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# Adoption of improved wheat varieties by smallholder farmers in Bale Zone, Ethiopia

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**Abstract**

Wheat is a strategic crop used for food security in Ethiopia. Cognizant of its importance, the Government of Ethiopia has been investing heavily in the development and dissemination of improved wheat varieties over the past 20 years. Despite such extensive intervention, farmers' adoption of improved wheat varieties is low, suggesting the country has not fully tapped the benefits of investment made on wheat technology generation and dissemination efforts. This study used cross-sectional data collected from a sample of 394 farm households selected through multistage random sampling procedures following probability proportional to sample size technique. Both qualitative and quantitative data obtained from primary and secondary sources were used. Based on the nature of the data, binary probit model was used to identify factors affecting the farmers' adoption decision of improved wheat varieties. The result of the study showed that from the total 394 sampled households, 45% (177) of them adopted the introduced improved wheat varieties. The probit model results showed that tropical livestock unit, frequency of advisory contacts, access to market information, farmers' perception of improved wheat variety attributes, and membership in a cooperative significantly influenced farmers' decisions in adopting the improved wheat varieties. Therefore, policy and development interventions should focus on improving such an economic and institutional support system to achieve wider acceptance of improved wheat varieties by smallholder farmers in the study area.

**Keywords:** Adoption, improved wheat varieties, binary probit model

## Introduction

Wheat (*Triticum aestivum* L) is one of the world's leading cereal grains and serves as a staple food for more than a third of the world's population. Wheat, which makes up one-fifth of the human diet, is the second most important source of calories in the diet of consumers in developing countries after rice (World Bank, 2015) [15]. Wheat is a particularly critical "stuff of life" for approximately 2.5 billion "wheat consuming" poor men, women and children who live on less than USD 2 per day. Ethiopia is the largest wheat producing country in Sub-Saharan Africa, by growing wheat on over 1.70 million hectares of land (ATA, 2017, FAOSTAT, 2018) [1, 8], which ranks it fourth in total land coverage after teff, Maize and Sorghum (CSA, 2017) [6]. To improve the production and productivity of smallholders, the Ethiopian government is doing its best by adding new technologies (improved wheat varieties) to existing technologies. Nevertheless, as expected, the introduced improved wheat varieties were not generally accepted in various parts of Ethiopia. In essence, the observed failure of farmers to adopt the improved wheat varieties and fully put it into practice could be attributed to several factors that appear to have some influence on farmers' decision to adopt the technologies, and further research on factors that hinder them is suggested (Biftu and Diriba, 2016; Hagos, 2016) [5, 9]. In addition, the decision to adopt improved wheat varieties by smallholder farmers is influenced by different factors in different areas. This suggests that to identify the influence of different factors on different areas, site- and crop-specific investigations should be done. Therefore, this study was carried out to identify the main factors influencing farmers' decision to adopt improved wheat varieties in the Zone.

## Research methodology

### Description of the study area

The study area, Gololcha district, is located 550 km southeast of the Ethiopian capital, Addis Ababa. The district's average annual temperature is 19 °C, while the district's average annual rainfall is 750 mm. The main crops grown in the district are cereals (wheat, barley, maize, teff, and other grains), legumes (beans, peas), and vegetables. Currently, all kebeles of the district produce wheat and it ranks first in terms of area coverage (41.24%) and total production (44.42%), followed by barley, maize, and teff.

### Sampling procedures

A multi-stage sampling process was used to draw respondents using a combination of purposive and simple random sampling. In the first phase, the Gololocha District was specifically selected as it is one of the potential wheat-producing districts in the Bale zone. In the second stage, out of 25 major wheat-producing rural villages in the district, a total of 12 most potential wheat-producing villages were identified. In the third stage, four rural villages were randomly selected from the 12 potentially wheat-producing villages and representative sample respondents were selected at random. The sample size for the study was determined based on Yamane (1967) [16], and is expressed as

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

Where N is the sample size for the study, N = total number

of wheat producers in the district (26837), and e is the level of precision (5%). Based on the formula, the total sample of the study was 394 farmers.

**Data collection**

For this study, both quantitative and qualitative data were collected from primary and secondary sources. The primary data sources were wheat producers, key informants, and focus group discussion; while the secondary data were collected from the Gololcha District Agriculture Office, published and unpublished documents such as Central Statistics Agency of Ethiopia (CSA).

**Data analysis**

In this study, the binary Probit model was used to analyze the likelihood of smallholder farmers' decision in adopting improved wheat varieties. The probit model is specified as:

$$Yi* = \beta X_i + \mu \quad (1)$$

$$Yi = Yi*, \text{if } Yi* > 0 \quad (2)$$

$$Yi = 0 \text{ otherwise}, \quad (3)$$

Where, $Yi^*$ and Yi is latent and observed level of participation in improved wheat production respectively, β is a vector of parameters to be estimated and $X_i$ is a vector of variables (demographic, socio economic, institutional and psychological factors) that affect households' adoption status of improved wheat varieties and μ is a vector of error terms.

**Variables definition, measurement and hypothesis**

**Dependent variables**

**Adoption decisions in improved wheat varieties**: It is dummy variable that takes value of 1 for adopter and 0 for non- adopter. Adoption of improved wheat varieties by households is the dependent variable. It refers to the model variable, which is adoption or non-adoption of improved wheat varieties.

**Explanatory variables**

The independent variables of the study were those which are hypothesized to have an association with farmers' decision in adoption of improved wheat varieties. The findings of past studies on adoption of improved agricultural technologies by smallholder farmers, the existing theoretical explanations and the researcher's preliminary knowledge of the farming systems of farmers in the study area were used to select explanatory variables for the hypotheses. Hence, the potential explanatory variables, which were hypothesized to influence farmers' decision in the adoption of improved wheat varieties, are presented. These include: demographic, socio-economic, institutional and psychological variables which are summarized in Table 1.

**Table 1:** Definition of explanatory variables and expected effect

| **Dependent variable** | **Dummy variable 1 for the adopters and 0 for non-adopters of improved wheat varieties.** | |
|---|---|---|
| **Variable Description** | **Variable Types and Measurement** | **Expected Sign** |
| Farming experience | Continuous, years of farming | +/- |
| Sex of household head | Dummy; male/female | + |
| Educational level | Continuous, years of schooling | + |
| Land holding size | Continuous, measured in hectares | + |
| Livestock holding size | Continuous, measured in TLU | + |
| Family size | Continuous, number | +/- |
| Access to credit | Dummy; yes/no | + |
| Frequency of extension contact | Continuous; days | + |
| Market distance | Continuous, kilometers | - |
| Perception on yield capacity | Dummy. yes/no | + |
| Membership to cooperative | Dummy; yes/no. | + |
| Access to market information | Dummy; yes/no | + |

**Source:** Authors definition, 2020.

**Results and Discussion**

**Descriptive results**

This section presents the demographic, socioeconomic, institutional and psychological characteristics of respondents in the study area. The characteristics of sample households were summarized under each sub section by descriptive (mean and percentage) and inferential statistics (chi-square and t-test).

For this study, the data were collected from both adopters 177 (45%) and non-adopters 217 (55%) of improved wheat varieties during the survey year. Out of the total respondents, 94.30% of them were male-headed households. The average farming experience of the sampled respondents was 20.03 years. The average household size of the sample farmers was 4.26 adult equivalents. The average year of formal education of the sampled respondent was 3.80 years (Table 2). In this study, the average land holding size of the respondents was found to be 3.67 ha. On average, the total sample households have about 6.91 tropical livestock unit. On average, the sampled households are at a distance of about 5.92 km from farmers' residence to the nearest market center. Among the interviewed farmers, 69.47% of them received credit. On average, they have made contact with extension agents specifically on wheat production issues 12.90 times per year and, 68.60% of them reported they had market information on wheat price from different sources. And also out of the total sample households, 65% of the sample respondents perceived that improved wheat varieties give higher yield advantage than local varieties.

**Table 2:** Descriptive results of sample households

| Variables | Adopters (n=177) | Non adopters (n=217) | Total (N=394) | t-/ χ2-value |
|---|---|---|---|---|
| Sex of household (male) | 94.26 | 94.33 | 94.30 | 0.732 |
| Farming experiences (years) | 20.33 | 19.79 | 20.03 | 1.163 |
| Family size (AE) | 4.17 | 4.35 | 4.26 | -0.180 |
| Educational level (years) | 4.34 | 3.36 | 3.80 | -1. 66* |
| Land holding size (ha) | 4.20 | 3.14 | 3.61 | 4.8*** |
| livestock holding size (TLU) | 8.39 | 5.42 | 6.75 | 6.01*** |
| Access to market information (%) | 87.36 | 53.22 | 68.60 | 13.622*** |
| Access to credit services (yes) | 83.10 | 58.30 | 69.47 | 12.26*** |
| Extension contact (days) | 16.48 | 9.97 | 12.90 | 3.63*** |
| Market distance (km) | 5.30 | 8.60 | 7.11 | 7.23*** |
| Membership to cooperative(yes) | 96.54 | 94.26 | 95.28 | 0.469 |
| Perception on yield advantage(yes) | 84.7 | 42.7 | 61.62 | 15.95*** |

**Determinants of adoption of improved wheat varieties among farmers**

Before running the model, outliers were checked using a box plot diagram so that no outlier problem occurred and no data were lost due to outliers. In addition, multicollinearity test showed that the largest VIFs value is 2.21 and that of CC is 0.5871, which is below the maximum value of 10 and 0.75, respectively. The chi-square distribution was used as a measure of the overall significance of probit model estimation. The specification of the model is important for estimating the determinants of adoption of improved wheat varieties. This means that the null hypothesis that all slope coefficients are zero does not apply with a statistical error of 1%. The results of the model presented in Table 3 show that of the twelve variables used in the study eight of them influenced the likelihood of the adoption of improved wheat varieties in the study area.

**Land size**

As expected, the estimates showed that land size had a positive influence on the probability of adoption of improved varieties at 5% significance level. With other variables constant, an increase in household land size by 1 ha would increase the likelihood of adoption of improved wheat varieties by 16.7%. The likely reason for this is that a farmer with a larger farm size harvests relatively more and therefore more money flows into the family. This result agrees with the results of Chilot and Dawit (2016) [7].

**Educational level**

As expected, the result showed a positive and significant influence of educational level of the household head on the acceptance of improved wheat varieties at a significant level of 5% (Table 3). Keeping other variables constant, the likelihood of improved wheat varieties being introduced would increase by 14.3% if farmers' formal education increases by 1 year. According to this, educated households accept inputs and apply them according to the recommendation. Hagos (2016) [9] and Mengistu *et al*. (2017) [13] found similar results in their studies.

**Livestock size**

Livestock are an important source of income, food, and traction for crop cultivation in general in Ethiopia and particularly in the study area. The model result showed a positive and significant influence of livestock on the adoption of improved wheat varieties at a significant level of 1% (Table 3). The results of the marginal effect analysis show that an increase in the unit of tropical livestock increased the adoption for improved wheat varieties by 17.7%; while the other factors remain constant. This is because farmers with relatively more livestock units use their income from the sale of livestock and their by-products to buy improved seeds and other inputs for growing wheat crops. The current study's finding is supported by Hassen *et al*. (2012) [11], Berihun *et al*. (2014) [4], Tolesa (2014) [17], as well as Leake and Adam (2015) [12].

**Access to credit**

As expected, access to credit showed a positive and significant influence of credit access on the adoption of improved wheat varieties by farmers at a significant level of 5% (Table 3). This variable accounts for 12.9% of the variation in the adoption of improved wheat varieties, while other factors remain constant. This may be because loans reduce a farmer's financial burden by enabling him to afford expensive improved cultural practices and technologies. Studies by Hassen (2014) [10] and Berihun *et al*. (2014) [4] found similar results.

**Frequency of extension contacts**

As was expected, the result showed that the frequency of contacts between farmers and extension workers positively and significantly influenced the acceptance of improved wheat varieties at a significant level of 1%. If other variables are held constant, the likelihood of adopting the improved wheat varieties increases by 24.4% for every additional day a farmer has been in contact with the extender. This is because the frequency of contact with extension agents increases the likelihood of getting updated information on improved wheat varieties. This result agrees with that of Teklemariam (2014) [14] and Mengistu *et al*. (2017) [13].

**Access to market information**

Access to market information from various sources on the prices of agricultural inputs and outputs, as expected, had positive influence on the decision of farmers to adopt improved wheat varieties at a significant level of 1% (Table 3). This variable explains a 16.6% variation in the adoption of improved wheat varieties, while other factors remain constant.

**Perception of the production capacity**

The farmers' perception of the production capacity of improved wheat varieties was positive and significantly influenced the decision to accept improved wheat varieties at 1% level of significance (Table 3). If other variables are held constant, a farmer who perceives improved wheat varieties to have higher yielding potential than the local ones would more likely increase adoption of the former varieties by 25.5%. The result of the focus group discussion also showed that farmers in the study area prefer wheat varieties which have high yield potential, tolerance to diseases, better wheat grain prices (color), and are of short duration.

**Membership in cooperatives**

The membership of farmers in organizations such as cooperatives, as hypothesized, positively influenced farmers' acceptance of improved wheat varieties at 1% significance level. When other variables are held constant, farmers membership in a cooperative increases the likelihood of adopting improved wheat varieties by 22.7% (Table 3). This result is in line with Aman and Tewodros (2016) [2] as well as Mengistu *et al*. (2017) [13].

**Table 3:** Estimated results of probit model likelihood of adoption of improved wheat varieties

| Variables | Coefficient | Robust. Std. Err | P>z | Marginal effects |
|---|---|---|---|---|
| Sex of household head (1=male) | 0.533* | 0.377 | 0.087 | 0.263 |
| Farming experience (year) | 0.008 | 0.015 | 0.136 | 0.007 |
| Educational level (year) | 0.275** | 0.136 | 0.028 | 0.143 |
| Distance to market center (km) | -0.0513 | 0.038 | 0.129 | -0.0201 |
| Family size (AE) | -0.0097 | 0.045 | 0.942 | -0.007 |
| Land holding size (ha) | 0.423** | 0.292 | 0.025 | 0.167 |
| Livestock holding size (tlu) | 0.193*** | 0.058 | 0.007 | 0.177 |
| Access to credit (1=yes) | 0.892** | 0.443 | 0.032 | 0.129 |
| Frequency of extension contact (day) | 0.622*** | 0.160 | 0.008 | 0.245 |
| Access to market information (1=yes) | 0.971*** | 0.321 | 0.004 | 0.166 |
| Perception on wheat variety (1=yes) | 1.438*** | 0.318 | 0.000 | 0.255 |
| Membership to cooperative (1=yes) | 1.146*** | 0.286 | 0.006 | 0.227 |
| Constant | -2.674*** | 0.832 | 0.005 | |
| Number of observation | 394 | | | |
| Wald $chi^2$ (12) | 53.15*** | | | |
| Prob> $chi^2$ | 0.0000 | | | |
| Pseudo $R^2$ | 0.3037 | | | |
| Log pseudo likelihood | -86.10 | | | |

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

**Source:** Own survey 2020**.**

**Conclusion**

This study was initiated to investigate and fill the information gap on the factors that influence the adoption of improved wheat varieties by smallholder farmers in Gololch District. Cross-sectional data were collected from a sample of 394 farmers selected through multi-stage sampling procedures. The results of the survey showed that 45% of the head of households in the sample accepted improved wheat varieties in the 2019/20 production year. The results of the probit model showed that factors such as households' head level of education, size of land holdings, and access to credit services positively and significantly influenced the smallholder farmers' decision to adopt improved wheat varieties at 5%. Further livestock ownership, frequency of advisory contacts, access to market information, farmers' perception of improved wheat variety attributes, and membership in a cooperative have more influence on farmers' decision to adopt improved wheat varieties positively. Therefore, policy and development interventions should focus on improving these variables to achieve wider acceptance of improved wheat varieties.

**Conflict of interest:** The authors have not declared any conflict of interest.

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