Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.12, No.23, 2022

Determinants of Adoption of Improved Rice Variety by Small Scale Farmers in Chewaka District of Buno Zone of Oromia Regional State

Galmesa Abebe [1]* Kifle Degefa[1] Getachew Biru[2] Tamirat Tsegaye[1]
1. Bako Agricultural Research Center, Bako, Ethiopia
2. Oromia Agricultural Research Institute, Finfinnee, Ethiopia
*Corresponding author: galmee2015@gmail.com

Abstract
Achieving national food security and diversifying export earnings from agricultural products is one of the major challenges currently facing developing countries like Ethiopia. Rice is considered as the "Millennium crop" expected to contribute to ensuring food security in the country. Despite the high production potential and the economic importance of the crop, adoption and dissemination of improved rice variety is constrained by various factors. To this end, this study aimed at identifying determinants of adoption of improved rice variety in Chewaka district, Buno Bedele zone of Oromia Region, Ethiopia with the specific objectives of identifying factors affecting adoption and intensity of adoption of improved rice variety. The study was based on cross sectional data collected from 162 randomly selected rice producing farmers. Descriptive and econometric analyses were used to analyze data. The results show that about 74.96% and 25.31% were adopters and non-adopters of the crop respectively. Double hurdle model results showed that education level and training affected the probability of adoption of improved rice variety positively and significantly while age affect it negatively and significantly. Sex, farm experience, participation on non-farm activities and credit utilization affected the intensity adoption of improved soya bean varieties positively and significantly. This study suggests that the high importance of institutional and government support in the areas of education, training, gender disparities in agriculture and credit. Therefore, policy and development interventions should give emphasis to the improvement of such institutional support system and decrease gender disparities in access to such institutions so as to achieve the adoption practice which increases production and productivity of small scale farmers.
Keywords: Adoption, intensity of adoption, Rice, double hurdle
DOI: 10.7176/JBAH/12-23-02
Publication date: December 31st 2022

1. INTRODUCTION

1.1. Background

Agriculture is the main stay of the Ethiopian economy. Although the transformation toward a more manufacturing and industrially oriented economy is well underway, the agriculture sector continues to be the most dominant aspect of the Ethiopian economy, accounting for nearly 46% of gross domestic product (GDP), 73% of employment, and nearly 80% of foreign export earnings (ATA, 2014).

Agriculture is a dominant sector of Ethiopian economy which makes a lion share contribution to the Gross Domestic Product, employment and foreign exchange earnings. Agriculture is still believed to remain a sector that plays an important role in stimulating the overall economic development of the country in the years to come. This would be realized if and only if strenuous efforts are made by the government and other concerned stakeholders including farmers to increase agricultural production and productivity. Several factors can influence agricultural production and productivity improvement. Among other factors, the increased use of modern farm inputs, modernization of farming activities by using improved farm implements as well as introduction of modern farming technologies to the sector are the major ones. In order identify, plan, implement and monitor agricultural projects and programs, availability of reliable, comprehensive and timely statistical data on the overall performance of the sector is essential (CSA 2016).

Rice is an important staple food crop in Africa with a growing demand that poses an economic challenge for the African continent. Annual rice production in Sub-Saharan Africa (SSA) is estimated at 14.5 million metric tons (MT), comprising 15 percent of the region's cereal production. Most of this rice is produced by smallholder farmers. In contrast, Africa's rice consumption is about 21 million MT creating a deficit of about 6.5 million MT per year valued at US$ 1.7 billion that is imported annually. Overall, imported rice accounts for roughly 40 percent of Sub-Saharan Africa local rice consumption (AATF, 2013). This indicates that the region needs to increase production and productivity to fill the gap of demand and supply created in rice consumption.

Rice is a new crop for the country. Before ten years, there has not been any large-scale commercial rice farm (Esayas Kebede, 2011). The author further stated that, currently the development in commercial rice farming is encouraging. Among the target commodities which have received due attention in promotion of agricultural production, rice is the one considered as the "millennium crop" expected to contribute to ensuring food security in the country.

Amongst of the target commodities that have received due emphasis in promotion of agricultural production, rice is considered as the "Millennium crop" expected to contribute to ensuring food security in the country. Even though, it is a recent introduction to the country, rice has shown promise as to be among the major crops that can immensely contribute towards ensuring food security in Ethiopia. The country has vast suitable ecologies for rice production along with the possibility of growing it where other food crops do not do well. Based on GIS techniques and agro-ecological requirements of rice, the potential rain-fed rice production area in Ethiopia is estimated to be about thirty million hectares (Teshome Negussie and Dawit Alemu, 2011).

The importance of rice as a food security crop, source of income and employment opportunity due to its relative high productivity as compared to other cereals is recognized by farmers as well as private investors who frequently request for improved varieties for different ecosystems (Teshome Negussie and Dawit Alemu, 2011).

Productivity improving crop technology can be an option for rural farmers to get rid of hunger and food insecurity by increasing production, reducing food price and making food more accessible to the poor. The use of high yielding crop varieties facilitates the growth of agro-processing enterprise and non-farm sectors, and stimulates the transition from low productivity subsistence agriculture to a high productivity agro industrial economy (Just and Zilberman, 1988). Further, developing and promoting the adoption of yield increasing crop varieties in a sustainable manner helps improve livelihood of rural farmers (Asfaw et al, 2012).

Clearly, food security of the majority of rural farmers can be improved if the performance of the agricultural sector is enhanced. Improvement and diffusion of rice varieties have an invaluable role in reversing food insecurity. Due to this Chewakka rice variety have been generated and promoted for many years in the study area by BARC. Despite such an intervention the adoption and intensity of adoption of improved rice variety not studied. Therefore, this study was proposed to identify the determinants of adoption and intensity of adoption of improved rice variety to fill the existing knowledge gap.

1.2. Objectives of the Study

1. To identify factors affecting adoption of improved rice variety in the study areas
2. To identify factors affecting intensity of adoption of improved rice variety in the study areas

2. RESEARCH METHODOLOGY

In this chapter a brief description of the study areas, sampling methods and sample size, sources and types of data and data collection methods, methods of data analysis and measurement & definitions of variables are presented.

2.1. Description of the Study Areas

2.1.1. Location and physical features

Chewaka is located in Buno Bedele zone, Oromia Regional state about 570 kilometers south west of Addis Ababa. It covers a total area of 342.167 km^2. It is situated in lowland areas of Dhidhessa valley, which lies below 1500m above sea level. The area is found between Dabena and Dhidhessa rivers. Dhidhessa River bounds the *District* from east to north and at the same time it is the boundary between Illubabor and East Wollega zone. On the other hand Dabena River bounds the area from west to north which joins Dhidhessa and finally leads to Blue Nile. *Chewaka* resettlement site is among areas that hosted large number of settlers in Oromia Regional State. About 12,000 households (60,000 people) from Western Hararghe resettled in the area since 2003. The area has not been used for settlement before the establishment of the resettlement scheme.

2.1.2. Agriculture

Agriculture is the economic base of the Chewaka district. Agriculture is mainly rain-fed and is characterized by low productivity. The majority of the residents depend on agriculture for their livelihood. The farmers are using traditional technologies and with limited (no) accesses to agricultural inputs. Moreover, the sector in the zone is characterized by low-level use of farm inputs, traditional farm practice, and other related problems. Farmers of the study area produce agricultural crops for consumption and commercial purposes. The major crops produced in the area include maize and sorghum mainly for consumption while rice and soybean are produced for sale. Other crop types produced include sweet potato, ground nut among others. It is one of the areas that produce cash crops mainly rice and soybean. The livestock production system of the resettles differs from the local indigenous farmers in that they own only few and fatten them for sale. This practice is more environmentally friendly than having high number of livestock as the local indigenous people do.

2.1.3. Population

The population of Chewaka district was 67,623 in 2015. The resettlement program was done by two phases where 8000 households settled in the first phase and 6000 households in the second phase.

2.2. Sampling Methods and Sample Size
A three stage sampling technique was employed to select sample respondents. In the first stage, Chewaka district was purposively selected for this study, due to the fact that improved rice technology is widely popularized by Bako Agricultural Research Center (BARC). In the second stage four Kebeles were randomly selected. Households in district were stratified in to adopters and non-adopters and representative samples were selected from each stratum.

The sample size will be determined by using following a formula developed by Cochran's(1977) sample size formula for categorical data .

$$n = \frac{Z_{\alpha/2}^{2}\, pq}{e^{2}}$$

Where n is the sample size for the study, $Z_{\frac{\alpha}{2}}^{2}$ is for selected alpha level of 0.025 in each trial =1.96, p is number of adopters and q is number of non-adopters and e is the precision level.

2.3. Sources and Types of Data and Data Collection Methods
Both primary and secondary data were used. For this study primary data were collected on one-to-one interview basis using a structured survey questionnaire pre tested and administered by well trained and experienced enumerators who have knowledge of the farming system and the local language. During the personal interview information on rice varieties grown, key socio-economic elements (include age, gender, education level, family size, asset ownerships, membership in farmers' organizations, consumption expenditures, distance of a residence from input and output markets and extension offices, and institutional and other relevant) factors were collected. The secondary data source include books, journals and other published and unpublished documents from Bako agricultural research center, zonal and district agricultural offices, internet and other related sources to supplement primary data.

2.4. Methods of Data Analysis
In this study, both descriptive statistics and econometric model were used to analyze the data.
2.4.1. Descriptive statistics
Descriptive statistics such as mean, standard deviation, frequencies distribution, and percentages were used to have a clear picture of the characteristics of sample units. Chi-square test and an independent sample t-test were also used to compare adopters and non-adopters in terms of explanatory variables.
2.4.2. Econometric model
According to Cragg's model, a farmer faces two hurdles while deciding on rice cultivation. The first is to decide whether to cultivate rice. The second hurdle is related to the level of adoption, or how much land or capital to allocate to rice production. The most important underlying assumption of the model is that these two decisions are made in two different stages. At the beginning of a cropping season a farmer may decide to cultivate rice without making exact plans about the quantity of land. Many factors can influence a farmer's decision afterwards, i.e., price and availability of inputs, potential to cultivate competing crops, information about production technology, etc.

The first stage of Cragg's model is a probit model to identify the determinants of adoption, and the second stage is a truncated model for identifying the determinants of the level of adoption (Cragg, 1971). Let d_i^* is the latent variable describing a farm's decision to adopt, y_i^* is the latent variable describing its decision on the level of adoption, and d_i and y_i are their observed counterparts, respectively. Based on the specification by Cragg (1971) and Moffatt (2005), the two hurdles for a farmer can be written as:

$$d_i^* = \alpha\, \boldsymbol{z}_i + v_i \quad (1)$$

$$y_i^* = \beta\, \boldsymbol{x}_i + \varepsilon_i , \quad (2)$$

Where

$$d_i = \begin{cases} 1, if \;\; d_i* > 0 \\ 0, if \;\; d_i* \le 0 \end{cases} and \;\; y_i = \begin{cases} y_i*, if \;\; y_i^* > 0 \;\; and \;\; d_i* > 0 \\ 0, if \;\; otherwise \end{cases}$$

Where $\boldsymbol{z}_i$ is the vector of variables explaining whether a farmer adopts rice technology, $\boldsymbol{x}_i$ is a vector of variables explaining level of adoption, and v_i and ε_i are the error terms.

The dependent variable in the first stage is the farmer's adoption decision. This variable is binary in nature, taking numeric value 1 for adopters, and 0 for non-adopters. In the second stage, the dependent variable is the rice land ratio (the ratio of quantity of land under rice production to total farm land). In the double-hurdle model, both hurdles have equations associated with them, incorporating the effects of farmer's characteristics and circumstances. Such explanatory variables may appear in both equations or in either of them (Teklewold *et al.*, 2006). According to Carroll *et al* (2005), equations 1 and 2 are assumed to be independent, and therefore the error terms are randomly and independently distributed, $v_i \sim N(0,1)$ and $\varepsilon_i \sim N(0, \sigma_\varepsilon^2)$.

The log-likelihood function for the double hurdle model is:

$$\log L = \sum \ln\left[1 - \Phi(\alpha Z_i'(\frac{\beta X_i}{\sigma})\right) + \sum \ln\left[\Phi(\alpha Z_i)\frac{1}{\sigma}\phi\left(\frac{Y_i - \beta X_i}{\sigma}\right)\right] \quad (3)$$

Where Φ and ϕ are the standard normal cumulative distribution function and density function, respectively. The log-likelihood function is estimated using the maximum likelihood estimation (MLE) technique.

The double-hurdle model is reduced to the Tobit model when the probit mechanism ($d_i^* > 0$) is absent in Equation 2. This can also be seen in the log-likelihood function presented in Equation 3, when $\Phi(z_i\ \alpha) = 1$. The Tobit model arises if $\alpha = \beta/\sigma$ and $x = z$ (Martínez-Espiñeira, 2006). Absence of the probit mechanism implies that the decision about adoption and level of adoption are made simultaneously. We also develop a Tobit model and do standard likelihood ratios test between the Tobit and double-hurdle model to know how these decisions are made. Following Gujarati (2003), the Tobit model for our specific case can be written as:

$$y_i = \begin{cases} y_i^* \text{ if land allocated for soybean} > 0 \\ o \text{ otherwise} \end{cases} \quad (4)$$

Where, $\beta_0 \ldots, \beta_k$ are the unknown parameters to be estimated and $\boldsymbol{x}_{1i} \ldots \boldsymbol{x}_{ki}$ are the same set of explanatory variables used in the second stage of the Cragg model. Using MLE, the Tobit model is estimated. According to Maddala (1992), the likelihood function for the Tobit model can be written as

$$L = \prod_{V_i > 0} \tfrac{1}{\sigma} f\ \left(\tfrac{yi - \beta x_i}{\sigma}\right) \prod_{V_i < 0} F\ \left(-\tfrac{\beta X_I}{\sigma}\right) \quad (5)$$

Through maximizing the function with respect to β and σ, we get the MLE estimates of these parameters.

As the Tobit model is nested in the Cragg model, it is possible to compare these two models through a standard likelihood ratio test when the determinants in both hurdles are the same (Buraimo *et al*, 2010). The test statistics can be computed as in Greene (2000):

$$\Gamma = -2[\ln L_T - (\ln L_P + \ln L_{TR})] \sim \chi_k^2, \quad (6)$$

Where L_T, L_P, and L_{TR} are log-likelihoods of the Tobit, probit, and truncated regression models, respectively. Rejection of the null hypothesis ($\Gamma > \chi_k^2$) argues for superiority of the double-hurdle model over the Tobit model and establishes that the decisions about adoption and level adoption are made in two different stages.

2.5. Measurement and Definitions of Variables for Adoption

2.5.1. Dependent variables

Adoption Decision

The dependent variable for probit model takes a dichotomous value depending on the farmers' decision either to adopt (one) or not to adopt (zero) the improved rice variety production.

Intensity of adoption

The dependent variable for truncated regression model would have a continuous value which is the intensity use of the technology. In this case, it indicates proportion of land for improved rice variety in hectare.

Adopters are farmers who used Chewaka rice variety. Non-adopters are farmers who didn't used Chewaka rice variety.

Table1: Summary of independent variables, their definitions and expected effect

Dependent variables			
1. Adoption of improved rice variety		Dummy (1.Yes 0.No)	
2. Proportion of area under improved rice variety		Continuous (hectare)	
Independent Variables	Definitions of variables	Unit of measurement	Expected sign
Age	Age of household head	Years	+/-
Sex	Sex of the household head	1.Male 0.Female	+
Family size	Number of persons per household	No	+
Marital statues	Marital status of household heads	0. Married 1.Divorced 2.Widowed 3.Single	+/-
Education	Formal education level of household head	Grade attended	+
non/off farm	participation on off/ non-farm activities	1.Yes 0.No	+
Farming experience	Rice farming experience of the household head	Years	+
Training	Participation on training of rice production	1. Yes 0. No	+
Demonstration	Participation on demo of rice production	1. Yes 0. No	+
Livestock	Number of livestock owned	TLU	+
Distance to market center	Distance of farmers house from nearby market	Hour	-
Credit	Use of credit for framing	1= Yes 0=No	+
Farm size	Total land holding size of the household head	Hectares	+
Extension	Frequency of extension contact	No	+

3. RESULTS AND DISCUSSION

3.1. Descriptive Results

The sample size handled during the survey was 162. Out of the total interviewed rice producers 154 (95.06%) were male headed and the remaining 8 (4.94%) were female headed. The chi-square test of sex distribution, marital status, credit utilization, participation on off farm and non-farm between the adopters and non-adopters was found to be insignificant while the chi-square test of participation on training and demonstration between the adopters and non-adopters was found to be significant at 1% level of significance.

Table 2: x^2-test for binary independent variables

Variable		Adopters (N=121)		Non- adopters (N=41)			Total (N=162)	
		No	%	No	%	x^2-test	No	(%)
Sex	Male	115	95.04	39	95.12	0.0004	154	95.06
	Female	6	4.96	2	4.88		8	4.94
Marital status	Married	120	99.17	40	97.56		160	98.76
	Divorced	1	0.83	0	0.00	3.2981	1	0.62
	Widowed	0	0.00	1	2.44		1	0.62
Training	Yes	98	80.99	9	21.95	47.6034***	107	66.05
	No	23	19.01	32	78.05		55	33.95
Demo	Yes	57	47.11	5	12.19	15.7997***	62	38.27
	No	64	52.89	36	87.81		100	61.73
Credit	Yes	21	17.36	6	14.63	0.1633	27	16.67
	No	100	82.64	35	85.37		135	83.33
Off farm	Yes	26	21.49	9	21.95	0.0039	35	21.60
	No	95	78.51	32	78.05		127	78.4
Non-farm	Yes	19	15.70	5	12.19	0.2985	24	14.81
	No	102	84.3	36	87.81		138	85.19

The average age, farm experience and education level of the adopters was 40.55 years,7.47years and 4.05 grade respectively and while it is about 42.19 years, 6.78 years and 2.54 grade respectively for non-adopters. The t-test of age farm experience, total land holding and total cultivated land between adopters and non-adopters was found to be insignificant. That means there is no statistical mean difference between adopters and non-adopters in terms of age and farm experience. The t-test of education level between adopters and non-adopters was found to be significant at 1% level of significance. That means there is statistical mean difference between adopters and non-adopters in terms of education level.

Table 3: t-test for binary independent variables

Variable	Adopter (N=121) mean	Std	Non-adopters (N=41) Mean	Std	t-test
Age	40.55	11.27	42.19	12.33	0.7865
Farm experience	7.47	3.26	6.78	3.72	-1.13
Education level	4.05	2.86	2.54	2.78	-2.95***
TLU	3.97	3.11	2.89	3.75	-1.8232
Total land holding	1.65	0.59	1.55	0.79	-0.77
Total cultivated land	1.62	0.58	1.51	0.79	-0.99
Extension contact	2.37	1.52	0.87	1.14	-5.58***

3.2. Econometric Results

In this sub-section, the results of the Double hurdle regression model is presented and discussed. Adoption decision of farm households is influenced by different socioeconomic, technical and institutional factors. Different variables are important across different space and over time in explaining adoption of technologies by farmers. Many factors are hypothesized to influence the adoption of improved soybean varieties based on theoretical models and empirical evidences.

Table 4: Determinants of adoption and intensity of adoption improved rice variety.

Variables	Probit regression			Truncated regression		
	Coef.	Std. Err.	Marginal Effect	Coef.	Std. Err.	Marginal Effect
Sex	-0.665	0.103	-0.112	0.186**	0.075	0.186
Age	-0.004**	0.003	-0.001	0.002	0.002	0.002
Marital status	-0.641	0.155	-0.152	-0.151	0.097	-0.151
Education	0.157***	0.013	0.0370	-0.002	0.006	-0.002
Farm experience	0.026	0.011	0.006	0.009*	0.005	0.009
Total land	0.192	0.052	0.045	-0.115	0.030	-0.115
TLU	0.439	0.103	0.119	-0.008	0.005	-0.008
Extension	-0.262	0.079	-0.062	0.013	0.039	0.013
Training	1.633***	0.101	0.465	-0.006	0.041	-0.006
Market	0.299	0.142	0.080	0.031	0.069	0.031
Distance to market	0.014	0.0020	0.003	-0.001	0.001	-0.001
Off-farm	-0.483	0.110	-0.130	-0.030	0.040	-0.030
Non-farm	0.089	0.097	0.020	0.111**	0.047	0.111
Credit	0.509	0.068	0.100	0.101**	0.043	0.101
constant	-1.051			0.831	0.181	0.831
sigma				0.154		
	Number of obs =162 LR chi2(15) =67.31 Prob > chi2 = 0.0000 Log likelihood = -57.98 Pseudo R2 =0.3672			Limit: lower = 0 Upper = +inf Number of obs = 121 Wald chi2 (15) = 43.30 Log likelihood = 63.34 Prob > chi2 = 0.0001		

The 3 explanatory variables which have been found to significantly influence the decision by the sample farm households with regard to whether or not to adopt improved rice variety and the 4 explanatory variables which have been found to significantly influence intensity of adoption of improved rice are interpreted and discusses below.

Age: Age of household head has a negative and significant influence on the adoption of rice variety at 5% level of significance. The possible interpretation here is, as age increases, farm households would become too reluctant and conservative in adopting new seed varieties and do prefer their indigenous seeds. Hence, as age increases by one year, citrus paribus, the probability of adoption of improved rice variety decreases by 0.1%. Studies by Assefa and Gezahegn (2010), Berihun *et al* (2014), Bedru and Dagne (2014), and Yenealem e*t al.* (2013) also obtained a similar result in their studies.

Education: Education level of the household head, which is one of the important indicators of human capital, has a positive and significant effect on adoption of improved rice variety at 1% level of significance, implying that the likelihood of adoption increases with farmer formal education level. On average, each additional year of education of the household head increases the probability that a farmer adopts improved rice variety by 3.7%. This is consistent with the research results of Moti *et al*. (2013), Afework and Lemma (2015), Sisay (2016) and

Hassen *et al.* (2012).

Training: The result of probit regression pointed out that training of farmers in relation to rice technology enabled them for making decision of better adoption. As compared to those farmers who participate on soybean training, those farmers who didn't participate on soybean training their probability of adoption of improved rice variety decrease by 46.5%. It implies that training is very important factor that influence adoption of improved rice variety and it is significant and positive at 1% probability level. This is in line with previous study by Wuletaw and Daniel (2015), Alemitu (2011) and Hadush (2015) who found that training influence adoption of new technology positively.

Sex (SEX): Sex is significant variable in truncated regression estimation is the dummy variable indicating sex of household head. The estimated coefficients for this dummy variable reveal the existence of different level of rice production participation based on sex household head. The obtained result suggests that, those farmers being male headed household are more likely to produce significant amount of rice than their counter parts, ceteris paribus. As compared to male headed households, the intensity of adoption of improved rice decrease by 18.6% for female headed households. This could be attributed to various reasons, which could be the problem of economic position of female headed households, including shortage of labor, limited access to information and required inputs due to social position. This is consistent with the studies by Bayissa (2014).

Farming Experience: Farming experience was found to be positively influencing the intensity of improved rice adoption and statistically significant at 10% significance level. This means as farm experience of the household increase by one year the intensity of improved rice variety adoption increases by 0.9%. This is as expected because more experienced farmers might have better skills and access to new information about improved technologies. It could also imply that knowledge gained over time from working in uncertain production environment may help in evaluating information thereby influencing their adoption decision and intensity. This is consistent with the studies by Bayissa (2014), Aman and Tewodros (2016) who found that Farm experience has a significant positive effect on the intensity adoption of improved technology.

Non-farm: Participation on non-farm is one of the important factors that affect intensity of adoption of technology. Participation on non-farm affects the ability of a farmer to obtain the necessary improved agricultural technologies at the right time and in suitable quantities. Participation on non-farm was positively related with intensity of adoption of improved rice variety at 5% level of significance. The model result indicates that as compared to households didn't participate on non-farm, the intensity of adoption of improved rice variety increases by 11.1% for households who participated on non-farm.

Credit: Credit utilization is one of the important factors that affect intensity of adoption of technology. Use of credit (cash) affects the ability of a farmer to obtain the necessary improved agricultural technologies at the right time and in suitable quantities. Utilization of credit was positively related with intensity of adoption of improved rice variety at 5% level of significance. The model result indicates that as compared to households didn't utilized credit, the intensity of adoption of improved rice variety increases by 10.1% for households who utilized credit.

4. REFERENCES

Afework Hagos and Lemma Zemedu. 2015. Determinants of improved rice varieties Adoption in Fogera District of Ethiopia. *Science, Technology and Arts Research Journal*, 4(1): 221-228.

African Agricultural Technology Foundation, 2013. Nitrogen use efficient, water use efficient and salt tolerant rice project.

Alemitu Mulugeta. 2011. Factors affecting adoption of improved haricot bean varieties and associated agronomic practices in Dale Woreda, SNNPRS. MSc Thesis, Hawassa university, Hawassa, Ethiopia.

Aman Tufa and Tewodros Tefera. 2016. Determinants of improved barley adoption intensity in Malga district of Sidama Zone, Ethiopia. *International Journal of Agricultural Economics,* 1(3): 78-83.

Asfaw S, Shiferaw B, Simtowe F, Lipper L. 2012. Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia. *Food Policy*, **37**(3): 283– 295.

Assefa Admassie and Gezahegn Ayele. 2010. Adoption of improved technology in Ethiopia. *Ethiopian Journal of Economics,* 1(5): 155-178.

ATA (Agricultural Transformation Agency). Transforming agriculture in Ethiopia. 2014; Annual Report 2013/2014, Addis Ababa, Ethiopia.

Bayissa Gedefa (2014). A Double-hurdle approach to modeling of improved tef technologies adoption and intensity use in case of Diga district of East Wollega Zone.*Global Journal of Environmental Research,* 8 (3): 41-49.

Bedru Beshir and Dagne Wegary. 2014. Determinants of small holder farmers' hybrid maize adoption in the drought prone Central Rift Valley of Ethiopia. *African Journal of Agricultural Research*, 9(17): 1334-1343.

Berihun Kassa, Bihon Kassa and Kibrom Aregawi. 2014. Adoption and impact of agricultural technologies on farm income: evidence from southern Tigray, Northern Ethiopia. *International Journal of Food and Agricultural Economics*, 2(4): 91-106.

Carroll, J., McCarthy, S., and Carol, N. 2005. An econometric analysis of charitable donations in the Republic of Ireland. *The Economic and Social Review*, 36: 229- 249.

Cochran, W. G. 1977. Sampling techniques (3rd ed.). New York: John Wiley & Sons.

Cragg, J.G. 1971. Some statistical models for limited dependent variables with application to the demand for durable goods. *Econometrical*, 39(5): 829-844.

CSA (Central Statistical Agency) 2016. Agricultural sample survey 2015/16 (2008E.C): volume v- report on area, production and farm management practice of belg season crops for private peasant holdings. Statistical Bulletin, Central Statistical Agency, Addis Ababa, Ethiopia.

Esayas Kebede, 2011. Trends and challenges on Rice investment in Ethiopia. Challenges and Opportunities of Rice In Ethiopian Agricultural development. Empowering Farmers Innovation. Series No. 2. EIAR/FRG II, Addis Ababa, Ethiopia.

Greene, W.H. 2000. *Econometric analysis, 4th edition*. Englewood Cliffs, NJ: Prentice Hall.

Hadush Hagos. 2015. Factors affecting adoption of upland rice and its implication on system innovation: the case of Tselemti district, North Western zone of Tigray, Ethiopia. MSc Thesis, Haramaya University, Ethiopia.

Hassen Beshir, Bezabih Emana, Belay Kassa and Jema Haji. 2012. Determinants of chemical fertilizer technology adoption in North Eastern highlands of Ethiopia: the double hurdle approach. *Journal of Research in Economics and International Finance,* 1(2): 39-49.

Just R E, Zilberman D. 1988. The effects of agricultural development policies on income distribution and technological change in agriculture. *J Dev Econ*, **28**(2): 193–216.

Maddala, G.S. 1992. *Limited dependent and qualitative variables in econometrics*. New York: Cambridge University Press.

Martinez-Espineira, R. 2006. A box-cox double-hurdle model of wildlife valuation: The citizen's perspective. *Ecological Economics*, 1: 192-208.

Moti Jaleta, Chilot Yirga, Menale Kassie, Groote. H.D. and Bekele Shiferaw. 2013. Knowledge, adoption and use intensity of improved maize technologies in Ethiopia. *Invited paper presented at the 4th International Conference of the African Association of Agricultural Economists,* September 22-25, 2013. Hammamet, Tunisia.

Sisay Debebe Kaba. 2016. Agricultural technology adoption, crop diversification and efficiency of maize-dominated smallholder farming system in Jimma Zone, South- Western Ethiopia. PhD Dissertation, Haramaya University, Haramaya, Ethiopia.

Teklewold H., Dadi L.,Yami A. and Dana N. 2006.Transforming village poultry systems into small agro-business ventures: a partnership model for the transfer of livestock technologies in Ethiopia. *Livestock Research for Rural Development. 18 (3), Article #169.*

Teshome Negussie and Dawit Alemu, 2011. An Overview of the National Rice Research and Development Strategy and its Implementation.

Wuletaw Mekuria and Daniel Tadesse. 2015. Determinants affecting adoption of malt- barley technology: Evidence from North Gondar Ethiopia. *Journal of Food Security* 3(3): 75-81.

Yenealem Kassa, Ranjan S. Kakrippai and Belaineh Legesse. 2013. Determinants of adoption of improved maize varieties for male headed and female headed households in West Harerghe Zone, Ethiopia. *International Journal of Economic Behaviour and Organization,* 1(4): 33-38.