Factors influencing Adoption of improved bread wheat technologies: a double hurdle approach in Northern Ethiopia

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Factors influencing Adoption of improved bread wheat technologies: a double hurdle approach in Northern Ethiopia

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Abstract

This study was conducted in Meket District, Amhara National Regional State, in northern Ethiopia. Cross-sectional data collected from 214 randomly selected farm households via a structured interview protocol was used for the study. Double-hurdle model was to identify factors affecting the probability of adoption and intensity of use of improved bread wheat varieties and associated technologies in the study area. The first hurdle of the model suggests number of oxen owned by household, mobile phone ownership, education level of the household head and access to extension services significantly affected the probability of any improved bread wheat variety adoption. The intensity of improved bread wheat variety adoption was significantly associated with ownership of main plots, participation in on-farm demonstrations, perception towards shattering problems of local bread wheat varieties, and annual income of household. The findings of this study highlight the importance of economic(such as ***number of oxen****) and institutional(such as* ***access to extension****) factors related to agricultural extension and communication, the participation of farmers in on-farm demonstrations, wealth creation and acknowledging farmers' perception regarding improved bread wheat variety attributes. Development interventions should strive to target such economic, institutional, and psychological factors to promote wider adoption of improved bread wheat technologies.*

Keywords: Technology adoption, bread wheat, double hurdle, perception.

Background

Agriculture is one of the biggest components in Ethiopian economy by contributing 34% of the country's gross domestic product (GDP) and 71% of employment. Crop production makes up 72% of the total agricultural GDP, while the livestock sector ejects about 20% and other areas contribute 8.6%. Cereals (such as wheat, maize, Teff, sorghum, and millet), comprise the major share of crop production as principal staples (ATA, 2018).

The role of new technology to economic growth can only be realized if the new technology is widely diffused and applied by the beneficiaries i.e. farmers. It is also undeniable that, the generation and transfer of agricultural technologies is not an end in itself. The goal of increasing productivity and production of wheat will be realized if and only if the ultimate users, namely farmers, adopt the technologies that are released by research institutions. The reasons for low or non-adoption of new agricultural technologies can be technical, socioeconomic, and/or institutional (Uaiene *et al*., 2009).

Sub-Saharan Africa, Public agricultural investments have recently shown renewed interest in "package" approaches. These approaches seek to increase farm productivity by addressing issues related to market inefficiencies and limited information simultaneously for a group of complementary inputs. The package approach assumes that the provision of complementary inputs and extension will ensure that the input mix and its application by farmers approach that of controlled agronomic trials, leading to optimal yield outcomes. Since the package approach is a recently grown strategy which is adopted by MoA and ATA, the adoption studies conducted to date are mostly on the basis of a single attribute of the technology might be improved variety, input application and other agronomic practices (Gashaw Tadesse *et al*., 2016).

There are various studies conducted in the area of adoption specifically in agricultural technologies. According to (D'Souza and Mishra, 2018), years of education, credit access and membership to different clubs significantly affect the adoption of partial conservation. For instance compared with heads of the households with primary education, household heads with secondary education and tertiary education household heads are more likely to adopt partial conservation technologies.

Another study (Akinola *et al*., 2010), identified asset owner ship and off farm income as significant factors in determining adoption of balanced nutrient management. Similar with (D'Souza and Mishra, 2018), Akinola *et al.*(2010) indicated access to credit as determinant factor of adoption. Studies by (Marc *et al*., 2012; Ghimire *et al*., 2015 and Abbas *et al*., 2018) indicated that, adoption of rice varieties significantly affected by extension related variables.

According to Tesfaye Solomon *et al*. (2014), credit access, household head sex, field day participation, access to all weather roads, access to credit, active family force, district and market distance as being key determinants on the intensity and adoption of use of improved wheat varieties. Hence, the study recommended that emphasize should be given to these variables to improve adoption and intensity of wheat.

Similarly, Manda *et al*., (2016) argues that education level of the household head has a positive and significant influence on adoption of improved maize varieties. In addition to this, *Manda* and his colleagues, result shows that access to extension services increases the likelihood of adoption of maize varieties.

The results of adoption study by (Rahman & Haque, 2013; Sosina Bezu *et al*., 2014 and Khonje *et al*., 2015) reveal that education level of the household head has a positive and significant effect on adoption of a given agricultural technologies. In addition to the above, Tariku Bezabih (2012) found out that frequency of contact with extension agents, exposure of mass media and participation on extension events has a positive significant effect on adoption of wheat technologies. According to (Djana Babatima, 2011 and Bayissa Gedefa, 2014), farming experience and education level significantly affect adoption decision of maize and Teff technologies respectively. Katengeza *et al.* (2012) identified labor endowment, access to rural credit, livestock wealth, access to agricultural extension, farm size and access to off-farm employment as significant factors increasing the likelihood of maize variety adoption.

Findings from Arslan *et al*. (2014) indicated that, age of the household head and education level significantly increase the intensity of adoption of conservation farming practices while cultivated land per capita decreases the intensity of adoption, resulted from labor constraints. According to Solomon *et al*. (2014)**,** factors such as**,** household head sex, credit access, active family force, access to all-weather roads, district and market distance had a significant effect on the intensity of use of wheat varieties at different significance levels.

Access to credit positively and significantly influences the adoption and use intensity of balanced nutrient management systems (BNMS). An additional source of credit results an increase of the probability of adoption of BNMS-manure by 11%. Hence, an improvement in access to formal or informal credit will enhance households' technology adoption according to the findings of this study. According to Katengeza *et al*. (2012), the intensity of maize adoption was found to be negatively related to livestock wealth and fertilizer use.

The findings of Aman Tufa and Tewodros Assefa (2016) indicated that age, farm experience, oxen, membership of cooperative, distance to all weather roads and annual income significantly affect adoption of Barley intensity. According to Abiro Tigabie *et al*. (2013), social participation and total farm size affected malt barley technology adoption negatively and significantly.

Considerable studies have been conducted on the adoption of agricultural technologies in different parts of the world as well as in our country Ethiopia, and most significantly on identifying factors affecting the adoption of agricultural technologies. However, most of the literatures were based on a single component of the technology (mostly improved variety) than the packages of the technology. Specifically in the study area where the current study was conducted, no empirical research on the adoption of bread wheat has been conducted. Thus, with the pursuit of filling the gaps identified in the above problem statements, the current study on ‘‘factors influencing adoption of bread wheat technologies" was conducted.

Methods

Research design and study area

The study is based on the cross sectional data collected from smallholder wheat producer famers. The empirical data comes from the farming households residing in the northern part of Ethiopia namely, Meket district. This district was selected primarily because of its presence mandate area of Sirinka Agricultural research center's agricultural technology development, multiplication and dissemination activities.

The study area, Meket is one of the districts in the Amhara Region of Ethiopia. Meket district consists of 34 rural kebeles (Meket District Office of Agriculture, 2018).

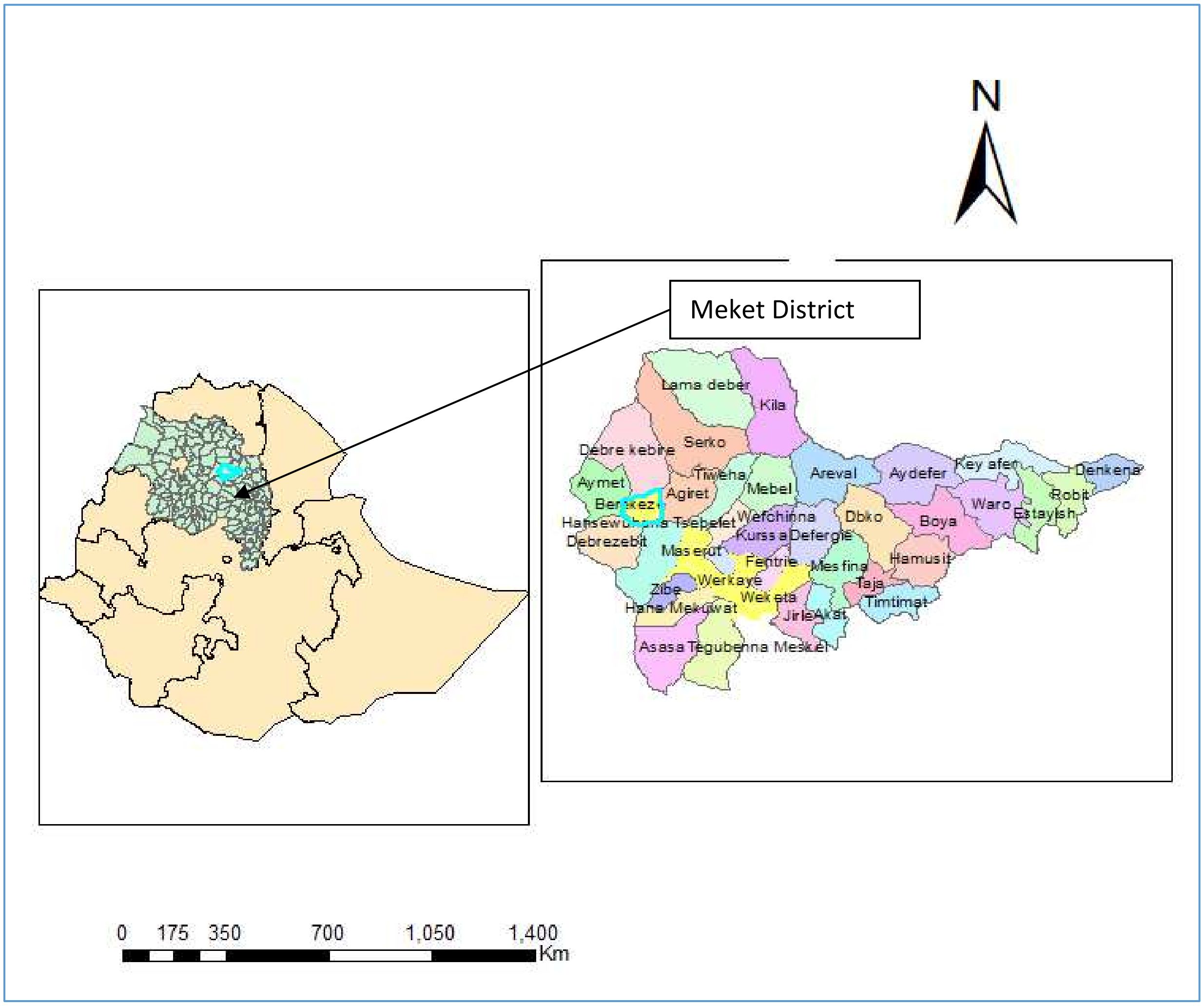

Figure 1 Location map of the study area

Source: CSA, 2011

Sampling design and procedure

Meket district was one of the intervention sites where bread wheat technology generation, multiplication and promotion conducted. In relation to technology generation and promotion, Sirinka agricultural research center has released and promoted various bread and durum wheat varieties at large scale clustered farms in the district.

Multi stage sampling technique was employed to select sample households for this study. Meket district has 34 rural administrative kebeles (Meket District Agricultural Office, 2018). From these, 15 of them were identified as potential bread wheat producer kebeles for selecting sample kebeles. Then, four sample kebeles were randomly selected for the study. Finally, sample respondents were selected using systematic random sampling technique. The number of respondents in each kebele was determined by proportionate to size.

Bread wheat grower households in the selected kebeles were used as the sampling frame and the sampling units were the household heads. Hence, based on the type of sampling design, the sample size for this study was determined based on the following formula given by Yamane (1967) as follows:

$$\mathbf{n}= \frac{N}{1+N(e)^2} \text{ ……………………………………………………………………………Equation 1}$$

Where n is the sample size for the study, N is the population of interest (wheat grower farmers in the production year 2017/18) which is 4022, e is the precision level which will be 0.07 in this study due to the fact that the population in the study area is relatively homogeneous in the socioeconomic set up. The formula is valid for 95% confidence level. Based on the above formula 194 sample respondents were selected randomly. According to Israel (2012), it is common to add 10% of the selected sample for compensating absentees of contact of respondents; hence, 214 samples were selected. The sample size for each kebele was determined based on their proportion to total share of households residing in each kebele.

Table 1. Distribution of sample respondents among selected kebeles

	Kebele	Name	Number of bread wheat Growers in 2017/18	Number of Samples selected(Using PPS)	Share (%)
1	029	Warkaye	1212	65	30.37
2	021	Maserut	1066	57	26.63
3	028	Weketa	966	51	23.83
4	017	Berekeza	778	41	19.15
	Total		4022	214	100

Source: Own survey, 2019

Data collection

Cross-sectional data were used for meeting the objective of this study. The data were collected both from primary and secondary sources. Primary data were collected from the sample farmers using structured questionnaire about bread wheat production, input utilization and demographic characteristics of the household. Secondary data were collected from published documents as, books, proceedings and journals and unpublished documents like annual reports of different organizations. Before the formal data collection, the questionnaire was pretested for further fine-tuning. In addition, orientation was given for enumerators to have a common understanding regarding the data collection instrument. Finally, the questionnaire was administered by trained researchers of Sirinka agricultural research center in close supervision of the researcher.

Methods of Data Analysis

In order to describe the overall wheat production status with respect to the desired characteristics, descriptive statistics such as mean, standard deviation, percentages and graphs were used. Furthermore, test statistics such as t-test for continuous variables and chi-square (χ^2) test for dummy/discrete variables were employed to compare means of socioeconomic characteristics among improved bread wheat technology adopters and non-adopters. Spearman's correlation was also used to test whether there exists significant correlation between categorical variables and intensity of adoption. One way ANOVA was employed for testing the overall mean differences among bread wheat technology adoption categories.

Adoption status of improved bread wheat technologies: Various econometric models have been employed to study the adoption behavior of farmers and to identify the key factors of technology adoption. The econometric specification largely depends on the objectives of the study and the type of data available. In most cases, data are collected on whether a given technology has been adopted or not, without considering additional information on the constraints some producers might face in accessing the technology. One of the most applied methods for modeling technology adoption behavior is the Tobit model. This model assumes that farmers demanding modern inputs have unconstrained access to the technology. However, in situations where input supply systems are underdeveloped, this is often untenable, as farmers demanding to apply fertilizer or improved seeds often face input access constraints. The Tobit specification has no mechanism to differentiate households with a constrained positive demand for the new technology from those with unconstrained positive demand, and assumes that a household not adopting the technology is making a rational decision (Yu *et al*., 2011). Hence, for access constraints to inputs, the Tobit model yields inconsistent parameter estimates (Croppenstedt *et al*., 2003).

The determinants of bread wheat technology adoption was estimated using double hurdle model because it was assumed that the rate of adoption and intensity of adoption will be affected by different set of factors at different levels. Moreover, it is assumed that the two decisions will be made separately.

The double hurdle model was used to identify factors affecting the probability and intensity of use of an improved bread wheat technology. The double hurdle model is a model in which two separate stochastic processes determine the decision to adopt and the intensity of use of a technology.

Assuming that many Ethiopian farmers have constraints in accessing inputs like fertilizer and improved seed varieties, the double hurdle (DH) model (Cragg, 1971) is a useful and proper approach to analyze technology adoption under constrained access to agricultural inputs. The DH model examines technology adoption in two steps. In the first stage, the farmer decides whether to participate in the fertilizer or other input market. If he/she chooses to participate, then the next step is to decide the quantity to purchase (Yu *et al*., 2011). In this model, the zero values in the dependent variable representing non adoption of the technology could result either from households that decided not to adopt the technology or households that have the willingness to adopt but are not able to do so due to reasons not embodied in the Tobit framework (for example, the non-availability of inputs discussed above). In other words, the DH model allows us to separate the sample of farming households into three groups: households applying fertilizer (or improved seed), households wanting to adopt but reporting no positive application, and households choosing not to adopt. Hence, using the DH model to incorporate this additional information allows us to obtain more efficient and consistent estimates of technology become inconsistent (Amemiya and Powell, 1981; Arabmazar and Schmidt 1981, 1982).

$Dh_i = 1$ … if $dh_i^* > 0$..Equation 2

$Dh_i = 0$ … if $dh_i^* <= 0$ ....Equation 3

$Dh_i^* = \alpha' Z_i + U_i$ ………………………………………..……...............................Equation 4

Where: dh_i* is a latent variable and DH takes the value 1 if a farmer adopts improved bread wheat technology and zero otherwise, Z is a vector of household socioeconomic and institutional characteristics and α is a vector of parameters. The level of adoption (Y) decision has an equation:

$Y_i = Y_i^*$--- if $Y_i^* > 0$--- and---- $DH_i^* > 0$……………………………………………..........Equation 5

$Y_i = 0$ ----otherwise

$Y_i^* = \beta' X_i + V_i$..Equation 6

Where Y_i is the observed amount of agricultural technologies, X_i is a vector of household socioeconomic and institutional characteristics and β_i is a vector of parameter.

The log-likelihood function for the double hurdle model is:

Log L $= \sum Ln[1 - \Phi(\alpha zi(\frac{\beta Xi}{\sigma}))] + \sum ln\ [\Phi(\alpha zi *)\frac{1}{\sigma}\Phi(\frac{Yi - \beta Xi}{\sigma})]$ ....Equation 7

Under the assumption of the independency between the error terms V_i and U_i, the double hurdle model is equivalent to a combination of Probit model (1) and the truncated regression model (2) (Greene, 2003).

Whether estimations are obtained simultaneously or one regression at a time, the results will be identical because of the separability of Cragg's likelihood function. That is, while using craggit makes estimation more coherent, it will not change results. The primary benefit of using craggit is its ability to facilitate post estimation analysis and interpretation (Burke, 2009). However, for this study ***craggit*** command was employed to estimate the model. Hence, both the probability and intensity of adoption were estimated via a single command.

Double-hurdle model involves two distinct decisions: the participation decision (whether to adopt bread wheat technologies) and the level of participation (the extent of use of bread wheat technologies). The type of association between these decisions and the specifications of the error terms determine the likelihood function to be estimated. Hence, if an individual makes both decisions separately, the two decisions are modeled independently; or if both decisions are made simultaneously, they are modeled jointly; or if one decision is made first and affects the other one, they are modeled sequentially (Martínez, 2006). The resulting models are called the independence, the dependence and the dominance models, respectively.

Levels of adoption of improved bread wheat technology: In order to estimate the level of adoption of improved bread wheat technology (improved variety, row planting, recommended chemical fertilizer application and herbicide/insecticide), adoption index was employed using the following formula.

$$AIi=\sum[\frac{AHi}{ATi}+\frac{FAUi}{FRU}+\frac{FADi}{FRD}+\frac{RP}{ARBi}+\frac{CAi}{CR}]/NP \quad \text{…..Equation 8}$$

Where: AIi= Adoption index

AHi= Area under improved variety of bread wheat of the i^{th} farmer

ATi= Total area allocated for bread wheat production (improved variety +local, if any of the i^{th} farmer

FA_{Ui}= Amount of urea fertilizer applied per unit area of land in the cultivation of bread wheat by i^{th} farmer

FR_U= Amount of Urea fertilizer recommended for application per unit of area in the cultivation of bread wheat (100 kg/ha)

$FA_{D=}$ Amount of NPS fertilizer applied per unit area of land in the cultivation of bread wheat by i^{th} farmer

FR_D= Amount of NPS fertilizer recommended for application per unit of area in the cultivation of bread wheat (100 kg/ha)

RP= Area under row planting of bread wheat

ARBi= Total area of bread wheat (both row planting and broadcasting if any)

$HA_{i\,=}$Amount of Herbicide Applied per unit of area of i^{th} farmer

CR= Amount of herbicide Recommended for application per unit of area, i^{th} farmer

NP = Number of practices

Determinants of bread wheat technology adoption

The results for the determinants of bread wheat technology has a binary nature and hence estimated by the Probit model (the first hurdle or tier one) is displayed in Table 2. The Wald chi-square value of 30.68 is statistically significant at 1% indicating that the explanatory variables in model jointly explain both the probability of adoption and intensity of adoption. There is no theoretical guidance as to which variable to include in each hurdle, hence an attempt was made to include a number of economic and perception variables in both hurdles.

Turning to the estimation results, coefficients in the first hurdle (tier1) indicate how a given decision variable affects the likelihood (probability) to adopt improved bread wheat technology. Those in the second hurdle (tier2) indicate how decision variables influence the intensity of bread wheat technology adoption. In the estimation process, 24 explanatory variables were included in the two hurdles (Tier 1 and Tier 2) (Table 2).

The decision to adopt improved bread wheat technology is significantly determined by five of the 12 explanatory variables. The result of the first hurdle (Probit Model) indicates that, number of oxen owned by household, mobile phone ownership, livestock ownership(measured in TLU), Education level of the household head (measured in years of schooling) and number of extension contact significantly determined it. Significant variables determining the decision to adopt bread wheat technologies are well distributed over four categories; household characteristics (education level), asset ownership (number of oxen, livestock ownership and mobile phone ownership), institutional variables (extension contact) and varietal perception.

Oxen based farming is commonly practiced in the study area so that oxen (the number of oxen owned) is included as a separate explanatory variable in the model. The coefficient of this variable is statistically significant at 5 % significance level and has a positive effect on the probability to adopt improved bread wheat technologies. Furthermore, its marginal effect implies that an increase in number of oxen increases the likelihood of adopting improved bread wheat technologies by 3.9%. This result is consistent with the findings of (Chilot Yirga *et al*.,2013; Aman Tufa and Tewdros Tefera, 2016) who found out positive and significant effect of number of oxen on adoption.

Access to information was expected to positively affect the likelihood of adopting improved agricultural technologies. In this study, the effect is captured by ownership of mobile phone. As expected mobile phone ownership has a positive effect for bread wheat technology adoption and statistically significant at 1% significance level. The marginal effect also reveals that possessing mobile phone increases the probability of bread wheat technology adoption by 12.5 %. Along with the development of information communication technology and the needs, mobile phone as an instrument or medium of information communication is widely used by farmers. Hence, farmers with cell phones can support the extension communication channel and access information easily. Thus, communication via mobile phone might contribute for facilitating advisory services with development agents. This result is consistent with the study by Solomon Asfaw *et al*., (2011) who find out that ownership of mobile phone positively and significantly affected agricultural technology adoption.

Livestock wealth also positively influences the adoption of bread wheat technologies. The coefficient of livestock ownership is statistically significant at 5 % level of significance and has positive effect on the probability to adopt improved bread wheat technologies. An increase in livestock ownership by one TLU increases the likelihood of adopting improved bread wheat technologies by 5.5%. This might be due to the reason that in Ethiopia farm machineries are not yet widely used by smallholder farmers (except large-scale investment farms) in this case livestock are the major source of drafting and traction power. Moreover, livestock are indicators of wealth in the farming community. This result is consistent with various adoption studies such as Njane (2007) and Katengeza *et al*. (2012).

The probability of improved bread wheat adoption was influenced positively and significantly by education level of household head at 10% significance level. The result implied that educated household heads were more likely to adopt improved bread wheat technology. More specifically an increase in years of schooling increases the probability of bread wheat adoption by 1.1%. This result is in agreement with Tariku Bezabih (2012) who find out a positive and significant effect of education and wheat variety adoption. Education level was included in both hurdles of the model. While the coefficient of this variable was significant in the first hurdle (probability equation), it was not significant in the second hurdle (intensity) of adoption. The result might be an indication that the two decisions (Adoption and intensity of adoption) can be affected by different set of explanatory variables. Once the education affects the decision to adopt, the decision on the intensity might not be influenced by education level.

Frequency of extension contact positively affects household's probability of bread wheat technology adoption at 5% level of significance. In addition, the marginal effect of this variable reveals that an increase in frequency of extension contact increases the probability of adoption by 4.96 %. The result indicates that farmers with frequent extension visit are more likely to adopt improved bread wheat technologies. This result is in agreement with (Simtowe *et al*., 2011; Sodjinou *et al*., 2011; Akalu Teshome and Ermias Abate, 2013; and Chandio and Yuansheng, 2018).

Determinants of intensity of adoption of bread wheat technologies

The decision to adopt improved bread wheat technology is significantly determined by four of the 12 explanatory variables. As shown in Table 2 below, the result of the second hurdle (Tier 2) indicates that the variables such as, ownership of main plots (Ownership), participation on on-farm demonstrations (Partondemon), perception towards shattering problem of bread wheat varieties (Shateringproblem) and annual income (logAnnualincome) are the significant determinants for adoption intensity of bread wheat technologies.

Ownership of land by title (Ownership) negatively influenced adoption intensity of bread wheat technologies and this variable was statistically significant at 10%. Ownership of land decreases intensity of adoption by 4 %, indicating that farmers cultivating bread wheat on renting are less reluctant to use improved bread wheat technologies than those possessing land. The implication of the result might be related to the fact that farmers renting land for bread wheat have to use intensive technologies to cover production costs related to land rent, labor and fertilizer. Since farmers are expected to reap significant benefits in the short run from bread wheat technology adoption, they tend to invest on agricultural intensification.

Participation on on-farm demonstration (proxy for access to agricultural extension services) positively and significantly affects intensity of bread wheat technology adoption at 5 % level of significance. Participation of farmers on on-farm demonstration increases the level of adoption by 6.72 %. The result suggests that, on farm demonstrations are means of learning by doing which enable farmers to develop confidence on the given technology. In addition, demonstration plots will create the opportunity for experience sharing among invited and host farmers of the demonstration plots. This result is consistent with Yigezu Atnafe *et al*. (2018) who find out that both hosting and involvement on-farm demonstration trials decreases the duration to adoption by 36.5%.

Farmers' perception towards shattering problem negatively affected intensity of bread wheat adoption at 5% significance level. The result implying that, farmers perceiving negative advantage about the improved variety towards shattering problem would allocate lower parcel of land for bread wheat production. This result is consistent with the theory of diffusion of innovation by Rogers (1983). According Rogers (1983), "*The greater the perceived relative advantage of an innovation, the more rapid its rate of adoption will be*." The degree to which the farmer perceives the technology as important matters how much to allocate his/her land for the introduced technology.

As expected, the coefficient of annual income is positive and significant at 10% significance level. Accordingly, an increase in household annual income by one Birr would lead to an increase in the intensity of bread wheat technology adoption by 2.49 %. This could happen because a household with necessary annual income could not be financially constrained and prohibited from the timely use of improved bread wheat technology packages. This result is consistent with the findings of (Hassen Beshir *et al.,* 2012 ; Aman Tufa and Tewodros Tefera, 2016 and Degefu Kebede *et al*., 2017).

Table 2. Estimates of double hurdle model for adoption of bread wheat technologies

Double Hurdle				
First hurdle(Tier 1)			Second hurdle (Tier 2)	
Variables	Coefficient	Marginal Effect	Variable	Coefficient
Fertistat	0.1547 (0.3679)	0.0178	Fertistat	0.06234 (0.04057)
Ownership	-0.0659 (0.3628)	-0.0080	Ownership	-0.07059 * (0.04033)
Corironsheet	0.2383 (0.2182)	0.0300	Edulevel	0.00306 (0.00557)
Marketinfo	0.1912 (0.2538)	0.0239	Age	0.00810 (0.00929)
Oxen_no	0.3123 ** (0.1585)	0.0394	Agesquare	-0.00005 (0.00008)
Oxplsetowned	0.1368 (0.1935)	0.0172	Plot_No	0.01899 (0.01314)
Mobileowned	0.7387 ***(0.2767)	0.1247	Partondemo	0.06727** (0.03058)
Offfarm	-0.4377 (0.2756)	-0.0518	Marketable	-0.02957 (0.02369)
TLU	0.4323 ** (0.1940)	0.0545	Credit use	0.00902 (0.02971)
Edulevel	0.0868 ** (0.0505)	0.0109	Yieldbetter	0.01612 (0.02199)
Social	0.0693 (0.0738)	0.0087	Shateringpr	-0.00533 **(0.00298)
EXTENSION	0.3935 ** (0.1633)	0.0496	LogAnincm	0.02494* (0.01473)
Constant	-1.0275 (0.5924)		0.29730 (0.36122)	
Sigma	0.1989 *** (0.0080)			

****p < 0.01, **p < 0.05 and *p < 0.10*

Wald chi2 (12) =30.68

Log pseudolikelihood = -22.882145 Prob > chi2 = 0.0022

Numbers in the parenthesis are robust standard errors

Conclusions and Recommendations

Descriptive results of the study revealed that, there exists a significant variation among adopters and non-adopters in relation to education level, age, livestock ownership, mobile phone ownership and number of oxen owned. Improved bread wheat varieties such as *Dinknesh*, *Digalu*, *Denda*, and *Kakaba* predominantly grown in the study area. On the other hand, the adoption rate of bread wheat technology was found to be 88.78% whereas the intensity of bread wheat technology package in the study area was about 67%.

The first tier of double hurdle model analysis indicated that number of oxen, mobile phone ownership, livestock ownership, education level of the household head and extension contact significantly determine the adoption of bread wheat. The second tier of double hurdle model indicates that, ownership of wheat plots, participation on on-farm demonstrations, perception towards shattering problem of bread wheat varieties and annual income significantly determine adoption intensity of bread wheat technology. Farmers' perception towards the perceived relative advantages demonstrated that; marketability, early maturity, better yield and color were perceived to be the most important technology attributes for bread wheat varieties by farmers. The low adoption rate and intensity of row planting was related to extra labor required compared to broadcast planting.

Based on the results of this study, it is suggested that the adoption of improved bread wheat technologies could be increased by raising farm household asset formation, providing frequent extension visit, improving agricultural information system, enhancing participation on agricultural events such as on farm demonstrations and field days. Moreover, bread wheat variety development strategies should be directed in alignment with farmers' perception.

Apart from grain yield, researchers in the area of bread wheat varietal development should consider farmers' varietal perception towards marketability, seed color, food (bread) quality and shattering problem. Increasing the efficiency of row planting related to labor could increase the adoption rate of the technology. Hence, measures related to improving labor efficiency of farm implements should be developed and promoted in the study area.

DECLARATIONS

Authors' contributions

NS carried out the study, worked out almost all of the technical details, performed the data analysis and wrote the manuscript. AG contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript. AA advised the coauthor from proposal writing to the main conceptual ideas and proof outline. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests

Availability of data and materials

Datasets used for analysis can be received up on the request of the corresponding author

Consent for publication

Not Applicable

Funding

Data collection was supported by Amhara Agricultural Research Institute

Consent to participate

Date: ____________________ **Interviewer:_____________________**

Any research work should respect certain ethical standards. Accordingly, this research entitled "**Determinants of Adoption of Improved Bread Wheat Technologies in East Amhara Region, Ethiopia**" had been carefully guided with research ethics. The research process was begun by asking the willingness of the participants whether they agree or not to participate in the interview. The purpose of the study was carefully informed for the interviewee. Moreover, the participants were informed as they have full right to discontinue or refuse to participate in the need assessment study. In addition, the participants were informed to freely answer in the questionnaire or to be free in expressing their experience as the information they provide would kept confidential. In order to secure the identity and to protect the confidentiality of the participants, the respondents were not forced to disclose their names at the questionnaire or during the interview. In the report document, anonymity of respondents was kept by using code.

Consent Form

Informed Consent For Farmers

Hello. Thank you for taking your time to talk to me. My name is ____________________________ and I am working with a research team of Sirinka Agricultural Research Center on "**Determinants of Adoption of Improved Bread Wheat Technologies in East Amhara Region, Ethiopia**". We are collecting data and I would like to ask you questions about yourself and your life experience. Your participation is very important to learn about bread wheat technology adoption and it also very helpful for the programmers and planners to design appropriate intervention. Your name will not be written in this form and the information you give are kept confidential. You will not get any harm being participating in this research. Do you agree to participate in the study?

1= Yes

2= NO (End the interview)

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Figures

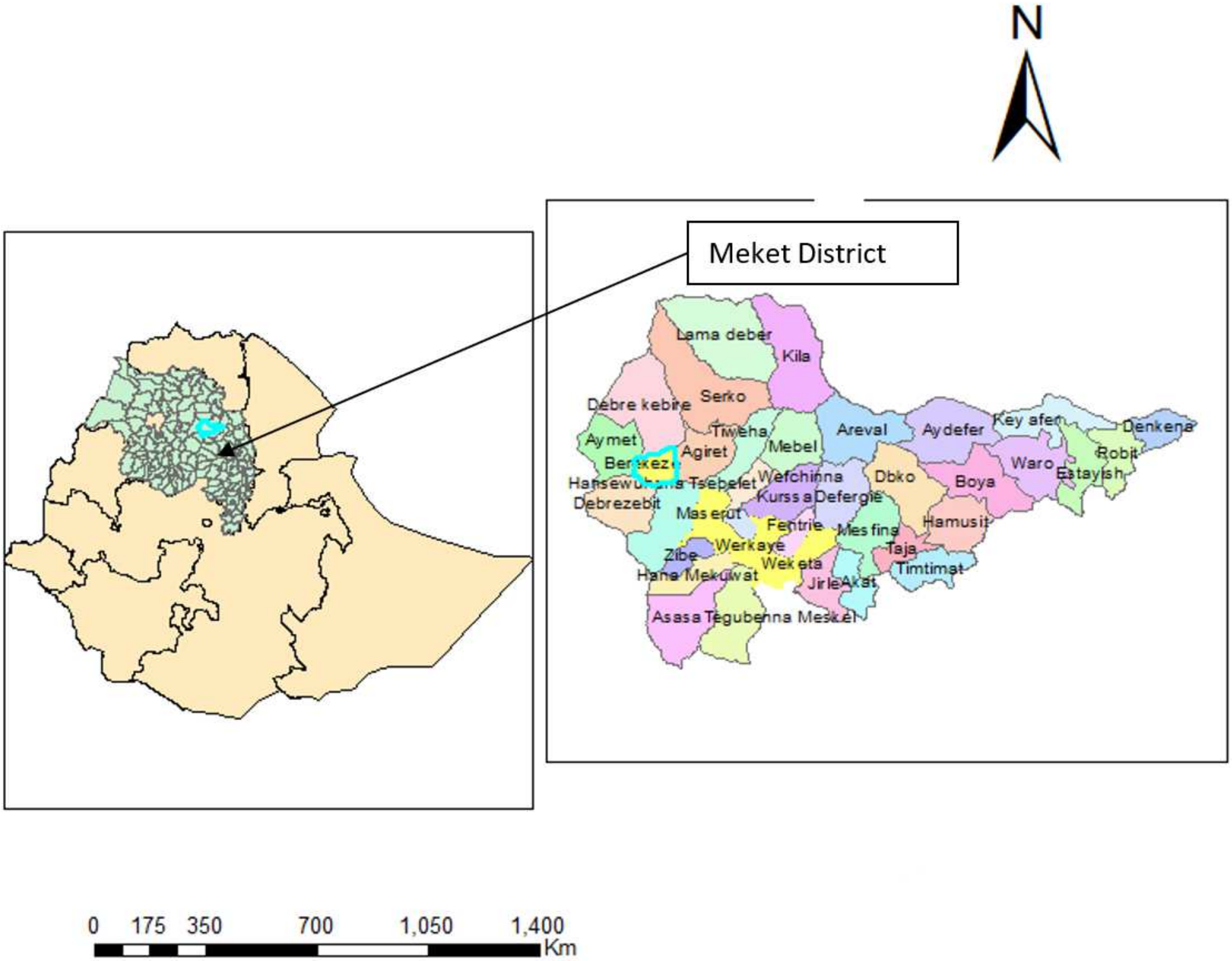

Figure 1

Location map of the study area