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IMPACTS OF ADOPTING IMPROVED WHEAT VARIETIES ON HOUSEHOLD FOOD SECURITY IN GIRAR JARSO DISTRICT, ETHIOPIA

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ABSTRACT

Research Background: Access and consumption of adequate food are essential components of development goals. Agriculture is expected to play an important role in ensuring food security by increasing the availability of food at the household level. Ethiopia is attempting to enhance agricultural production and productivity to combat food insecurity.
Purpose of the article: The purpose of this study was to assess the impact of adopting improved wheat varieties on food security in Girar Jarso Woreda, Oromia Region, Ethiopia.
Methods: First multistage sampling techniques were used to select a target sample of 192 households, 90 adopters, and 102 non-adopters. Three kebeles were selected at random from Girar Jarso Woreda based on wheat crop cultivation. Primary and secondary sources were used to acquire both qualitative and quantitative data. The data was gathered through a household survey, key informant interviews with sample farmers, focus group discussions, and a review of reports. The researchers utilized a logit model to identify factors influencing wheat variety adoption, and the Household Food Balance Model (HFBM) was utilized to calculate net available food at the household level. A Propensity Score Matching (PSM) technique is also employed to quantify the impact of improved wheat varieties on households' food security.
Findings, Value-added & Novelty: The findings demonstrated that education level, involvement in training, demonstration, and field day events, distance to market, access to market information, and farmer cooperative membership all had a substantial impact on the adoption of improved wheat varieties. Hidase, Digelu, Dandeha, and Kubsa were improved wheat varieties planted by adopters in the study region during the 2017/2018 crop year. Adopting improved wheat varieties has the potential to increase food availability at the household level, which is a good indicator of food security.

Keywords: impact; improved variety; grain crop; household food security
JEL Codes: R52; R58; H41

INTRODUCTION

Access and utilization of adequate food are an indispensable part of developmental goals **(Sachs, 2012**). Agriculture is anticipated to play a critical role in ensuring food security. Growth in agricultural production can minimize food insecurity by increasing the amount of food available for consumption at the household level **(Bogale, 2012).** Ethiopia is struggling to develop agricultural production and productivity to combat food insecurity.

Wheat is a basic food crop that is grown in both developed and developing countries and served as a source of food and cash. It has been the most grown cereal crop in the world, and the amount produced is more than that of other cereals, feeding around 40% of the world's population (**Acevedo *et al.*, 2018**). Wheat is an important cereal crop that helps to grow the agricultural sector in general and farm households' food security in particular **(Shiferaw *et al.*, 2013).** Ethiopia is a major wheat producer in terms of total wheat area grown and total production **(CSA, 2017).** Ethiopia's wheat production did not meet the national consumption, with the remaining obtained from imports **(Elias *et al.*, 2019).** This indicates that the country is still dependent on food imports, which requires high investment in the agriculture sector to close the demand gaps. Conducting extensive scientific studies can help to reduce the wheat yield imports. Cultivating local seeds with low disease resistance and low yield per unit area is common in rural areas. Crop disease has been restricted the potential wheat-producing regions, particularly Oromia regions of the country. Low adoption of improved varieties over time has been attributed to a range of circumstances that leads to low production that exposes an individual, household, community, and country to economic, psychological, and health-related stresses. As a result, food security and the adoption of improved varieties must be assessed concurrently.

The country has been focused on generating high-

yielding, disease-resistant, and stable varieties that can fulfill the food demand for the growing population. The research system has been working on varietal development and seed replacement. Currently, more than 74 wheat varieties have been introduced in Ethiopia to satisfy the growing production demands of the population (**Anteneh & Asrat, 2020**). Adoption of improved varieties can support the achievement of food security. Several studies suggest that better agricultural technology adoptions have a substantial positive influence on household food security **(Shiferaw *et al.*, 2014; Kassie *et al.*, 2014; Zewdie *et al.*, 2014)**. Improved technological adoption contributes significantly to food security by increasing yields and farm revenue **(Shiferaw *et al.*, 2014a; Khonje *et al.*, 2015)**. Disseminating productivity-enhancing agricultural technology is critical for fostering economic growth and alleviating food insecurity. Given this, the government of Ethiopia has been emphasizing the adoption of agricultural technologies to increase food security. Therefore, this study aims at assessing factors affecting the adoption of improved varieties. The study also evaluated the impact of improved wheat varieties adoption on the food security of farm households. It is expected that the findings will add to our understanding of food security and can also inform policy and action to address food insecurity.

LITERATURE REVIEW

Achieving food security is one of the priority issues in Ethiopia to sustain development efforts. Domestic food production has been below the requirements as a result of insufficient adoption of agricultural technology. There is a close relationship between food security and the adoption of agricultural technologies (**Spielman *et al.*, 2010)**. Generating and transfer of improved agricultural technologies in general and that of disease-resistant, and high-yielding wheat varieties is one of the pillars in the national food security strategy adopted by the Government of Ethiopia **(Shiferaw *et al.*, 2013).** Even though the Ethiopian government is struggling to implement agricultural technologies due to various factors, low-level adoption has been recorded.

Many factors influence the decision to utilize agricultural technology or practice. Farmers' decisions to adopt improved agricultural technologies are influenced by different socio-economic factors. Education, extension services, seed access, and field characteristics all play important roles in the adoption decisions of farmers **(Ghimire *et al.*, 2015).** Similarly, institutional factors such as government policy, prices, credit, input supply, land tenure, market, research, development, and extension activity have a role in farmers' decisions towards new agricultural technology. The adoption of improved agricultural technologies is affected by different institutional factors **(Suvedi *et al.*, 2017; Asfaw *et al.*, 2012; Abebaw & Haile, 2013; Abate *et al.*, 2016**). According to **Abate *et al.* (2016**), access to institutional finance has a considerable positive influence on both the uptake and extent of technology use. There are also environmental and market-related drivers for the adoption of agricultural technology. The adoption of agricultural technology is influenced by variables such as access to weather information, assets, and involvement in social organizations **(Wood *et al.*, 2014; Timu *et al.*, 2014; Lalani *et al.*, 2016).** Likewise, farmers' preference towards the technology influence the decision to use it **(Asrat *et al.*, 2010).** Many kinds of literature exist on determinants of adoption of improved agricultural technology by smallholder farmers in Ethiopia **(Abate *et al.*, 2016; Abro *et al.*, 2017; Abebaw & Haile, 2013; Abebe *et al.*, 2013)**.

There are also studies on assessing the impact of improved agricultural technologies on income and food security of households in Ethiopia **(Shiferaw *et al.*, 2014a; Asfaw *et al.*, 2012; Tesfaye & Tirivayi, 2018; Habtewold, 2018). Leake & Adam (2015),** the use of improved variety is considered as the most important input for the achievement of agricultural productivity and food security status of farm households in Ethiopia. While success stories about an extension of wheat technology in Girar JarsoWoreda are to be expected, no published study on the impact of adopting improved wheat varieties on household food security has been identified (to the best of the author's knowledge). So far, research on the study area that has been done by **(Seyoum, 2016; Abi *et al.*, 2020; Haile & Asfaw, 2018).** These investigations revealed the situation of poverty, income, and food security in Girar Jarso Woreda, but they did not go further to analyse the impacts of the adoption of agricultural technologies on food security.

DATA AND METHODS

The Study Area

The study was conducted on Girar Jarso *Woreda* in the North Shewa Zone of *Oromia* National Regional State of Ethiopia. Girar Jarso *Woreda is* located at a distance of 112 km from Addis Ababa, the capital city of Ethiopia, along the highway to Amhara National Regional State in the Northwestern direction. It shares borders with the Amhara Region in the North, Yaya Gullalle *Woreda* in the East, Debre Libanos *Woreda* in the South, and Degem *Woreda* in the West. Astronomically, the *Woreda* occupies $9^0$35'-$10^0$00'N latitude and $38^0$39'-$38^0$39'E longitude.

The *Woreda* has a total of 17 *Kebele*/peasant associations. The total population of the Woreda was 67,312 (34,467 males and 32,845 females). The total area cultivated was 21,401 hectares in the 2009E.C with an expected output of 599,454.6 quintals. Due to rusts, pests, climate change, and weed-related factors, the Woreda suffered 14 percent losses, with only 515,521.9 quintals of various crops were harvested. Aside from grain production, livestock husbandry is another source of income, with an estimated 108,972 cattle, 67,465 sheep, 23,929 goats, 3,611 horses, 589 mules, 26,331 donkeys, 115,447 chickens, and 3,067 traditional and contemporary beehives (report from WARDO, 2018).

Sampling

The probability sampling technique was employed to generate the desired sample size in the study area. A simplified formula provided by (**Yamane, 1967)** was used

to determine the sample size. The desired sample size was obtained based on a 93% confidence level, 0.5=degree of variability, and a 7% level of precision (Equation 1).

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

Where:
n the required sample size
N population size
e the level of precision

$$n = \frac{3334}{1 + 3334(0.07)2} = 192$$

The research was based on cross-sectional data on the 2017–2018 production year. A household cultivating a wheat crop at the kebele level is taken as the study's sample unit. The researchers followed three stages to select a sample of households. At stage one, a purposive selection of wheat crop-growing *kebeles* in the *Woreda.* In the meantime, the potential wheat production area was considered as a selection criterion. At a stage, two out of five identified wheat-growing *kebeles o*f the *Woreda,* households cultivating wheat with improved and traditional/local seeds were identified in partnership with kebele leaders and development agents. Finally, at the kebele level, a sample of households was selected at random with a probability proportionate to the size of the sample. Based on this, 90 adopters and 102 non-adopter farmers were selected randomly from the three kebeles with a probability proportional to the sample size.

Data Collection Techniques and Instrument

The research was based on a combination of quantitative and qualitative research design. Both primary and secondary data sources were utilized. The primary data gathering involves the incorporation of household survey focus group discussion and key informant interview. Similarly, an observation technique was also utilized to verify the data. Secondary data collection was also employed, such as reviews of reports, published and unpublished materials, relevant literature, and organizational reports. To ensure data quality, data collectors were well-trained, questionnaires were pretested, logistic regression and PSM measuring models were employed and calibrated. In addition, completed surveys were checked daily. The enumerators were assigned to Kebeles where they did not work to decrease data bias, and the researcher observed and supervised them regularly.

Method of Data Analysis

Data were analysed statistically by using SPSS version 21 and STATA version 13. A Logit model is used to investigate factors influencing the adoption of improved wheat varieties. The study utilized Household Food Balance Model (HFBM) to quantify available food at the household level. A Propensity Score Matching approach was also used to measure the influence of improved wheat varieties on food security.

Measurement of Food Security

The Household Food Balance Model, which was created from the FAO Regional Food Balance Model via a modified form of a simple equation by (**Tolossa, 1996)** was used to compute the amount of food available at the household level.

The HFBM was used to calculate the net available gr ain food for the sample households in Girar Jarso *Woreda.* All variables needed for the HFBM model were transformed from local grain measurement units to kilogram grain equivalents. To compare what is available (supply) with what is needed (i.e., demand) grain food **(FDRE, 1996),** 2,100-kilocalories per person per day was used as a measure of calories required (i.e., demand) to allow an adult to enjoy a healthy, moderately active life A comparison of calories available and calories needed by a household was used to estimate a household's food security status (Equation 2)

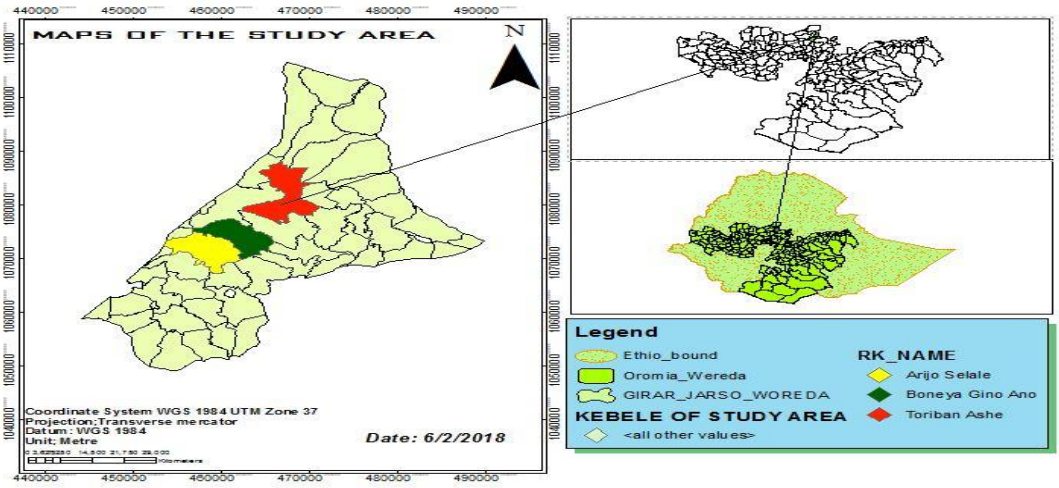

Figure 1: Map of the study area
Source: Ethio GIS (2007)

$$NGA_{ij} = \left(GP_{ij} + GB_{ij} + FA_{ij} + GG_{ij}\right) - (HL_{ij} + GU_{ij} + GS_{ij} + GV_{ij}) \quad (2)$$

Where:
NGA_{ij} Net grain available by i^{th} household in year j
GP_{ij} Total grain produced by i^{th} household in year j
GB_{ij} Total grain bought by i^{th} household in year j
FA_{ij} Quantity of food aid obtained by i^{th} household in year j
GG_{ij} Total Grain obtained through gift or remittance by i^{th} household in year j
HL_{ij} Post-harvest losses by i^{th} household in year j
GU_{ij} Quantity of grain reserved for seed by i^{th} household in year j
GS_{ij} Amount of grain sold by i^{th} household in year j
GV_{ij} Grain Given to others by i^{th} household in year j

Specification of the model

The study attempted to identify factors influencing the decision to use or not use improved wheat varieties by utilizing a logistic regression model. The factors were socioeconomic characteristics of households, agricultural extension service (training and extension contact), availability and accessibility of input, and market-related factors. If the response of the ith farmer to the question of adoption was denoted by a random variable Y_i and a corresponding probability (i.e., probability of adopting improved variety or not by P_i such that the probability of adoption $(Y_i = 1) = P_i$ and the probability of non-adoption $(Y_i - 0) = 1 - P_i$

The logistic model is specified by Equation (3).

$$Y_i = \beta_0 + \beta_i X_i + U_i \quad (3)$$

Where:
Y_i be a dichotomous outcome random variable with categories 1(adoption) and 0 (non–adoption);
X_i denotes the collection of P - predictor variables;
U_i Denotes to the error term, which has an independently distributed random variable with a mean of zero.
In the regression model, the dependent variable in this case adoption is taking the value 1 or 0. The use of LPM has a major problem in that the predicted value can fall outside the relevant range of 0 to probability value. Therefore, the model was estimated by using Maximum Likelihood Estimation (MLE). So, the logistic cumulative probability function for adopters is represented by Equation (4).

$$P_i = \frac{1}{1+e^{-Z_i}} = \frac{e^{Z_i}}{1+e^{Z_i}} \cdots \quad (4)$$

Where:
P_i is the probability that the i^{th} farmer adopted the improved wheat varieties and that P_i is Non-linearly related to Z_i ($i.e. X_i$ and β_s)
$Z_i = \beta_0 + \beta_1 X_1 + \cdots + \beta_n X_n$
e represents the base of natural logarithms.

Then, $(1 - P)$, the probability of non-adopter of improved wheat varieties is presented as Equation (5).

$$1 - P_i \frac{\mathbf{1}}{\mathbf{1+e^z}} \cdots \quad (5)$$

And then, by dividing Equation (4) by Equation (5), the odds ratio in favour of adopting the improved variety was obtained as Equation (6).

$$\frac{P_i}{1-P_i} = \frac{1+e^{Z_i}}{1+e^{-Z_i}} = e^{Z_i} \quad (6)$$

Then the dependent variable was transformed by taking the natural log of Equation (6) specified by Equation (7).

$$L_i = Ln\left(\frac{P_i}{1-P_i}\right) = Z_i = \beta_0 + \beta_1 X_1 + \cdots + \beta_n X_n + U_i \quad (7)$$

Where:
L_i is the log of the odds ratio, L is the logit;
Z_i in the stimulus index, where P_i ranges between 0 and 1.

Propensity Score Matching

Propensity Score Matching estimates the average impact of the adoption of improved wheat varieties on adopters by constructing a statistical comparison group based on the probability of adopting in the treatment T conditional on observed characteristics X, given by the propensity score (**Rosenbaum & Rubin, 1983)**.

$$P(\chi_i) = Pr\,(T_i = 1 \perp X) \quad (8)$$

Where:
Y_i^1 the outcome of unit i if i were exposed to the treatment
Y_i^0 the outcome of unit i if i were not exposed to the treatment
$T_i \in \{0,1\}$ indicator of the treatment actually received by unit i
$Y_i = Y_i^0 + T_i\,(Y_i^1 - Y_i^0)$ the actually observed outcome of unit i and
X multidimensional vector of pre-determined characteristics or covariates (**Rosenbaum & Rubin, 1983)**. As a result, if the population of units denoted by i and the propensity score $P(X_i)$ is identified, the average effect of Treatment on the Treated (ATT)can be estimated as Equation (9).

$$T = E\,\{Y_i^1 - Y_i^0 \,|\, T_i = 1 = E\,\{E\,\{Y_i^0 - Y_i^0 \,|\, T_i = 1, p\,(X_i)\}\} = E\,\{E\,\{Y_i^1 | T_i = 1, p\,(X_i)\} - E\,\{Y_i^0 | T_i = 0, p\,(X_i)\}\,|T_i = 1\} \quad (9)$$

Where the external expectation is over the distribution of $(p\,(X_i)|T_i = 1)$, Y_i^1 is the potential outcome of the treatment, and Y_i^0 is an outcome of the control. Following (**Rosenbaum & Rubin, 1983**)the matching algorithms work with the following two strong assumptions: The first one is conditional independence /un-confoundedness assumption: this presumes that given a set of observable

covariates X which are not affected by treatment, the potential outcomes are independent of treatment assignment: un-confoundedness, is that after controlling for covariates (X), mean outcomes of non-treated will be identical to outcomes of the treated if they had not received the program (**Rosenbaum & Rubin, 1983)**.

$$Y_i^1, Y_i^0 \perp T_i, X_i \quad (10)$$

This implies that selection is only based on observable characteristics and that all variables that influence treatment assignment and potential outcomes simultaneously are observed by the researcher (**Caliendo & Kopeinig, 2005**). (**Caliendo & Kopeinig, 2005)**, further suggested that if the balancing hypothesis of un-confoundedness is satisfied, observations with the same propensity score must have the same distribution of observable (and unobservable) characteristics independently of treatment status. In other words, for a given propensity score, exposure to treatment is random, and therefore treated and control units should be, on average, observationally identical.

In this case, the treatment effects can be estimated by Equation (11).

$$\beta = E(Y_i^1 \mid X_i, T_i = 1) - E(Y_i^0 \mid X_i, T_i = 0) = E(Y_i^1 - Y_i^0 \mid X_i, T_i = 1) + E(Y_i^0 \mid X_i, T_i = 1) - E(Y_i^0 \mid X_i, T_i = 0) = Y_i^1 - Y_i^0 \mid X_i, T_i = 1) \quad = E(Y_i^1 - Y_i^0 \mid X_i) \quad (11)$$

Thus, because of conditional independence the selection effect=0, since

$$E(Y_i^0 \mid X_i, T_i) = E(Y_i^0 \mid X_i)$$
$$ATE = ATET \quad (12)$$

The second assumption is the common support assumption additional criterion besides independence is the satisfaction of overlap condition. It works with the trend of perfect predictability of D given X (Equation 13).

$$(\text{Overlap}) \quad 0 < P(T = 1 \mid X) < 1 \quad (13)$$

It makes sure that individuals with the same X values have a positive probability of being both participants and non-participants (**Heckman & Smith, 1999**). Treatment units would therefore have to be similar to non-treatment units in terms of observed characteristics unaffected by the treatment; thus, persons that fall outside the region of the common support area would be dropped.

Estimation Strategy

If conditional independence assumption is satisfied and there is sufficient overlap between the two groups which is called 'strong ignorability assumption'. According to **Rosenbaum & Rubin (1983),** the PSM estimator for *ATT* can be written in general as Equation (14).

$$ATT = E\,p(x) \mid T = 1\{E[Y(1) \mid T = 1, P(X)] - \{E[Y(0) \mid T = 0, P(X)]\} \quad (14)$$

The Propensity Score Matching estimator is simply the mean difference in outcomes more than the common support, properly weighted by the propensity score distribution of adopters.

The dependent variable: is the adoption decision of improved wheat varieties. The variable takes the value of 1 for the household that cultivated improved wheat varieties during the 2017/2018 production year and 0 for the household that did not cultivate improved wheat varieties. Independent variable: Based on past research findings on the adoption of agricultural technology, major variables expected to influence the adoption of improved wheat varieties were selected. It is categorized under Household socio-economic characteristics, institutional and market-related factors. Farmers' adoption decisions were influenced by socioeconomic traits, institutional factors, and market-related factors **(Leake & Adam, 2015; Shiferaw *et al.*, 2014; Abebe *et al.*, 2016).**

RESULTS AND DISCUSSION

Socio-Economic Characteristics of Adopter and Non-Adopter of households

According to the findings (Table 1), 79 percent of respondents were male-headed, while 21 percent were female-headed households. 74% of adopters were male-headed households, whereas 26% were female-headed households. Non-adopter farmers were 83 percent male-headed and 17 percent of female-headed households. The Chi2-test showed that this association was not significant. The marital status of the household head revealed that 87 % of respondents were married. Disaggregated data among married farmers, 92 percent were adopters and 82 percent were non-adopters. Divorced farmers make up 6% of the sample of households, of which 2% were adopters and 9% were non-adopters. The Chi2-test indicated that the relationship was statistically significant at the 10% level.

Education can improve the use of agricultural technology. In terms of educational attainment, 34% of respondents were illiterate. The percentage differs greatly between adopters and non-adopters which is 23% of adopters and 44% of non-adopters were illiterate respectively. Non-formal education was scored by 46 percent of the total sample, with 46 percent adopters and 46 percent non-adopters. 20% percent of the total sample had primary education, with 31 percent adopters and 10 percent non-adopters. The Chi2-test showed that the relationship was significant at a 1% level. The result of the focus group discussion also revealed that adult education provided at farmer training centers by extension workers helps farmers to improve their capacity to read and write. Farmers' use of technology can be increased by educational attainment.

Farmers in the study area have been engaged in agricultural activities like crop cultivation, animal husbandry, and non-farm activities. Crop production is the primary source of income in the research area. Farming was a key occupation for the vast majority of the respondents. According to the findings, 82 percent of adopters and 81 percent of non-adopters engaged in agricultural activities. 18% of adopters and 18% of non-

adopters engaged in both farm and non-farm activities. The Chi2-test showed that this association was not significant.

Age is an essential demographic attribute of the household head in deciding whether to use improved wheat varieties or not. The result in (Table 2) shows Adopters were on average 45 years old, whereas non-adopters were 46 years old. The t-test results show, there is no statistically significant difference in household age between adopters and non-adopters. The size of a farm also affects a household's choice of crops and improved agricultural technologies. The results showed that adopters had a larger average land size of 2.19 hectares compared to non-adopters, who had a mean of 1.9 hectares. The t-test result indicated that there is a 5% significant difference in total landholding between adopters and non-adopters. The total land size computed includes rented in, rented out the land, and sharecropping land. The larger land size of adopters is due to rent inland. The results from the focus group discussion also revealed that farmers who rented inland work more aggressively using agricultural inputs than those who never rented.

The mean household size of adopters and non-adopters is 6. In rural households, the higher number of households (working group) can contribute to the decision to adopt improved wheat varieties. The study area was also characterized by livestock rearing activities that include cattle, sheep, goats, pack animals, and poultry. The result of the study showed that non-adopters and adopters were found to own 7.88 and 8.26 of the Tropical Livestock Unit (TLU), respectively. The difference in livestock ownership among non-adopters and adopters was not statistically significant. This implies that having livestock is not correlated with adopting improved wheat varieties. This study is not in line with the study by Alemaw, 2014, which found a significant correlation between livestock ownership and the decision to adopt improved maize varieties in the Oromia region, Ethiopia.

Income from farms indicated that non-adopters had a lower mean farm income of Ethiopian Birr 17,479 compared to adopters, which is 37,321 Birr per season. The t-test result indicated there is a difference between adopters and non-adopters in terms of income from farm activities at a 1% significance level. At the same time, adopters had slightly more non-farm income at Ethiopian Birr 2,569 per season than the non-adopters, who had a mean of Ethiopic Birr 1,607 per season. The t-test result indicated there is a difference between adopters and non-adopters in terms of income from non-farm activities at a 1% significance level. The mean years of wheat farming experience of both adopters and non-adopters were 17 years. The t-test result also shows there is no difference between adopters and non-adopters in terms of wheat farming experience.

Institutional Characteristics of Rural Households

This study also tried to assess the awareness of respondents about agricultural extension services, particularly whether they possessed the required information and whether they needed the service (Table 3). The result on contact with extension agents indicated that 87% of adopters and 54% of non-adopters had contact with an extension agent. The Chi^2-test confirmed that the association in terms of contact with the extension agent was significant at a 1% level. Farmers' understanding of agricultural technology has increased as a result of the efforts of governmental, non-governmental, and social media organizations.

Field day and demonstration events were attended by 78 percent of adopters and 22 percent of non-adopters. Farmers were more interested in learning from field day activities than from regular meetings, implying that they were more interested in learning from field day activities. The Chi^2-test indicated that there is a significant association between adopters and non-adopters at a 1% significant level. In terms of training, the descriptive analysis revealed that 81 percent of adopters and 50 percent of non-adopters had attended the training. The more farmers that are trained, the more likely decide to use technology. The Chi^2-test confirmed that the association was significant at a 1% level. Farmers that are members of a farmer's cooperative profit the most. Farmers' cooperatives were represented by 68 percent of adopters and 20% of non-adopters. The results from the focus group discussion also revealed that farmers who were members of farmer cooperatives could access input technology more easily than non-members, and hence this could maximize the opportunities to use technology. The Chi^2-test showed that the association between adopters and non-adopters in terms of being a member of a farmer's cooperative was significant at a 1% level.

Concerning access to credit, both adopters and non-adopters had limited access to credit services. The result indicated that 7% of adopters and 10% of non-adopters had access to credit. Even though access to credit allows households to bridge budget gaps, both adopters and non-adopters in this research had limited credit service. The result from the focus group discussion also revealed that farmers did not take credit because they were afraid of payback. The Chi^2-test also indicates that there is no significant association between adopters and non-adopters in terms of access to credit. Creating a conducive environment for farmers in terms of infrastructure has played an important role in adopting technology. The more farmers have road access, the more they can easily access inputs. They may also offer their products on the market easily. The result indicated that 66% of adopters and 51% of non-adopters had access to vehicle roads. The Chi^2-test reveals that these associations were significant.

Market-Related factors

Distance to the market result shows that the adopters an average of 12 kilometers, whereas the non-adopters are expected an average of 10 kilometers at a significant level of association. The decision to use improved wheat varieties might be influenced by distance from the market. The cost of transportation is directly related to the distance to the market. A result of the key informant interview at Ilamu Kebele indicated that farmers paid 20 Ethiopian Birr/quintal for transport costs. This result is in line with the study by **Shiferaw *et al.* (2014b),** who found proxy distance to the output markets was positively correlated with improved varieties' adoption. The result of the price of wheat shows that adopters sell their product at a higher

price of 1,231 Ethiopian Birr per quintal, while non-adopters sell at 1,154 Ethiopian Birr per quintal. This result confirmed that there is a difference between adopters and non-adopters selling the price of wheat grain at a 1 % significance level (Table 4). As stated in subsection three of this paper, a farmer's decision to adopt improved varieties is based on utilizing maximum utility. Therefore, we can deduce that the high price of wheat grain from improved seed is what triggers farmers' decision to use improved wheat varieties.

Table 1: Household characteristics of the adopter and non-adopters (dummy variable)

Variable		Adopters		Non-adopters		Full sample		
	Category	Fre	%	Fre	%	Fre	%	Chi^2-test
Sex	Male	67	74.4	85	83.3	152	79.1	0.13
	Female	23	25.5	17	16.6	40	20.8	
Marital status	Married	83	92.22	84	82.35	167	87	0.087**
	Divorced	2	2.22	9	8.8	11	5.73	
	Widowed	5	5.56	9	8.82	14	7.29	
Educational status	Illiterate	21	23.3	45	44.2	66	34.38	0.000*
	Non-formal education	41	45.56	47	46.08	88	45.83	
	Formal education	28	31.11	10	9.80	38	19.79	
Occupation	Only own farming	74	82.2	83	81.4	157	81.8	0.642
	Farm and non-farm activities	16	17.8	18	17.6	34	17.7	

Note * and ** =significant at 1%and 10% respectively
Source: Field survey, 2018

Table 2: Household characteristics on continuous variables

Variables	Non –adopters		Adopters		
	Mean	SD	Mean	SD	t-test
Age (in years)	46	9	45	9	0.253
Total Land	1.779	.860	2.031	0.687	0.026**
Number of households	6	2	6	2	0.510
Farming experience	17	7	17	7	0.930
Livestock holding(TLU)	7.88	4.22	8.26	3.25	0.490
Income from farm per year	17479.53	13935.06	37321.88	24934.28	0.000*
Income from non –farm per year	1607.45	1281.49	2569.24	1716.46	0.000*

Note: * and ** =significant at 1%and 5% respectively
Source: Field Survey,2018

Table 3: Institutional Characteristics of the adopter and non-adopters

Variables		Adopters		Non-adopters		Chi^2–test
		Frequency	%	Frequency	%	
Contact with extension agent	Yes	78	86.6	55	53.9	0.000*
	No	12	13.3	47	46.08	
Participated in demonstration	Yes	70	77.7	22	21.5	0.000*
	No	20	22.2	80	78.4	
Attend in training	Yes	82	91.1	51	50.0	0.000*
	No	8	8.8	51	50.0	
Member of farmers	Yes	61	97.7	20	19.6	0.000*
	No	29	32.2	82	80.3	
Access to credit	Yes	6	6.6	10	9.8	0.433
	No	84	93.3	92	90.2	
Vehicle road access	Yes	59	65.5	52	50.9	0.041
	No	31	34.4	50	49.2	

Note * significant at 1%.
Source Field Survey, 2018

Table 4: Market-related factors among adopter and non-adopters

Variables	Non- adopters		Adopters	
	Mean	SD	Mean	t-test
Distance to the market	11	4	12	0.11
Price of wheat grain	1154	86	1231	0.00*

Note * and **=significant at 1%
Source: Field Survey, 2018

Access to market information plays an important role in the adoption of agricultural technologies. The result in (Table 5), indicates 62% of adopters and 52% of non-adopters had access to market information. The Chi^2-test result showed that there is no significant association between adopters and non-adopters in terms of access to market information.

Factors Affecting Adoption of Improved Wheat Varieties

A logit model is estimated to determine the factors influencing the adoption of the improved wheat varieties. Adoption of improved variety was affected by the technology's maximum utility **(Hagos, 2016; Asfaw *et al*., 2012)**. According to **Asfaw *et al.* (2012**), adopting improved varieties increased the chance of food security and had a beneficial influence on the cash wages of adopting families. **Leake & Adam (2015**), also found that the utilization of improved varieties is the most significant input for farm households in Ethiopia to attain agricultural production and food security. **Hagos (2016)** found, that 80 percent of farmers expressed a readiness to plant improved wheat varieties maximum utility. Based on this, a model containing 12 selected predictor interaction terms was included in the multivariate analysis. Using the stepwise (likelihood ratio) method, four of the twelve predictor variables (education status, participation in training, demonstrations, and field days, distance to the market, and member of a farmer's cooperative) have a significant joint impact on determining household adoption of improved wheat varieties. The overall model is proven, as it is statically significant at a p-value of 0.000. The pseudo-R-squared is found at about 0.3759, meaning all the explanatory variables included in the model explain 37% of the probability of a household's adoption of improved wheat varieties. The $LRCh^2$ (12) 99.77 with a P-value (Prob > ch2) 0.000 also tells us the logit model as a whole is statically significant. The signs of the regression coefficients of the model (Table:6) fulfil the underlying assumption and the corresponding p-values imply that the predictor variables included in the multivariate model have a significant joint influence on the outcome variable. The estimation variance inflation factor was done to test whether multi-collinearity problems exist or not. There was no explanatory variable dropped from the estimation model since no series problem of multi-collinearity was detected from the VIF results which are very far less than 10 and again those of the tolerance level (1/VIF) were greater than 0.2 which further revealed no problem of multicollinearity.

The marginal effect results provided in Table 6 show that keeping other factors constant, an increase in the level of education of a household by one year increases the probability of adopting improved wheat varieties by 0.23 (23%). Again, it is statically significant at a 5% significance level. The education status of a farmer had a positive and significant influence on the adoption of improved wheat varieties. Results from focus group discussion also revealed that better education attainment of farmers could increase the adoption of improved wheat varieties. This finding has conformity with other studies that found, the educational level of the household head can have a significant and positive effect on the adoption decision **(Asfaw *et al.*, 2012; Shiferaw *et al*., 2014; Leake & Adam, 2015)**. **Leake & Adam (2015)**, found that using the marginal effect increases the level of education by one year increases the level of adoption by 0.049 among the adopters.

From the analysis of marginal effects, households who participated in the training, demonstration, and field day practices were 56% more likely to adopt improved wheat varieties relative to those who did not participate. It is statically significant at a 1% significance level. Farmers are more interested in learning from other farmers' life experiences than they do in regular training. The result of the focus group discussion revealed that farmers learn more on-field days because the farmers share the life path of their farming experience at each step, so attending field days is positively and significantly related to the adoption of improved wheat varieties. The result is consistent with other studies that suggest participation in training and field days is one of the means of the teaching and learning process of improved technologies **(Bola *et al.*, 2014; Wondale *et al.*, 2016; Suvedi *et al.*, 2017; Davis *et al*., 2012).** Field days provide an opportunity for the farmers to observe how the new technology is practiced in the field. **Wondale *et al.* (2016)**, found the same result by using the logit model, in that attributes other being kept constant, the odds-ratio in favour of adopting improved varieties increases by a factor of 1.719 as a farmer ''engagement in field days'' increases by one unit. The study indicated that demonstration and dissemination of information through field day and demonstration activities might facilitate the adoption of improved wheat varieties.

Being a member of the farmer's cooperative of the household head was found to have a positive significant influence on the adoption of the improved wheat varieties. The result shows a one-unit increase in household participation as members of a farmers' cooperative. The probability of adopting improved wheat varieties increases by a factor of 0.43. It is statically significant at a 5% probability level of significance. This might be farmers' engagement in farmer cooperatives would improve the use of improved wheat varieties. The result is consistent with **(Wossen *et al.*, 2017; Awotide *et al.*, 2016; Ma & Abdulai, 2016; Khonje *et al.*, 2015)**. The result also shows that as the distance to the market becomes proximate, adoption of improved wheat varieties increases by 0.04 and it is statically significant at a 5% probability level of significance. This implies farmers near the main road can get transportation facilities easily and at a lower cost than those farmers who are far from the main road to put wheat grain on the market. This implies that access to market information about the demand and supply of wheat grain and its products highly motivates farmers to cultivate improved wheat varieties**.** The result is consistent with **(Abate *et al.*, 2016; Khonje *et al.*, 2015).**

Two sample T-test on outcome Variable before matching

The study employed a two-sample t-test to check whether the adoption of improved wheat varieties has a significant impact on household food security. The mean value of food availability for the treated group is 1728 and the control group is 889 cal per day (Table 7). This indicates the treated group is higher by 839 cal per day compared to

the control group. The difference is significant at the 1% critical level.

Estimation of the Impact of Adoption of Improved Wheat Varieties on Food Security

This section describes the whole process of arriving at the impact of the adoption of improved wheat varieties on food security. The researcher estimated improved wheat varieties' production effect on food security based on the cross-sectional data available. To determine the impact of improved wheat varieties on food security, and to obtain the impact of improved wheat varieties on food security The Propensity Score Matching method was performed by using STATA Version 13. The main purpose in using Propensity Score Matching was to identify the Average Treatment Effect on the Treated (ATT). In the estimation data from the two groups, namely, adopters of improved wheat varieties and non-adopters of improved wheat varieties, households were grouped on the dependent variable that takes a value of 1 if the household cultivated improved wheat seed, otherwise 0.

Matching Adopter and Non-Adopter Households

Four main tasks should be completed before presenting the matching task. First, predicted values of adoption decisions (propensity scores) should be estimated for all households of adopters and non-adopters. It is to predict the propensity score of characteristics that are not affected by the treatment variable. Secondly, a common support condition should be imposed on the propensity score distributions of adopters and non-adopter households. The common support region is the area in which the maximum and minimum propensity scores of adopters and non-adopters are included. Thirdly, discarding observations whose predicted propensity scores fall outside the range of the common support region. After this, the identification of an appropriate matching estimator was done. Finally, a check of the balancing test is done to see whether the matching quality was satisfied or not.

Defining the common support region

From the total treated observations, 8 households (8.6%) are off support, while 82 households (91.3%) are on support, and all the control households are included in the common support region (Table 8).

Each treated unit is matched only with the control units whose propensity scores fall into a predefined common support region of the propensity score matching, which is [0.04585088, 0.90580642]. The ATT result shows that adopters of improved wheat varieties had an average availability of food of 856.715097kcal, which is 49% higher than the non-adopters of improved wheat varieties, which is significant at a 1% level (Table 9).

The result on (Table 10), shows the ps- test of all explanatory variables. A low R^2 value means that program households do not have many distinct characteristics overall, and as such, finding a good match between adopters and non-adopter households becomes easier. Also, the pseudo-R2 indicates how well the regressors explain the participation probability. After matching, there should be no systematic differences in the distribution of covariates between both groups, and therefore, the pseudo-R^2 should be fairly low **(Caliendo & Kopeinig, 2005**).

The ATT result is confirmed through checking the balancing "ps-test," which helps us to know how much bias was reduced. From the result, the p-pseudo R^2 is minimized to 0.030 after matching, and the mean bias is also minimized to 7.9, which indicates the matching was good (Table 11).

As shown in Figure 2, treated on support indicates, the farmers in the adoption group who found a suitable match, whereas untreated indicates non-adopters, and treated off support indicates the individuals in the adoption group who did not find a suitable match. The balancing procedure tests whether adopters and non-adopters have the same distribution of propensity scores, and if not, they need a check-up. When the balancing test failed, the researcher tried alternative specifications of the logit model as suggested by (**Khandker *et al.*, 2010)**. Therefore, in this study, a complete and robust specification that satisfied the balancing tests was carried out.

Matching adopters and non-adopters

To estimate the average treatment effect of the adoption of improved wheat varieties on food security, we have used different matching algorithms. These are nearest-neighbour matching, radius matching, kernel matching, and stratification matching **(Khandker *et al.*, 2010)**. Across all NNM, RM, KM, and SM matching methods, adopters have higher calories per day than non-adopters at a 1% significant level (Table 12). However, the researcher selects the radius and stratification matching methods based on large sample size for the control group and a significant t-Value. So, on average, treatment effects on the treated range from 826.140 cal per day, radius matching method, to 869.932 cal per day, stratification matching method, at a 1% significant level.

Table 5: Access to Market Information

Variables		Non-adopters		Adopters		
		Frequency	%	Frequency	%	Chi^2-test
Access to Market Information	Yes	53		52	52	570.419
	No	49		48	38	43

Source: Field survey, 2018

Table 6: Adoption decision of farmers on improved wheat varieties

Variables	dy/dx	Std. Err.	Z	P>|Z|
Sex	0.1973	0.1272	1.55	0.121
Age of HH head	-0.0001	0.00621	-0.03	0.977
Educational Status	0.2344	0.08124	2.89	0.004**
Total land holding	0.0634	0.0641	0.99	0.322
Household size	-0.0212	0.0341	-0.62	0.534
Contact with extension agent	-0.0713	0.14341	0.50	-0.619
Participation in training and demonstration	0.5683	0.14236	3.99	0.000*
Member of farmer cooperative	0.4367	0.11062	3.95	0.000*
Access to credit	0.1220	0.2176	0.56	0.575
Distance to nearest market	0.0417	0.1218	3.34	0.001**
Vehicle road access	0.0003	0.11598	0.00	0.998
Market information access	0.1246	0.11708	1.06	0.287

Number of obs = 192; LR chi2(12) = 99.77; Prob > chi2 = 0.0000;
Log likelihood = -82.825805; Pseudo R2 = 0.3759
Note: that * and ** are statically significant at 1 and 5 %respectively.
Source: Field Survey, 2018

Table 7: Two-sample T-test on cal per day before matching

Variable	Groups	Obs	Mean	Std. err	Std. dev	T-test
Cal per day	Treated	90	1728.621	97.21	922.247	0.000*
	Control	102	889.0735	35.991	363.4922	
	Mean difference		839.5477	99.00381		

Source: Field survey, 2018

Table 8: Common support region

Psmatch2 treatment assignment	Off support	On support	Total
Untreated	0	102	102
Treated	8	82	90
Total	8	184	192

Source: Field Survey, 2018

Table 9: ATT with common support range

Variable sample	Treated	Controls	Difference	S.E	T-stat
Cal-per day unmatched	1728.62117	889.07349	839.54767	99.003805	8.48
ATT	1748.22602	891.510923	856.715097	164.179908	5.22

Source: Field Survey, 2018

Table 10: Ps- test of independant variables after macthing

Variable	Mean			t-test		V(T)/
	Treated	Control	%bias	T	p>|t |	V(C)
Sex	1.2317	1.2317	0.0	0.00	1.000	1.00
Age	44.707	45.915	-14.0	-0.88	0.381	1.01
Educational status	2.0244	1.9756	7.0	0.42	0.672	1.00
Total Land	2.1771	2.2195	-5.4	-.034	0.736	0.72
Family size	6.2805	6.4146	-8.4	-0.57	0.570	3.19*
Contact with agent	1.1341	1.1098	5.6	0.47	0.636	1.19
Access to training	1.0976	1.0854	3.0	0.27	0.788	1.13
Member of farmer cooperative	1.3415	1.3659	-5.6	-0.32	0.746	0.97
Distance to the nearest market	1.939	1.9634	-8.8	-0.72	0.471	1.62*
Access to credit	11.707	12.923	-12.5	-1.01	0.315	2.58*
Vehicle road access	1.3537	1.4634	-22.4	-1.43	0.155	0.92
Access to information	1.3659	1.3537	2.5	0.16	0.872	1.01

* if variance ratio outside [0.64; 1.55]
* if B>25%, R outside [0.5; 2]
Source field survey, 2018

Table 11: Mean bias Reduction after matching

Ps R^2	LR chi^2	$P>chi^2$	MeanBias	MedBias	B	R	%Var
0.030	6.76	0.873	7.9	6.3	40.8	1.16	25

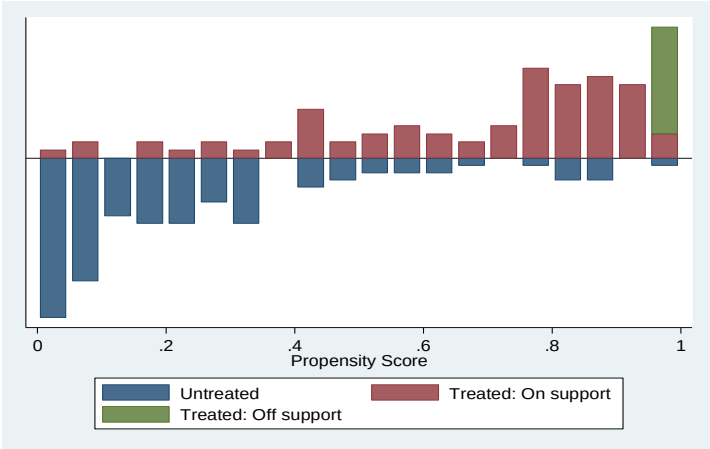

Figure 2: Histogram of propensity scores

Table 12: Average Treatment effect on the treated by the different matching algorithm

Matching	Number of treatment	Number of control	ATT	Std.Err	t-value
NNM	90	28	813.072	172.604	4.711
RM	90	81	826.140	100.400	8.228
KM	90	81	843.563		
SM	90	81	869.932	139.916	6.308

Source field survey, 2018

The result of the average treatment effect on the treated through radius and stratification matching methods indicates that the adoption of improved wheat varieties has brought a significant impact on adopters' household food security status. The Average Treatment Effect on the Treated (ATT) revealed that increment comes from the adopters' availability of food at the household level, which is a good indicator of a household's food security. This finding is consistent with (**Shiferaw *et al.*, 2014). Shiferaw *et al.*(2014a)**, found the same result by using both the Endogenous Switching Regression Model and the Propensity Score Matching method. The actual effect of adopters' experiences through adopting improved wheat varieties was Ethiopian Birr 976 of food consumption expenditure and a 2.7% binary food security outcome in Ethiopia. Likewise, the study is in line with studies **(Ahmed *et al.*, 2017; Khonje *et al.*, 2015; Kassie *et al.*, 2014b; Bezu *et al.*, 2014b). Kassie *et al.* (2014),** found that a one-acre increase in the level of maize adoption on average increased the probability of food security and per capita consumption in Tanzania. **Khonje *et al.* (2015),** also found that using both propensity score matching and endogenous switching regression models, adopting improved maize varieties results in considerable benefits in crop revenue, consumer spending, and food security.

CONCLUSIONS AND RECCOMENDATIONS

This study assessed the impact of adopting improved wheat varieties on food security among wheat farming households in Girar Jarso *Woreda*, Oromia region. From the study, it is possible to understand that adoption of improved wheat varieties is affected by different factors. Participating in training, field days or demonstration activities, educational status of the household head, and gender of the household head have positively contributed to the decision to adopt improved wheat varieties. In contrast, distance to the market and members of farmer cooperatives negatively affects the adoption of improved wheat varieties. This finding implies that creating a conducive production environment for farmers plays a vital role in the adoption of agricultural technologies.

The overall results are remarkably robust and the analysis supports the robustness of the matching estimator. From the findings, adopters of improved wheat varieties are significantly better than the non-adopters in terms of food availability at the household level, which is a good indicator of food security. From the findings of the study, it is possible to conclude that households who participate in training and field day, who have more access to market information, who have better educational status, and who have a shorter distance to the market tend to adopt improved wheat varieties. Similarly, it was found that households who could use the technology would improve the status of food availability and consumption. Overall, the adoption of improved wheat varieties significantly has a positive effect on the food security of rural households. The findings of the study are consistent with other study findings on the impact of technology adoption on food security **(Shiferaw *et al.*, 2014; Khonje *et al.*, 2015)**.

The results of the study give important evidence on the impact of agricultural technology adoption on improving food security in Girar Jarso*Woreda*, so governmental and non-governmental organizations in the study area should give due attention to the adoption of

improved varieties to minimize the problem of food insecurity in the study area. Policy support, such as increasing market access and arranging field day programs to disseminate knowledge and information would aid in the adoption of improved wheat varieties. The government of Ethiopia should emphasize increasing access to and use of new wheat types to increase food security.

Future analysis using panel data may be needed to examine the relationship between the adoption of improved wheat varieties and food security, to control for unobserved specific heterogeneity, to provide more robust evidence on the implication of the adoption of improved wheat varieties for food security, and to see whether the result persists over time.

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