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Factors determining allocation of land for improved wheat variety by smallholder farmers of northern Ethiopia

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This study was conducted in Northern Ethiopia, Adwa district. The main objective of the study was to examine factors influencing allocation of land for improved wheat variety by smallholder farmers of the study area. Descriptive, inferential and econometric methods were used to analyze data. Results of descriptive and inferential analyses showed that; adopters had high family size in adult-equivalent, high number of tropical livestock unit, large land size, high frequency of extension contact, access to credit service, they were followed formal schooling, and they were nearest to main road and market as compared to non-adopters. Tobit model was used to analyze factors influencing adoption of improved wheat technology econometrically. A total of thirteen explanatory variables were included in the model. From the tested variables only eight variables (education level of household head, family size, tropical livestock unit, distance from main road and nearest market, access to credit service, extension contact and perception of household towards cost of the technology) were found to be the significant factors affecting adoption of improved wheat variety. Implication of results of this study is that any development intervention through improved wheat technologies should consider the aforementioned socioeconomic characteristics and determinants of adoption for success.

Key words: Adoption of Improved wheat variety, Adwa, smallholder farmers, Topit model.

INTRODUCTION

Agriculture is the mainstay of the Ethiopian economy. It employs 80% of the population and contributes about 41% of GDP and 86% of exports (Bingxin et al., 2011). Besides its contribution as the main income-generating sector for the majority of the rural population, it serves as the main source of household food consumption (Samia, 2002).

The agricultural sector in Ethiopia is dominated by subsistence, low input, low output and rain-fed farming system. The use of improved seeds is quite limited despite government efforts to encourage the adoption of modern agricultural system and intensive agricultural

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practices. Therefore, improving the productivity, profitability, and sustainability of smallholder farming is the main pathway out of poverty in using agriculture for development (World Bank, 2008). One important way to increase agricultural productivity is through the introduction of improved agricultural technologies and management systems. Adoption of new agricultural technology such as high yielding varieties stimulates the transition from low productivity subsistence agriculture to a high productivity agro-industrial economy (World Bank, 2008).

Cereals dominate Ethiopian agriculture; accounting for about 70% of agricultural GDP. Wheat is one of the major cereal crops grown in Ethiopia (Hailu, 2003). It is grown by smallholder farmers in the highlands and mid highland areas of the country (Bingxin et al., 2011). The productivity of the crop has been low and a number of yield improving technologies like seeds of improved varieties have been recommended for use by wheat producing smallholder farmers in the country. However, the level of adoption of the technologies is not as expected. Farmers of the study area faces problem of low productivity of the crop due to use of traditional method of farming system and use of low productive inputs.

Studies conducted in Yelmana Densa and Farta Districts of Northwestern Ethiopia (Tesfaye et al., 2001) indicate that socioeconomic, institutional and technical factors are accountable for determining technology adoption. However, these recommendations are location specific and would justify the need for research elsewhere. It is expected that geographical and climatic differences would affect the adoption decision of farmers and studies done elsewhere may not be of direct relevance to address the problems and opportunities of the present study area. Therefore it is relevant to examine the specific factors that affect the adoption of improved wheat variety by farmers of study area. This information is expected to make easy the distribution of the improved wheat technologies in the study area and suggest interventions that may help improve the efficiency of agricultural research and extension in promoting smallholder, climate risk-prone agriculture in wheat production.

The main objective of this study was to analyze factors affecting allocation of land for improved wheat variety by smallholder farmers of the study area.

METHODOLOGY

Description of the study area

This study was conducted in Northern Ethiopia, rural Adwa district. Adwa is found about 1006 kilometers from Addis Ababa and 223 kilometers away from Mekelle. The district has total area coverage of 66,618 ha of which 13,714 ha is cultivated land. The geographical structure of the district is both low land and semi-low land. About 32.2 and 67.8% of the cultivated land is found in the low land and semi-low land respectively. The district has a total household of 24,692 and has a total population of 108,647, out of which 54,659 were females and the rest of 53,988 were males. The average temperature of the area is 27°C and average annual rainfall ranges from 600 to 850 mm. The main economic activity of the study area includes both crop and livestock production. Some of the major crops grown in the area include teff, wheat, barley, finger millet, sorghum and maize and the major livestock production includes cattle, sheep, goat, donkey and poultry.

Data collection

The study uses both primary and secondary sources of data. The primary data was collected through individual interviews of the selected respondents whereas the secondary data was gathered from annual and monthly report of district agriculture Office and reports from the center statistical agency. During sampling process two-stage sampling procedure was used to select sample farmers that were included in the study. In the first stage, out of the total 18 *peasant associations* of the district four *peasant associations* were selected purposively based on their wheat production performance. In the second stage, from the selected *peasant associations,* 160 respondents were identified based on probability proportional to size of households of each *peasant associations* and the subsequent application of random sampling technique. After the sampling process was completed data were collected by using formal and informal survey methods of data collection.

Data analysis

In this study both descriptive statistics and econometric models were utilized to assess the relationship between explanatory and dependent variables. Descriptive statistics involving mean, percentage and standard deviations was used to assess the socio-economic characteristics of the sample households and farmer's response for adoption of improved wheat technologies and the type and distribution of improved wheat variety among the farmers of the study area. Also, t-test and χ^2 -test were employed to assess the relationship among the variables of interest. For the econometrics model Tobit model was used to analyze factors affecting the farmer's decision to allocate land for improved wheat variety and the intensity of adoption by farmers. In Tobit model, decisions whether to adopt or not and how much to adopt are assumed to be made jointly and hence the factors affecting the two level decisions were taken simultaneously (Solomon et al., 2010). As stated in Gujarati (2004) the Tobit model to estimate the factor affecting the adoption was defined as:

$$\begin{cases} y_i = y* = X_i\beta + u_i \quad \text{if} \quad \mathrm{y_i}^* > 0 \;\; \mathrm{u_i} \approx \mathrm{n}(0, \sigma^2) \\ \mathrm{y_i} = 0 \;\; \text{otherwise} \end{cases} \tag{1}$$

Where: y_i = land size allocated for improved wheat variety at a given level of *Xi*; y^* = unobserved latent variable, *n* = number of observations; *Xi* = vector of explanatory variables; β = vector of unknown coefficients (parameter to be estimated); and U_i = independently and normally distributed error term with zero mean and constant variance σ^2.

The model parameter was estimated by maximizing the Tobit likelihood function of the following:

$$L = \prod_{Y_i^* > 0} \frac{1}{\sigma} f\left(\frac{Y_i - \beta_i X_i}{\sigma}\right) \prod_{Y_i^* \le 0} F\left(\frac{-\beta_i X_i}{\sigma}\right) \tag{2}$$

Where; *f* and *F* are respectively, the density function and

Table 1. Description of independent variables.

Variables	Nature of the variable	Unit of measurement	Expected sign
Age of household head	Continuous	Years	+
Education level of household heads	Continuous	Year of formal schooling	+
Sex of household head	Dummy	Male/female	Male adopt more than female
Sizes of land holding of household	Continuous	Hectare	+
Frequency of contact with extension agents	Continuous	Number of visit farmer's land by development agents per month	+
Access to credit facility	Dummy	Yes/Not	+
Distance from market	Continuous	Kilometer	-
Distance to the main road	Continuous	Kilometer	-
Family size in adult-equivalent	Continuous	Number of adult-equivalent	+
Livestock holding (TLU):	Continuous	Number of TLU	+
Perception of farmers about cost of technology	Dummy	Ordinal variable	-
Perception of farmers about yield of improved wheat technologies	Dummy	Ordinal variable	+
Participation of the household head in leadership position	Dummy	Yes/no	+

cumulative distribution function (Maddala, 2005).

The marginal effect of an explanatory variable on the expected value (mean proportion) of the dependent variable was estimate by:

$$\frac{\partial E(Y_i)}{\partial Xi} = F(z)\beta_i \quad (3)$$

Where z is defined by:

$$\frac{\beta ixi}{\sigma}$$

The change in the probability of adopting improved wheat technology as independent variable X_i changes was estimate by:

$$\frac{\partial F(z)}{\partial X_i} = f(z)\frac{\beta_i}{\sigma} \quad (4)$$

Where, $z = X\frac{\beta}{\sigma}$, F (z) is the cumulative distribution function, f (z) is the value of derivative of the normal curve at a given point, z is the Z-score for the area under normal curve, ß is a vector of Tobit maximum likelihood estimates and σ is the standard error of the error terms. Similarly, the change in intensity of adoption with respect to change in an explanatory variable among adopters was estimated by:

$$\frac{\partial E(Y|Y_i^* > 0)}{\partial X_i} = \beta\left[1 - z\frac{f(z)}{F(z)} - \left(\frac{f(z)}{F(z)}\right)^2\right] \quad (5)$$

In this study the dependent variable was the land size allocated for the production of improved wheat varieties. Whereas the independent variables that were expected to affect the dependent variable with their unit of measurement and expected sign are presented in Table 1.

RESULTS AND DISCUSSION

Socio-economic characteristics of sample households

The descriptive statistics of some selected socio-economic characteristics of sample farmers examined in this study are presented in Tables 2 and 3. Table 2 presents for continuous variables whereas Table 3 presents for dummy variable. Out of the total sample respondents 118 were adopters and 42 were non-adopters.

Table 2 shows the result of descriptive statistics for continuous variables. As shown from the table, t-value was computed for all continuous variables and it was found to be statistically significant for family size in adult equivalent, education level, TLU, Average extension contact per month and farm size at 1% level of significance. This implies that there was significant difference in all these variables between the two categories (adopters and non-adopters).

Table 3 shows the result of descriptive statistics for dummy variables. The chi-square test was computed for the dummy variables and it was found to be statistically significant for credit access, Perception of farmers towards yield and cost of the variety at significance level

Table 2. Descriptive statistics of some selected continuous variables.

Variables	Adopters		Non adopters		Total		t-value
	Mean	Std.dev	Mean	Std.dev	Mean	Std.dev	
Age	48.89	9.93	47.45	11.66	48.51	10.40	0.769(NS)
Family size in adult equivalent	3.89	0.99	2.54	0.63	3.54	1.09	8.282***
Education level of household head in year	2.96	2.59	1.4	2.64	2.29	2.64	5.937***
Farm experience in year	26.5	10.69	24.7	12.9	26	11.29	0.883(NS)
TLU	4.44	0.64	3.21	0.48	4.13	0.81	11.453***
Average extension contact per month	2.5	0.95	1	0.74	2	1.18	10.669***
Land holding	0.71	0.3	0.52	0.17	0.65	0.30	5.53***

Source; Own computed result, 2011. ***, Significant at 1%; **, significant at 5%; NS, not significant.

Table 3. Descriptive statistics of some selected dummy variables.

Variables		Adopters		Non adopters		Total		χ^2
Sex		**No.**	**%**	**No.**	**%**	**No.**	**%**	
Sex	Male	96	81.4	35	83.3	131	81.9	4.738(NS)
	Female	22	18.6	7	16.7	29	18.1	
Participation in leader ship activity	Yes	50	42.37	15	35.71	65	40.63	5.134(NS)
	No	68	57.63	27	64.29	95	59.37	
Access to credit service	Yes	110	93.2	9	2.38	119	74.38	12.79***
	No	8	6.8	33	97.62	41	25.62	
Perception towards yield	Low	1	0.8	2	4.8	3	1.9	34.435***
	Medium	15	12.7	22	52.4	37	23.1	
	High	102	86.4	18	42.9	120	75	
Perception towards cost	Cheap	30	25.4	-	-	30	18.8	16.93***
	Medium	46	39	-	-	46	28.8	
	Expensive	42	35.6	42	100	84	52.4	

Source; Own computational result, 2011; NS, Not significant; ***, significant at 1%.

Table 4. Category of respondents based on type of improved wheat Varieties used and total land allocated for improved wheat.

Description	Number of respondents	%
Variety type		
HAR1685	79	66.95
HAR1686	32	27.12
HAR2501	7	5.93
Total	118	100.0
Land size in hectare		
<0.25	76	64.4
0.25	39	33.1
>0.25	3	2.5

Sources: Own computational result, 2011.

of 1%. This indicated that there was systematic difference in these variables between the two categories.

Category of respondents based on type of improved seed they used and allocation of land for improved seed

The types of improved wheat varieties distributed to farmers of the study area were HAR1685, HAR2501 and HAR 1686. From Table 4; out of the total adopters 79(66.95%) of them were user of HAR1685, 32 (27.12%) were used HAR1686 and the remaining 7 (5.93%) were user of the variety type of HAR2501. Since most farmers of the study area had problem of land shortage; the proportion of land allocated for improved variety was very small. From Table 4, 64.4% of adopters allocated less than 0.25 ha, 33.1% of them allocated 0.25 ha and 2.5% of them allocated greater than 0.25 ha of land to the improved wheat variety.

Table 5. Maximum likelihood estimates of Tobit model of adoption of improved wheat variety.

Land	Coefficient	Robust Std. Err.	t-Value
Sex of house hold head	0.087	0.008	1.13
Educational level of household head	0.064	0.001	5.22***
Participation of HH head in leadership activity	0.065	0.006	1.12
Farming experience in year	1.94e-06	0.000	0.01
Family size in adult-equivalent	0.128	0.005	2.65***
Sizes of land holding of HH	0.132	0.012	1.13
Distance to main road	-0.082	0.003	-2.64***
TLU	0.304	0.007	4.42***
Access to credit facility	0.563	0.011	4.90***
Frequency of contact with extension agents/month	0.012	0.004	3.38***
Perception of HH about yield of the variety	0.012	0.009	1.34
Perception of HH about cost of the technology	-0.015	0.005	-3.07***
Distance from market	-0.033	0.002	-2.44**
CONSTANT	-0.108	0.044	-2.45**
Numbers considered	160		
Log likelihood function	226.81403		
Lift censored	0		
Right censored	+infinity		

Source: Computed from the field survey data 2011; TLU, Tropical Livestock Unit, HH, household**.** ***,** significant at 1 and 5% respectively.

Table 6. Marginal effect of explanatory variables on use of improved wheat variety.

Variable	Change in probabilities as independent variable changes $\frac{\partial F(z)}{\partial X_i}$	Change among entire sample $\frac{\partial E(Y_i)}{\partial Xi}$	Change among adopters $\frac{\partial E(Y\|Y_i^* > 0)}{\partial X_i}$
Educational level of household head	0.117	0.051	0.049
Family size in adult equivalent	0.023	0.13	0.098
Distance from main road market	-0.015	-0.064	-0.063
TLU	0.056	0.025	0.021
Access to credit facility	0.103	0.513	0.425
Frequency of contact with extension agents/month	0.022	0.126	0.092
Perception of HH about cost technology	-0.027	-0.014	-0.012
Distance from market	-0.060	-0.028	-0.025

Source: Computed from the field survey data 2011; TLU, Tropical livestock unit; HH, household**.**

Determinants of adoption of improved wheat variety

It is well known that adoption of improved technologies depends on different socio-economic, demographic and institutional factors. Different variables are important across different space and time in explaining adoption of new technologies. For this study thirteen (5 discrete and 8 continuous) variables were hypothesized to influence the adoption of improved wheat variety in the study area. Among these, eight of the explanatory variables were found to be statistically significant in explaining the status and intensity of adoption of improved wheat technology in the study area. The estimated results of the Tobit model in Tables 5 and 6 showed that the significant variables affecting use of improved wheat variety in the study area include; educational level of household head, family size in adult-equivalent, distance to main road, tropical livestock units, access to credit facility, frequency of contact with extension agents, perception of household towards cost of the technology and distance from the

nearest market.

Educational level of household head

As expected educational level of household head was affected the adoption decision of farmer of the study area positively and significantly at less than one percent significance level (Table 5). This result is similar with studies by Nzomoi et al. (2007) education of household head affects positively and significantly adoptions of production of horticultural export produce. Also the studies by Ozor and Madukwe (2005), Motuma et al. (2010) and Isaiah et al. (2007) confirmed similar results. Results of analysis of marginal effect show that an increase in the level of education by one year increases the probability of being an adopter by 11.7% and it increases the level of adoption by 0.049 and by 0.051 among the adopters and the total sample in that order (Table 6). This implies that having high formal year of education increases the level of adoption of new agricultural technology by farmers. Farmers who have higher formal year of education are expected to analyze information and adopt earlier than the uneducated persons; because farmers with higher education level are eager to grasp new ideas and to try the technology by allocating some proportion of their land. Hence education level and adoption have positive relationship.

Family size in adult-equivalent

As expected family size in adult-equivalent affects the adoption decision of farmers of the study area positively and significantly at 1% (t=2.65) significance level (Table 5). A unit increase in family size increases the probability of adoption by 2.34% whereas it increases the level of adoption among adopters and the total sample by 0.098 and 0.13 respectively (Table 6). This result is consistent with the study on adoption of improved maize seed by Motuma et al. (2010). From this; household with high number of family size in adult-equivalent adopts more agricultural technology (improved wheat technology) than households with low number of family size. This could be because households with high number of family size can undertake the agricultural activity in time and effectively manage the wheat fields. On the other hand, the increase in number of family members would urge the families to look for high productivity and return options to meet the demand for food and expenditure. These scenarios would increase the adoption of improved wheat technologies providing better options to meet the pressing demand.

Distance from the main road

This variable affects adoption decision of farmers negatively and significantly at 1% (t = -2.64) (Table 4). This result agrees with the study by Isaiah et al. (2007); according to his study; accesses to means of transportation affect positively adoption of improved barley varieties. A unit increase in distance from home to main road in kilometer decreases the probability of adoption in favour of adopters by 1.5% and it increases level of adoption by 0.063 among adopters and by 0.064 among the whole sample (Table 5). This implies that farmers near the main road adopts more than farmers away from the main road. Farmers near the road can get transportation facility easily and they can transport the improved wheat variety easily and at low cost than the other farmers.

Tropical livestock unite (TLU)

As expected TLU affects the adoption level of farmers positively and significantly at 1% (t = 4.42) level of significance (Table 4). A unit increase in TLU increases the probability of adoption by 5.56% and increases level of adoption by 0.021 and 0.025 among adopters and among the total sample respectively (Table 5). This implies that being owner of more livestock increase the level of adoption of improved agricultural technology. Livestock increases household income from sale of animals and farmers can finance their agricultural requirement easily from their livestock income. The study by Solomon et al. (2011) confirms this result. According to his study TLU affects adoption of agricultural technology positively and significantly.

Access to formal credit facility

As expected this institutional factor affected adoption level of improved wheat variety by farmers of the study area positively and significantly at significance level of 1% (t = 4.9) (Table 5). Results of analysis of marginal effects; show that having access to credit service increases the probability of being an adopter by 10.3% and it increases level of adoption by 0.42 and 0.51 among adopters and the total sample respectively (Table 6).

The reason behind is that most farmers of the study area suffers from shortage of money to purchase improved agricultural inputs and it force them to use the input what they have on hand; which is the local one. But having access to credit facility solves such type of problem and farmers can purchase the improved input. According to Namwata et al. (2010) access to credit facility affect adoption of improved agricultural technology for Irish potatoes positively and significantly. Also studies by Isaiah et al. (2007), Motuma et al. (2010) and Odoemenem and Obinne (2010) confirmed similar results.

Frequency of contact with extension agents

This variable represents the number in which extension agents visit farmer's field of production per month. As expected this institutional factor affects adoption of improved wheat variety of farmers of the study area positively and significantly at 1% significance level (t=3.38) (Table 5). According to Namwata et al. (2010) extension contact was affected adoption of improved agricultural technology for Irish potatoes positively and significantly. And also according to the study by Isaiah et al. (2007), Solomon et al. (2011), Ayinde et al. (2010), Odoemenem and Obinne (2010) and Matata et al. (2010) frequency of contact with extension agent affect positively and significantly adoption decision of farmers for improved agricultural technology. From the analysis of marginal effects a unit increase in frequency of contact with extension agent increases the probability of being an adopter by 2.18% and it increases level of adoption by 0.092 and 0.126 among adopters and the entire sample respectively (Table 6). This implies that contact with extension agent increases availability of information about the improved technologies to farmers. Farmers can learn more about the technology. Hence farmers with more contact with extension agents adopt more than farmers with less contact.

Perception of households about the cost of the technology

As expected this variable affects the adoption decision of farmers negatively and it was statistically significant at 1% (t = -3.07) level of significance (Table 5). From the analysis of marginal effect perceiving the cost of technology in high as compared with the local one decreases the probability of adoption of the improved wheat variety by 2.73% and it decreases adoption level of the technology by 0.0123 and 0.0145 for adopters and for the entire sample respectively (Table 5).

Distance from nearest market

This variable affects adoption decision of farmers negatively and significantly at 5% level of significance (Table 4). The study by Solomon et al. (2011) was consistent with this result; distance from nearest market affects adoption of improved agricultural technology negatively and significantly. And also the studies by Isaiah et al. (2007) and Mesfin (2005) were consistent with this result. Table 5 shows a unit increase in distance of the nearest market from farmers home decreases the probability of adoption by 6% and it decreases the level of adoption by 0.025 among adopters and by 0.028 among the entire sample. This implies that farmers nearest to market can get and buy the technology without any difficulties and it decreases transportation and marketing cost, in addition to this farmers nearest to market are nearest to any market information than farmers away from the market and they have updated market information.

CONCLUSION AND POLICY IMPLICATION

The use of improved variety is considered as the most important input for the achievement of increased agricultural productivity and food security status of farm households in Ethiopia. However, adoption of improved variety remains very low, especially among small-scale farmers of the country. The results of this study showed that variables like access to credit facility, family size in adult-equivalent, TLU, extension contact and education level of household head affect adoption of improved wheat variety positively and significantly. Whereas variables like distance from nearest market and main road and perception of households about cost of the technology affects adoption of improved wheat variety negatively and significantly.

The fact that access to extension service affect adoption of improved wheat variety positively and significantly; implies the important role the extension personnel played in order to impact farmers' attitude and enhance farmers' awareness on the benefit of improved wheat technology. This in turn implies the need for advancing farmers perception on the use and advantage of improved wheat technology to increase the sustainable food production. Therefore, the government and other stakeholders should encourage access to extension agents to enhance dissemination of improved wheat varieties among the farmers through workshops, seminars, trainings and pertinent demonstration activities.

Formal credit service had been found as one of the important factors affecting the adoption of improved wheat variety. As credit service should provide better ground for making improved decision to access improved inputs particularly those unaffordable to smallholder farmers through its effect of reducing the existing cash constraint for undertaking agricultural decisions and accessing high value inputs. Therefore it is recommended that credit service should be made available to farmers at an affordable rate to increase better and wider adoption of improved wheat technologies.

Distance from farmers' home to main road was an important variable which affects adoption of improved wheat variety negatively and significantly. Hence attention should be given to expand the road infrastructure in the rural area to increase farmer's access to transportation facility and decrease transaction cost to get better access to improved agricultural technologies. Perception of household towards cost of technology was significant variable which affect the

adoption of improved wheat variety. Information about the benefits of new technology should be given for farmers to increase farmer's awareness about the technology and to develop farmer's attitude towards the technology. However, since in most cases cost is associated with the existing scenario of lack of capacity to buy the technologies, any agricultural development effort advocating the adoption of improved technologies should consider an enabling environment such as access to credit.

Conflict of Interest

The authors have not declared any conflict of interest.

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