P-ISSN: 2305-6622; E-ISSN: 2306-3599

International Journal of
Agriculture and Biosciences

www.ijagbio.com; editor@**ijagbio**.com

Research Article

Adoption of Improved *Tef* Varieties in Central Ethiopia: A Double-Hurdle Model

Addisu Getahun[1*] and Gadisa Muleta[2]

Ethiopian Institute of Agricultural Research (EIAR), Holeta Agricultural Research Center, P.O. Box: 31, Holeta, Ethiopia
Ethiopian Institute of Agricultural Research (EIAR), National Agricultural Biotechnology Research Center (NABRC), P.O. Box: 249, Holeta, Ethiopia
***Corresponding author:** addisgeta127@gmail.com

Article History: 12327 Received: 10-App-21 Revised: 22-May-21 Accepted: 25-Jun-21

ABSTRACT

Adoption of improved and high yielding varieties is essential to improve production and productivity of the Producers. This study was conducted with the objective of assessing the adoption and intensity of adoption of improved *Tef* varieties in West Shewa Zone of Oromia Region, Ethiopia. Both primary and secondary data were used. The primary data were collected from 210 sample households sampled from Dendi district using two-stage random sampling technique. Descriptive statistics and Double Hurdle econometric model were used to analyze the data. The descriptive result revealed that 60% of the households in the district were cultivating improved *tef* varieties. To identify the determinants of adoption and level of adoption of improved *tef* varieties, a Double hurdle econometric model was employed. The results of probit model revealed that sex of the household head and livestock owned showed positive effect on the probability of adoption of improved *tef* varieties. The truncated model result identified that sex of household head, household size, total land owned, livestock owned, and frequency of extension contact positively and significantly influenced the intensity use of improved *tef* varieties. Hence, future development intervention should give emphasis for solving the adoption and production constraints of *tef* to improve the probability of adoption and intensity of use of improved *tef* varieties.

Key words: Adoption, Intensity of adoption, Improved tef verities, Double Hurdle model

INTRODUCTION

Agriculture in Ethiopia is continuing to be a vital sector and largely dominated by smallholder farmers. In the agricultural sector, cereals cover about 80% of the total grain crop area (9.97 million hectares) and contribute about 87% (23.1 million tons) of the grain production. Among cereals, *tef* (Eragrostis *tef*) stands first in terms of land area, followed by maize and wheat (CSA, 2016). Ethiopia is the center of both origin and diversity for *tef* (Vavilov, 1951). Ethiopia implemented several extensions approach to the agricultural sector since mid-1960s. One effective way to increase agricultural productivity is through wider adoption of new farming technologies (Minten and Barrett, 2008). Agricultural extension systems are an agricultural information exchange system which shows the actors, people and institutions, their interactions and communication networks among these actors to coordinate the information related processes from generation to transfer, utilization and diffusion of improved agricultural technologies and new agronomic practices.

Adoption is a mental process through which an individual passes from hearing about an innovation to its adoption that follows awareness, interest, evaluation, trial, and adoption stages (Bahadur and Siegfried, 2004). The study area is found in West Shewa zone of Oromia region, central Ethiopia. West Shewa zone is potential area of *tef* production in central Ethiopia. According to CSA data, *tef* covering 2,866,052.99 hectares of cultivated area of land and grown by 6,562,325 farmers in Ethiopia, it covers 1,369,934 hectares of cultivated area of land and grown by 2,519,210.00 farmers in Oromia region and it covers 205,573 hectares of cultivated area of land and grown by 280,033 farmers in west Shewa zone. The national productivity of *tef* is (15.6 qt/ha), and in Oromia region it is (16.17 qt/ha) where as in west Shewa zone it is (18.53 qt/ha) which is higher than the national and regional average (CSA, 2016). The sustained cultivation of *tef* in Ethiopia has been emphasized by a multitude of its relative merits over the other crops in terms of its broad adaptation to a wide range of altitudes and to varied agro-ecological conditions; reasonable tolerance to both low and high

Cite This Article as: Addisu G and Gadisa M, 2021. Adoption of Improved *Tef* Varieties in Central Ethiopia: A Double-Hurdle Model. Int J Agri Biosci, 10(3): 140-146. www.ijagbio.com

moisture stresses; minimal post-harvest losses since the grains suffer less from storage pests (such as weevils) (Kebebew *et al*., 2013). Despite the suitability of the climatic condition's smallholder farmers are still food insecure. Ethiopian *tef* yields have not met the increased market demands, thus leading to ever-increasing prices of *tef* (Demeke *et al.,* 2013). Agricultural advisory services are defined as the entire set of organizations that support and facilitate people engaged in agricultural production to solve problems and to obtain information, skills, and technologies to improve their livelihoods and well-being (Birner *et al.*, 2009).

The adoption of new technologies, such as fertilizer, improved seed and agronomic practices is a central to agricultural growth and poverty reduction efforts. The extension system is mandated to promote improved agricultural technologies and knowledge generated by the research system to the producer which contributes for food security. So far Ethiopian institute of agricultural research and government agricultural extension systems performs technology and knowledge dissemination, capacity building, and enhanced the linkage and partnership with technology adopter/beneficiaries but still there is low yield. An acceptable and meaningful transformation of agricultural technologies through research extension system will be expected to improve productivity, build resilience to farming systems, improve livelihoods and reduce harm to the environment (Nyasimi *et al.,* 2014). Even different extension systems implemented so far there is a gap on the level of agricultural technology adoption and productivity among smallholder *tef* cultivating farmers.

Adoption of improved agricultural technologies is a central for increasing production and productivity. Different improved *tef* varieties are introduced to farming communities by research institution and other development partner but the probability and intensity of adoption were affected by different household socio-economic and demographic factors, infrastructural and institutional factors, and so on. Given the high potential of Dendi district for *tef* production this study aims to identify both factors determining adoption decision and intensity of adoption of improved *tef* varieties among smallholder farmers in the study areas.

MATERIALS AND METHODS

Description of the Study Areas

Dendi district is one of the thirty-three districts in West Shewa zone of Oromia regional state and lies at about 80 km west of Addis Abeba. The district is geographically situated within 038010'54"E longitude and 9º 01'16"N latitude and at an altitude of 2200 meter above sea level. Dendi district is bordered on the south by Dawo and Wenchi, on the west by Ambo and Elfeta, on the north by Jeldu, and on the east by Ejersa Lafo districts. The district has a total of 38 kebeles, of which, 35 are rural and 3 are urban.

The total population of the district is 200715. Out of the total population 42953(21.4%) are urban dwellers and 157762(78.6%) are rural dwellers. Of these total population 19231 are rural households, and male and female households constitute 85.6 % and 14.4 %, respectively. The total area coverage of the district is 79,936.29 hectares of which 39,227.5 hectares are cultivated land, 14,912.36 hectares are grazing land, 7,925.93 hectares are forest land, 14,829.5 hectares are uncultivated and others (homestead, rivers and road) constitute 3,041 hectares. The mean annual rainfall of the district is 1094 mm with minimum and maximum annual rainfall of 750mm and 1170mm, respectively while the mean temperature is 16.30C with minimum and maximum temperature is 9.30C and 23.80C, respectively. Cereal crops grown in the district includes: *tef*, wheat, barley, maize and sorghum. The district is known for its highest production of *tef* (DDAO, 2017).

Data Types, Sources and Methods of Data Collection

The study uses both primary and secondary data. Primary data were collected from randomly selected *tef* producers in the district. Primary data were collected by structured and semi-structured questionnaires. Secondary data on socio-economic information were taken by reviewing secondary sources from published and unpublished documents, journals and websites were visited focusing on the objectives of the study.

Sampling Procedure and Sample Size Determination

In this study a purposive and two-stage sampling procedure was employed. Dendi district were selected purposively based on potential area of *tef* production. In the first stage, five *tef* producing were selected randomly from a total of 24 *tef* producing kebeles. In the second stage, from the total of 2425 households 210 sample household heads were selected randomly, using probability proportionate to size. The total sample size (n=210) was determined following a simplified formula provided by Yamane (1967).

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

Where: n = sample size, N = population size (sampling frame) and e = level of precision which is (6.6) and a 95% confidence level with degree of variability of 5%.

Methods of Data Analysis

Both descriptive statistics and econometric models were used to analyze the data collected from primary sources.

Descriptive Statistical Analysis

Descriptive statistical analysis method such as mean, proportions, percentages, standard deviations, t-test and chi^2 test were used in describing the demographic and socio-economic characteristics of respondents.

Econometric Analysis

To identify factors influencing adoption and intensity of adoption a Double hurdle model which interprets the zero observation as corner solution and addresses the intensity of adoption is used. Double hurdle model was first introduced as a class of models by Cragg (1971). The modeling approach assumes a two-step decision process. This is based on the assumption that farming household heads makes two separate decisions with regard to adoption and intensity of use of improved *tef* varieties.; the first step involves the decision whether to adopt or not and secondly the extent of adoption. The model estimation involves a probit regression to identify factors affecting the decision to adopt improved *tef* varieties in the first stage, and a truncated regression model on the participating households to analyze the extent of adoption, in the second stage.

The general form of Cragg's double hurdle model (probit and truncated models) that was used for this study is specified as follows.

$$D_i^* = W_i'\alpha + U_i \text{ (Adoption decision equation)} \quad (2)$$

$$D_i = 1, if\ D_i^* > 0, D_i = 0, Otherwise$$

Where, D* is the latent variable describing the household's decision of whether or not to adopt improved *tef* varieties that takes the value 1 if the household adopted and 0 otherwise, D_i is the observed variable which represents the household's adoption decision, W_i is a vector of explanatory variables, α is a vector of parameters to be estimated and U_i is the error term.

$$Y_i = X_i^*\beta + V_i \text{ (Intensity equation)} \quad (3)$$

$$Y_i = Y_i^* = X_i\beta + V_i \text{ if } Y_i^* > 0 \text{ and } D_i^* > 0, Y_i=0, \text{ Otherwise}$$

Where, Y_i^* is the latent variable describing the intensity of adoption of improved *tef* varieties. Y_i is the area of improved *tef* varieties cultivated in hectare indicating the intensity of adoption and X_i indicates the vector of explanatory variables influencing how much the household use improved *tef* varieties, β is a vector of parameters to be estimated and V_i is the error term. If both decisions are made by the individual farmers independently, the error term are assumed to be independently and normal distributed as: U_i~N (0, 1) and V_i~N (0, δ2).

The log-likelihood from the Cragg type double-hurdle model is the sum of the log-likelihood from a probit and a truncated regression. Hence, double-hurdle model is given by:

$$\text{Log } 1 = \boldsymbol{\Sigma}_0 \ln\left(1 - \phi\left(W_i'\alpha\left(\frac{X_i^*\beta}{\sigma}\right)\right)\right) + \boldsymbol{\Sigma}_+ \ln\left(\phi(W_i'\alpha)\frac{1}{\sigma}\emptyset\left(\frac{Y_i - X_i^*\beta}{\sigma}\right)\right) (4)$$

Where, Φ and ∅ are standard normal cumulative distribution function and density function respectively.

To determine the appropriateness of models, a hypothesis test for the double-hurdle model against the Tobit model was made. Likelihood ratio test (LR test) is a statistical test used for comparing the goodness of fit of Tobit model and Double-hurdle model. A test of the Tobit model against the double-hurdle model comes from the fact that the hurdle model log likelihood can always be written as the sum of the log likelihoods of the two separate models: a probit and a truncated model (Greene, 2000 cited in Hailemariam *et al.*, 2006). Therefore, whether a Tobit or a double hurdle model is more appropriate can be determined by estimating the Tobit and the double hurdle models (the truncated regression model and the probit model) separately and then conducting a likelihood ratio test that compares the Tobit with the sum of the log likelihood functions of the probit and truncated regression models (Genanew and Alemu, 2010).

The likelihood ratio test statistics Γ can be computed (Greene 2000) as:

$$\Gamma = -2\left[\ln L_{Tobit} - \left(\ln L_{Probit} + \ln L_{Truncated}\right)\right] \sim \chi_k^{\ 2} \quad (5)$$

Where, Γ= likelihood ratio statistic;

ln= natural logarithm;

L_{Tobit}, L_{Probit} and $L_{Truncated}$ = likelihood of Tobit, Probit and Truncated regression models,

χ^2 = chi-square statistic and k are the number of independent variables in the equations.

The hypothesis test for accepting and rejecting the null is written as H_0: $\lambda = \frac{\beta}{\sigma}$ and $\lambda \neq \frac{\beta}{\sigma}$ (Hailemariam *et al.*, 2006). Thus, Tobit model arises as we accept the null hypothesis $\lambda = \frac{\beta}{\sigma}$. Decision rules to accept the null hypothesis is when the likelihood ratio statistic (Γ) is less than the value of the chi-square statistic (χ^2_k). The chi-square statistic is obtained from the chi-square table for a pre-defined level of statistical significance and degrees of freedom (where, degrees of freedom = number of parameters involved in the analysis).

Hypothesis and Variables Definition

In order to identify factors determining the probability of adoption and intensity of use of improved *tef* varieties in the study areas the following dependent and independent variables were defined and hypothesized.

Adoption of Improved *tef* Varieties (ADOPTEF)

It is a dummy dependent variable, depending on the farmers' decision either adopt or not adopt the improved *tef* varieties. It takes value of 1 if the household adopted improved *tef* varieties otherwise 0 in 2016/17 production year.

Intensity of use of Improved *tef* Varieties (INTADOPTEF)

It is a continuous dependent available measured in hectare of land covered by improve *tef* varieties in 2016/17 production year. Based on the information from different literatures the expected sign and hypothesized explanatory variables used in the study were shown on Table 1 below.

RESULTS AND DISCUSSION

This chapter presents major results of the study with brief discussion organized into two sub-parts of descriptive analysis and econometric model results.

Descriptive Analysis

Demographic and Socio-economic Characteristics

The results of the study revealed that out of total 210 sample households, 126 (60%) households are adopters of improved *tef* varieties and 84 (40%) households are non-adopters of improved *tef* varieties in 2016/17 production year. Group comparisons of Improved *tef* adopters and non-adopters was computed using *t*-test for continuous variables and chi^2-test for dummy variables, and the results are presented in the consecutive tables.

As indicated in Table 2, out of total sample respondents, 172 (81.9%) were male-headed and 38(18.1%) were female-headed households. Regarding cooperative membership, 104(49.52%) of the sample households were members of cooperatives and 106(50.48%) were not organized under cooperatives. The chi^2 (Fisher's exact)-test result among adopters and non-adopters indicate the existence of significant difference between the groups in terms of cooperative membership and adopters are more in number than non-adopters (Table 2).

The two-group mean-comparison test of continuous variables used in the study revealed that there was statistically a significant mean difference between adopters and non-adopters in frequency of extension contact and

Table 1: Description and hypothesis of explanatory variables

Variables	Type	Measurement	Expected effect	
			Adoption	Intensity
Sex of the household head	Dummy	0 if the hh is male; 1 otherwise (being male)	+	+
Education level of hh	Continuous	Grades completed	+	+
Household size	Continuous	Household size in man equivalent	+	+
Farming experience	Continuous	No of years	+	+
Total Livestock owned	Continuous	TLU	+	+
Total land size owned	Continuous	Hectare	+	+
Access to credit service	Dummy	1 if the hh has access to credit; 0 otherwise	+	+
Frequency of extension contact	Discrete	Frequency	+	+
Access to information	Dummy	1 if the hh has mobile phone; 0 otherwise	+	+
Non/off-farm income	Continuous	ET Birr	-	-
Cooperative membership	Dummy	1 if the hh is member of coop.; 0 otherwise	+	+

Table 2: Test statistics of improve tef varieties adopters and non-adopters (chi^2 -test)

Variables	Adopter		Non-adopter		x^2-value
	n	%	n	%	
	126	60	84	40	
Sex of household head					
Male	100	58.14	72	41.86	1.371
Female	26	68.42	12	31.58	
Access to Credit					
No	106	58.24	76	41.76	1.758
Yes	20	71.43	8	28.57	
Cooperative membership					
Yes	68	66.67	34	33.33	3.673**
No	58	53.70	50	46.30	
Access to information					
Yes	93	59.62	63	40.38	0.037
No	33	61.11	21	38.89	

Symbols: ** indicates significant at 5% levels.

Table 3: Test statistics of improve tef varieties adopters and non-adopters (t-test)

Variables	Mean			Std. Dev.	*t*-value
	Adopter	Non-adopter	Total		
	(n=126)	(n=84)	(n=210)		
Education level (Formal schooling)	4.5	3.67	4.17	3.61	-1.6
Household size (Man equivalent)	2.87	2.91	2.88	1.2	0.3
Farming experience (No of years)	18.88	17.53	18.34	7.33	-1.3
Livestock owned (TLU)	5.86	4.62	5.37	2.92	-3.1***
Total land owned (Hectare)	1.91	1.75	1.84	1.31	-0.86
Frequency of extension contact	8.1	6.65	7.51	5.74	-1.77*
Non/off-farm income (ET Birr)	3.68	4.22	3.89	5.10	0.75

Symbols: *** and * indicates significant at 1% and 10% levels, respectively.

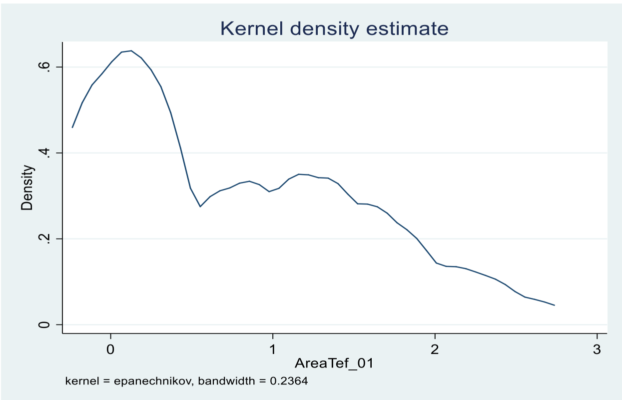

Fig. 1: Kernel density estimate of intensity use of improved *tef* varieties.

number of livestock owned (Table 3) below. Educational level of sample household was measured by the formal schooling the household head attended. With regards to the educational level of sample household heads, the average number of formal schooling completed was 4.17 years with a standard deviation of 3.61.

As depicted in variable definition the household size of sample household was measured in man equivalent and the average household size of sample respondents was 2.88 with standard deviation of 1.2 (Table 3). The farming experience in *tef* production is taken to be the number of years that an individual was continuously engaged in *tef* cultivation. The average farming experience of sample respondents was 18.34 years with standard deviation of 7.33.

In the study areas, mixed crop and livestock farming system is dominantly used by farm households. Livestock resources are highly useful and the major contributors to crop production including for *tef*. Farmers in the study area used livestock resources to undertake different agronomic practices out of which ploughing and threshing and as a source of income to purchase agricultural inputs are the major ones. The mean difference in livestock owned among improved *tef* varieties adopters and non-adopters is statistically significant at 1% in favor of the former.

Table 4: Farm input use of sample households for tef

Type of inputs used	Mean	Std. Dev.
Improved seed (kg)	23.38	6.93
NPS fertilizer (kg)	117.63	33.92
Urea fertilizer (kg)	52.17	23.97
Herbicide 2-4-D (litter)	0.64	0.28

Table 5: Type of varieties of tef used by sample households

Name of varieties used	Frequency	Percent	Category
Kuncho	116	55	Improved
Kora	10	5	
Bunisie	11	5.3	Local
Gololisa	73	34.7	

Table 6: Probit model estimates on probability adoption of improved *tef* varieties

Variables	Coefficient	Robust Std. Err.	p-value	Marginal effect
Sex of household head	0.521**	0.252	0.039	0.187
Education level of hh	0.000	0.037	0.999	-0.000
Household size (Man equiv)	-0.043	0.079	0.583	-0.017
Farming experience	0.003	0.015	0.821	0.001
Livestock owned	0.116**	0.048	0.015	0.045
Total land owned (Hec)	-0.050	0.082	0.544	-0.019
Frequency of extension	-0.006	0.024	0.815	-0.002
Non/off-farm income	0.002	0.019	0.897	0.001
Access to Credit	0.234	0.274	0.393	0.087
Access to information	-0.088	0.220	0.689	-0.034
Cooperative membership	0.092	0.242	0.702	0.036
Constant	-0.268	0.380	-0.70	
Wald chi2 (11)	16.67			
Prob > chi2	0.109			
Log likelihood	-133.62			

Symbols: ** indicates significant at 5% levels.

Table 7: Truncated regression estimates on intensity of improved *tef* varieties

Variables	Coefficient	Robust Std. Err.	p-value
Sex of household head	0.211**	0.101	0.037
Education level of hh	0.004	0.015	0.812
Household size (Man equiv)	0.080**	0.033	0.015
Farming experience	0.003	0.007	0.675
Livestock owned	0.081***	0.020	0.000
Total land owned (Hec)	0.076*	0.039	0.050
Frequency of extension	0.029***	0.010	0.002
Non/off-farm income	-0.005	0.008	0.503
Access to Credit	0.075	0.128	0.555
Access to information	-0.036	0.096	0.705
Cooperative membership	0.114	0.093	0.220
Sex of household head	-0.018	0.164	0.913
Constant	-0.0179	0.163	0.913
Sigma	0.403***	0.031	0.000
Wald chi2 (11)	215.92		
Prob > chi2	0.000		
Log likelihood	-56.835		

Symbols: ***, ** and * indicates significant at 1%, 5% and 10% levels, respectively

The average livestock owned by sample households was 5.37 TLU with a standard deviation of 2.92 (Table 3).

Agricultural **e**xtension service provision on improved agricultural technologies has a direct influence on the adoption and production performance of the farmers. The major extension services provided in relation to *tef* production includes: use of improved varieties of *tef*, row planting, input use, soil and water conservation. The mean difference in extension contact among improved *tef* varieties adopters and non-adopters is statistically significant at 10%. The average frequency of extension service provided for sampled households was 7.51 day/year with standard deviation of 5.74 (Table 3).

Types of inputs used in *tef* production by sample households

The farm inputs used in *tef* production by sample households includes in-organic fertilizers (NPS and Urea), *tef* seed, and herbicide. As shown in Table 4 the mean improved seed of *tef* used per hectare was 23.38 kg with standard deviation of 6.92, the mean NPS fertilizer used per hectare was 117.63 kg with standard deviation of 33.92, the mean Urea fertilizer used per hectare was 52.17 kg with standard deviation of 23.97, and the mean Herbicide used per hectare was 0.64 litter with standard deviation of 0.28.

Types of varieties used and intensity of use of improved *tef* varieties

Adoption of high-yielding varieties have a positive effect on production and productivity. Sampled household heads in the study area used different types of tef seed for production. The result in Table 5 shows that the majority of households 116 (55%) in the study areas cultivate improved tef varieties called Kuncho.

The results of the study Figure 1 below shows that the kernel density estimates of intensity use of improved *tef* varieties.

Econometric Analysis

Before econometric analysis essential tests that verify the hypothesized explanatory variables and existence of econometric problems were done using appropriate test statistics. Likelihood ratio test (LR test) is a statistical test used for comparing the goodness of fit of Tobit model and Double-hurdle model. The test statistic for log likelihood ratio ($\Gamma = 8.44$) was higher than the chi-square distribution (5.23) at 12 degrees of freedom, statistically significant which is in favor of the Double-hurdle model. The implication of the result is that for identifying determinants adoption and intensity of use improved *tef* varieties, Double-hurdle model feet the data.

The model estimation involves a probit regression to identify determinants of the decision to adopt improved *tef* varieties in the first stage, and secondly a truncated regression model for the intensity of adoption of improved *tef* varieties in the study area. The estimated coefficients of probit model and truncated regression model are presented in Table 6 and 7, respectively.

Factors affecting the probability of adopting improved *tef* varieties

The Probit regression model estimated results in Table 6 showed that out of the explanatory variables used in the model two of them the sex of household head and the number of livestock owned (TLU) were found statistically significant to influence the likelihood of adopting improved *tef* varieties in the study area.

Sex of the household head was found to be a statically significant and positive effect on the probability of adoption of improved *tef* varieties at 5% level of significance. The positive association implies that sex of household head being male increases the probability adoption improved *tef* varieties by 18.7%. This implies that male headed households are more advantageous for the likely to adopt improved *tef* varieties than females headed households and the result implies empowering of female household head is crucial to improve the probability of adoption of improved *tef* varieties. This result is in line with the findings of Ogeto *et al.,* (2019) Male-headed households are more likely to adopt improved varieties compared to female-headed ones.

The number of livestock owned had a significantly significant and positive effect on the likelihood of adopting of improved *tef* varieties at 5% probability level. The result implies that an increase in number of livestock owned by one TLU rises the likelihood of adopting improved *tef* varieties by 4.5%. This is due to the positive effect of livestock resources on *tef* cultivation as a source of cash to purchase improved *tef* varieties and inorganic fertilizers. This outcome is in line with Susie and Bosena (2020) findings that an increase in number of livestock by one tropical livestock unit the probability of adoption of improved *tef* varieties also increases.

Factors affecting adoption intensity of improved *tef* varieties

The result of Truncated regression model showed that out of twelve explanatory variables used in the model five explanatory variables were significantly affect the intensity of uses of improved *tef* varieties. These are sex of household head, household size (man equivalent), total land owned (hectare), number of livestock owned (TLU) and frequency of extension contact (Table 7).

Sex of the household head (being male) had found to be a statically significant and positive effect on the intensity of use of improved *tef* varieties at 5% probability level. The positive relationship implies that as compared to female headed household being male household head increases the intensity use of improved *tef* varieties by 21.1%. This result implies that male headed households allocate and cultivate more areas for improved *tef* varieties than female headed one this was due to the fact that activities accomplished at home like fall upon the females and they have no aware of improve varieties. This specifies that empowering of female household head on improved *tef* cultivation is vital to improve their livelihoods. This finding is similar with the study done by Susie and Bosena (2020) found that sex of household heads had positive and significant effect on the intensity of use of improved *tef* varieties.

Livestock owned (TLU) had a positive and significantly significant at 1%. The result revealed that an increase of livestock resource owned enhances the intensity use of improved *tef* varieties. The result indicates that an increase the number of livestock by one TLU increase the intensity use of improved *tef* varieties by 8.1%. This is result indicated that household heads with higher number of livestock allocated more hectare of land for improved *tef* varieties cultivation than their counterparts. This is due to the fact that oxen serve as a traction power and other livestock resource used as means of income to purchase inputs for improved *tef* cultivation. This result is in line with Regasa *et al.,* (2018) found that the positive and significant effect of different types of livestock ownership effect on the area allocated under improved *tef* varieties.

Household size measured as man equivalent was found to have a positive and statistically significant at 5% probability level. As hypothesized an increase of household member by one man equivalent enhanced the intensity use of improved *tef* varieties by 8%. The findings due to the fact that *tef* cultivation activity is a labor intensive from land preparation to harvesting and households with more household size tend to increase the areas of land to improved *tef* production than those household with few household members. This result supported by the findings of Susie and Bosena (2020) who showed that family labor was positively and significantly influenced the intensity of using improved *tef* varieties.

Total hectares land the household owned had positive and statistically significant effect on the intensity use of improve *tef* varieties at 1% level of significance. The result revealed that having one additional hectare of land would increase the intensity use of improved *tef* varieties by 7.6% This is due to the positive effect of cultivating one more additional hectare of land from self-owned, by rented-in or shared-in land helps the household's to increases the extent use of improve *tef* varieties. This result is consistent with the findings of Dawit (2020) who finds that farm size had positively and significantly influenced the probability of adoption of high yielding *tef* varieties.

Frequency of extension contacts had statistically significant and positive effect on the intensity use improved *tef* varieties at 1% significant level. The result shows that a rise in extension contact by one day would increase the intensity use improved *tef* varieties by 2.9%. This result infers that the technical advice on improved *tef* cultivation and related agronomic practices provided for farmers by agricultural development agent improves farmers knowledge and enhance the areas allected to improved *tef* varieties production. This result is similar with the findings of Regasa *et al.,* (2018) who found that access to training and information on new improved *tef* varieties had a positive and significant effect on increasing areas allocated to improved *tef* varieties.

Conclusions and Recommendations

The study was aimed at identifying factors determining adoption decision and intensity of adoption of improved *tef* varieties among smallholder farmers in Dendi district of Oromia region, Central Ethiopia. For the study primary data were collected from randomly selected 210 *tef* cultivating farmers. To identify factors influencing adoption and intensity of adoption improved *tef* varieties a Double hurdle model was employed. The model estimation involves a probit regression to identify factors affecting the decision to adopt improved *tef* varieties in the first stage, and a truncated regression model on the participating households to analyze the extent of adoption, in the second stage. The descriptive statistics results revealed that out of total sample households, 126(60%) households are adopters of improved *tef* varieties and 84(40%) households are non-adopters of improved *tef* varieties. The majority of households 116 (55%) in the study areas cultivate improved *tef* varieties called Kuncho.

The probit model result shows sex of household head and the number of livestock owned were positive and significantly influence the likelihood of adopting improved *tef* varieties. The Truncated regression model result implies that the intensity use of improved *tef* varieties is positivelly and significantly affected by sex of household head, household size, total land owned, number of livestock owned, and frequency of extension contact. Hence, future development intervention and the collective efforts of stakeholders should give emphasis to these variables in order to enhance the probability of adoption and strengthening intensity of use of improved *tef* varieties to enhance the livelihoods of farming households.

REFERENCES

Bahadur KL and B Siegfried, 2004. Technology Adoption and Household Food Security. Analyzing Factors Determining Technology Adoption and Impact of Project Intervention: A Case of Smallholder Peasants in Nepal, Paper prepared for presentation at the Deutscher Tropentag, 5-7 October 2004, Humboldt University, Berlin.

Birner R, KE Davis, J Pender, E Nkonya, P Anandajayasekeram, J Ekboir, A Mbabu, DJ Spielman, D Horna, S Benin and M Cohen, 2009. "From Best Practice to Best Fit: A Framework for Designing and Analyzing Pluralistic Agricultural Advisory Services Worldwide. Journal of Agricultural Education and Extension 15(4): 341–355.

Cragg JG, 1971. Some Statistical Models for Limited Dependent Variables with Application to the Demand for Durable Goods. Econometrica, 39: 829-844.

CSA (Central Statistical Agency) 2016. Agricultural Sample Survey 2015/2016 (2008 E.C): Report on area and production of major crops, volume-I. Addis Ababa, Ethiopia.

Dawit M, 2020. Factors Affecting High Yielding Teff Varieties Adoption Intensity by Small Holder Farmers in West Showa Zone, Ethiopia. International Journal of Economy, Energy and Environment. 5: 6-13. doi: 10.11648/j.ijeee.20200501.12

DDAO (Dendi District Agriculture Office) 2017. Annual report of Dendi district, Oromia region, Ethiopia.

Demeke M and F Di Marcantonio, 2013. Analysis of incentives and disincentives for tef in Ethiopia. Technical note series, Monitoring Africa Food and Agricultural Policies (MAFAP), FAO, Rome.

Genanew B and M Alemu, 2010. Investments in land conservation in the Ethiopian highlands: A household plot-level analysis of the roles of poverty, tenure security and market incentives. Environment for Development, Discussion Paper Series, March 2010.

Greene WH, 2000. Econometric analysis. 4th Edition. Macmillan, Inc., New York.

Hailemariam Teklewold, Legesse Dadi, Alemu Yami and N Dana, 2006. Determinants of adoption of poultry technology: A double-hurdle approach. Livestock Research for Rural Development, 18(3): 1-14.

Kebebew Assefa, Solomon Chanyalew and Zerihun Metaferiya, 2013. Achievements and Prospects of Tef Improvement. Proceedings of the 2nd International Workshop, November 7-9, 2011, Debre Zeit, Ethiopia.

Minten B and BC Barrett (2008). Agricultural technology, productivity, and poverty in Madagascar. World Dev., 36(5): 797-822.

Nyasimi M, D Amwata, L Hove, J Kinyangi and G Wamukoya, 2014. Evidence of impact: climate-smart agriculture in Africa. In: CCAFS working paper no. 86

Ogeto MA, JH Mohammed and DG Bedada 2019. Adoption of improved potato varieties in Jeldu District, Oromia Region, Ethiopia: a double-hurdle model. Int J Agril Res Innov Tech, 9(2): 15-22. DOI: 10.3329/ijarit.v9i2.45405

Regasa Dibaba, Afework Hagos, Chilot Yirga and Endeshaw Habte, 2018. Determinants of Improved Teff Varieties Adoption and Its Impact on Productivity: The Case of Non-Traditional Teff Growing Areas of Western Ethiopia. Journal of Natural Sciences Research 8: 2018. www.iiste.org.

Susie T and T Bosena, 2020. Determinants of Adoption of Improved Teff Varieties by Smallholder Farmers: The Case of Kobo District, North Wollo Zone, Amhara Region, Ethiopia. International Journal of Agricultural Economics 5: 114-122. doi:10.11648/j.ijae.20200504.14

Vavilov NI, 1951. The Origin, Variation, Immunity and Breeding of Cultivated Plants. Translated from the Russian by K.S. Chester. Ronal Press Co, 13(1/6): New York, USA.

Yamane T, 1967. Statistics: An Introductory Analysis, 2nd Edition. Harper & Row, Publisher, New York. pp: 919.