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Determinants of farmers' utilization of improved agricultural technologies in Ethiopia

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Abstract

Few studies assessed the determinants of improved agricultural technologies on farmers' utilization of improved agricultural technologies. Hence, the objective of this study was to analyze rural farmers' utilization of improved agricultural inputs in Ethiopia. Data were collected through household survey/interviews with 141 sample respondents using multi-stage sampling techniques. The result of the logistic model regression output shows that education status of the household head, sex, age, family size and access to credit is significantly associated with the utilization of improved agricultural technologies. Farmers' utilization of improved agricultural technologies was determined by different demographic socio-economic, institutional and psychological factors. Finally, for further utilization of improved agricultural technology and development of the sector, the Ministry of Agriculture, policy makers and other stakeholders should participate in rural areas.

Keywords: Agriculture, Improved technology, Logit model, Utilization, Ethiopia

Introduction

Ethiopia's economy is dependent on agriculture, which accounts for 40 percent of the GDP, 80 percent of exports, and an estimated 75 percent of the country's workforce (https://www.usaid.gov/ethiopia/agriculture-and-food-security). According to Ousmane and Nafiou (2019), agricultural technologies like forage technologies, improved seeds, inorganic fertilizers, land conservation practices, tractors, stall-feeding management and irrigation technologies can enhance rural livelihoods. A new agricultural technology that enhances sustainable production of food and fiber is therefore critical for sustainable food security and economic development. Thus, boosting agricultural productivity has been an issue of paramount importance to the development of institutions; and the use of improved agricultural technology has played a key role to achieve this (Mwangi and Kariuki, 2015).

Agricultural technologies help to mitigate the risks of crop production related to crop pests besides increasing agricultural productivity like improved seeds and inorganic fertilizers (de Janvry et al., 2011). Adoption of new agricultural technology has attracted the attention of development economists and policymakers nowadays since it is believed that the introduction of new technology increases production and productivity and technology transfer helps to achieve economic growth of the developing countries (Milkias, 2018; Feder et al., 1985). Farmers are usually informed about the existence as well as the effective use and benefit of new technology through extension agents and the importance of farmers' adoption of new agricultural technology has long been of interest to agricultural extension experts and economists (Mwangi and Kariuki, 2015). Agricultural extension facilitates the access of farmers, their organizations and other market actors to knowledge, information and technologies. Extension service goes beyond technology transfer to general community development through human and social capital development, improving skills and knowledge for production and processing, facilitating access to markets and trade, organizing farmers and producer groups, and working with farmers towards sustainable natural resource management (Swanson, 2008).

There is scanty empirical evidence on the importance of improved agricultural technologies and their roles in improving food security and livelihood outcomes for rural poor farmers. Agriculture is the main economic activity in Mirab Badawacho district. The main source of economy for the population is *teff (Eragrostis tef),* Coffee, Maize, Haricot bean and livestock. Low access to input, lack of knowledge, skill gap and attitude problem of farmers on new innovative technologies make the production and productivity low. However, few studies assessed the determinants of farmers' utilization of improved agricultural technologies in the study area. Therefore, the objective of this study was to assess the status of farmers' utilization of improved agricultural technologies and analyze its determinant factors.

Research methodology

Description of the study area

The study was conducted in Mirab Badawacho district, which is located in Hadiya Zone, South Nations Nationalities and Peoples Regional State (SNNPR) at a distance of 352km away from

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the south west of Addis Ababa: Ethiopia. Geographically, the absolute location of the district is between 07°69'00″N to 07°91'91″N latitude and 37°95'00″E to 38°10'00″E longitude (Muleta, 2011). Mirab Badawacho Woreda is bordered on the north and northeast by Kambata Tambaro Zone, on the east by Misrak Badawacho, on the south by Wolaita Zone, and the northwest by Kachabira. It has a total of 21 rural and 1 urban kebele (small administrative unit).

Agriculture is the main occupation of the people of the study area. It is mainly rain-fed, although it is supplemented by small-scale irrigation. *teff*, Barley, Maize, Wheat, Haricot beans, Enset and Banana are the most widely produced in the study area. Coffee and chat are also important cash crops.

Sampling techniques and sample size determination

A two-stage sampling technique was used to select sample respondents in the study area. In the first stage, Mirab Badawacho district was selected purposively based on the extent of agricultural production mainly Maize, Haricot bean and *teff*. In the second stage, three kebeles were selected by using a simple random sampling technique based on proportional to population size principle (PPS) randomly from 22 kebeles. A total of 141 households were selected from the three kebeles. The study applied Yamane’s (1967) sample size formula to determine the sample size.

$$n = \frac{\mathrm{N}}{1 + \mathrm{N}(e^2)} = \frac{1451}{1 + 1451(0.08^2)} = 141$$

Table 1. Study kebeles and number of sample respondents

Kebele	Total population			Sample size		
	Male	Female	Total	Male	Female	Total
Offoda	400	42	442	39	4	43
Illifata	416	31	447	40	3	43
Danema	526	36	562	51	4	55
Total	1342	109	1451	130	11	141

Data type, source and method of data collection

The study used both qualitative and quantitative types of data. Primary data from sample respondents using questionnaire household surveys and secondary data from journals, reports, and unpublished and published documents used to identify the important factors that affect farmers' utilization of agricultural extension services.

Data analysis

Data were entered, coded, and analyzed using STATA Version 13. Descriptive and inferential statistics were used to analyze the collected data. A binary logistic regression model was employed to identify determinant factors that affect the participation of rural farmers in agricultural extension services. The hypothesized variables were tested by using chi-square and t-test accordingly. The most widely used approaches to estimate dummy dependent variables regression models are the linear probability model (LPM), the logit and the probit models. The study applied the logit model to identify the utilizer and non-utilizer farmers of improved agricultural inputs.

Before the estimation of the model parameters, it is crucial to look into the problem of multico linearity among the potential selected variables. The two measures that often suggested to testing the existence of multicollinearity are the Variance Inflation Factor (VIF) for association among the continuous explanatory variables and contingency coefficients (CC) for dummy/discrete variables. Before running the logit model, all the hypothesized explanatory variables were checked for the existence of multicollinearity problem. Two measures suggested to testing the existence of multicollinearity.

The test for multicollinearity report suggests that there is no serious problem of multicollinearity among explanatory variables because the mean VIF is about 1.04. VIF of 1 indicates that the variable provides completely independent information or no multicollinearity.

Table 2. Multicollinearity test for continuous explanatory variables using (VIF)

Variable	VIF	1/VIF
Distance	1.09	0.915804
Frequency of extension contact	1.06	0.942569
Family size	1.05	0.956335
Farming experience	1.04	0.961277
Marital status	1.02	0.975941
Age	1.02	0.984756
Land size	1.01	0.990291
Mean VIF	1.04	

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The test contingency coefficients for dummy/discrete variables shows no longer a problem and data have no serious problem of multicollinearity in access to utilize improved agricultural technology dependent variable.

Table 3. Multicollinearity test for dummy/discrete explanatory variables

	Sex	Marital status	Education	Social organization	Credit access	Perception
Sex	1.0000					
Marital status	-0.0283	1.0000				
Education	-0.0606	0.0761	1.0000			
Social organization	-0.1151	-0.0171	-0.0039	1.0000		
Credit access	-0.1192	-0.1537	0.0123	0.0747	1.0000	
Perception	-0.0183	-0.0510	0.0400	0.1201	0.1261	1.0000

The logistic model is of the form

$$Y = \text{Ln} = \frac{Y}{1-Y} = \beta o + \beta 1x1 + \beta 2x2 + \beta 3x3 + \cdots + \beta nxn + \mu i$$

Where Y= the predicted probability of the event (farmers' utilization of improved agricultural technologies), which is coded with 1= user; and 0= non-user.

$1 - Y$= the predicted probability of the other decision (non-utilizes of improved agricultural technologies)

β0= Constant, βn= Coefficients of explanatory variables, xn= Predictor variables, μi= Error term.

Hypothesis of Variables

Table 4. Summary of definitions, measurements and expected signs of variables

Definition of variables	Measurement of variables	Expected sign
Dependent variable		
Utilization of improved agricultural technology	Yes/No	
Independent variables		
Age of household head in years (AGE)	Continuous	-ve
Sex of household (SEX)	Dummy, 0=female, 1= male	-ve
Education level of household (EDU)	Dummy, 0=Illiterate, 1= Literate	+ve
Total land holding size of household in hectare (LAND)	Continuous	+ve
Access to credit services (ACRDT)	Dummy, 1 is access to credit 0 otherwise	+ve
Frequency of extension contact (FRQEX)	Continuous	+ve
Family size of households (FAMLS)	Continuous	+ve
Total farm income of households in ETB (FARM)	Continuous	+ve
Marital status of households (MART)	Categorical	+ve
Access to social participation (SOCOP)	Dummy, 1 if yes and 0 otherwise	+ve

Distance to market in km (DISTA)	Continuous	-ve
Perception towards mobile use in Likert scale (PERCEPT)	Categorical	+ve
Farming experience in years (FAREX)	Continuous	+ve

Results and discussion

General characteristics of households

The mean (SDs) ages of improved agricultural technology user and non-user households were 34.74 (6.22) years and 45.56 years (9.65), respectively (Table 5). This is differed significantly among households. This implies that most of the farmers in the study area were young and eager to use new technologies. Similar study conducted by Melesse (2018) revealed that younger farmers are characterized as innovative, which enables them to make decision on adoption of new agricultural technologies than older farmers.

The mean (SDs) land sizes of extension service users and non-users households were 1.09 (0.76) hectares and 1.18 (0.80) hectares, respectively (Table 5). It implies that the mean land size of extension service users and non-users households were not significantly different. The means (SDs) of family size of improved agricultural technology user and non-user households were 5.8 (1.22) and 5.5 (1.29), respectively (Table 5). The result shows that there is no difference of family size between extension service users and non-users households.

The means (SDs) distance from the nearest extension center for improved agricultural technology user and non-user households were 2.93 (1.14) and 3.09 (1.58), respectively (Table 5). This implies that distance was one of the factor that affect non-user households from those using new technology. They are less likely to adopt the new technologies. The study confirmed that the farmers who live away from service centers such as demonstration place, development agent, market place are less likely to adopt the technology (Admassie and Ayele, 2011).

The means (SDs) farming experience of improved agricultural technology user and non-users households were 7.18 (2.64) and 7.79 (2.48), respectively (Table 5). This implies improved agricultural technology user households are experienced. The study conducted by Tandogan and Gedikoglu (2020) confirmed that the experience of farmers allows them to take better decisions about the use of new technologies.

The means (SDs) farm income of improved agricultural technology user and non-user households were 7639.42 (5421.55) and 7354.06 (4522.23), respectively. From this finding, the income of improved agricultural technology user households was better than other farmers and it was similar with the study by Tandogan, and Gedikoglu (2020) that confirm income was positively and significantly related to adoption of improved technologies.

Frequency of extension contact is one of the important institutional factors that can transform the agricultural sector. The means (SDs) of improved agricultural technology user and non-users households were 2.19 (0.81) and 2.15 (0.15), respectively (Table 5). This implies that all of the farmers in the study area have equally communicated with extension agents.

Table 5: Descriptive statistics for continuous variables

Utilization of agricultural extension services					
	Users of agricultural technology N=107		Non-users of agricultural technology N=34		t-value
Category	Mean	SD	Mean	SD	
Age	34.74	6.22	45.56	9.65	7.65***
Total land size	1.09	0.76	1.18	0.80	0.57
Family size	5.8	1.22	5.5	1.29	-1.17
Distance	2.93	1.14	3.09	1.58	0.62
Farming experience	7.18	2.64	7.79	2.48	1.20
Farm income	7639.42	5421.55	7354.06	4522.23	-0.28
Frequency of extension	2.19	0.81	2.15	0.15	-0.24

Source: Own field survey, 2020

Sex/gender is one of the demographic variables that affect the rural farmer's use of improved agricultural technology services. Among improved agricultural technology user households, 56.03% were male-headed households and 19.86% were female-headed households. On the other hand, non-user male-headed and female-headed households were 16.31% and 7.80% respectively (Table 6). The finding shows that the numbers of female-headed participation on improved technology usage were lower than male-headed households. The study is in line with the previous studies that confirmed female-headed households are more resource-constrained (Isah et al., 2013 and Ogada et al., 2014).

Education is one of the most important factors that influence the farmer's use of improved agricultural technology. Among improved agricultural technology user households, 61.70% and 14.18% of households were literate and illiterate, respectively. On the other hand, 2.84% and 21.28% of non-user households were literate and illiterate, respectively (Table 6). The result implies that most of the technology user farmers were literate and non-users were illiterate. The study confirmed that those farmers who have better educational status have higher probability to adopt agricultural new technologies (Melesse, 2018; Ogada et al., 2014). The finding of Ogada et al. (2014) also confirms that expectation of high yield, plot size, and the farm household head's education level determine the joint adoption of inorganic fertilizers and improved maize varieties in Kenya.

Marital status is one of the demographic factors that affect farmers' use of improved agricultural technology. Out of the total improved agricultural technology users households, 1.42%, 70.92%, 1.42%, and 2.13% of households were single, married, divorced, and widowed, respectively (Table 6) (Table 6). The result shows that most of technology user farmers were married. It indicates that the farmers who were married have more probability to use technologies than other famers do.

The survey results show that 65.25% of improved agricultural technology users' households participated in social organization and 10.64% improved agricultural technology users households did not participate in traditional social organization (e.g. *edir, equb*). On the other hand, 3.54% of non-users households participated in social organization and 20.57% of non-users households did not participate in social organization (Table 6). The result shows that the farmers who participated in social organization have high probability to get new information and to use new agricultural technologies than others. Social participation enhances access to information on improved technologies, material inputs of the technologies such as fertilizers and pesticides, and credit for the purchase of inputs and payment of hired labor (Odoemenem and Obinne, 2010).

Perception is one of the psychological factors that affect farmers' use of improved agricultural technology. Out of total improved agricultural technology users' households, 29.79 %, 12.06%, 2.84%, 3.55%, and 27.66% strongly agreed, agree, neutral, dis-agree and strongly dis-agree towards mobile use, respectively. Non-user households strongly agreed (12.06%), agree (2.84%), neutral (0.71%), dis-agreed (4.96%), and strongly dis-agreed (4.26%), respectively (Table 6). The result shows that the perception level of the technology user farmers towards new technology were very strong. This entails that the attitude change on farmers could make them accept new technology. The study conducted by Daniso et al. (2020) revealed that most of the farmers were highly perceived to use different rural innovation services.

The survey result shows that 19.86% of improved agricultural technology user households had access to credit and 56.03% of improved agricultural technology user households had no access to credit services. On the other hand, 2.84% of improved agricultural technology non-user households had access to credit and 21.28% did not have access to credit services (Table 6). This implies that most of the farmers did not have improved agricultural technologies due to less credit utilization.

Table 6: Descriptive statistics for dummy and discrete variables

		Users N=107		Non-users N=34		
Variable	Characteristics	Frequency	Percent	Frequency	Percent	Chi-square
Sex	Male	79	56.03	23	16.31	0.493
	Female	28	19.86	11	7.80	
Education level	Illiterate	20	14.18	30	21.28	
	Literate	87	61.70	4	2.84	54.523***
Marital status	Single	2	1.42	1	0.71	
	Married	100	70.92	33	23.40	1.764
	Divorced	2	1.42	0	0	
	Widowed	3	2.13	0	0	
	Yes	92	65.25	29	20.57	
Social participation	No	15	10.64	5	3.54	0.010
	Strongly-agree	42	29.79	17	12.06	
Perception	Agree	17	12.06	4	2.84	
	Neutral	4	2.84	1	0.71	
	Disagree	5	3.55	7	4.96	0.222
	Strongly dis agree	39	27.66	6	4.26	
Credit access	Yes	28	19.86	4	2.84	3.051**
	No	79	56.03	30	21.28	

Source: Own field survey, 2020

Status of farmers utilization of improved agricultural technologies

The result in the table below shows that most of the farmers in the study area have used pesticide (93.5%), fertilizer (88.8%), and improved maize (72.9%), respectively. This shows that the farmers have jointly used pesticides and fertilizer for improved variety. The use of technology has played a key role in sustainable food security and economic development (Annemie and Christopher, 2013). Using improved variety has its role to enhance food security and reducing poverty. However, the farmers' usage status of improved *teff* variety and improved Haricot bean variety is 42.9% and 32.7%, respectively. The result implies that the farmers’ usage status of improved *teff* variety and improved Haricot bean variety is less than other improved variety. The study conducted in Southwest Ethiopia, reported that most of the farmers uses different rural innovation services (Daniso et al., 2020).

Table 7: Usage status of utilization of improved agricultural technologies by farmers

Type of technologies	Technology users N=107	
	Frequency	Percent
Improved Maize variety	78	72.9
Improved Haricot bean variety	35	32.7
Improved Teff variety	46	42.9
Pesticide use	100	93.5
Fertilizer use	95	88.8

Source: Own field survey, 2020

Determinants of rural farmers' utilization of improved agricultural technologies

Results of the logistic regressions concerning the probability of utilization of improved agricultural technology are presented in Table 8 below.

The likelihood ratio (LR) chi-square statistics, probability of chi-square, and pseudo R-square values reported indicates that model specification provides a reasonably good fit of the data. The logit model also correctly predicts 89% of the sample observations.

Table 8. Binary logistic regression estimates of the factors affecting the farmers' utilization of improved agricultural inputs (n=141)

Variables	β	S. E.	Wald value	Significance	Odd ratio
Sex	1.345	.786	1.71	0.087*	3.837
Age	-.193	.062	-3.10	0.002***	.824
Marital	3.985	4.262	0.94	0.350	53.784
Education	2.948	.736	4.00	0.000***	19.071
Family	.458	.253	1.81	0.071*	1.580
Land	-.469	.505	-0.93	0.353	.625
Farm experience	-.160	.149	-1.08	0.282	.852
Social organization	.146	.906	0.16	0.872	1.157
Distance	.050	.262	0.19	0.847	1.052
Credit access	2.266	1.009	2.24	0.025**	9.638
Perception	-.213	.710	-0.30	0.765	.808
Frequency of extension contact	-.088	.415	-0.21	0.832	.916
Farm income	.000	.000	0.73	0.463	1.000
_cons	-3.270	9.256	-0.35	0.724	.038

Notes: Number observations 141, LR Chi2 (13) 86.09, Prob > Chi2 0.000, Pseudo R2=0.5527
***, ** and * significant at Significant at 1%, 5% and 10% respectively.
Computed from own survey result, 2020

Sex, as indicated in Table 8, had influenced the utilization of improved agricultural technology negatively and significantly at a 10% level of significance. This indicates female-headed households have a low probability of adopting new agricultural technology. The result is in line with the study by Isah et al. (2013) and Ogada et al. (2014) that shows the numbers of female-headed participation on adoption of new technologies were lower than male-headed households.

The age of the household head is negative and statistically significant at a 1% level of significance. This indicates that the probability of household utilization of improved agricultural technology decreases with increasing an additional year of the household head. It could be due to young farmers are willing to bear more risk than older farmers and it may also be associated with older farmers being less able and willing to put in increased efforts because of perceived or real physical and/or mental demands associated with the use of improved crop varieties. This result is consistent with the findings of previous studies (Melesse, 2018).

The result shows that education was positively and significantly related to the utilization of improved agricultural variety at a 5% significance level. The odd ratio indicating that the probability of households utilizing improved agricultural technology increase by 19.07 when households are literate (Table 8).. Those farmers who were educated more had a probability of utilizing improved agricultural technology than those who were not. These results are in agreement with scientific literature (Melesse, 2018; Ogada et al., 2014).

Family size was positively and significantly related to the utilization of improved agricultural variety at a 5% significance level (Table 8). The partial effect of a unit increase in the household size on the conditional probability of utilizing improved agricultural variety increases by a factor of 1.56. This means that an additional household member will increase the probability that the farmer will utilize improved agricultural variety by 15.6%. The reason for a positive sign for the membership variable could be the fact that farmers discuss new information and extension programs in the group meetings and this may motivate farmers to participate in extension programs. This result is in line with the earlier studies (Kabeto, 2014; Martey, 2012).

As the model result shows the variable access to credit had positively and significantly influenced the likelihood of utilization of improved variety at a 5% level of significance. The odds ratio in favor of utilization of improved agricultural technology increased by a factor of 9.6 for users who had received credit. The availability of credit had increased the utilization decision of the household head on improved agricultural technology positively and significantly. This means that additional credit access will increase the probability that the farmer will participate in the utilization of improved agricultural technology by 96%. A study conducted in Ethiopia has revealed access to credit influenced farmers' participation in red Bean market positively and significantly (Kabeto 2014). Kafle (2011) also reported that access to credit could increase the probability of adoption of agricultural new technologies by offsetting the financial shortfall of the households. The result from personnel observation, key informant and focus group discussions also confirmed that a financial resource was necessary to initiate the uptake of new technologies and households who had more access to formal and/or informal sources of credit significantly adopted technologies rather than other farmers who had no access to credit.

Conclusion and recommendations

This paper analyzed the determinants of rural farmers' utilization of improved technologies. It aimed at suggesting recommendations and a systemic intervention to help further innovations in agricultural sector because agriculture is the backbone of Ethiopians' economy, the engine of growth and improving the knowledge of farmers for rural development. Considering the lion's share contribution of extension in Ethiopia, the government has emphasized on the extension system and its approach.

Most of the farmers in the study area used pesticides and fertilizer. The utilization status of haricot bean and *teff* improved variety was low. Therefore, GOs and NGOs need to facilitate the utilization of agricultural improved crop varieties with affordable/subsidized price to encourage farmers' utilization and promote new innovative technology.

Education, age, sex, family size of household, and access to credit significantly affect rural farmers' utilization of improved agricultural inputs. Education is highly recommended for farmers to utilize new innovative technology. Therefore, the government of Ethiopia need to schedule an adult literacy program in their village for further utilization of agricultural technology.

The local government, specifically the districts' office of agriculture and natural resource management, women affairs, and kebeles extension experts need to encourage rural women to utilize new agricultural innovative technology.

In the study area, the Omo credit and saving institution was the only formal micro-financial institution providing credit service. Thus, the local government need to facilitate a more simple rural finance strategy for farmers in providing credit services for further utilization of agricultural technology. Furthermore, this finding suggests a need for establishing research–extension– farmer linkages to promote technology adoption, transform subsistence agriculture into a more business and market-oriented agriculture.

Notes

Idir: indigenous voluntary mutual help associations in Ethiopia

Equb: informal savings associations in Ethiopia

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