Available online at www.agrifarming.org

DOI: http://dx.doi.org/10.18782/2582-7146.216

ISSN: 2582 – 7146

Curr. Rese. Agri. Far. (2023) *4*(5), 22-32

Research Article

Current Research in Agriculture and Farming

Peer-Reviewed, Refereed, Open Access Journal

Analysis of Teff Producer's Economic Efficiency in Borana zone, Southern Ethiopia

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Received: 5.08.2023 | Revised: 23.09.2023 | Accepted: 8.10.2023

ABSTRACT

The study intended to identify economic efficiency level of Teff producers and associated factors based on data from 142 households. The Cobb-Douglas stochastic frontier production and its dual cost functions estimated. Among six input variable used by household the result of production function revealed land, labor, seed and chemical inputs turned significant factor in teff production with the expected sign in coefficients. The mean level technical efficiency, alloactive efficiency and economic efficiency of small scale teff producers found to be to be 47.88%, 53.59%, 39.88% indicates wide inefficiency. If inputs efficiently used, would increase teff output by 52.12% of current output level without additional inputs with current technology on average or decrease cost of inputs by 46.88% without decreasing current level of production. In general household could increase teff output by 60.12% through simultaneous proper use of inputs and reduction of cost of inputs. Tobit regression used to identify source of efficiency differentials showed being female household head, family size, and distance to crop market found negatively and significantly affected technical efficiency of household while age of household have positive relationship. Family size, distance of household from nearest office (Kebele), access to credit and nonlocal teff variety usage contributed to allocative inefficiency of teff producers. Family size, distance from nearest office (kebele), distance from extension service, contributed to inefficiency of household in teff production while distance from asphalt road, and local teff variety usage found to contribute to economic efficiency of teff producers in the area. There was possible potential Teff output increment by technical, alloactive and economic efficiency improvement without additional input or with the same level of cost incurring in Teff production with existing technology through adjusting policy variables that related to efficiency in Teff production of the study area.

Keywords: *Borana zone, stochastic frontier, economic efficiency, Tobit regression, Teff.*

Cite this article: Gabisa, B. B., & Betru, S. (2023). Analysis of Teff Producer's Economic Efficiency in Borana zone, Southern Ethiopia, *Curr. Rese. Agri. Far. 4*(5), 22-32. doi: http://dx.doi.org/10.18782/2582-7146.216

INTRODUCTION

Teff annually occupies over 29% of the entire field and contributes 19.33% of the gross grain output of all cereals in Ethiopia (CSA, 2015). Teff is malleable to a wide range of environmental conditions and even under unfavorable environmental condition (Tadele & Assefa, 2012). It has market demand, higher nutritional value, low incidence of damage by insects, better adaptation to drought and high value of straw (Yan Weikai & Kang Manjit, 2002). As reported by Solomon and Desta (2018), the livelihood based on only livestock production at Borana zone has been declining. The main reason for livelihood diversification trace back to the range land production and productivity shrinkage due to Drought, erratic rainfall, land degradation, and bush encroachments coupled with deforestation and livestock population add the limiting impact on a livestock production (Negasa et al., 2014). In order to build pastoral relicense to livestock death especially cattle development initiatives in the pastoral area dedicated to promote the various income diversification among which is crop farm expansion. Most of the pastoralists tend to diversify into agricultural production (Ayana, 2007).

Next to Common bean, Teff is the third major crop produced in Boran Zone (Diriba, 2019). The production of Teff is mainly for home consumption and market. However, the yield of Teff is by far below average national yield (Natol et al., 2018). Low production and productivity of agriculture output is due to inefficiency problems or exogenous factors (rainfall, drought, flood, etc.). Development intervention not target technical nor allocative efficiency but to change organizational and behavioral features of the area (Liao, 2014). As the result, crop production trends especially teff in the area is increasing over time as introduction of crops to ever non farmed pastoral areas seen on ground from year to year. However, introduction of Production of crops hardly contribute to pastoral livelihood income diversification unless the productivity of producers solved.

Identification of teff economic efficiency level and limiting factors hence help development initiatives support this new pastoral livelihood income diversification activities through Teff production form both technical and allocative view. However there was still no information on Economic efficiency of producers in teff production in Borana Zone. Hence, this activity conducted to bridge the existing research information gab.

MATERIALS AND METHODS

Method of Data Collection and Sampling

The survey questionnaire used to collect primary data from producers. Purposive sampling method followed by simple random sampling employed to select sample households from the population in the districts. Accordingly, the study districts purposively selected based on the potential production in major cereal crops. Then two peasant associations from each district again purposively selected based on production potential taking into consideration remote areas of pastoralist from market access. Then, simple random method used to select respondents from each kebeles. Accordingly, out of households in the selected districts, sample households constituted in the selected *kebeles* at 95% confidence interval with 0.9 degree of variability at 5% precision level (Yemane, 2001).

$n = \frac{N}{1+N(e^2)}$ Where: n is the required sample size, N is population size in the study area

e Represents level of precision.

Accordingly about 142 sample household selected from three districts of Borana zone. Households Proportion to sample size selected based in simple random sampling method from each selected PAs.

Table 1.Proportional household sample

District	PA	Household head	Sample Proportion	Total Sample
Yabello	Dida Yabelo	1382	27	56
	Ganya	1413	29	
Elwaye	Hidi Ale	951	20	43
	Ade gelchat	1025	23	
Teltele	Bila	1101	24	43
	Bule korma	867	19	

Methods of data analysis

Descriptive statistics, and economic model used for data analysis. Parametric method of approach (ASF) employed to estimate producer's technical, allocative and economic efficiencies in Teff production with best fitting production function. The most specified production function in empirical studies in agricultural production is the Cobb-Douglas functional form. Cobb-Douglas imposes a severe prior restriction on the farm's technology by restricting the production elasticity to be constant and the elasticity of input substitution to unity (Wilson, et al., 1998). However, despite its well-known limitation, it is argued by Binam et al. (2004) that as long as interest rest on efficiency measurement and not on the analysis of the general structure of the production technology, the Cobb-Douglas production function provides an adequate representation of the production technology. The stochastic frontier Cobb-Douglas production function specified as follows.

$lny_i = \beta_0 + \sum_i ln\, \beta_i X_{j,i} + \varepsilon_{j,i}$ where $\varepsilon_{j,i} = v_{j,i} - u_{j,i}$

$u_i = \delta 0 + \sum \delta mZm$ is inefficiency effect.

Proposed Factors affecting technical, allocative and economic efficiency:

Technical, allocative and economic efficiencies derived using stochastic production frontier regressed using a censored Tobit model against specific explanatory variables. The rationale behind using the Tobit model is that the bounded nature of efficiency between zero and one (Jackson & Fethi, 2000). Estimation with OLS regression of the efficiency scores would lead to biased parameter estimates, as the OLS assumes normal and homoscedastic distribution of the disturbance and dependent variable (Green, 2003b).

$u_i = \delta 0 + \sum \delta mZm$

where $u_i = efficiency\ level$, $\delta m =$ the parameter to be estimated

$Zm =$ the explanatory variable = sex of households (SEXhh), Family size (Fsize), Age of household (Agehh), distance to Kebeles (DPA), education of household (edhh), livestock size (tlu), distance to extension worker (Dexrwork),distance to farmer training centre (DFTC), distance to crop market (Dcrmarket), distance to asphalt road (Dashroa), teff variety(teffvar1), credit use, non/off farm income (NonFIN) and training proposed explanatory variables to be source of teff efficiency differentials among households.

RESULTS AND DISCUSSION

Households characteristics

From the total 143 sample households, 61.26% were illiterate while 38.73 % were literate. Households had a family size ranging from 2 to 18. The proportion of females to males in the household constitutes a ratio of 0.96 with 7.11 family sizes on average. Chi square test shows, family size of the household heads in the three districts selected is different at 1% significance level. At some selected districts polygamy marriage is common than other districts. The age of sample households' varies between 20-90 years with a mean of 44.23% years. The average household ages differ among selected districts at 5% significance level. Most of the sample households were male-headed households, which constitute about 92.25% of the sample households.

Table 2.Sex, education status, marital status, and livelihood practice

Variables	Categories	Sex of the respondents		χ^2
		Male	Female	
Education status	Illiterate	76	11	7.53
	Educated	55	-	
Marital status	Married	130	7	49.05***
	Divorced	1	3	
	widowed	-	1	

Households' access to infrastructure

Producers must travel far to gate market centers than any other services next to hospital. About 21.41% of the sample households travel more than 15 km to reach market. Due to poor roads, households could not get to use transportation service.

Table 3.Distance to infrastructures

Variable	N	Mean	Std. error	Std. error	Min
Distance to town	142	11.31	8.99	0.1	50
Distance to extension	142	2.017	3.54	0	20
Distance to asphalt road	142	6.95	9.13	0.01	50
Distance to crop market	142	11.38	8.79	0.02	55
Distance to FTC	142	1.73	3.09	0.05	17
Distance to Kebele	142	2.62	3.90	0.01	17

Livestock ownership

Livestock plays vital role, and it is integral component of the farming to contribute a lot to crops production. Even though there is large shift to use of tractors for farmland plough at first round and for threshing due to lack of oxen, oxen is the main preference of producers and source of farm power for plowing especially for sowing. Donkeys kept for transporting farm implements, water, and farm produce to homes and markets. The livestock producers have is cattle, goats, and sheep, poultry, donkey and camel ordered based on numbers respectively.

Table 4.Household's livestock asset composition

Variable	N	Mean	Std. Dev.	Min	Max
Cows	142	2.85	3.86	0	30
Oxen	142	1.51	1.77	0	10
Heifer	142	1.49	3.17	0	30
Bulls	142	0.77	1.71	0	12
Calves	142	1.77	3.24	0	30
Goats	142	6.32	8.28	0	50
Sheep	142	4.68	17.43	0	200
Camel	142	0.18	0.7	0	5
Poultry	142	4.2	5.6	0	30
Donkey	142	0.57	0.89	0	5

Crop farming

All households selected for this study own 2.907 hectares farmland on average with minimum 0.48 hectare and maximum 8.5 hectares. All households selected for this study produces at least one crop I season 1while about 91.55% households participate in crop production in season two (hagayya). Crops produced in the study area reported to be maize, teff, common bean and wheat listed according to their importance to households. The area is characterized with cereal and legume production where among cereal maize

dominated while common bean is the major legume grain produced.

Teff production and productivity

Teff production in the study area is mostly for cash needs followed by for home consumption. According to the survey result sample households used about hectares 96.98 of land and produced 672.35quintals in main rainy season while they used 65.67 hectare of land and produced 282.57quintals in short rainy season. This implies that the production maize from sample households was 6.93 quintals per hectares in main rainy season and 4.30 quintal per hectare in short rainy season. This was much lower than the national average yield which was 13.6 t0 24.1 quintals per hectare (CSA, 2020). The average Teff produced was 5.17 quintals per sample household involved in Teff production in main rainy season while it was 3.25 quintals in short rainy season.

Teff production inputs

Inputs used to produce Teff at household level include land, labor, and oxen as a capital, urea, Dap, insecticide, and herbicide.

Table 5.Summary of teff production variables

	Obs	Mean	Std. Dev.	Min	Max
Land	142	1.14	0.85	.1	6
Labor	142	104.66	87.00	4	587
Seed	142	43.46	37.29	4	250
Oxen	142	20.69	24.19	1.5	174
Fertilizer	64	82.75	53.72	10	225
Chemical	64	693.82	552.59	120	2400
Production	132	735.02	725.05	10	4000

Table6. Varieties of crops grown

No	Types of varieties	Participants	
		Season 1	Season 2
1	Dz-cross	50	49
2	Ajjord	4	4
3	Manya	40	40
4	Local	36	37

Teff production Cost

The cost of urea and DAP estimated to the cost producers pays at the area to supplier/government found to be 17birr/kg and 19.2birr/kg respectively. The amount that was paid by farmers (35birr per kg) to purchase seed was the recorded mean seed cost. The unit cost for land was estimated using the local average rental cost in the area, which was 11500 Birr/hectare for three consecutive years which is about 3833.33birr/hectare for one production year. For labor, the average wage rate for hired labor, 100Birr/man-day, was used. Oxen power was estimated as the amount of cash paid for the rental per oxen day was 150 birr per day.

Table 7.Summary of cost of inputs in teff production

Variable	**N**	**Mean**	**Std.error**
Labor cost	142	7873.94	6504.55
Land cost	142	1318.50	993.01
Fertilizer cost	64	1497.77	972.34
Oxen cost	142	2067.60	2419.41
Seed cost	142	1521.02	1304.97
Chemical cost	64	693.82	552.58

Econometric Analysis

Estimation of stochastic production function

Table 8.ML Estimates for SFA parameters and for CD model

lnproduce	Coef.	Std. Error	z	P>z
Lnland	0.26617	0.105	2.51	0.012
lnlabor	0.477559	0.111	4.28	000
lnoxen	-0.05552	0.085	-0.65	0.515
lnseed	0.487599	0.112	4.34	000
fertilizer	0.0000982	0.001	0.08	0.938
lnchemical	0.028605	0.013	2.13	0.033
constant	3.290133	0.419	8.5	0000
Diagnostic statistics				
$\lambda = \sigma u/ \sigma v$	3.41	0.1629		
σ^2	1.54***	0.293		
$\gamma=\lambda 2/(1+\lambda 2)$	0.9208***			
Log likelihood	-204.53			

Form the above input output frontier function among the five input variables for teff production land, labor and seed turned to be significant while fertilizer and oxen turned to be insignificant in Teff production. Land is significant in Teff production at 5% level of significance level while labor and seed is significant at 1% significance level. The γ value show that about 92.08% variation in teff output from frontier production is due to inefficiency problems of Teff producers. The coefficient of all under the Cobb-Douglas production function shows elasticity.

Estimation of cost function

The dual cost function and derived analytically from the stochastic production function is given as follows: Dual cost function lnminimumcost=2.74bo+0.20plLnd+0.46p2seed+-0.0001p3fert+-0.050R4oxen 0.38W5labor+-9.70E-066chimical+0.00045output Where Cs is minimum cost of producing teff; P1 refers to the price of land, P2 is price of seed; P3 is price of fertilizer; R4 is rental of oxen; W5 is cost of labor; P6 is average price of chemicals; output is output of teff in KG adjusted for statistical noise.

The coefficients of observed cost of land, labor cost, seed cost turned to be significant with positive sing in coefficient at 1% significance level. Coefficients of output adjusted for statistical noise, cost of oxen, cost of fertilizer and chemical turned to be negative and significant at 1% except fertilizer cost which was significant at 5% significance level.

Table 9.MLE of Estimation of stochastic cost frontier with observed cost of inputs used

Variables	**Coef.**	**Std. Err.**	**z**	**P>z**
lnlandcost	0.203***	.0001033	1966.95	0.000
lnlaborcost	0.379***	0.00028	130000	0.000
lnseedcost	0.468***	.0000118	4.0e+04	0.000
lnfertilizercost	-0.0000196**	9.48e-06	-2.07	0.038
lnoxencost	-0.0509***	0.00022	23000	0.000
Lnoutput	-0.0000159***	3.00e-06	-5.31	0.000
lntotcostchemical	-7.52e-06***	1.01e-06	-7.47	0.000
constant	0.417***	.000026	16000	0.000
$\lambda = \sigma u/ \sigma v$	1.2586	0.0137		
σ^2	3.78*	.0510		
$\gamma=\lambda 2/(1+\lambda 2)$	0.6130*			

The gamma (γ) estimate was 0.98 and was significant at 1% level indicating that 98% of the variation in observed cost from minimum cost was caused by allocative inefficiency. The Coefficient of sigma square (δ2) was significant at 1% level, and indicated the goodness of fit and correctness of the specified assumptions of the distribution of the compound error term. The gamma (γ) estimate was 0.6130 and was significant at 5% level indicating that 61.30% of the variation of observed cost from minimum cost was caused by allocative inefficiency. The Coefficient of sigma square (σ^2) was significant at 5% level, and indicated the goodness of fit and correctness of the specified assumptions of the distribution of the error term.

Level of technical efficiency of Teff producers

Through technical efficiency improvement, producers on average can increase Teff production by 52.19% of what they are producing without requiring additional input with the existing technology. Through allocative efficiency improvement, household can decrease cost of production by 46.41% without decreasing current level of production

Table 10.Efficiencies scores

Variable	N	Mean	Std. Dev.	Min	Max
TE	142	0.4789	0.2466	0.0009	0.8981
AE	142	0.5359	0.1741	0.1068	0.9938
EE	142	0.3989	0.1162	0.0951	0.6721

Sources of efficiency among sample producers

Table 11.Tobit model estimates determinants inefficiencies measures

	Technical efficiency		Allocative efficiency		Economic efficiency	
Vriables	Coefficients	Marginal effect	Coefficients	Marginal effect	Coefficients	Marginal effect
SEXhh	-0.2001***	-0.2001	0.0081	0.0087	0.0145	0.0145
Fsize	-00.025***	-0.0253	-0.010**	0.008	-0.0071**	-0.0071
Agehh	0.0025**	0.0025	0.0011	-0.0103	0.0007	0.0008
edhh	-0.0111*	-0.0111	-0.0012	0.0011	0.0003	0.0003
tlu	0.0026	0.0026	-0.0003	-0.0012	0.0011	0.0011
DPA	-0.0034	-0.0034	-0.0051**	-0.0003	-0.0038**	-0.0038
Dextwork	0.0028	0.0028	-0.0009	-0.0051	-0.0030*	-0.0030
DFTC	-0.0028	-0.0028	-0.0048	-0.0009	0.0007	0.0007
Dcrmarket	-0.0084***	-0.0084	-0.0006	-0.0048	0.0003	0.0003
Dasphroa	0.0033	0.0033	0.0015	0.0006	0.0019**	0.0019
teffvar1	0.0104	0.0104	0.0942**	0.0015	-0.0465**	-0.0465
Credit use	-0.0473	-0.0473	-0.0583*	-0.09425	-0.0263	-0.0263
NonFIN	-0.0071	-0.0071	-0.0119	-0.05837	-0.0176	-0.0176
training	-0.0188	-0.01886	0.0229	0.011933	0.0315	0.0315
Constant	0.6290	-	0.6682	-	0.4767	-

Sex of household head: This variable is dummy variable whether household is female or male. If household is female 1 is given and otherwise 0. It showed female households are less technically efficient than their counterparts at 1% significance level. The farming requires labor force. Females require help from male households for tillage, harvest and thresh that this activity might not on time. Females have more additional reproductive activity that hinders them to work farm field. In addition, Female-headed households face gender-specific constraints, mainly the poor quality of farmland, limited access to institutional supports, and low level of assets and livestock ownership. The result is consistent with the findings of Mango et al. (2015); Gebrehiwot (2017), Birhanue et al. (2022) that found female household is technically less efficient.

Age of households: Age of household has proposed to have positive or negative contribution to efficiency based on the argument whether if elders household attach to the existing technology resisting the new one that can increase production or as proxy variable with experience where more experienced in production to produce more. According to this study age of household positively and significantly contributed efficiency at 5% significance level. These showed elders were more experienced in Teff production and technically efficient than the younger. The increase in age of producer might help experience in farm management that helps them to optimize their production. This work is in line with Kassa et al. (2019), Endalew et al. (2023), Alamu (2018), and Desale (2019) found age contributed to technical efficiency of crop production in their study. Tesfaw et al. (2021) found variable that age is explaining (experience) in teff production contributed to technical efficiency.

Household education: Education assumed to contribute to technical, allocative and economic efficiencies with the assumption that more educated household were flexible in decision making to accept new method, information and direction in yield improvement. But, in this finding, household education turned to be against the assumption and more educated household found to be technically less efficient in teff production. Education hardly contributed to production if there is limited production and productivity improvement intervention. Thus, household tried to develop their experience for themselves to solve the problems than from information and intervention that could be facilitated through education.

Family size: it is the number of people in the household. The result showed increase in family number will contribute to decrease technical, allocative and economic efficiency of households at 1%, 5%, and 5% significance level respectively. As the number of household increase at a fixed technology it is natural that labor productivity will decrease after a fixed point on the given activities. The areas of pastoralist depend on their fixed technology with limited availability or limited adoption. Additional labor force thus might contribute to productivity problems. Large family size also might stress production activities due to reproductive activities competed time for farm activities. Apart from highland areas, large family size involved in other non-crop related activities and they might be less experienced as they are to diversify livestock production only livelihood option. This finding is disagreed with who found Family size significantly contributed to technical efficiency. This finding also needs further research to establish family size category to production efficiency as this finding has limitation due to variable in this study was family size than working age.

Distance to facilities and institution: it is believed that household near to market center access different marketable inputs from market compared to household found far from market. In this result, distance to crop market decrease technical efficiency at 1% significance level respectively. The finding is consistent with the work of Gebregziabher et al. (2012) and Nisrane et al. (2012), Tesfaw (2021) who found distance to household from market contributed to household inefficiency in their respective works. Distance to Kebele administration (which is distance from government support input source and other information delivery place) where negatively affected alloactive and economic efficiency at 5% significance level. Distance to extension worker negatively and significant influenced economic efficiency. Distance to asphalt road and economic efficiency of households showed negative relationship.

Seed variety: it was adjusted to be dummy variable with household practicing new (improved variety) being 1 and otherwise 0. The result showed negative relationship of improved variety with both allocative and economic efficiency at 5% significance level unfavorably to the assumption improved variety contributes to production efficiency. The variety of Teff released from research centre indeed was not superior to local seed in

productivity. The other (Magna) variety introduced from other development source and well-practiced also not contributed to technical efficiency. It needs further research in Teff variety that able to contribute to productivity at this area as the existing variety productivity is much less than the national yield. This work is against Assefa et al. (2011) and Elias et al. (2014), and Tesfaw (2021).

Credit use: is dummy variable if household used credit is set to 1 and otherwise 0. The source of these credit household used include rural cooperative saving and credit, friend or kin relation, and formal institutions (bank/microfinance). The result showed Household used credit is less allocative efficient than household not used credit. The major credit source household used is (97) % rural cooperative. The credit in this form established and encrouged by non-government organizations to relief rural household cash need problems during critical times. This type credit and saving is not used to finance investments and production activities but it is lifesaving. Thus, household with credit is those who lost their crop produce, livestock and face other shock.

CONCLUSION AND RECOMMENDATION

The study intended two stage analysis of economic efficiency of teff producers in the study area. Primary data collected through household survey from 142 samples selected randomly. The Cobb-Douglas stochastic frontier production and its dual cost functions estimated from which TE, AE and EE extracted. Six variables used to be input function in selected stochastic production function (Cobb-Douglas). The result revealed land, labor input, seed and chemical input turned significant factor in teff production with the expected sign in coefficients. From the elasticity of input, teff production in the area was found to be at an increasing scale of production stage indicating a room to increase teff output than proportional increasing of inputs. The mean level technical, alloactive and economic efficiency found to be 0.4788, 0.535, 39.88.

Tobit regression model used to identify source of efficiency differentials expressed as functions of 14 explanatory variables. Among variable assumed, being female household head, family size, and distance to crop market found to decrease technical efficiency of household while age of contribute to efficiency. Family size, distance of household from nearest office (Kebele), access to credit and improved teff variety usage decreased allocative efficiency of teff producers. Family size, distance from nearest office (kebele), distance from extension service decreased economic efficiency of household while distance from asphalt road, and improved teff variety usage found to contribute to economic efficiency. The stage of production is operating at underutilization of teff production inputs it is important to move from first production stage to second production stage through increase use of factors of teff production. Involving elders in any production plan of the area is much important as elder's experience contribute to technical efficiency in this model. Younger producer should be encouraged to operate teff production in efficient way through information and experience sharing from elders.

Family size which could be assumed as the source of labor force, is decreased both technical and economic efficiency. There should be proper use of family labor force in teff production and further research to establish relation of working age to efficiency. Investment in insuring household access to nearest government office such as kebele administration office, agricultural extension office, crop market and asphalt road, will improve teff production efficiencies. The improved varieties used showed negative relation to allocative and economic efficiency. There should be further research on new adaptive variety of teff. The new seed variety introduction with cost wise and out-way existing variety productivity is needed as productivity of the area is operating much

below national average. Improving household access to credit oriented production than lifesaving and further research on its impact on efficiency is needed.

Acknowledgement:
I would like to sincerely thank my co-authors for their support and kind gesture to complete this manuscript in time.

Funding: NIL.

Conflict of Interest:
There is no such evidence of conflict of interest.

Author Contribution
All authors have participated in critically revising of the entire manuscript and approval of the final manuscript.

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