Original Research

Determinants of Improved Rice Varieties Adoption in Fogera District of Ethiopia

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Abstract	Article Information
The Ethiopian agriculture is characterized by the use of inadequate production technologies that in a variable climate produces important fluctuations in crop yields, uncertainties, and food insecurities. Consequently, the study has focused to analyze factors affecting adoption of rice improved varieties in Fogera district of Ethiopia. It particularly focused on the determinants of improved varieties. For this study purpose 151 households were randomly drawn from three randomly selected Kebeles in probability proportional to size method. The demographic and socio economic factors that determine the participation in improved varieties were households labor availability, education level of the household head, land holding, distance to the nearest village market, proximity to the main market, distance to access agricultural extension, access to the source of rice seeds, access to new cultivars of rice and off-farm income. Consequently, finding ways to strengthen smallholder access to inputs, technology, and information, and improving the incentives for their use and adoption, all within highly heterogeneous agro ecologies is very important.	
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INTRODUCTION

Ethiopia is situated in the tropical zone, but because of its wide range of altitude (from below sea level to over 3000 m above sea level); it is endowed with a broad diversity of climates ranging from humid tropics to alpine climates suitable for successful growth of most types of both temperate and tropical crops. The total mean annual flow of water from all the river basins is estimated to be 122 billion cubic meters and the ground water potential is estimated at 2.6 billion cubic meters (MoARD, 2010). These water resources can potentially be used for irrigation. Ethiopia has also one of the largest livestock inventories in Africa (CSA, 2008; MoARD, 2010).

However, Ethiopian agriculture is characterized by the use of inadequate production technologies that in a variable climate produces important fluctuations in crop yields, uncertainties, and food insecurities. In addition to the above, access and availability to improved production technologies including seed, fertilizers, mechanization and markets are limited. The most recent estimate by the Ethiopian Central Statistical Agency (CSA, 2009) indicates, from a total cultivable area of 12.8 million ha, only about 8 million ha is under cereal crops. Various studies indicate that improved seeds are used in less than 3% of the total cultivated area. For smallholder farmers, the main constraints are availability and affordability to quality seeds.

Over the past two decades, decision makers in Ethiopia have pursued a range of policies and investments to boost agricultural production and productivity, particularly with respect to the food staple crops that are critical to reducing poverty in the country. A central aim of this process has been to increase the availability of improved seed, chemical fertilizers, and extension services for small-scale, resource-poor farmers, particularly those cultivating food staple crops (David *et. al,* 2010). Thus, rice is one of the staple food crops for more than 60 percent of the world's population.

Rice belongs to the family "Gramineae" and the genus "Oryza". There are about 25 species of Oryza. Of these only two species are cultivated, namely Oryza sativa Linus and Oryzaglaberrima Stead. The former is originated from North Eastern India to Southern China but has spread to all parts of the world. The latter is still confined to its original home land, West Africa. Rice (Oryza sativa Linu) is one of the main staple foods for 70% of the population of the world. Africa produces an average of 26.4 million tones of rough rice (17.4 million tonnes, milled) in 2012 (FAO, 2013).

Rice is among the important cereal crops grown in different parts of Ethiopia as food crop. The country has immense potentials for growing the crop. It is reported that the potential rice production area in Ethiopia is estimated to be about 5.4 million hectares. According to the national

rice research and document strategy (2009), the trend in the number of rice producing farmers, area allocated and production shows high increase rate especially since 2006. The number of farmers engaged in rice production has increased from about 53 thousand in 2006 to about 260 thousand in 2008. Similarly, the area allocated has increased from about 18 thousand in 2006 to about 90 thousand ha in 2008 along with production increase from about 150 thousand tonnes in 2006 to about 286 thousand tonnes in 2008 (NRRDS, 2009).

Bull (1988) estimated that about 3.5 million hectares of vertisols is found in the Amhara region, which remains waterlogged for most of the year and possible to produce food crops in these soils through better water management (drainage) and use of water loving crops such as rice. Attempts have been made to improve the rice varieties in the Fogera area. The popular upland rice variety in the Fogera plain was X-Gigna (N. KOREA) but now three rice varieties Kokit (IRAT-209), Tigabe (IREM-194) and Gumara (IAC-164)) were released for Fogera and similar areas. Other introduced varieties like New Rice for Africa (NERICA) are being tested for adaptation trial (Sewagegne, 2005).

Clearly, in Ethiopia, rice is among the target commodities that have received due emphasis in promotion of agricultural production, and as such it is considered as the "millennium crop" expected to contribute to ensuring food security in the country. Although rice is introduced to the country very recently, rice has proven to be a crop that can assure food security in Ethiopia, the second most populous nation in Sub-Sahara Africa (SSA) with about 74 million people in 2007(MoARD, 2010).

Under the current situation of the rice sector in Ethiopia, research and development gaps were identified in different producing regions of the country. Fogera Woreda is one of the main producers of rice which contributes 58% of the region and 28% of the national production of rice. In the Woreda rice is one of the food crop produced by the majority of the farmers, after teff, maize and finger millet. Study conducted by Gebremedhin and Hoekstra (2007) indicated that 72% of the households are producers of rice and about 50% of the farmers sell rice in the area.

Ethiopia has the potential to increase food production by increasing the area of land under agriculture, though the present availability of quality seeds falls well below present demand. Consequently, finding ways to strengthen smallholder access to inputs, technology, and information, and improving the incentives for their use and adoption, all within highly heterogeneous agro ecologies. However, there is no clear information and research that shows the adoption status of these improved rice varieties. This study therefore helps to identify the determinants of improved rice varieties for possible interventions and policy implications.

Adoption of New Technologies

Adoption was defined as the degree of use of a new technology in long-run equilibrium when a farmer has all the information about the new technology and its potential. Adoption refers to the decision to use a new technology, method, practice, etc. by a firm, farmer or consumer. Adoption of the farm level (individual adoption) reflects the farmer's decisions to incorporate a new technology into the production process. On the other hand, aggregate adoption is the process of spread or diffusion of a new technology within a region or population. Therefore, a distinction exists between adoption at the individual farm level and aggregate adoption, within a targeted region or within a given geographical area (Feder et al., 1985).

Adoption of technological innovations in agriculture has attracted considerable attention among development economists because the majority of the population of less developed countries derives their livelihood from agricultural production and a new technology, which apparently offers opportunities to increase production and productivity (Feder et al., 1985).Agriculture progresses technologically as farmers adopt innovations. The extent to which farmers adopt available innovations and the speed by which they do so determines the impact of innovations in terms of productivity growth (Diederen et al., 2003).

According to Sunding et al.(2000), measures of adoption may indicate both the timing and extent of new technology utilization by individuals. Adoption behavior may be depicted by more than one variable. It may be depicted by a discrete choice, whether or not to utilize an innovation, or by a continuous variable that indicates to what extent a divisible innovation is used.

Adoption at the farm level describes the realization of a farmer's decision to implement a new technology. On the other hand, aggregate adoption is the process by which a new technology spreads or diffuses through a region. Therefore a distinction exists between adoption at the individual farm level and within a targeted region. If an innovation is modified periodically, however, the equilibrium level of adoption will not be achieved. This situation requires the use of econometric procedures that can capture both the rate and the process of adoption (Getahun et al., 2000).

According to Alemu et al. (1998), many variables can influence farmers' awareness and adoption of new varieties: human capital variables such as literacy; farm size; information sources such as agricultural extension or the research station; and distance from seed sources. Farmers with more land had a higher probability of adoption, probably because they are wealthier and have more land to experiment with improved wheat varieties. Extension visits also resulted in a higher probability of adoption by raising farmers' awareness of new wheat varieties and providing information about agricultural practices to accompany them. Oxen ownership increased the probability that farmers would adopt improved wheat varieties. Oxen owners usually participate more frequently in a demonstration, which gives them access to information on new technologies.

Distance is a major obstacle for adoption of technologies in developing countries. The impediment posed by distance is likely to decline with the spread of wireless communication technologies. It is a greater challenge to adopt technologies across different latitudes and varying ecological conditions (Sunding et al., 2000).

Farmers with some education attainment are likely to adopting one or more of the technology choices: the

marginal effect of the education variable is significantly positive for the probability of adoption. More educated households are commonly well informed and receptive, which translates to a higher likelihood of engaging in new technologies. This finding is in line with several previous studies which point out innovation is positively related to farmers' abilities to decipher and analyze information (Ersado *et al*., 2003).

In principle, a farmer views an improved seed as a derived input embodying production attributes and a technology embodying consumption characteristics and jointly decides on its adoption and the quantity of seed required planting a predetermined area. Consequently, different approaches have been used for estimating farm level seed demand in developing countries. A.S. Langyintuo *et al.,* (2006) employed a unified methodology for estimating the demand for improved seed at the farm level in the developing agriculture in the Manica, Sussundenga and Chockwé districts of Mozambique. The demand model results suggest that adoption rate, household wealth, distance to market, and input support programs (or free seed distribution) significantly influence farmers' seed purchase decisions. Moreover, the researchers suggested that wealth has a direct impact on seed demand and could be achieved through asset accumulation, credit access or competitive grain markets and to improve adoption rates and subsequently seed demand, it was recommended that agricultural extension activities should emphasize field demonstrations to show the superiority of improved maize varieties over the local ones in terms of yield and resistance to storage pests. Making seeds available to farmers at short distances also improved adoption rate.

Several adoption studies in Malawi have pointed out that improved groundnut adoption rates are low with the exception of the CG7 variety (Minot, 2007; Minde, *et al.,* 2008; Simtowe *et al.*, 2010a 2010b). Similar cases have been reported for beans and soybeans. Despite their importance in agricultural policy analysis, adoption studies have, however, not addressed the issue of how farmers' seed purchases change with respect to changes in improved seed's own price, other crops' seed prices and farmers' incomes. Furthermore, much less is known about market places, in general, and very few citations discuss characteristics of seeds, product quality, homogeneity, market transactions and demand for products and inputs (Lipper *et al*., 2009).

Asfaw *et al*., (2010) studied the determinants of the intensity of variety adoption conditional on overcoming seed access constraints using augmented double hurdle model. Results show that knowledge of existing varieties, perception about the attributes of improved varieties, household wealth (livestock and land) and availability of active family labour force play a significant role in enhancing the level of adoption of improved chickpea varieties. Integration into output market is also positively associated with household wealth and availability of active family labour force and negatively associated with age of household head and distance to main market. Results confirm the potential direct role of technology adoption on market integration among the rural households, as higher productivity from improved technology translates into higher output market integration.

MATERIALS AND METHODS
Description of the Study Area
Based on the CSA (2008), Amhara Region has a population of 17.2 million of which about 8.6 million were men and 8.5 million were women. Urban inhabitants were 2.1 million or 12.3% of the total population. With an estimated area of 0.16 million square kilometres, this region has an estimated population density of 108.15 people per square kilometre. For the entire region about 4 million households were counted. This results to an average of 4.3 persons per household. The average family size in urban and rural area is 3.3 and 4.5 persons, respectively.

Fogera Wereda is one of the 106 Woredas of the Amhara Regional State and found in South Gondar Zone. It is situated at 11^0 58 N latitude and 37^0 41 E longitude. Woreta is the capital of the Woreda and is found 625 km from Addis Ababa and 55 km from the Regional capital, Bahir Dar.

The woreda is bordered by LiboKemkem Woreda in the North, Dera Woreda in the South, Lake Tana in the West and Farta woreda in the East. The Woreda is divided into 29 rural Peasant Associations (PAs) and 5 urban Kebeles (RDBOA, 2007/8).

The total land area of the Woreda is 117,414 ha. The current land use pattern includes 44 percent cultivated land, 24 percent pasture land, 20 percent water bodies and the rest for others. The total population of the Woreda is 251,714. The rural population is estimated at 220,421. The proportion of male and female population is almost similar in both rural and urban areas. The number of agricultural households is 44,168.

The mean annual rainfall is 1216.3 mm, with Belg and Meher cropping seasons. Its altitude ranges from 1774 up to 2410 masl allowing a favourable opportunity for wider crop production and better livestock rearing (IPMS, 2005). Most of the farm land was allocated for annual crops where cereals covered 51,472 hectares; pulses cover 9819.98 hectares; oil seeds 6137 hectares; root crops 1034.29 hectares; and vegetables 882.08 hectares (CSA, 2003). The major crops include teff, maize, finger millet and rice, in order of area coverage. According to IPMS (2005), average land holding was about 1.4 ha with minimum and maximum of 0.5 and 3.0 ha, respectively.

Methods of Data Collection and Sampling Procedures
The data for this study were collected from both primary and secondary sources. Primary data were collected from samples of the respondents. The data that were collected through a questionnaire survey includes; data on type of improved rice seed rice cultivated, total acreage allocated to improved rice cultivars, distance from market, quantity of other inputs used, access to market, livestock ownership, land holding, contact to extension service, credit access, family size, were collected and these have been used to analyse factors determining adoption of rice varieties.

In addition to primary data on the above issues, secondary data like population number, agricultural inputs and output prices, land use pattern and agro-ecology were collected from different sources. Secondary data sources were Woreda office of Agriculture Rural Development, Research centers, Cooperatives at different

levels, Ethiopian Seed Enterprise (ESE), and other bureaus, different publications, research studies, websites, etc.

For this study, a multi-stage random sampling technique was employed. For rice producers, a multistage sampling technique was employed to draw sample respondents. In the selection process, Woreda agricultural office experts, Adet Research Center and BahirDar University were consulted. In Fogera Woreda, there are 5 urban and 29 rural Kebeles. Out of 29 rural Kebeles, 15 administrative Kebeles are producing rice.Then samples of respondents that cultivate both upland and lowland rice varieties were selected randomly proportional to their population size. The sample frame of the study is the list of households obtained in the Fogera Woreda of agricultural office. Hence out of 29 rural KAs with population size of 44, 168 only 15 KAs and with population size of 12,162 cultivate both upland and lowland varieties. Three KAs were selected randomly in order to get adequate information about the adaption of the improved seeds.

Finally the sampled households were selected using probability proportional to size from each group that makes a sample size of 151 households, which is estimated by the following formula at precision level of 8 % and sample of households were randomly selected from the selected KAs using probability proportional to size.

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

where n is sample size to be computed, N is the total households in the study area and e is the level of precision. Before selecting households to be surveyed, rice growers were identified in collaboration with the aforementioned stakeholders.

Data Analysis and Model Specification
Determinants of participation: Univariate Probit model
In order to address the objective i.e. the factors that influence the decision to participate in improved rice

varieties, the probit model is used because its likelihood function is well behaved as it gives consistent Maximum Likelihood Estimate (MLE) coefficients (β) and standard error of the estimate (s) (Maddala, 1992).The probit model estimates the probability of participating in improved seed technologies for household level data and measures this likelihood after controlling the relevant variables used in the model. The dependent variable in the first step is defined as a dichotomous variable with the values 1 for participants and 0 for non-participants.

$$\gamma *_{im} = \beta_m' X_i^* + \varepsilon_{i,} m = 1, \dots, i \qquad (2)$$

$$\gamma *_i = 1 \text{ if } \gamma *_i$$
$$> 0 \text{ if adopted improved rice varieties and } 0 \text{ otherwise; } (3)$$

The X_i is a vector of explanatory variables and β_i are unknown parameters to be estimated. The probability function of the probit model is usually the standard normal density which provides predicted values within the range (0, 1).

RESULTS AND DISCUSSION
The descriptive analysis made use of tools such as mean, percentages, standard deviation and frequency. Econometric analysis was used to identify the determinants of adaption of improved of varieties' and to estimate the parametric elasticities of demand for the improved varieties. The statistical significance of the variables was tested using chi-square (χ^2) and F statistics.

Descriptive Statistics
Socioeconomic and institutional characteristics
For this study, data were collected from 151 randomly selected respondents. Data collected from 151 respondents were used for the analysis purpose. From the total sample of 151, 146 which are 96.7% of the respondents were male headed households and only 5 which are 3.3 % were female headed households. Out of the total randomly selected households, 86 (57 %) were adopters and 65 (43 %) were non-adopters of improved rice seed.

Table 1: Demographic factors, farm assets ownership and Institutional factors of non-adopters and adapters

Characteristics	Adoption status		Total	Difference	t-test
Demographic factors	Non-Adopters	Adopters			
Proportion of Male HHS	0.97	0.97	0.97	0	-0.139
Age	39.86	44.8	41.99	-4.94	-2.838***
Household family size	5.15	5.88	5.45	-0.73	-2.743***
Economically active labor	2.87	4.51	3.58	-1.64	-9.548***
Rice growing experience years	14.3	22.8	17.96	-8.5	-5.337***
Education years spent in School	0.65	2.32	1.37	-1.67	-5.096***
Farm assets ownership					
Total value of farm implements	441.45	526.08	477.8	-84.62	-1.674*
Total land holdings of the HHs	1.39	1.84	1.58	-0.45	-5.147***
Area under cultivation	0.94	1.29	1.09	0.35	-4.952***
Total Land allocated for rice	0.81	1.13	0.95	-0.31	-4.229***
TLU	4.1	7.37	5.51	-3.27	-5.922***
Institutional factors					
Contact with DAs	0.47	8.60	3.97	-8.13	-14.27***
Contact with NGO	0.73	0.86	0.79	-0.13	-1.931*
Membership in farmers club (%)	28	66	44	0.38	-5.033***
Distance to the main market	5.84	4.65	5.32	1.19	4.534***
Distance to the village market	1.10	0.53	0.86	0.57	2.486**
Distance to source of rice seed	5.02	2.72	4.30	2.30	8.322***
Distance to Fertilizer source	5.024	3.00	4.15	2.02	7.855***
Distance to Agri- extension	1.79	0.89	1.04.	0.90	7.535***

***, ** and * significance at 1, 5 and 10% respectively

Econometric Model Output

The chi-square (χ2) distribution is used in the measure of overall significance of a model in probit model estimation. The result of the univariate probit model shows that, the probability of the chi-square distributions (43.70) with 14 degree of freedom less than the tabulated counterfactual is 0.0001, which is less than 1%. So, this shows that, the variables included explaining adoption status fits the probit model at less than 1% probability level. This implies that the joint null hypothesis of coefficients of all explanatory variables included in the model were zero should be rejected. In general, it shows that, the data fits the model very well. The results are given in Table 2.

Determinants of Adoption of Improved Rice Varieties; Univariate probit model

The univariate probit model presented as Table 2 below was estimated to identify factors that affect the decision to participate in improved rice varieties farming. The model had a log likelihood of -15.0880. It also had a Wald chi-square equal to 43.70 which was significant at 1 percent. Robust standard errors are used to correct for heteroscedasticity. The results of the probit model are presented in Table 2 with its respective marginal effects. Moreover, we attempt to include all theoretically important factors in the estimated model. Out of these variables, those found to have a weak influence on participation in improved rice varieties were excluded from further consideration (Legesse *et al.,* 2001) and the variables considered in the model are discussed below.

Table 2, show that household size was positive in the improved rice varieties participation. Household size positively influences the decision to use improved rice seed. Though household family size is not significant, it was positively related with participation in improved varieties and this finding corresponds with Henery *et al.,* (2012) Simtowe *et al.,* (2010) who consistently found evidence that participation increases with household size among smallholder farmers in Malawi.

The availability of larger family labour for agriculture affects the likelihood of participation in improved rice cultivation positively, as expected. In rural areas, large households provide labour on the farm as such it is likely that farmers who have large families would provide the necessary labour to cultivate improved varieties. Household economically active labour size significantly affects the decision of improved rice farming. The coefficient for the aggregate model is significant at 1 per cent probability level. The marginal effect of 0.049 suggests that if household size increases by one individual, the probability of participating in improved seed would increase by 0.049. This may be due to the behaviour of rice cultivation is labour intensive where households with more family labour could produce more outputs. This result is consistent with Asfaw *et al.,* (2010), Simwaka, *et al.,* (2011) research done in improved chick pea and ground nut varieties in Ethiopia and Malawi respectively.

Education of the household head positively influences participation in improved technology. Education was significant at 1% level of significance. The positive marginal effect indicates increasing participation with every additional year of education. For instance, a marginal effect of 0.0279 implies that if an individual adds one more year in school the probability of participating in improved seed technology would increase by 0.0279. This implies that education of the household head increases the probability of using improved varieties. This finding corresponds with Henry et al. (2012), Giné and Yang (2008) and Zeller *et al.,* (1997) who also found that education increases participation in improved technology in Malawi.

Land is a constraining factor of production. The total land holdings is positive and significant at 5 percent probability level and influences participation. The marginal effect indicates that if land cultivated increases by 1 hectare, farmers' probability of participating in improved technology transfer would increase by 0.0571. This outcome is consistent with Hennery *et al.* (2012) and Asfaw *et al.,* (2010) researches done in Ethiopia and Malawi respectively. Thus, households with large tends to allocate more land for the improved rice varieties. In addition to this, the amount of land allocated to rice crop (TLR) is positively related to use improved rice varieties. However, the variable is non-significant.

Rice farming experience of the household head is expected to influence in technology adoption. In this study, rice growing experience of the household head is positively contributed to improved seed technology participation. Nevertheless, the variable was not significant; it was positively related to adoption of rice seeds.

Institutions play a great role in technology transfer by establishing the basis for production, exchange, and distribution on one hand and by creating relations between economic units that define how those units can cooperate or compete on the other hand. It is obvious that different governmental and non-governmental institutions participates in developmental activities to enhance smallholders livelihoods by delivering inputs like fertilizer, seeds, plant protection chemicals, and other related services.

Distance to the nearest village market was negatively and significantly affect participating in improved rice cultivation at 1 percent probability level. Similarly, the coefficient for the nearest village market was negative and significant at 1 percent. The marginal effect indicates that if distance decrease by one kilometre, the probability of participation in rice seed technology would increase by 16 percent. Thus, households nearest to village market places enable to access inputs both spatially and temporally. The finding was also consistent with Asfaw *et al.,* (2010) in chick pea technology adoption study in Ethiopia.

Similar to access village market, access to main market is negatively and significant at 1 percent significance value to participate in rice seed technologies. The marginal effect reveals that 1 km decrease in distance to the main market would increase probability of participating in improved rice varieties by .0742. Hence, farmers nearest to the main market, infrastructure like main road and seasonal roads, agricultural inputs both adequately and timely. Moreover, distance to main market variable is negatively correlated with participating in improved varieties because of the increased transaction costs associated with purchasing inputs. Furthermore, investment policies aimed at building up more rural road

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networks and improving the quality of roads may increase better access to main market and other key agricultural inputs. The finding is consistent with Henry *et al.,* (2012) and Asfaw *et al.,* (2010) with their studies analysis of legume seed demand and chick pea adoption.

The distance to access agricultural extension office was negatively and significantly affect in improved technology participation. The marginal effect of the aggregate participation equation shows that, 1 kilometer decrease in the distance to access agricultural extension office would increase the probability of being involved in new rice technology by 0.1075. Thus, shows that farmers nearest to agricultural extension would adopt improved technologies. As a result, access to Agricultural Bureau will enable farmers to get expertise advice and knowledge about the newly released varieties by taking part in

participatory research like farmers research group, advisory council meetings and participatory variety selection. The same finding was obtained by Asefa *et al.,* (2010) research done on chick pea varieties adoption in Ethiopia.

Different institutions (governmental, NGOs and private) participate in rice seed system in the study area. Hence, access to those institutions play a vital role in disseminating and popularization of modern rice technologies. It is significant at 1 percent significance level and the marginal effect of the probit model indicates that 1 km reduction in distance to the source of rice seed will increase the probability of participating in improved technology by 0.035. Research findings show result in line with this statement (Asfaw *et al.,* 2010).

Table 2: Determinants of participation in improved seed technology

Variables	Robust		Marginal effect		Z-Value
	Coefficients	SE	dF/dx	Std. Err.	
Total land holdings (in ha)	1.79**	0.85	0.0571	0.07	2.1
Fertility status (1=Fertile, 0=otherwise)	0.63	1.21	0.0202	0.04	0.52
Labour	1.56***	0.59	0.0497	0.06	2.66
Education level of the HHs(years)	0.88***	0.3	0.0279	0.04	2.95
Distance to village market(in km)	-5.00***	1.21	-0.1596	0.17	-4.15
Distance to main market (in km)	-2.33***	0.62	-0.0742	0.08	-3.75
Distance rice to the seed source (in km)	-1.10***	0.3	-0.0349	0.04	-3.71
Value of farm implements (in Birr)	-0.012	0.05	-0. 013	0.00	-0.26
Distance to agricultural extension service centers (in km)	-3.37***	0.93	-0.1075	0.11	-3.63
Total rice land holdings of the households (in ha)	1.24	0.92	0.0395	0.05	1.35
Credit availability (0=No, 1=Yes)	4.39***	1.12	0.2446	0.15	3.93
Household family size (no.)s	0.06	0.63	0.0162	0.02	0.08
Rice growing experiences (in years)	0.06	0.05	0.002	0.0022	1.02
Off farm income of the HHs(in '0000 Birr)	0.01**	0.1	0.001	0.0105	2.34
Constant	4.86	3.65			
Inverse Mills Ratio(λ)	2.17	1.20			
Observations	151				
Log likelihood	-15.088				
LR chi2 (14)	43.7				
Pseudo R2	0.8538				
Prob>Chi2	0.0001				

Robust standard errors in parentheses *** *P*<0.01, ** *P*<.05, * *P*<0.1

The access to new cultivars of rice was positively and significantly contributed to influence technology adoption. It is significant at 1 percent significance level according to the aggregate Probit model indicates that the probability of participating in improved technology with yes response (those who get access credit to seed) increased participation by 0.244. This implies that to better access to seed credit will improve participation of households in technology dissemination and integration. Like the Research findings show result in line with this statement (see Asfaw *et al.,* (2010).

According to the model results, the coefficient of the off-farm income was positively related to participation in improved technology farming at 5 percent. The marginal effect coefficient reveals that Birr 1000 increase in households' off-farm income would increase probability of participation in improved rice cultivars by 0.907 %. Thus, off farm income may contribute to the smallholder farmers to purchase agricultural inputs like seed and fertilizers and or to hire additional labour for rice cultivation.

CONCLUSIONS

Ethiopian agriculture is characterized by the use of inadequate production technologies that in a variable climate produces important fluctuations in crop yields, uncertainties, and food insecurities. To solve these problems, decision makers have pursued a range of policies and investments to boost agricultural production and productivity, particularly with respect to the food staple crops like rice that are critical to reducing poverty. Hence, this study has made an attempt to assess the determinants of adoption of improved rice varieties analyzed.

Demographic and socio economic factors including households labor availability, education level of the household head, land holding, distance to the nearest village market, proximity to the main market, distance to access agricultural extension, access to the source of rice seeds, access to new cultivars of rice and off-farm income affects technology adoption and choice decision of the households. However determinants of choice decision varied with the varietal difference of rice technology.

Given the current potential and demand in production, marketing and consumption of rice, both at domestic and foreign markets, improving the production and productivity of rice through adoption of improved varieties is needed. Based on the results of the study, the following recommendations are drawn:

The availability of larger family labor for agriculture affects the likelihood of participation in improved rice cultivation highly significantly and positively, as expected. This is because perhaps in rural areas; large households provide labor on the farm as such it is likely that farmers who have large families would provide the necessary labor to cultivate improved seed. It further suggested that, households with economically active labor size improved their decision behaviour on improved rice cultivation since rice is considered as labor intensive where households with more family labor could produce more outputs. It is therefore, while disseminating improved rice varieties priority should be given to households with large family size to enhance technology adoption and dissemination.

Education of the household head positively influences participation in improved technology. Thus, indicates that increasing adoption of improved rice varieties would increase as the educational level of the households. This implies that interventions to speed up rice technology adoption and dissemination must be targeted at improving farmers' knowledge and skills by capacitating and supporting FTCs focused especially on aspects of rice production, marketing and consumption.

Land is a constraining factor of production in agriculture. A total land holding is positive and significant influences technology participation. Thus, intervention aimed at improving the fertility status and would enhance technology adoption. Moreover, improved varieties distribution must be targeted at households with large land holding size to improve rice technology dissemination and adoptions.

Most of the institutional factors considered in the model were statistically significant and negative effect on adoption. These includes, distance to the nearest village market, proxy to the main market, distance to access agricultural extension and access to the source of rice seeds in. This implies policies intervention that promotes and establishes the basis for production, exchange, and distribution on one hand and creating relations between economic units that define how those units can cooperate or compete on the other hand would contribute for improving in technology transfer by delivering inputs like fertilizer, seeds, plant protection chemicals, and other related services spatially and temporally. Furthermore, the farthest, the distance is from these institutions, the transaction cost associated with input purchases will increase and this in turn discourages households, to purchase agricultural inputs like seeds, fertilizer etc. Hence, investment at building up more rural roads (main and seasonal roads) and networks aimed improving the quality of roads may increase better access to main market and other key agricultural inputs and the technology transfer.

The access to new cultivars of rice was positively and significantly contributed to influence to transfer and popularization of rice improved varieties. This implies that intervention that promote the purchasing power of households and targeted to better access to seed credit will improve participation of households in technology dissemination and integration.

Off-farm income was positively and significant effect on improved rice technology adoption participation. Thus, activities that generate additional income to the households would enable the smallholder farmers to purchase agricultural inputs like seed and fertilizers and or to hire additional labor for rice cultivation and adoption of the improved cultivars.

In general, the findings of this study are consistent with other researches and the recommendations will contribute to the National Rice Research and Development Strategy to contribute to ensuring food security in the country through enhancing the dissemination and adoption of improved rice technologies.

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