Economic Efficiency of Korerima [Aframomum Korerima] Production; Empirical Evidence from Smallholder Producers in Gewata District Kaffa Zone

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Abstract

Purpose: This study aimed to evaluate the economic efficiency of Korerima [Aframomum korerima] production by determining the level of technical, allocative, and economic efficiency of production of smallholder producers.**Methodology:** The stochastic Production Frontier model was employed to estimate the elasticity of production function and level of efficiencies. In the study area, there are 1250 smallholder Korerima [Aframomum korerima] producers. The combination of non-probability and probability sampling, named purposive sampling, two-stage, and simple random sampling was used to select 234 final sample units. **Finding:** The mean technical, allocative, and economic efficiency value of the sample households was 76.8%, 72.0%, and 55.0%, respectively. The result indicated that there exists room to increase the efficiency of Korerima [Aframomum korerima] production of smallholder producers. The determinants of the level of efficiency were the age of the household head, sex of the household head, family size, Education level, Extention frequency, Livestock holding, credit utilization, Experience in Korerima [Aframomum korerima] production, off-farm activities, land ownership, total cultivated land, and organic fertilizer utilization has a positive and significant impact on technical, allocative and economic efficiency.

Keywords: Technical efficiency, Allocative efficiency, Economic efficiency, production function, stochastic frontier model, censored Tobit model, Korerima [Aframomum korerima], Gewata District, Kaffa zone
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1. INTRODUCTION

The agricultural sector plays a crucial role in the global economy, particularly in developing nations where larger portions of the population depend on the agricultural industry (Smith, 2018). Agriculture not only provides food and raw materials but also contributes to employment, income generation, and overall economic growth (World Bank, 2020). Resources are abundant in Africa, and the continent has a great deal of potential to draw investors and producers in a range of agricultural productions and emerging markets (Fiergbor, 2020).

The agricultural sector holds a crucial role in Sub-Saharan Africa, as is reflected in its high share in GDP, employment generation, and prioritization in the development agenda. In Ethiopia specifically, the economy heavily relies on agriculture, which accounts for 36.3% of GDP and over 70% of export earnings (United Nations Development Programme [UNDP], 2018). Furthermore, agriculture employs 73% of the total population and supplies 70% of the raw material requirements for local industries (UNDP & FAO, 2016).

The low productivity of Ethiopian agriculture is a result of technological, allocative, and socioeconomic issues. Due to inefficient input management, sparse application of cutting-edge agricultural technologies, and antiquated farming practices, farmers typically produce varied amounts of output per hectare when given the same resources (FAO, 2012). Adopting innovative technologies and using contemporary inputs is one of the fundamental techniques used by the Ethiopian government to increase agricultural output (David et al., 2011).

Due to Ethiopia's intricate agroecology, a wide variety of products, especially spice crops, can be grown there. Ethiopia can cultivate more than 146 different types of crops thanks to its 18 core agroecological zones and several agroecological sub-zones. Ethiopia has also produced a variety of spices for a long time. The nation produces up to 50 of the 109 spices, herbs, and aromatic plants that the International Organisation for Standardisation (ISO) has nominated, of which 23 are traded as export goods. Aframomum Korerima [Aframomum korerima], ginger, turmeric, black cumin, rosemary, cardamom, capsicum, fenugreek, coriander, Timiz, hot pepper, long red pepper, white cumin/bishops weed, rue, celery, coriander, fenugreek, sage, cinnamon, and thyme are the main agricultural products of Ethiopia (Ethiopian Investment Commission, 2019).

Korerima [Aframomum korerima] a native crop of Ethiopia, is well known for its extensive use in Ethiopian cuisine, according to Eyob et al. (2019). The plant is mostly grown and cultivated in the south and southwestern regions of Ethiopia, including the woods of Gamo Gofa, Debub Omo, Kaffa, Iluababor, Sidama, and Wollega, among others. It is also the primary type of spice produced in the Kaffa and Sheka Zone.

For Ethiopian populations, Korerima [Aframomum korerima] offers several advantages. Some of these include their use in food preparation, the fact that most Ethiopians use dried fruits in their daily diets, their therapeutic properties, and their economic significance both locally and as an export good (Getasetegn and Tefera, 2016).

The crop is mostly found in the Southwest of Ethiopia as undergrowth inside the natural forest canopy, although it is also farmed in smallholder farms as a cultivated crop or in a natural habitat or forest (FAO, 2007). According to Peethambaran C. et al. (2016), the forest ecosystem of lowland and highland coffee growing regions in the south and southwest, including Bonga, Maji, and Jimma, is appropriate for Korerima [Aframomum korerima] production.

The production, productivity, and efficiency status of the Korerima [Aframomum korerima] productivity was below the national average with 187.5 and 189 kg per hectare in the production years of 2018/19 and 2019/20, respectively. The low productivity is primarily attributed to inefficiencies. Gewata District Agriculture and Natural Resource Office (GDANRO, 2021).

Therefore, a proper analysis of the economic efficiency of farmers requires the estimation of both technical and allocative efficiencies. Different research has been conducted on the efficiency of production in Ethiopia including Technical efficiency in spice production (Lindara M.*et al.,* 2004), coffee production (Temesgen and Getachew, 2018), Major crops in Ethiopia (Solomon, 2014), black cumin (Abebe *et al.,* 2020), teff production (Yimer, 2017), and on Economic Efficiency of Coffee Production (Mustafa *et al.,* 2017), maize production (Kifle *et al.,* 2017), Tomato Production (Kifle *et al.,* 2020) and, none of these researchers considered in Economic efficiency of Korerima [Aframomum korerima] production.

Almost all of these studies focused only on technical efficiency and not economic efficiency which also includes allocative efficiency. This study was intended to fill these gaps. To the best of the researcher's knowledge, there has been no study that analyses comprehensively the efficiency of inputs of Korerima [Aframomum korerima] production in the study area.

Therefore, this study is useful in formulating appropriate policies and research information for reducing the level of economic inefficiency with objectives of evaluating the level of technical, allocative, and economic efficiencies and identifying the determinants of economic efficiencies in Korerima [Aframomum korerima] production of smallholder producers in the study area by answering the following research questions.

The general objective of this study was to evaluate the economic efficiency of Korerima [Aframomum korerima] production in Gewata District, Kaffa zone. More specifically,

- To determine the level of technical efficiency of Korerima [Aframomum korerima] production of smallholder farmers in the study area
- To determine the level of allocative efficiency of Korerima [Aframomum korerima] production of smallholder farmers in the study area
- To determine the economic efficiency of Korerima [Aframomum korerima] production of smallholder farmers in the study area
- To identify the determinants of economic efficiencies in Korerima [Aframomum korerima] production of smallholder producers in the study area

2. REVIEW OF RELATED LITERATURE

Kifle *et al.* (2020) estimated the technical, allocative, and economic efficiencies of tomato growers in the Bako Tibe District of the Oromiya region. the result shows that labor, land fertilizer, and seed significantly affect tomato production with a return to scale of 1.96 which is increasing return to scale. Factors including sex, frequency of extension visits, and training significantly affect technical, allocative, and economic efficiencies.

Tsegaye *et al.* (2019) estimated the Economic Efficiency of Smallholder Rice producer Farmers in Guraferda south western Ethiopia by obtaining data from 102 randomly selected producers. The mean technical and allocative efficiencies were 78.5 and 80.56%, respectively while the mean economic efficiency was 63.18%. the average technical and allocative efficiencies imply that there exists a possibility to increase rice production by 21.5% without using extra inputs and decrease the cost of inputs by 19.44%, respectively. Rice output was positively and strongly influenced by land and labor.

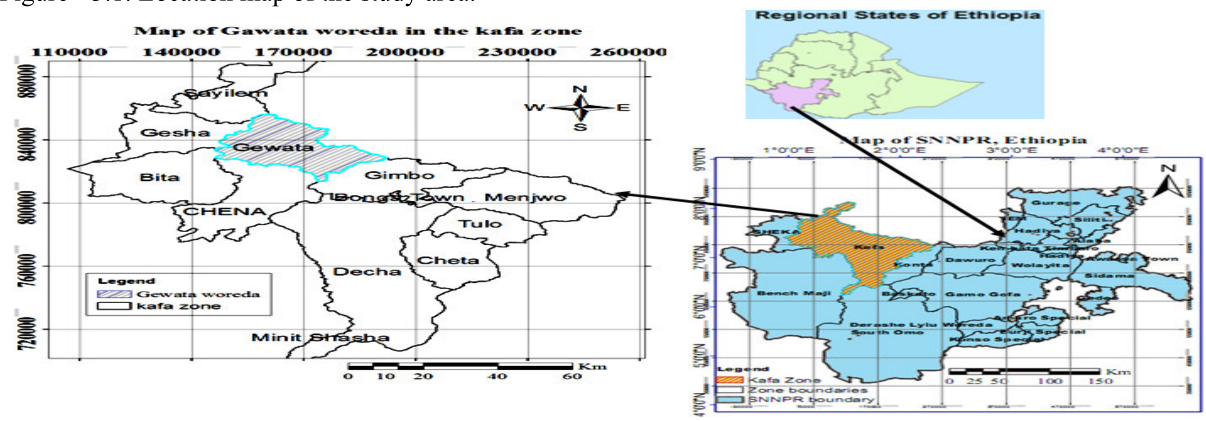
3. RESEARCH METHODOLOGY

3.1. Description of the study area

The Gewata District is situated in the Kaffa zone, in the southwest of Ethiopia. It is located 83 km away from Bonga town, 810 km from Hawassa, and 543 km from Addis Ababa. The area lies within 07°25'- 7°50'N Latitude and 35°56'-35°89'E Longitude. It is bordered in the South by Gimbo and Chena District, in the West by Bita and Gesha District, in the North by Saylem and Oromia region, and the East bordered by Oromia region. The District has a total of 31 kebele of which 28 are rural-based kebele administration areas and 3 are urban kebele Gewata District Administrative Office (GDAO, 2021). According to the data obtained from Gewata District Agriculture and Natural Resource Office (GDANRO, 2020) the total area coverage of Gewata District is 91,500 hectares. According to the population statistical report of the Gewata District Health Office (GDHO, 2021), the total population of the District is 100,494 of which male accounts for 49,242 (49%) and female accounts for 51,252 (51%) of the total. Among the total households, 97.32% are rural agricultural households.

The District is dominated by midland agroecology which is favorable for coffee and spice specially Korerima [Aframomum korerima] production. It is characterized by a subsistence mixed farming system in which the production of both crops and livestock is common economic activity. The District is well-known for its highest production of coffee, Spices, and other cereal crops. However, coffee production takes the lion's share and main source of income generation for the household in the District. Major spices grown in the District are Korerima [Aframomum korerima], Timiz, and Ginger; and cereal crops grown in the District are also maize, barley, fava bean, chickpea, *teff.*

Figure - 3.1: Location map of the study area.



Source: Adapted from Engida *et al*. (2021)

3.2. Research Design

A cross-sectional study design with the quantitative and qualitative approach of research was employed on data from Smallholder Korerima [Aframomum korerima] producers in Gewata District Kaffa zone in the 2019/20 production Year.

3.3. Data type and source

Primary and secondary data were both gathered for this study from diverse sources. Key informant interviews and semi-structured questionnaires were the main primary data-gathering techniques. Five knowledgeable enumerators chosen from five kebele delivered the semi-structured questionnaire schedule, and in the same vein, they conducted key informant interviews. The researcher also conducted field observations to confirm the data collected from respondents by the enumerators. The interview and questionnaire schedule which consists of semi-structured questions were prepared in English and translated into the Amharic language to collect information on farm characteristics, farmer characteristics, and institutional characteristics of Korerima [Aframomum korerima] producer households. Additionally, the questionnaire was pilot-tested before the actual poll, and any necessary changes were made afterward. Finally, a semi-structured questionnaire was administered by enumerators for 234 Korerima [Aframomum korerima] producers.

3.4. Target population and sampling

The study has 3,761 smallholder Korerima [Aframomum korerima] producers as the total population and the target population due to their best practice in producing Korerima [Aframomum korerima] was 1250 smallholder producers from 5 rural kebele in Gewata District, especially 352 smallholder farmers in Kasha, 203 in Gawamecha, 245 in Bera, 250 in Yesha and 200 in Tura Kebele (GWANRO, 2020). The researcher used a combination of non-probability and probability sampling, named purposive sampling, two-stage, and simple random sampling to select the final sample units. The 234 sample Korerima [Aframomum korerima] producers were selected through two-stage probability sampling techniques. The sample producers were chosen using a two-stage sampling procedure. In the first stage, five main Korerima [Aframomum korerima] producer kebele namely, Kasha, Gawamecha, Bera, Yesha, and Tura, were selected using purposive sampling technique due to the best producers' experience in the production of Korerima [Aframomum korerima] output. In the second stage, 234 sampled Korerima [Aframomum korerima] producers 66 from kasha,38 from Gawamecha,46 from Bera,47 from Yesha, and 37 from Tura were selected using a simple random sampling technique by keeping proportion to sample size and total smallholder farmers in each Keble. The sample size for this study was determined by using a Formula developed by (Kothari, 2004) at a 5% level of significance.

$$\mathbf{n} = \frac{z^2 pqN}{e^2(N-1) + z^2 pq}$$

Where: - n = the sample size,

N= Total population in the study

e = the level of acceptable error of 5%, which shows e value will be assigned as 0.05 and p and q are estimates of the proportion of the population to be sampled which is p=0.75 and q=1-p and z is the value of the standard variance at a given level of significance and to be worked out from table showing area under the normal curve which is shown Z=1.96.

Based on the above formula the sample size of this study is calculated as follows:

$$\mathbf{n} = \frac{\mathbf{1.96^2(0.75)(0.25)(1250)}}{\mathbf{0.05^2(1250-1)+1.96^2(0.75)(0.25)}}$$

$$\mathbf{n} = \frac{\mathbf{900.375}}{\mathbf{3.8428}}$$

$$\mathbf{n = 234}$$

3.5. Methods of data analysis

3.5.1. Empirical Analysis

The stochastic Production Frontier model was employed to estimate the elasticity of the production function and the level of efficiency whereas the determinants of efficiency were determined by using the censored Tobit model.

3.5.1.1. Model specification

The physical relationship between production inputs and Korerima [Aframomum korerima] output was measured using the most popular production functional model, such as the Cobb-Douglas function.

The general form of Cobb–Douglas production function:

$Y = F(X_i\beta)\exp(v_i - u_i)$, where i = 1, 2, 3 …………………234……………………… (1)

For the investigation of the technical, allocative, and economic efficiencies of Korerima [Aframomum korerima] production, separate SPFF of the following form was estimated by using the Maximum Likelihood Estimation Model:

$\ln(\text{output}) = \beta0 + \beta1(\text{lnland}) + \beta2(\text{lnDap}) + \beta3(\text{lnUrea}) + \beta4(\text{lnseed}) + \beta5(\text{lnlabor})$
$+ \beta6(\text{lnchems}) + \beta7(\text{lnexperik}) + \beta8(\text{lnoxenp}) + v_i - u_i$ ………………. (2)

Where: Output*:* denoted total physical quantity, of Korerima [Aframomum korerima] output of the i^{th} farm (Kg); *land:* denotes the total land allotted to Korerima [Aframomum korerima] production in hectare; Urea and DAP, most commonly used fertilizers in Ethiopia, are important inputs for production applied on the plot of land Kg per hectare is used in this study. *Seed* denotes the total quantity of seed used in kg per hectare, *Human Labor* (labor): This input captures family, shared, and hired labor used for different agronomic practices of Korerima [Aframomum korerima] production. But the differences in sex and age among laborers will be expected. Hence to make a homogeneous group of labor to be added, the individual labor will be changed into Man Days (MDs) using the standard (Storck, 1991). Therefore, the human labor input is expressed in terms of total MDs employed to perform land preparation, planting, input application, cultivation, and harvesting. *Chemicals* (chems): denotes quantity of chemicals (pesticides) used for Korerima [Aframomum korerima] production liters per hectare, Experience in Korerima [Aframomum korerima] production (expert): This refers to the experience of farmer in years in the production of output, and Oxen Power (*Oxenp):* denotes the total own oxen, exchange oxen and hired oxen was used in Oxen-days; and;βi denotes vector of unknown parameters to be estimated; v_i denotes a disturbance term which accounts for elements beyond the farmer's control, and ui stands for a non-negative random variable that encapsulates the production's economic inefficiency.

According to the observed output (Yi) and corresponding frontier output (Yi*), the farm-specific technical efficiency (TE) is also described. This is done by converting the observed output to the best estimate of the technology's potential frontier output.

$$TEi = \frac{Yi}{Yi*} = \frac{Actual\ Yield}{Potential\ Yield} \quad \text{...........} (3)$$

Technical efficiency takes the value on the interval (0, 1), where 1 indicates a fully efficient farm.

The farm-specific minimum cost (economic efficiency) of production is defined as the ratio of minimum total production cost (Ci*) to the actual observed total production cost (Ci).

$$\text{EEi} = \frac{Ci*}{Ci} = \frac{\text{minimum total production cost}}{\text{actual observed total production cost}} \quad \text{...........} (4)$$

Following Farrell (1975), the AE index will be derived from equations (4) and (3) as follows:

$$\mathrm{AEi} = \frac{EEi}{TEi} \quad \ldots\ldots (5)$$

In this study, TE, AE, and EE estimates from SPFF were regressed using a censored Tobit model on farmer-specific explanatory variables that explain variation in efficiency across farmers. The Tobit model (Tobin, 1958) is defined as follows because the estimated efficiency distribution is suppressed from above at the value 1:

$$\mathrm{Ei} = \sum_{j=0}^{n} \mathrm{Bj}\, xj + v \quad \ldots\ldots (6)$$

Ei=1 if Ei*> 1 and Ei = Ei* if Ei*< 1

Where, Ei is an efficiency score representing TE, AE, and EE; V~N (0, δ^2);
βj are vector parameters to be estimated;
Xj represents various farmer-specific variables and
Ei* is a latent variable with E [Ei*/Xi] equals Xiβ.

3.5.1.2. Variable Definition

The variables that are used both in the production functions and determinants of efficiency are here defined briefly as follows.

3.5.1.2.1. Definitions for Variables of stochastic production frontier model

Output: The unit of measurement for output, which serves as the dependent viable in the estimate of production functions, is kilograms (Kg). The data was collected using different local measurement units of output, however for consistency and it was changed to the standard measurement unit, kilogram. Hence output measured in Kg per hectare is used in the analysis.

Inputs: This refers to input (explanatory) variables used in the estimation of production functions.

1. **Land (*land*):** This refers to the area of the plot of land allotted for Korerima [Aframomum korerima] production in hectares. It is a continuous variable measured in hectares and has negative relation with the economic efficiency of smallholder Korerima [Aframomum korerima] production (Endrias *et al.*, 2013 and Rebecca, 2011).
2. **Dap (*Dap*):** Most commonly used fertilizer in Ethiopia and important input for production. Total Dap applied on the plot of land Kg per hectare is used in this study. It is a continuous variable measured in kg per hectare and has a positive relation with the economic efficiency of smallholder Korerima [Aframomum korerima] production (Rebecca, 2011).
3. **Urea (*Urea*):** Important input for the production of Korerima [Aframomum korerima]. It is continuous variable measured in kg per hectare and has positive relation with the economic efficiency of smallholder Korerima [Aframomum korerima] production.
4. **Seed (*seed*):** This refers to the amount of seed used in the production of output. Hence, the total amount of seed in clumps (vegetative method) in Kg per hectare was used in this study. It is continuous variable measured in kg per hectare and has positive relation with smallholder Korerima [Aframomum korerima] production (Oyewo, 2011).
5. **Human Labor (*labor*):** This input captures family, shared, and hired labor used for different agronomic practices of Korerima [Aframomum korerima] production. But the differences in sex and age among labor would be expected. Hence to make a homogeneous group of labor to be added, the individual labor is changed into Man Days (MDs) using the standard (Storck, 1991). Therefore, the human labor input is expressed in terms of total MDs. it is continuous variable measured by the number and has a positive relation with smallholder Korerima [Aframomum korerima] production.
6. **Chemicals (*chems*):** This refers to the quantity of chemicals (pesticides) used for Korerima [Aframomum korerima] production. This variable is continuous variable measured in litter per hectare and has negative relation with the economic efficiency of smallholder Korerima [Aframomum korerima] production (Elibariki, 2008).
7. **Experience in Korerima [Aframomum korerima] production (*experik*):** This refers to the experience of a farmer in years in the production of output. It is continuous variable measured in years and which has a positive relation with the economic efficiency of smallholder Korerima [Aframomum korerima] production *(*Rebecca, 2011)**.**
8. **Oxen Power (*oxen*):** This input captures the total own oxen, exchange oxen, and hired oxen used in Oxen-days (one oxen-day is equivalent to eight working hours). This is continuous variable having positive expected relation with the economic efficiency of smallholder Korerima [Aframomum korerima] producing households (Endrias *et al.* (2013).

3.5.1.3. Estimation of the Determinants of Economic Efficiency

Determinants of efficiency: These farm characteristics, farmer characteristics, demographic and institutional variables chosen about former studies, and logical reasoning are used in identifying the determinants of efficiency. Instead of inefficiency, efficiency factors are more commonly examined in the the literature. However, the .only difference between them is only on the interpretation. These determinants are the age of the household head, Sex of the household head, Family size, educational level of the household head, Soil and Water Conservation, Extension contact, Irrigation, Off-farm income, farm income, livestock size of the household, total land cultivated, Organic fertilizer and adopted improved seed.

The most common procedure is to examine determinants of efficiency, in that the inefficiency or efficiency index was taken as a dependent variable and was then regressed against several other explanatory variables that were expected to affect efficiency levels (Bravo-Ureta and Rieger, 1991; Sharma *et al.*, 1999).

Estimates of technical, allocative, and economic efficiency were regressed on the following farm-specific explanatory factors using a censored Tobit model to explain variability in production efficiencies between farms. The rationale behind using the Tobit model is that there were many for which efficiency was one and the bounded nature of efficiency between zero and one (Jackson and Fethi, 2000).

The determinants of technical, allocative and economic efficiencies are explained by:

$$Ui = \alpha o + \alpha 1\ (Age) + \alpha 2\ (Age)^{2} + \alpha 3\ (Sex) + \alpha 4\ (Family) + \alpha 5\ (Educ) + \alpha 6\ (SWC) + \alpha 7\ (Extfreq) + \alpha 8\ (Irrig) + \alpha 9\ (Offincom) + \alpha 10\ (TLU) + \alpha 11\ (Impseed) + \alpha 12\ (Acscdt) + \alpha 13\ (Experik) + \alpha 14\ (Landowner) + \alpha 15\ (Totfincom) + \alpha 16\ (Totcultlnd) + \alpha 17\ (Orgfert) + wi \quad (7)$$

Where: for farm i, α is a vector of unknown parameters. Thus, the parameters of the frontier production function are simultaneously estimated with those of an efficiency model, in which the efficiency effects are specified as a function of other variables. U represents efficiency effects; αo represents the intercept. After a thorough review of previous studies and the prevailing situation in the study area, farmer characteristics, farm characters tics, socioeconomic, demographic,, and institutional factors that would affect efficiency were hypothesized as follows:

3.5.1.3.1. Definitions for Variables of economic efficiency determination model

1. **Age of household head (Age):** This refers to the age of the household head measured in years. It is continuous variable that has a positive relation with economic efficiency. It is assumed that older farmers are more experienced in farming activities and are better able to assess the risks involved in farming than younger farmers age of the household head contributes positively to technical efficiency. (Rebecca, 2011).
2. **Sex of household head (Sex):** This is a dummy variable measured as 1 if the household is headed by a male and 0 otherwise. Female-headed households are responsible for domestic activities (Aynalem, 2006).
3. **Family size (Family):** This refers to the number the people in the household measured in numbers. This is continuous variable that has a positive relation with economic efficiency. (Coelli *et al.,* 2002).
4. **Education level of household Head (Educ):** This is the educational level of the household head measured in years of schooling, and is continuous variable. It has an expected positive relation with economic efficiency.
5. **Soil and Water Conservation (SWC):** This is a dummy variable measured as 1 if farmers adopted soil and water conservation practices and 0 otherwise. This has an expected positive relation with economic efficiency.
6. **Extension contact (Extfreq):** This variable is measured as the frequency of contact of a farmer with the extension workers in the 2019/20 production year. This continuous variable has a positive relation with economic efficiency (Ike and Inoni, 2006).
7. **Irrigation (Irrig):** This is a dummy variable that is measured as 1 if the household head used irrigation in the last three months (which is production season counting back starting from the survey period) or 0 otherwise. It has a positive relation with economic efficiency.
8. **Off-farm/non-farm income (Offincome):** This variable captures all income in ETB by involving in off-farm/non-farmactivities, (Like; ttailoringng, Hair making, Carpenter, Pottery, Trading). Continues variable measured in ETB has negative relation with economic efficiency. Increasing offoff-farmportunities take away farm resources and farmers' efforts that could otherwise be used for production and hence reduce efficiency (Endrias *et al.,* 2013).
9. **Livestock size of the household (TLU):** This is the total number of livestock in the household in terms of Tropical Livestock Unit (TLU). It is continuous variable having positive relation with economic efficiency (Wondimu, 2010).
10. **Improved seed (Impseed):** continuous variable weighted in kilograms per hectare. It has a favorable relationship with economic effectiveness (Oyewo, 2011).
11. **Access to credit (Acscdt):** is a dummy variable that indicates accessibility of credit which is 1 if the household can access credit, 0 otherwise. It has a positive relation with economic efficiency (Okoye *et al.,* 2007).
12. **Experience in Korerima [Aframomum korerima] production (Experik):** This continuousinuous variable measured in a number of years of experience which is directly related to the farmer's economic

efficiency in Korerima [Aframomum korerima] production (Rebecca, 2011).

13. **Land ownership (Landowner):** This is a dummy variable measured as 1 if the farm for the the production of Korerima [Aframomum korerima] is on own land and 0 otherwise. It has a positive relation with economic efficiency.
14. **Farm income (Totfincom):** This includes all income from farm activities of the household out of Korerima [Aframomum korerima] production. It is a continuous variable measured in the amount of income (birr) the household head and/or other members get per year. It has negative relation with economic efficiency.
15. **Total cultivated land (Totcultlnd):** This is continuous variable measured in hectares having negative relation with economic efficiency and refers to the size of (owned, contract, or rented) all land the household managed during the 2019/20 production year.
16. **Technology (tech):** denotes technology adoption for Korerima [Aframomum korerima] production. It has a positive relation with economic efficiency (Hussien and Öhlmer, 2007).
17. **Organic fertilizer (Orgfert):** Is continuous variable measured in Kg per hectare. It has a positive relation with economic efficiency.

4. PRESENTATION OF THE RESULT

4.1. Estimation of the Cobb-Douglas frontier production function

Table - 4.5: Estimation of the Cobb-Douglas frontier production function.

Variables	Parameters	Coefficients	Std. Err.	P – value
Constant	β0	5.978***	0.693	0.000
ln(land)	β1	0.789***	0.127	0.000
ln(DAP)	β2	0.014**	0.0057	0.015
ln(urea)	β3	0.181	0.033	0.580
ln(seed)	β4	0.096***	0.009	0.000
ln(labor)	β5	0.028*	0.015	0.057
Ln(chems)	β6	0.090	0.116	0.437
Ln(experik)	β7	-0.017	0.0186	0.558
ln(oxen)	β8	0.0184**	0.0075	0.014
$Sigma^2$ –v		-2.2507*	0.0925	0.075
$Sigma^2$ – u		-11.8382***	174.95	0.000
Sigma square	(σ2)	-14.089	0.00977	
Gamma	(γ)	0.84		
Log-likelihood function		71.64		

***, **, * significant at 1%, 5%, and 10% levels of significance, respectively

Source: Field survey, 2021

To calculate allocative and economic efficiency, the dual cost function that was analytically deduced from the stochastic production function is presented as follows:

$$\ln C_{kpi} = 4.35+0.335\ln^{w}{}_{land}+0.36\ln^{w}{}_{seed}+0.35\ln^{w}{}_{dap}+0.029\ln^{w}{}_{urea} +0.24\ln^{w}{}_{oxen}+0.052\ln^{w}{}_{chemicals}+0.32\ln^{w}{}_{labor}+0.86\ln Y^*$$

Where: $\ln C_{kpi}$ is minimum cost of Korerima [Aframomum korerima] production; w_1 is cost of land per ha; w_2 refers to the price of seed per kg, w_3 is cost of Dap per kg; w_4 is cost of urea per kg; w_5 is cost of oxen per day; w_6 is price of chemicals per liter, w_7 is cost of labor per day, $Y*$ is output adjusted for any statistical noise; i^{th} refers to the ith sample household.

The maximum-likelihood (ML) estimates of the parameters of the SPFF were obtained using the STATA 11 computer program. The influence of each of the inputs used in Korerima [Aframomum korerima] production and their interaction effects are presented in Table 4.5. The result of the model showed that five of the input variables in the production function: ln(land), ln(Dap), ln(Seed), ln(labor), and ln(Oxenp) had a positive and significant effect on the level of Korerima [Aframomum korerima] production. Hence, the increase in these inputs would increase the production of Korerima [Aframomum korerima] significantly as expected. A one percent increase in the size of land, amount of DAP, amount of seed, amount of labor, and amount of oxen power would increase Korerima [Aframomum korerima] production by 0.789%, 0.014,0.096%, 0.028%, and 0.0184% respectively.

The value of σ2 for the frontier of Korerima [Aframomum korerima] output was -14.089 which was significantly different from zero. The significant value indicates the goodness of the specified assumption of the composite error terms distribution (Okoye *et al*., 2007). The estimated value of gamma was 0.84 which indicated that 84% of the total variation in Korerima [Aframomum korerima] farm output was due to technical, allocative, and economic inefficiency.

Table- 4.6: Elasticities and returns to scale of the parameters of stochastic frontier production function.

Variables	Elasticities
ln(land)	0.789
ln(DAP)	0.014
ln(urea)	0.180
ln(seed)	0.096
ln(labor)	0.028
Ln(chems)	0.09
Ln(experik)	-0.017
ln(oxen)	0.0184
Returns to scale	1.036

Source: Field survey, 2021

The returns to scale analysis coefficients were calculated to be 1.03%, indicating increasing returns to scale. This implies that there was potential for Korerima [Aframomum korerima] producer to continue to expand their production because they are in stage II of production surface, where resource use and production is believed to be inefficient. A percent increase in all inputs proportionally would increase the total production by 1.03%. The result was in agreement with Fekadu and Bezabih (2009) who estimated the return to scale to be 1.09% in the study of TE of wheat production in Ethiopia.

4.2. Efficiency Scores

Table – 4.7: Frequency distribution and summary statistics of Korerima [Aframomum korerima] production.

Range	TE		AE		EE	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
00 – 10	0.0	0.00	0.0	0.00	0.0	0.00
11 – 20	0.0	0.00	0.0	0.00	4.0	1.71
21 – 30	2.0	0.85	0.0	0.00	23.0	9.83
31 – 40	4.0	1.71	5.0	2.14	23.0	9.83
41 – 50	10.0	4.27	14.0	5.98	6.0	2.56
51 – 60	22.0	9.40	14.0	5.98	46.0	19.66
61 – 70	33.0	14.10	81.0	34.62	122.0	52.14
71 – 80	52.0	22.22	59.0	25.21	7.0	2.99
81 – 90	55.0	23.50	40.0	17.09	2.0	0.85
91 – 100	56.0	23.93	21.0	8.97	1.0	0.43
Minimum	26.0		31.0		12.0	
Maximum	99.0		98.0		95.0	
Mean	76.8		72.0		55.0	
Std. Deviation	16.0		13.5		14.6	

Source: Field survey, 2021

Table 4.5 shows the frequency distributions and summary statistics of efficiency measures for Korerima [Aframomum korerima] production. The mean TE, AE, and EE of sample households were 76.8%, 72.0%, and 55.0%, respectively, indicating that there are substantial inefficiencies in Korerima [Aframomum korerima] producers.

The mean of TE indicates that, if sample households operated at full efficiency level they would increase their output by 23.2% using the existing resources and level of technology. In other words, on average the sample households decrease their inputs by 23.2% to get the output they are currently getting.

The mean of TE score 76.8 indicates that, if sample households operated at full efficiency level they would increase their output by 23.2 using the existing resources and level of technology. In other words, on average the sample households decrease their inputs by 23.2% to get the output they are currently getting. The finding is in agreement with Kifle *et al.* (2020); Tsegaye *et al.* (2020); Mustefa *et al.* (2017).

The mean score of AE score 72.0% result indicates that on average the sample households could increase Korerima [Aframomum korerima] output by 28.0% if sample households produced the desired output at the appropriate price and with the appropriate inputs. This result is in line with Kifle *et al.* (2020); Tsegaye *et al.* (2020); Mustefa *et al.* (2017).

The mean EE score of 55.0% showed that there was a significant level of inefficiency in the production process. The mean of EE score 55% indicates that Korerima [Aframomum korerima] producers could increase Korerima [Aframomum korerima] production by an average of of 45%, if they operated at full technical and allocative efficiency levels. This result is consistent with Ali *et al.* (2020); Tsegaye *et al.* (2020); Essilfie *et al.* (2017).

4.2.1.1. Determinants of efficiency in Korerima [Aframomum korerima] Production

Table – 4.8: Determinants of efficiency in Korerima [Aframomum korerima] production among sample households.

Variables	TE		AE		EE	
	Coefficents	Std. Err.	Coefficents	Std. Err.	Coefficents	Std. Err.
age	0.026***	0.003	0.028***	0.002	0.021***	0.002
Age2	-0.003***	0.0001	0.0002***	0.0001	0.0001***	0.0001
Sex	0.004	0.027	0.367*	0.025	-0.048*	0.002
Family	0.031*	0.005	-0.034	0.005	-0.062	0.0001
Educ	0.014***	0.003	0.027*	0.003	0.007**	0.003
Swc	-0.018	0.026	-0.034	0.024	-0.029	0.023
Extfreq	0.016**	0.007	-0.035	0.007	0.095*	0.007
Irrig	-0.026	0.024	-0.009	0.022	-0.022*	0.0001
Offincom	0.000	0.000	0.0003**	0.0001	0.0001	0.0005
Tlu	0.027*	0.003	0.036*	0.003	0.018**	0.003
Impseed	0.066	0.395	-0.909*	0.362	-0.448	0.350
Acscdt	0.272**	0.023	-0.046*	0.002	0.303*	0.021
Experik	0.042**	0.002	-0.001	0.002	0.020*	0.002
Landowner	0.076**	0.031	0.081***	0.029	0.057**	0.028
Totfarminc	0.0001	0.0002	0.0003	0.0002	0.0005	0.0006
Totcultlnd	-0.384	1.831	-4.469***	1.678	-2.276*	1.062
Tech	0.040	0.030	0.025	0.028	0.404	0.027
Orgfert	0.003*	0.001	-0.001	0.001	-0.037	0.000

***, **, * significant at 1%, 5%, and 10% levels of significance, respectively
Source: Field survey, 2021

Age of the household head: At the 1% level of significance, the calculated coefficient of age for TE, AE, and EE is positive and significant. This implies that age contributed positively to TE, AE, and EE, which may be because of the farming experiences that have been accumulated over the years. The age of the producer was statistically significant and positively influences the technical efficiency of Korerima [Aframomum korerima] production at 1% of the level of significance. The significantly positive relationship between age and technical efficiency of Korerima [Aframomum korerima] production implies that older producers are more technically efficient than younger producers. This can be explained by the fact that as a producer become more aged, it becomes easier to properly utilization of inputs and adoption of the latest technologies on their farms. This finding is in agreement with the finding of Kifle *et al.* (2017) Likewise, elder producers will be more experienced, and active and can make well-thought decisions in the farming system, and as a result, their efficiency level in Korerima [Aframomum korerima] production increases. This implies that as the age of the decision-maker increases, allocative and economic efficiency will increase. This result is consistent with the recent findings (Tsegaye et al., 2020; Solomon 2012; Kifle et *al.,* 2018; Rebecca, 2011).

Sex of household head: At a 10% level of significance, it was discovered that the household head's gender had a detrimental and significant impact on EE. This finding is in line with the finding of Aynalem (2006) and Kifle *et al.* (2014) reported that the negative significant relation is those female households headed are the one who were responsible for many household domestic activities.

Family size: Family size on TE is positive and statistically significant at a 10% significance level. because family labor is the main input in Korerima [Aframomum korerima] production the farmer has a large family size would manage other crop plots and may able to use appropriate input combinations by using their labor on Korerima [Aframomum korerima] plot. Moreover, the coefficient of family size showed that a one-person change in the number of families in man equivalent would increase the probability of a farmer being technically efficient by 0.031%. This result is similar to the findings of (Mustafa *et al.,* 2015; Kifle *et al.,* 2020).

Level of Education: The education level of farmers had a positive relationship with economic efficiencies significantly at 1%, 10%, and 5% significance level for TE, AE, and EE respectively. For every increment in education level by one year of schooling, the economic efficiency of smallholder Korerima [Aframomum korerima] producers was increased by 0.014%, allocation efficiency increased by 0.027%, and cost minimization efficiency by 0.007% other variables remain constant. In another word, they invest more amount of their income in purchasing agricultural inputs and choosing a high combination of their resource at a given price of inputs. This result is in line with the results found by Giang (2013) and (Tsegaye *et al.,* 2020).

Extension Frequency: As expected, the coefficient of estimation was positive and significantly affected the level of economic efficiency at a 5% level of significance for TE and a 10% level of significance for EE. This might be due to the reason that the high frequency with better information obtained from extension workers had a strong power to increase the awareness and know-how of farmers towards technologies and efficient utilization of the existing resource to increase their efficiency and decrease wastage of resource use. As the extension workers frequently visit and follow up with farmers become more and more, farmers may obtain important and influential information to increase their economic efficiency level by 0.016% and 0.095% keeping other variables constant. This finding was in agreement with the findings of Nejuma (2011) and Mustafa (2017).

Irrigation: Irrigation is a dummy variable that represents whether the farmer uses small irrigation canals on Korerima [Aframomum korerima] plots or not. To boost output by recycling and recovering nutrients needed for Korerima [Aframomum korerima] production and maybe lower expenses, it was hypothesized that farmers who used irrigation might be more effective than their counterparts. Unexpectedly, It is with a negative sign and is statistically significant for economic efficiency at a 10%, significance level. The result is in line with the argument made by Musa (2017).

Off-farm income earning: Unexpectedly, the coefficient of off-farm or non-farm activities has a positive and considerable impact on AE because the money made from these activities can be utilized to buy agricultural inputs and supplement funding for household expenses that are solely dependent on agriculture. This revenue availability disperses the cash crunch, allowing people to swiftly purchase the inputs that their on-farm income makes it impossible for them to acquire. The result is consistent with Hassan (2011) and Kifle *et al.* (2017).

Livestock holding (TLU): The coefficient for livestock holding was a positive and significant impact on TE, AE, and EE which confirms the considerable contribution of livestock in the Korerima [Aframomum korerima] production system. The result is in line with Solomon (2012). It affected economic efficiencies positively at 10%, 10%, and 5% levels of significance for TE, AE, and EE respectively. This means that farmers who increased their number of livestock holding by one TLU could increase their technical, allocative, and economic efficiency by 2.7%, 3.6%, and 1.8% respectively. This finding was consistent with the result obtained by Wassie (2012) and Kifle *et al.* (2017).

Access to credit: Credit utilized had a positive and significant impact on TE & EE which suggests that, on average households with more credit utilized tend to exhibit higher levels of efficiency. Low Credit utilization badges a household to lack of ability to enhance efficiency by money constraints which may affect their ability to apply low inputs, implements, and less farm management decisions on time. The finding is consistent with the finding of Hasan (2006) and Nejuma (2012).

Experience in Korerima [Aframomum korerima] production: The coefficient of farming experience of farmers on Korerima [Aframomum korerima] production positively affected the economic efficiencies of farmers significantly at 5 and 10% levels of significance on TE and EE respectively. Its positive sign might be due to the reason that those farmers having more experience in farming may be responsive to modern inputs combination that minimizes their costs. So, as the farming experience increased by one year, the economic efficiencies of farmers also increased by 2%, and other factors kept constant. This result is in agreement with the result found by Adeyemo *et al.* (2010).

Land ownership: The use of the farmer's property is indicated by the dummy variable "land ownership," which is present. It was anticipated that farmers who used their land would be more effective than their competitors since it increased output by reducing technical, allocative, and economic inefficiency and had a favorable and significant impact on TE, AE, and EE. A considerably higher level of TE, AE, and EE is seen in households that produced Korerima [Aframomum korerima] on their land. This suggests that farmers who manage sharecropped land are less likely to use inputs effectively or give priority during agronomic practice periods than those who cultivate their fields. The result is in agreement with Fekadu and Bezabih (2009) and Solomon (2012).

Total cultivated land: Total cultivated was found to have a significant and negative impact on AE at a 1% significance level and EE at a 10% level of significance. The result implies that as farm size increases technical inefficiency. The use of traditional technologies for timely and appropriate agricultural operations on bigger tracts of land may not be successful, which results in a higher level of inefficiency. The spread of agricultural lands to more remote places due to larger plot sizes can hinder the efficient production of crops. As a result, efficiency and productivity can be negatively affected when the plot size is large given the current level of technology. The result is in agreement with Kifle *et al.* (2017) and Solomon (2012).

Organic fertilizer utilization: organic Fertilizer plays a vital role in Korerima [Aframomum korerima] production as no matter how large and small the farm size is, if it is applied properly, yields will increase. Small-scale farmers tend to have difficulties in obtaining fertilizer as they lack financial means. There is a positive relationship between organic fertilizer utilization and the technical efficiency of small-scale Korerima [Aframomum korerima] producers at a 10% significance level. The use of organic fertilizer is known to be a commonly used method in improving productivity and in the intensification of agricultural production as a whole.

5. CONCLUSION AND RECOMMENDATIONS

The central conclusion derived from the analysis of the efficiency of Korerima [Aframomum korerima] production is that there exists considerable room to enhance the level of technical, allocative, and economic efficiency of smallholder Korerima [Aframomum korerima] producers. The result of the production function indicates that ln(land), ln(Dap), ln(Seed), ln(labor), and ln(Oxenp) were restrictive constraints, all with positive signs as expected except ln(land). The average TE, AE, and EE values of the sampled households were calculated to be 76.8, 72.0, and 55.0 %, respectively. The factors that affect the level of efficiency are identified, to benefit different participants to enhance the current level of efficiency in Korerima [Aframomum korerima] production. Accordingly, the age of the household head, sex of the household head, family size, Education level, Extention frequency, Livestock holding, credit utilization, and Experience in Korerima [Aframomum korerima] production, Land ownership, and organic fertilizer utilization has positive and significant impact on TE. Allocative efficiency, the ability to use the least cost combination of inputs to produce a given output, of farmers was affected by age of the household head, education level, off-farm activities, livestock ownership, land ownership and Total cultivated or farmland affected positively and significantly. Farmers who have accumulated age with work experience, and better schooling are more efficient in allocating their resources. Similarly, given the importance of livestock in Korerima [Aframomum korerima] production, livestock ownership has a significant and positive impact on AE. Finally, the age of the house hold the head, sex of the household head an especially male-headed household, level of education, Extention frequency, livestock ownership, Korerima [Aframomum korerima] producing experience, and land ownership have a positive and significant impact on EE. But Unexpectedly, Irrigation was statistically significant and affected the economic efficiency of Korerima [Aframomum korerima] production of smallholder farmers negatively. This also implies as this determinant was a basic tool to enhance the level of the economic or overall level of efficiency. Based on the findings discussed above, recommendations are made and forwarded to Government officials of the zone, policymakers, and stakeholders of the agriculture sector to increase the technical, allocative, and economic efficiency of Korerima [Aframomum korerima] production in the study area.

- As pointed out by the results of this study, female head households were found to be less technically, allocative and economically efficient than male head households. This may be because female-headed households are too busy with domestic activities and had less time to manage their farm plots. Thus, promoting improved technologies that reduce the domestic burden of female household heads would improve their technical efficiency level in Korerima [Aframomum korerima] production.
- Age showed a positive and significant effect on technical, allocative, and economic efficiency. Therefore different mechanisms should be devised to encourage farmers with little experience to work with the experienced ones or train them.
- Education was a very important determining factor that has a positive and significant impact on TE, AE, and EE in the study area. Hence, the key policy implication is that appropriate policy should be designed to provide adequate and effective basic training-based educational opportunities for farmers in the study area.
- Extension contact has a positive and significant effect on technical and economic efficiencies in the study area. Therefore, suitable and sufficient extension services should be provided by government bodies for Korerima [Aframomum korerima] producers. Policies and strategies that improve extension services could help raise the efficiency of Korerima [Aframomum korerima] production.
- Participation in off/non-farm activity had a positive and significant effect on allocative efficiency. Therefore, strategies that enhance the ease of use of off/non-farm employment opportunities would help to increase the appropriate use of inputs for better efficiency in Korerima [Aframomum korerima] production.
- Particularly the system of the study area is mixed farming, farmers with large numbers of livestock were relatively better in the technical, allocative, and economic efficiency. Hence, technologies that would support the production and productivity of livestock should be adopted, which in turn will enhance the overall efficiency of Korerima [Aframomum korerima] production.
- Access to Credit utilization has a positive and significant effect in improving the technical, allocative, and economic efficiency of Korerima [Aframomum korerima] producers. Therefore, efforts towards establishing and strengthening micro-finance institutions are recommended.
- Farmers who produce Korerima [Aframomum korerima] on their farm were more efficient in technical, allocative, and economically efficient than those who produce on sharecropping arrangements. Hence better support is mainly required from the government for smallholder share cropping-based Korerima [Aframomum korerima] producers.
- Organic fertilizer utilization had a positive relationship with the technical efficiency of small-scale Korerima [Aframomum korerima] producers. Hence the government should encourage the utilization of organic fertilizer on Korerima [Aframomum korerima] plots by training and giving skill-based support to producers.

- In conclusion, the existing level of inefficiency in Korerima [Aframomum korerima] production is high and this calls for better attention of policymakers, and development practitioners in tackling the sources of these inefficiencies to improve the well-being of Korerima [Aframomum korerima] producing farmers by using best practices of the efficient farmers as a point of reference would help setting targets in improving efficiency levels and finding the weakness of the present farm practices. Through learning from others about the optimal resource allocation choices, reasonably efficient farms can likewise increase their efficiency. This can be achieved by arranging field days, cross-visits, creating forums for experience sharing with elder households, and job training.

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