant, confirming the model's goodness of fit. The estimated gamma (γ = 0.6715) indicates that 67.15% of the variation in farm output is due to inefficiency.

The return to scale coefficient was 1.489, showing increasing returns to scale. This suggests *teff* producers can still expand production efficiently, with a 1% increase in all inputs resulting in a 1.489% increase in output. This finding aligns with [21, 11] study on wheat production efficiency.

4.3. Efficiency Scores

The mean technical, allocative and economic efficiencies of the sampled *teff* producers was 70.7%. These imply substantial inefficiencies in *teff* producers in the study area. The mean technical efficiency score indicates that, if sample households operated at full efficiency level they would increase their *teff* output by 29.3% using the existing resources and level of technology. In other words, on average the sample households can possibly decrease their inputs by 29.3% to get the output they are currently getting.

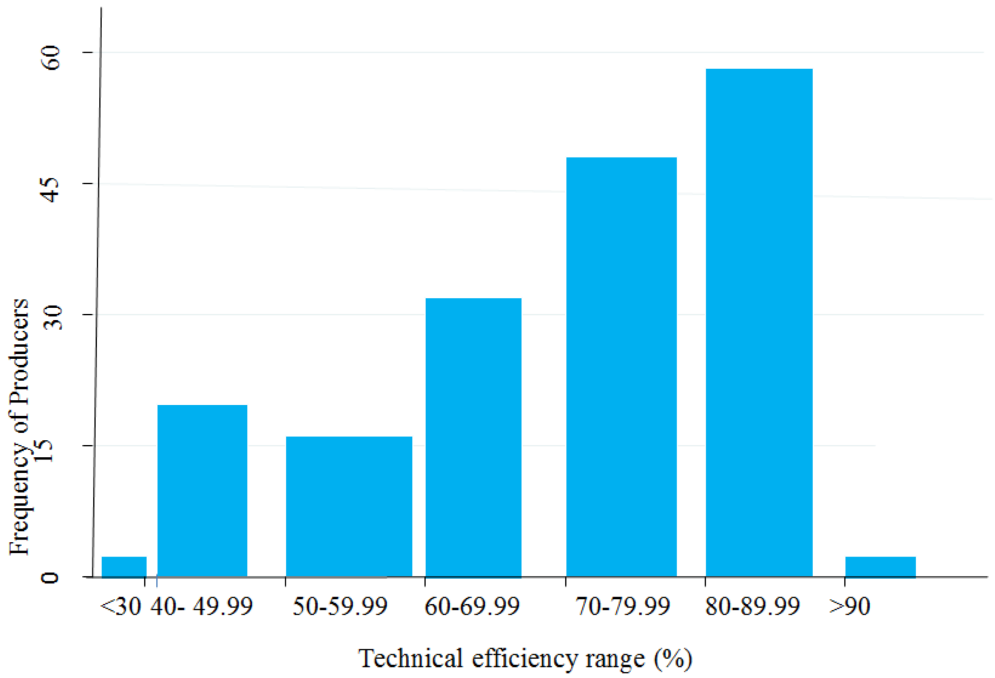
Table 4. Technical, allocative and economic efficiencies of teff production.

Variables	Mean	Std. Deviation	Minimum	Maximum
Technical efficiency	0.707	0.134	0.39	0.91

Source: Own computation, 2022/23

4.4. Technical Efficiency Estimates

The technical efficiency analysis of Figure 1, shows that there is a group of farmers about 55.13% where technical efficiency level range from 50% to 80 whereas, only 12.97% of farmers have a technical efficiency falls below 50%. Farmers in this group have a room to increase their *teff* production at least by 50% on average. Out of total sample respondents, only 31.89% of farmers have technical efficiency of greater than 80%. This implies that around 68.11% of farmers can enhance their production at least by 20%.



Source: Own computation, 2022/23.

Figure 1. Distribution of technical efficiency.

4.5. Determinants of Technical Inefficiency in *teff* Production

Sex of Household Head: Male-headed households were more efficient than female-headed households, implying a negative impact of female household leadership on efficiency.

Education: Higher education significantly reduced inefficiency. Each additional year of schooling decreased inefficiency by 5.1%, as educated farmers better adopted new technologies.

Soil Fertility: Farmers with fertile land were more efficient, as fertile soils required less fertilizer, reducing costs and inefficiency.

Livestock Ownership: Owning more livestock significantly decreased inefficiency by 44%, providing draft power and income for inputs.

Farm Size: Larger farm sizes increased inefficiency by 9%, indicating that smaller farms were more efficiently managed.

Off/Non-Farm Income: Participation in off-farm activities reduced inefficiency by 4.2%, as additional income helped cover farm input costs.

Access to Credit: Access to credit decreased inefficiency by 4.6%, allowing farmers to overcome financial constraints and improve farm management.

Extension Contact: Frequent visits by extension workers significantly reduced inefficiency by 9.1%, providing farmers with crucial information to optimize resource use.

Table 5. Determinants of technical inefficiency.

Inefficiency variables	Technical inefficiency	
	ME	Std. error
Age	0.023	0.053
Sex	-0.032**	0.023
Family size	0.109	0.137
Education Level	-0.051*	0011
Soil fertility	-0.096**	0.097
Livestock ownership	-0.044*	0.056
Farm size	0.090***	0.057
off-farm income	-0.042**	0.021
Credit	-0.046*	0.021
Frequency of extension contact	-0.095*	0.016

Source: Own computation, 2019/20
***, **, * refers to 1, 5 and 10% level of significance, respectively.

5. Summary, Conclusions and Recommendations

5.1. Summary and Conclusion

This study aimed to measure the technical efficiency of *teff*-producing farmers in Mareka district, southwestern Ethiopia, and identify the factors influencing their efficiency. Data were gathered from 174 *teff* farmers during the 2021/22 production season using structured questionnaires. The sampling involved a multistage selection technique, and data analysis combined descriptive statistics with econometric modeling. A Cobb-Douglas stochastic frontier production function was employed to estimate technical efficiency levels, while Maximum Likelihood estimation identified the determinants of inefficiency.

The results confirmed significant variation in technical efficiency among farmers, revealing opportunities for improvement. The average technical efficiency was found to be 70.7%, meaning *teff* production could increase by 29.3% without additional inputs if farmers operated at full efficiency. The stochastic frontier model highlighted land size, DAP, UREA, labor, and oxen power as significant inputs that positively influenced *teff* output.

The Maximum Likelihood analysis identified key determinants of technical inefficiency, including household head's gender, education level, soil fertility, livestock ownership, off-farm income, credit access, and extension contact frequency. Male-headed households, educated farmers, those with fertile land, higher livestock ownership, and participation in off-farm income activities were more efficient. Additionally, access to credit and frequent extension visits contributed to higher efficiency. In contrast, larger farm sizes were associated with increased inefficiency, suggesting difficulties in managing larger plots effectively.

5.2. Recommendations

The recommendations for improving the technical efficiency of *teff* farmers in Mareka district focus on several key areas:

Strengthen both formal and informal education for farmers by utilizing available human and infrastructural resources such as extension agents and Farmers Training Centers (FTCs). Improved education can enhance farmers' ability to efficiently manage their farms and adopt new technologies.

Promote improved land management practices to maintain and enhance soil fertility, thereby increasing farmers' efficiency in *teff* production. This can lead to reduced costs and improved resource use.

Increase the frequency of extension contact with farmers to provide essential advisory services and support. Frequent visits can equip farmers with knowledge to reduce inefficiencies and improve productivity.

Address farmers' financial constraints by encouraging microfinance institutions like Omo-Microfinance to provide larger, more accessible credit with flexible repayment terms that align with the agricultural cycle. The government should also strengthen rural savings and credit institutions to improve farmers' access to financial resources.

Support farmers' participation in off/non-farm income-generating activities, which can provide additional resources for purchasing agricultural inputs and reduce inefficiencies in farming.

Promote technologies that improve livestock productivity, as farmers with more livestock are better able to allocate resources efficiently, enhancing *teff* production.

Facilitate access to machinery services, either through credit-based or cooperative rental models, to help farmers manage larger farms more efficiently and overcome the labor-intensive nature of *teff* production.

Abbreviations

CSA	Central Statistics Agency
DEA	Data Envelopment Analysis
FTC	Farmer Training Center
GDP	Gross Domestic Product
SFA	Stochastic Frontier Analysis
TE	Technical Efficiency

Author Contributions

Selamu Desta is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

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