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Factors Influencing High Yielding Wheat Varieties Adoption by Smallholder Farmers in Ethiopia

Abstract
Wheat yield is low in Ethiopia. Adoption of high yielding wheat varieties is one of the measures presumed to enhance wheat yield in the country. However, there are several socio-economic and institutional factors that limit the adoption of high yielding wheat varieties. The main objective of this study was to analyze factors affecting adoption of high yielding wheat varieties by small holder farmers in Ethiopia. The study used cross-sectional data collected from sample of 174 farm households selected through two-stage stratified random sampling techniques. Descriptive statistics and econometric models were used to analyze the data. Probit model was employed for adoption analyze of high yielding wheat varieties. The probit model result depicted that land holding size, tropical livestock unit, access to agricultural information, frequency of extension contacts, off-farm income and perception of farmers toward attributes of high yielding wheat varieties affected the likelihood of adoption of high yielding wheat varieties positively and significantly. But, sex of household heads and affiliation to organizations had negative and significant effect on the adoption of high yielding wheat varieties. The finding suggest that the government and stakeholders should need to focus on improving farm land and livestock productivity, strengthening frequency of extension visits, encouraging participation in non-farm activities, creating reliable information and awareness towards farmers' perceptions in the area. Finally, further support of high yielding wheat varieties adoption should be given due attention for smallholders.
Keywords: Adoption, High yielding wheat varieties, Smallholder, Binary probit

1. INTRODUCTION

The economic development of Ethiopia is highly dependent on the performance of its agricultural sector since it is the main economic pillar of economic growth of the country. Agriculture contributes 42 % of the GDP of the country and about 85 % of the population gains their livelihood directly or indirectly from agricultural production [12].

Wheat (*Triticum aestivum L.*) is one of the major food and cash crops for smallholders in Ethiopia. It is important cereal crop with annual production of about 4.23 million tons and cultivated on an area of 1.66 million hectares [11]. According to the CSA report, it occupies about 24.02 % of the total cereal area in the country and contribute the grain production about 15.65 %. However, its national average yield is about 25.43 quintals per hectare. This is low yield compared to global average of 40 quintals per hectare [18]. The low yield has made Ethiopia unable to meet the high demand and the country is net importer of wheat [40].

To feed the rapidly growing population and meet the high demand of wheat in the country, it needs to increase the production and yield of wheat. However, increasing yield requires successful adoption of improved agricultural technologies [16]. Low yield due to low adoption of improved agricultural technologies is believed to be the main factor that prevented agricultural production from coping with the rapid population growth in Ethiopia. For this reason technological change is commonly considered as one of the major options leading to successful productivity growth in agriculture. The objective of this study was to assess the adoption of high yielding wheat varieties by smallholder farmers.

2. Empirical Studies on Adoption of Agricultural Technologies

A number of empirical studies have been conducted by different people and institutions on farmers' adoption behavior both outside and inside Ethiopia using econometric models. The results of various empirical studies confirmed that adoption of a new technology offers opportunities for increasing productivity and production.

Studies conducted by [5], [44] and [26] found that age of household head, educational status, livestock holding, non-farm income, sex, and information access plays important factors in affecting the decision of farmers to adopt improved technology. Similarly, study conducted by [30] on factors affecting adoption of improved sorghum varieties in Somali Region of Ethiopia, found out that more educated farmers are more likely to adopt improved sorghum varieties in the study area.

The study conducted by [15] on agricultural technology adoption, diversification and commercialization for enhancing food security in Eastern and Central Ethiopia by using multivariate probit revealed that adoption of high yielding crop variety was influenced by land allocated, agricultural income, distance to research institution, and the farming system. It also was reported significantly and negatively affected by other exogenous shocks. Moreover, the study by [14] found that membership to farmer cooperatives has a strong positive effect on adoption of chemical fertilizer.

The study by [7] on adoption of improved wheat varieties and impact on household food security in Ethiopia, indicated that wheat technology adoption has generated a significant positive impact on food security and these results provide strong evidence for the positive impact of adoption of modern agricultural technologies

for a major food staple on alleviating food insecurity in rural Ethiopia.
Study conducted [28] on factors influencing allocation of land for improved wheat variety by smallholder farmers in Adwa district. They pointed out adopters had high family labor, high number of tropical livestock unit, large land size, high frequency of extension contact, access to credit, access to education, access to nearest to main road and market as compared to non-adopters. They also indicated that education level of household head, family size, tropical livestock, distance from main road and nearest market, access to credit service, extension contact and perception of household toward cost of the technology have to be significantly affecting factors adoption of improved wheat variety.

The study conducted by [43] on agricultural technology adoption, crop diversification and efficiency of maize-dominated farming system in Jimma Zone of South-Western Ethiopia by using Tobit model indicated that age, family size, level of education, family education, ownership of mobile phone, extension services, cooperative membership, livestock holding and land holding size have positively and significantly influenced probability of improved maize variety and/or chemical fertilizer adoption in maize farming while distance of development center from residence has a significant negative effect.

3. RESEARCH METHODOLOGY

3.1. Description of Study Area

The study was conducted in Mao-Komo Special district of Benishangul-Gumuz Region located in the Western part of Ethiopia and stretches along the Sudanese border found around 661 km away from Addis Ababa. Mao-Komo Special district is one of the 20 districts found in Benishangul-Gumuz Region. The altitude of the district ranges from 950-1960 m.a.s.l. The temperature of the district ranges from 17.5-32 ^{o}C. The rainfall is uni-modal which starts in the month of April and ends in mid-October. The annual rainfall ranges from 900-1800 mm with mean annual rainfall is 1316 mm, mostly received between May and September with the highest in July and August. The duration is about 6 to 7 months with good amount of rainfall distribution.

Having an area of about 2100 Km^2 and population of about 42,050 [10], the district has a total 7848 households with 7185 and 663 male and female headed households, respectively. Farming is the predominant occupation of the people in the area since it is the main economic stay of the district. Maize, sorghum, wheat, and finger millet are the dominant cereal crops produced for consumption. Coffee, *chat*, sesame, nigger seed and *teff* are produced for income generation in the district. Cattle, small ruminant, donkey, poultry and honey bee are the most important livestock species. The district has potential and favorable environmental and socio-economic conditions that would suitable for wheat production.

3.2. Sources and Methods of Data Collection

The data for this study were collected from both primary and secondary sources on a wide variety of variables. The primary data were collected through individual interviews of selected respondents. The survey was administered using semi-structured questionnaires within individual interview. To complement the primary data, secondary data were obtained from different unpublished and archival sources such as articles/literatures, official reports, and personal communications. At final, overall collection of quantifiable data through quantitative survey which is essential to generate concrete and quantifiable information on selected parameters, such as the adoption of high yielding wheat varieties was identified.

3.3. Sampling Procedure

This study defines the survey population at two levels, namely at the rural kebele level and at the farm household level. A two-stage stratified random sampling method was employed to draw representative sample respondents to increase homogeneity within adoption stratum and heterogeneity between strata. In the first stage, rural kebele administrations were stratified into two categories as potential and less potential wheat growers. Accordingly, three potential wheat producing kebeles were selected.

In the second stage, members of each kebele were stratified into two groups based on their adoption status of high yielding wheat varieties. Then, a total of 174 farmers were randomly sampled taking into account probability proportional to size of households in each kebele for both groups. Finally, the survey was administered and data were collected and analyzed on 174 respondents.

3.4. Methods of Data Analysis

Adoption of high yielding wheat varieties was evaluated by statistical tools and econometric models for concluding the socio-economic, institutional, and environmental factors that hinder the adoption by smallholder farmers in the study area.

3.4.1. Descriptive statistics

Descriptive statistics were utilized to assess socio-economic characteristics of the sample respondents for adoption of high yielding wheat varieties in the study area. These information was considered to augment the

econometric analysis results. The descriptive analysis tools such as t-test and chi-square were employed to assess the relationship among the variables of interest that statistically to compare users and non-users of high yielding wheat varieties.

3.4.2. Econometric models

In this study, the econometric analysis that employed was binary probit model for adoption of high yielding wheat varieties by smallholders.

Probability of Adoption

A household level adoption study considers the decision made by the household head to include new or improved variety in usual farming practice. The decision made to adopt or otherwise depend on different factors. Farmers' decision to adopt high yielding wheat varieties is assumed to be the product of a complex preference comparison made by a farm household. To adopt or not to adopt high yielding wheat varieties is often a discrete choice. Discrete choice models have widely been used in estimating models that involve discrete economic decision-making processes [21].

The dependent variable which is normally used with these models is dichotomous in nature, taking the values 1 or 0, a qualitative variable which is incorporated into the regression model as dummy variable. In this case the value 1 indicates a farmer who adopts the high yielding wheat varieties while the value 0 indicates the farmer who does not adopt. A number of studies conducted on agricultural technology adoption of smallholder farmers indicate that for such type, the most commonly used models are the logit and probit models. The binary model, a logistic distribution function, and the probit model, a normal distribution function, is used in estimating the probability of technology adoption [39], [17], [9], [20]. Such models have been widely used in different adoption studies not only to help in assessing the effects of various factors that influence the adoption of a given technology, but also to provide the predicted probabilities of adoption [4]. The estimating model that emerges from normal CDF is popularly known as the probit model [22].

Thus, this study utilized the probit model to analyze likelihood of adoption of smallholder farmers because it is an appropriate econometric model for the binary dependent variable and the error term is assumed to be normally distributed. Often, probit model is imperative when an individual is to choose one from two alternative choices, in this case, either to adopt or not to adopt high yielding wheat varieties. An individual makes a decision to adopt high yielding varieties of wheat if the utility associated with that adoption choice is higher than the utility associated with decision not to adopt. Hence, in this model there is a latent or unobservable variable that takes all the values in (-∞, +∞).

In this study the classical probit model was employed to analyze the adoption decision behavior of the respondents. To motivate the Probit model it can be assumed that the decision of a household (in this case an adopter) to adopt the high yielding wheat varieties (Yi=1) or not (Yi=0) depends on an unobservable utility index (also known as a latent variable), that is determined by one or more explanatory variables, Xi, in such a way that the larger the value of the latent variable, the greater the probability of a household to adopt the high yielding wheat varieties.

The Probit model is specified as:

Where $Y_i = X_i \beta_i + \varepsilon_i$ where i= 1, 2, 3…..n (1)

Where: Y_i is a dummy variable indicating the probability of adoption and related as:

$Y_i = 1$ if $Y_i > 0$, otherwise $Y_i = 0$

X_i - is household characteristics of variables that determining farmers adoption in the probit model

β_i - is unknown parameter to be estimated in the probit regression model

3.5. Definition and Measurement of Variables

The hypothesized variables expected to influence adoption of high yielding wheat varieties in this study were explained in the following.

Dependent Variable

Adoption of high yielding wheat varieties: Adoption of high yielding wheat varieties by households is the dependent variable. It represents the observed statuses of a farmer's adoption decision towards high yielding wheat varieties. It refers variable of the model that is adoption or non-adoption of high yielding wheat varieties. It has a dichotomous nature-representing farmer's adoption decision on wheat varieties; taking value of 1 for adopter and 0 for non-adopter of the wheat varieties.

The Independent variables

Different theoretical and empirical studies conducted elsewhere on factors influencing adoption of agricultural technologies indicate the role of many personal, institutional, socio-economic and bio-physical factors in determining farmer's adoption decision. The independent variables of the study were those which were expected to have association with the adoption of agricultural technologies on basis of past research studies, based on the literature reviews and prior knowledge of the study area. The study considered that farmer's

decision to adopt high yielding wheat varieties being used on farmer's perception of technology-specific attributes. This is based on evidence from empirical works of [2], [31] and [38] that have shown farmer's perception of technology-specific attributes significantly influence on farmer's adoption decisions.

The theoretical hypotheses of adoption of high yielding wheat varieties could be include resources, farmer, and technology specific characteristics. The model assumes that the dependent variables that were adoption of high yielding wheat varieties depends on the education of the household head in years of schooling, sex of the household head, involvement of the household in off-farm activities, farming experience of the household head in years, family size of households, total farm size in hectare, livestock unit owned by farmers, farmers' perception of varietal characteristics, frequency of extension contact, distance from market center, distance to main road, access to credit, farmers' membership to village organization. The variables utilized in the study and their theoretical expectations about the sign and magnitude of these variables on the probability of adoption decision of high yielding wheat varieties were discussed below.

Table 1. Summary of variables affecting adoption of high yielding wheat varieties

Variables	Measurements/Unit	Expected effect on Adoption
Sex of household	Dummy; Male/Female	Female adopt less than Male
Family size	Continuous, total no. of family members	+ve
Educational level	Continuous, years of schooling	+ve
Farming experience	Continuous, years of farming	+ve
Land holding of household	Continuous, hectares	+ve
Livestock holding unit (tlu)	Continuous, values	+ve
Distance from market center	Continuous, kilometers	-ve
Access to credit	Dummy; yes/not	+ve
Distance to main road	Continuous; Kilometers	+ve
Frequency of extension contact	Continuous; no. of days	+ve
Non-farm income	Continuous (log); ETB	+ve
Farmers' perception of HYV of wheat attributes	Dummy/ Ordinal variable	+ve
Farmer's affiliation to organizations	Dummy; yes/not	+ve

4. RESULTS AND DISCUSSION

The study presents the results explaining smallholder farmers' probability of adoption of high yielding wheat varieties by smallholder farmers through the statistical analysis of descriptive tools and empirical results of econometric analysis.

4.1. Descriptive Results

Descriptive statistics such as mean, minimum and maximum values, range and standard deviations were used to describe the socio-economic and institutional characteristics of the households under considered in the study of high yielding wheat varieties adoption. For this study, the data was collected from both adopters and non-adopters of high yielding wheat varieties that consists of 50 % each of two group. Table 2 below, depicts the statistical t/χ^2-test comparison of variables expected to determine adoption of high yielding wheat varieties and intensity of market supply wheat produce by sample households.

The descriptive results revealed that adopters of high yielding wheat varieties were significantly different from non-adopters in many cases such as farm land holding size, family size, livestock ownership, frequency of extension visit, educational level, and perceptions' of farmers toward high yielding wheat varieties on certain attributes. On the other hand, adopters did not make significant difference in terms of distance from market center, distance to main road, farming experiences, access to credit services, sex of household head, off/non-farm income activities, and participation in local level organization with compared to non-adopters.

The survey results showed that the households' average cultivable farm land possession ranged from the smallest 0.125 ha to the highest 5.125 ha. The mean difference of total land holdings for the two groups have strong significance. The average experience of the adopters and non-adopters were 25.39 and 23.48, respectively and did not have difference and statistically insignificant difference. The adopter groups are distinguishable in terms of asset holding whereby adopters own more assets in terms of tropical livestock unit and land holding size. On average, the total sample households have about 2.88 tropical livestock unit. The tropical livestock unit was strongly and statistically significant difference between adopters and non-adopters of the sample households (Table 2).

Table 2. Descriptive Statistics for Some selected Continues Variables

Descriptions	Adoption Status			t-test value
	Adopters Mean	Non-adopters Mean	Total Sample Mean	
Land holding size (ha)	1.83	1.16	1.50	-5.114***
Total livestock unit (tlu)	4.29	1.46	2.88	-6.803***
Educational level (years)	1.99	1.49	1.74	-1.517*
Distance from market center (km)	4.20	4.37	4.29	0.447
Distance to main road (km)	2.83	2.77	2.80	-0.145
Farming experiences (years)	25.39	23.48	24.44	-1.165
Family size (number)	7.59	6.72	7.16	-2.100**
Off/non-farm income (ETB)	3.26	3.25	3.26	-0.024
Frequency of extension contact (days)	20.48	12.97	16.72	-3.263***

*, **, and *** indicates significant at 10 %, 5 % and 1 % significance levels, respectively.
Source: Own survey (2015)

Literate households are expected to have better skills, better access to information and ability to process information. Adopter categories were seem to significantly vary in terms of formal education level that is years of schooling and adopters have higher proportion of household heads with more years stayed in education (Table 2). The maximum educational level of adopters was 10 years where as for non-adopters was only 8 years. This indicate that education have slightly significant difference between the two groups. The average family size of households were 7.60 and 6.72 persons for adopters and non-adopters, respectively. The difference is statistically significant between the adopters and non-adopters.

Households' access and arrangement to institutions play a vital role in providing agricultural services like access to market information, microfinance/credit services, and information about new wheat varieties, consultancy services provided by development agents, NGOs, researchers, cooperative and other social services. There is no significant difference in terms of household average distance from nearest market center, distance to main road between adopters and non-adopters (Table 3).

An agricultural extension services provided to farmers is believed to be the main source of information about improved agricultural technologies and it is widely accepted that substantial productivity increases could be achieved when farmers get appropriate extension services. The survey result showed that frequency of extension contacts by extension workers varies among the sample households. As indicated in table 3 below, around 16.72 days for the whole sample respondents had visited by extension workers within a year to get extension service. This indicates that adopters had relatively a better frequency of extension contact than non-adopters. The mean difference between the two groups was statistically significant; showing that there is strong discrepancies between adoption groups of households based on the frequency of extension contacts with development agents.

Table 3. Descriptive Statistics for Some selected Discrete/ Dummy Variables

Descriptions	Adoption Status			χ^2 value
	Adopters Mean	Non-adopters Mean	Total Sample Mean	
Farmers perceptions' for HYWV				
Good	45.98	19.54	65.52	55.441***
Average	2.30	26.44	28.74	
Poor	1.72	4.02	5.75	
Access to credit services				
Yes	3.45	2.87	6.45	0.755
No	46.55	47.13	93.68	
Access to information				
Yes	43.68	31.61	75.29	13.622***
No	18.39	6.32	24.71	
Affiliation to organizations				
Yes	48.28	47.13	95.40	0.469
No	1.72	2.87	4.60	
Sex of household				
Male	47.13	47.70	94.83	0.732
Female	2.87	2.30	5.17	

*, **, and *** indicates significant at 10 %, 5 % and 1 % significance levels, respectively.
Source: Own survey (2015)

Access to relevant agricultural information makes farmers to be aware of high yielding wheat varieties,

which in turn, will facilitate change in the behavior of farmers and may ultimately lead to decision to take risk for high yielding wheat varieties adoption. The adopter groups are significantly distinguishable in terms of access to information. Farmers could get access to agricultural information in different ways. These include participation on events like training, demonstration and attending field days, farmer-to-farmer information sharing, etc. The survey result revealed that on average about 43.68 adopters had chance to access available agricultural information while only 31.61 non-adopters access to agricultural information (Table 3). The chi-square test results show that access to information related to high yielding wheat varieties between adopters and non-adopters was statistically significant at 1 % significance level. This shows that the adopters have got more opportunity of information on high yielding varieties than non-adopters.

Those farmers who affiliated to different organizations in a community level are assumed to have more access to agricultural input, information, and better interpret and use the available information related to new technology. Farmers' membership to organizations in local level like *Idir, Equip*, cooperatives, farmers' group, and women groups' used as a proxy for access to inputs and information on the adoption of the high yielding wheat varieties. The mean difference between the two groups (adopters and non-adopters) was statistically insignificant; showing that there is no difference between the two groups based on adoption statuses of households in terms of participation in the formal organization.

Credit is an important institutional service to finance poor farmers who could not afford to purchase input from own savings especially at early stage of adoption. The chi-square test result revealed that there is no difference between adopters and non-adopters farmers in relation to access to credit services in the study area (Table 3). Because, the formal organization available in the study area like primary cooperative didn't have financial capacity in serving farmers for necessary agricultural inputs such as improved seeds of different crops, plant protection chemicals, fertilizers, and only farmers those have position in resource ownership purchased on cash these inputs from available sources and the incapable farmers fail to utilized agricultural inputs.

From 174 total sample households, only 9 were female-headed and the majority of sample respondents were male-headed households. The survey data revealed that no significant difference is observable in the sex of household head since almost all of the respondents were male headed households.

As various studies results indicated, perception toward attributes of high yielding wheat varieties by smallholder farmer is one of the determinant factors for decisions making on adoption of high yielding wheat varieties. Mostly, peoples living in same environment share a common understanding of various circumstances and from more or less similar perception about certain situation. However, the degree of perception varies from individual to individual due to different factors. Adopters have more experienced advantages of high yielding wheat varieties with attributes like higher yield per hectare, short duration to maturity, better market price, and resistance to pests and diseases. This simple comparison of the two groups suggests that adopters and non-adopters have significant difference in some proxies of preferences particularly with higher yield per hectare of high yielding wheat varieties. The chi-square test indicated that there is systematic relationship between perception of respondents about high yielding wheat varieties and the two categories of sample household groups were statistically significant (Table 3).

4.2. Econometric Results

Analysis of adoption

The probit model was employed to identify factors influencing adoption of high yielding wheat varieties by smallholder farmers in the study area. The chi-square ($\chi 2$) distribution was used as the measure of overall significance of a model in probit model estimation. The Wald chi^2 test statistics with 13 degree of freedom, and prob > chi^2 = 0.0000 is used to test the dependence of the adoption of high yielding wheat varieties on the selected independent variables in the model (the hypothesis that all coefficients are equal to zero is rejected at 1% significance level). The pseudo R^2 (0.30) which indicates 30 % of the variation between adopters and non-adopters of high yielding wheat varieties which explained by the variables. The results indicate that the independent variables are related to the propensity of adoption of high yielding wheat varieties at 1 % significance level, indicating that the model have good explanatory power.

Hence, the results of the model show that out of the thirteen variables included in the model, eight were correlated with propensity of high yielding wheat varieties adoption and found to have statistically significant effects on the adoption of high yielding wheat varieties on the sample respondents. The binary probit model outputs showed that sex of household, difference in land holding size, tropical livestock unit, frequency of extension contacts, access to information, off-farm income activities, perception of farmers' toward attributes of high yielding wheat varieties, affiliation to local organizations are significant factors affecting the probability of adoption of high yielding wheat varieties.

The model outputs showed that sex of household and affiliation to local organizations have influence on the households' adoption decision of high yielding wheat varieties at 10 % significance level. Whereas having difference in land holding size, frequency of extension contact/visit, and of off-farm income are significant

factors affected adoption of high yielding wheat varieties at 5 % of significance level. Having more tropical livestock unit, access to information, and perceptions of farmers towards high yielding wheat varieties attributes have strongly and significantly correlated with decision of households' high yielding wheat varieties adoption at 1 % significance level (Table 4).

The probit model results revealed that household head sex is negatively and significantly associated with adoption of high yielding wheat varieties. The result confirms that as compared to male-headed households, female-headed households are less likely to adopt high yielding wheat varieties than male-headed farmers. Implication of female-headed households on likelihood of adoption of high yielding wheat varieties might be that female headed households have a lower labor endowment, lower farm land holding and livestock unit ownership, and less access to information on high yielding wheat varieties compared to their counterpart. From marginal effects, being female-headed households, *citrus paribus*, reduce by 23.6 % the adoption of high yielding wheat varieties as compared to male-headed households. In the study area, letting females to be a household head is not yet well developed and recognized since almost majority of the farmers are Muslim followers, and female-headed households mostly are those who are widowed and divorced. In such instances, due to the cultural and socio-economic factors, their likelihood of adopting high yielding wheat varieties becomes negligible. The overall finding is consistent with the results reported by others. Results of [38] and [51] pointed out, a negative association between a female-headed household and improved maize variety adoption. Contrary to this, results by [34] and [46] found significance influence of sex of household head on adoption of agricultural technologies.

Table 4. Estimated results of probit model for adoption of high yielding wheat varieties

Adoption of high yielding wheat variety	**Coefficient**	**Robust Std.Err**	**Marginal effects**
Sex of household head (1=male; 0=female)	-0.633*	0.376	-0.236
Farming experience (years)	0.011	0.012	0.005
Educational level (years)	0.085	0.061	0.034
Distance to main road (km)	0.054	0.053	0.021
Family size (numbers)	-0.017	0.045	-0.007
Land holding size (ha)	0.413**	0.195	0.164
Tropical livestock unit (tlu)	0.193***	0.058	0.077
Access to credit (dummy)	-0.350	0.484	-0.138
Frequency of extension contact (days)	0.022**	0.009	0.009
Access to information (0=no; 1=yes)	0.971***	0.321	0.366
Off/non-farm income (ln ETB)	0.063**	0.029	0.025
Perception of farmers' toward HYWV	1.438***	0.362	0.455
Affiliation to organizations (0=no; 1=yes)	-0.768*	0.446	-0.278
Constant	-2.884***	0.822	
Number of observation	174		
Wald chi^2 (13)	51.05***		
Prob > chi^2	0.0000		
Pseudo R^2	0.3027		
Log pseudo likelihood	-84.10		

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

Source: Own survey (2015)

It is worth to note that, having more farm land size is one best option whereby smallholders could be prompted in diversifying their crop production and adopt all imperative yield increasing technologies. Farm size have a positive and significant effect on adoption of high yielding wheat varieties. The positive effects of farm size indicate that farmers with relatively large farm land size decide to adopt high yielding wheat varieties than owners of small farms land size. This is in agreement with the hypothesis formulated regarding the relationship between high yielding wheat varieties adoption and land holding size of the households (Table 4). As a basic production factor, the more farmers have cultivable land, the more likely to adopt agricultural technologies particularly high yielding wheat varieties that could possibly increase crop yield.

Probably, owning more arable land could be taken as a prerequisite to adopt and employ agricultural technologies since farmers incur a cost. Being rational decision makers, while incurring a cost for improved varieties, totally, farmers want to employ improved varieties within their own land where the final crop yield could not be shared and sub-divided. Results of marginal effects indicated that as land holding of the households' increases by a unit, farmers' likely to participate in adoption of high yielding wheat varieties increases by 16.4 % as compared to non-adopters. During focus group discussion farmers told that shortage of farm land especially in some villages' due to expansion of urban and degradation of farm land influence the cultivation of high yielding wheat varieties. Besides this, increasing number of family members per households in the area enforce farmers to share their farm land to children that reduce the yet low farm land size and made

influence in adoption of high yielding wheat varieties. The result is supported by findings of earlier studies on technology adoption of [25], [3], [53] and [1]. Other studies by [27], [5], [35] and [43] also found a similar result.

Livestock are considered as an asset that could be used either in the production process or be exchanged for cash (particularly small ruminants) for the purchase of inputs (seed, fertilizer, herbicide, etc.) whenever the need arises. Tropical livestock unit, which is a proxy for measuring wealth status of household head (in terms of tropical livestock unit), is found to have a positive and significant influence on adoption of high yielding wheat varieties, indicating that farmers with large number of livestock are more likely to adopt high yielding wheat varieties than others. Results of marginal effect show that a unit increase in tropical livestock unit, increases the decision of high yielding wheat varieties adoption by 7.7 % for adopters of sample households. This is because farmers with relatively more livestock unit make use of their income obtained from sale of livestock and byproducts for the purchase of wheat seeds and fertilizers. Also livestock, particularly oxen, are used for draft of different farm operations. This implies that being owner of more livestock unit increase the probability of adopting high yielding wheat varieties. The study is supported by [25], [44], [26], [8], [50], [28] and [43] which confirms the same result.

The number of extension contacts per year (season) has positively and significantly related to adoption of high yielding wheat varieties, implying that farmers with more frequency of extension contacts are more likely to adopt high yielding wheat varieties than those with less frequency of extension contacts. Frequency of extension contact are powerful and crucial to achieve better adoption of improved agricultural innovations like high yielding wheat varieties which is expected from the very purpose of extension services. Henceforth, frequency of extension contacts by development agents with farmers is assumed to be the potential force which accelerates the effective dissemination of adequate agricultural information to the farmers, thereby enhancing farmers' decision to adopt high yielding wheat varieties.

From the analysis of marginal effects, increases in one number more frequency of extension contacts by development agents during production season, increased the likelihood of adopting high yielding wheat varieties by 0.09 % of smallholder farmers. Farmers who have more frequency of extension contacts with development agents update themselves on the availability and arrival of high yielding wheat varieties and aware of its application techniques than those less visited by development workers. The reason is that farmers can learn more about the technology and familiarized using of high yielding wheat varieties. The studies conducted by [23], [25], [44] and [28] found that frequency of contacts with extension agent affect positively and significantly adoption decision of smallholder farmers. Similarly, [5], [35] and [43] also indicated that the frequency of extension contact has a significant and positive effect on adoption of agricultural technologies.

Agricultural information was essential factor that found to have significant influence on the adoption decision of high yielding wheat varieties by smallholder farmers. The availability of timely information on high yielding wheat varieties was found to have a positive and significant influence on the decision possibility of households' adoption of high yielding wheat varieties. Access to relevant agricultural information is usually supposed to make farmers to be aware of and get better understanding of high yielding varieties. This might be ultimately facilitate change in the behavior of farmers and lead to adoption decision to take risk for high yielding wheat varieties. The role of information in decision-making process is to reduce risks and uncertainties, to enable farm households to make right decision on adoption of high yielding wheat varieties.

Access to agricultural information from different sources in the local and wide area play the greatest role in provision of information in shortest possible time, and create awareness toward high yielding varieties in their localities. It could be taken as an important source for adopting high yielding wheat varieties in such a way that farmers could easily afford seed and other costs; and farmers are mostly exposed to new and updated information since they access relevant information available in the area. For this reason, having more access to agricultural information, *citrus paribus*, increases likely use of high yielding wheat varieties by 36.6 % for smallholders. This result go along with the study done by [29] and [36].

Many farmers can earn additional income engaging in various off-farm income generating activities. The model output indicated that participating in different off-farm activities was found to have a positive and significant influence on adoption decision of high yielding wheat varieties. This is believed to raise their financial position to acquire new agricultural inputs. As expected having alternative sources of income from off-farm activities, had significant relationship with probability of adopting high yielding wheat varieties. The estimated marginal effect of the probit regression model shows, for each additional or unit increase in off-farm income, increases the likelihood of adoption of high yielding wheat varieties by 2.5 % than those did not have off-farm income activities. The result indicates that households with relatively higher alternative income from off-farm sources are expected to better adopt the high yielding wheat varieties than their counterparts. This study confirms the findings of [24], [47] and [8].

Technologies are viable only when farmers use them. No matter how well the new technologies work on research stations, if farmers do not have them for use, their development would be in vain. With regard to the perception of farmers towards certain attributes of high yielding wheat varieties meet farmers' preference.

Perception of farmers toward attributes of high yielding wheat varieties is one of the factors that could speed up the change process and adoption of new crop varieties. As being major crop in the study area, high yielding wheat varieties play a vital role in fulfilling household consumption and cash requirements. The result of probit model shows that perception of farmers toward attributes of high yielding wheat varieties (high yield per unit area, better price of wheat grain, short maturity period, resistance to diseases and lodging) positively and significant affected adoption of high yielding wheat varieties.

From the analysis of marginal effect perceiving that high yielding wheat varieties have better yield per unit of area, likely increases the likelihood of adopting high yielding wheat varieties by 45.5 % of adopters' farmers. The results suggest that farmers in the study area seek specific varietal attributes, such as yield potential, tolerance to disease and lodging, better wheat grain price and short maturity period. While focus group discussion farmers in the area told that they got first seed sources from research center and it has higher yield per unit of area. Furthermost, some farmers adopt by purchasing from other farmers and exchanging with other commodities. They also reported reduction in productivity after some years due to diseases (rust) was the major problem. However, they prefer it due to better yield from small land and have high market price. The finding of farmer perceptions of high yielding wheat varieties-specific characteristics significantly determine adoption decisions and is consistent with evidences in literature, which suggests the need to go beyond the commonly considered socio-economic, demographic and institutional factors in adoption modeling by [17] and [19]. Similar to this, adoption studies by [52] and [6] considering farmers' perception of technology attributes have found that attributes determine the adoption choices of farmers. In addition, studies by [2] revealed that farmers have subjective preferences for technology characteristics and this could play major roles in adoption.

Farmers' memberships to local organizations, which have an indirect influence on the adoption behavior of farmers. It links the individual to the larger society and exposes households to a variety of ideas. This exposure makes farmers positively predisposed towards innovative ideas and practices. Memberships to organizations have negative and significant influence on adoption of high yielding varieties, implying that farmers who are members of different local organizations are less likely to adopt high yielding wheat varieties. A possible reason for this result relates to the fact that organizations found in the study area are not actively participate in the high yielding wheat cultivation supporting activities and unable to provide credit services for member farmers to purchase high yielding wheat seed and fertilizers since majority are like *Equib, Idir* which serves as a social security support. The primary cooperatives available also facilitate mostly basic supplies as sugar, and edible oil at reasonable price rather than supplying production supporting agricultural inputs such as plant protection chemicals for farmers and purchasing their outputs at better price. As a result, memberships in the local organizations have adversely influence the households' likelihood decision to adopt high yielding wheat varieties. The marginal effects result show that being member of local organizations, *citrus paribus*, reduces by 27.8% the likelihood of adoption of high yielding wheat varieties. Contrary to this, the studies by [48] and [14] found a positive result of relationship of cooperative membership with technology adoption.

5. CONCLUSIONS AND POLICY IMPLICATIONS

5.1. Conclusions

The use of improved agricultural technologies particularly high yielding wheat varieties is considered to be the most important input for the achievement of increased agricultural productivity by smallholders in Ethiopia. Wheat contribution to households' food sources (nutritional value), income, feed for livestock, hatching for roofing, and provides job opportunities for farming households and urban dwellers who are engaged in its trading activities.

This study was initiated to fill the gap of information on what factors influence adoption of high yielding wheat varieties by smallholder farmers in Ethiopia. Cross-sectional data were collected from sample of 174 farmers selected by using a two stage stratified random sampling techniques. Descriptive statistics and econometric data analysis methods were employed. Hence, the study addressed the adoption of high yielding wheat varieties that affected farmer's decision to use or not use high yielding wheat varieties.

The study identified key factors that influence adoption decision in the study area. This insight is also useful to rethink about the barriers of adoption of high yielding wheat varieties by smallholder farmers. The prominent variables were categorized as household personal and demographic, socio-economic, institutional and psychological factors. Results confirmed that the likely adoption decision of high yielding wheat varieties were strongly related to a range of factors, which need due consideration.

Comparisons of the main features of farmers from descriptive statistics results revealed that adopters relatively more educated than non-adopters of sample households; have more frequency of extension contacts, owning more land holding, tropical livestock unit, and slightly less family size in the study area. In addition, adopters have better accessibility to information, and good perceptions towards certain attributes of high yielding wheat varieties (high yield per unit area, better market price, short maturity, resistance to diseases and lodging) as compared to non-adopters.

The probit model results revealed that factors such as land holding size, tropical livestock unit, and frequency of extension contacts, access to information, off-farm income, and perception of farmers toward high yielding wheat varieties attributes have more influence on the decision of adopting high yielding wheat varieties positively and significantly. On the other hand, variables like sex of household head and memberships organizations influence the decision to adopt high yielding wheat varieties significantly and negatively at 10 % significance level. Whereas deviated from most studies variables like educational level of household head, and access to institution (distance from market center, and distance to main road) did not have effects on adoption of high yielding wheat varieties.

5.2. Policy Implications

Based on results of descriptive statistics and econometric models, recommendations are suggested for future research, policy and development intervention activities to promote adoption of high yielding wheat varieties by smallholders. Therefore, the following recommendations were generalized based on results of this study:

Since land is a limiting factor of production in agriculture, farmers with more land are more likely to adopt and allocate a relatively higher share of their land for high yielding wheat varieties. Thus, adoption becomes more difficult in the farms with relatively small land size. However, increasing the size of landholding cannot be an option to increase high yielding wheat varieties adoption since land is a finite resource. Therefore, intervention aimed to improve land fertility status and increasing productivity of land through proper utilization of available land resource is required.

Livestock possession is also an important determinant of adoption of high yielding wheat varieties. Enhancing the livestock assets of the household as it provides manures for their farm, means of transportation of their produce to the market, and provide financial liquidity for the farmers at cash shortages necessary. Therefore, it is recommended that smallholder farmers need to be provided technical support especially medication services of animals and improving productivity of livestock for draught power. Therefore, research centers, agricultural development offices, and extension workers need to play more role on the livestock production, management, and diseases control through improving resistance of livestock and their nutritional supply.

Promoting and facilitating access to information is found to be one of the key area of intervention. Relevant and timely information should reach to the targeted farmers to achieve better adoption of high yielding wheat varieties. Hence, it is recommended that agricultural development offices and development endeavors should take measures on the access of overall agricultural information to the farmers mainly timely and relevant information is necessary.

Increasing frequency of extension contacts would enhance farmers' likelihood adoption decisions of high yielding wheat varieties. Accordingly, for the effectiveness of the agricultural extension services, an appropriate and effective frequency of extension contacts can encourage farmers to use high yielding wheat varieties. Thus, the researcher suggests that the development agents increase the frequency of extension contacts by identifying farmers' situation and problems that encourages the adoption of high yielding wheat varieties by smallholders. The agricultural development offices, and other stakeholders' have great role on the frequency of extension visits with farmers on agricultural technologies particularly high yielding wheat varieties.

Off-farm income activities are important through which rural households get additional income and exposure to informal ways of acquiring information. The income obtained from such activities helps farmers to purchase farm inputs including high yielding wheat varieties. Thus, it is recommended that encouraging households' participation on off-farming activities by creating favorable conditions and better opportunities for smallholders during their off-seasons to have some off-farm income source in addition to their regular farm activities.

Farmers have their own preference criteria for adoption among the available high yielding wheat varieties. The finding of this study suggested that farmers in the area seek specific varietal attributes, such as yield potential, tolerance to disease and lodging, better wheat grain price and short maturity period. Information about the benefits of high yielding wheat varieties should be given for smallholders by creating awareness about preferences and develop their attitudes towards high yielding wheat varieties. Therefore, the research centers and extension system has to give more attention to participatory research which considers farmers' priorities and needs.

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