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Factors Affecting the Adoption of Row Planting Technology in Wheat Production: The Case of Womberma District, West Gojjam Zone, Amahara Region, Ethiopia

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Abstract

The study aims to assess factors influencing the adoption of row planting technology on wheat production in Womberma district. Cross-sectional data were collected through structured interview schedule from 337 randomly selected sampled farmer households in the district. Moreover, focused group discussion and key informant interviews were conducted for in-depth information and data triangulation. The descriptive findings of this research showed that about 36% and 64% of the surveyed households were adopter and non-adopter of wheat row planting technology respectively. The results of logit regression analysis also demonstrated that family size, livestock ownership, extension service, participation in training, and cultivated land size are the factors significantly affecting adoption of technology for wheat row planters positively. It was only distance to the nearest market center found to have a significant and negative effect. This suggests that there is a need to arrange a tailor-made short-term training for enhanced adoption of the technology by the vast majority of farmers. Extending the extension services to address issues related to this emerging mechanization technology is so important in encouraging farmer's wheat row planting technology adoption confirming that appropriate and modernized extension services is essential for further improvement in the adoption of wheat row planting technology. It is also demanding that stakeholders should allocate financial resources to improve road infrastructures through maintenance and development in rural areas and hence accessing market.

Keywords*:* *Row planting Technology adoption, Wheat, Logit, Ethiopia*

1. Introduction

In Africa, Ethiopia is one of the main cereal producers such as wheat, rice, teff, sorghum and maize. In addition, from sub-Saharan Africa, Ethiopia is largest producer of wheat indicating that, next to teff, sorghum and maize, wheat is one of the main cereal food items which constitutes 15.33% of cereal production and 13.73% of area coverage (Gruber et al., 2019). In 2019 the total wheat yield in Ethiopia was approximately 1.83 tons/ha and increased to 3.1 tons/ha in 2020 (CSA, 2020). Others reported that the total land used for producing wheat is about 17% of the total arable land used for cereal production with an average country level production of 21.10 q/ha (Solomon et al., 2019). But, comparing to the world average yield of 40 q/ha, Ethiopian wheat production at national level is the lowest (Alemu, 2014). The dependency of the country's agriculture on rain -fed, traditional and subsistence ways of farming practices, low input usage production activity and highly scattered farming practices is the major reason for low wheat productivity. Besides poor infrastructure, decreased soil fertility, unfavorable and unreliable climatic conditions, degradation of environmental and the existence of scattered small farming land per farmer have also contributed to this low wheat productivity in the country.

According to Amare, (2018), in Amhara, Oromia, SNNPR, and Tigray in 200 kebeles, nearly 400,000 farm households adopted wheat row planting technology which decreases the minimum amount of wheat seed required to increase productivity of wheat crop yields, farmers' household food consumption and income at household level to the minimum and at country level at large. In order to meet the increasing demand of food consumption due to continuously increasing population growth in the country, usage of agricultural technology to increase agricultural productivity has become the primary agenda of agricultural extension services and policy practiced by Ethiopian government. However, the lion shares of wheat producing farmers do not adopt wheat row planting technology at larger scale in the study district. Besides, only few studies, are conducted on wheat row planting technology adoption practices in various regions of the country (Amare, 2018; Dinku & Beyene 2017; Tamirat et al., 2021). The effect of adopting farming technology on the income of a rural households' income is the primary focus of previous studies (Yonas et.al, 2015; Tesfaye et al., 2016). Moreover, as to our knowledge, no research has been carried out in recent years about factors affecting row planting technology adoption on wheat production considering Womberma district as the case. Therefore, this study aims to fill these knowledge gaps and give empirical evidence on the factors affecting wheat row planting technology adoption in Womberma district, in the Amahara region, Ethiopia.

2. Material and Methods

2.1.Study Area Description

The study was conducted in Womberma district, West Gojjam Zone, Amahara region, Ethiopia. Geographically, the district is situated at latitude 10^{0}38'00" N and longitude 37^{0}00'00" E. Its immediate surroundings include Oromiya region in South, Burie district in East, Awi-zone in the north and west. Mixed agricultural system is the unique features of the agricultural production system of the district. From pulses, horse beans and field peas, from oil seeds, rapeseed and linseed and from cereals, barley, teff, wheat, and maize are some of the main farming agricultural products growing and produced crops in the district. In addition, to support their households' livelihoods, farmers in the study area rear livestock including goats, poultry, cattle, and pack animals such as donkey horses and others. In the district, wheat which covers the largest agricultural land and constitutes the main cereal crop used for fulfilling their households' food consumption demand. Womberma is one of the well-known, highest wheat producing 12 districts in West Gojjam zone. Currently, most smallholder farmers in the district continue to use broadcasting of seed for wheat cultivation indicating that they have not yet been using the technology for row planting, despite, some are using both broadcasting and row planting method to produce wheat. But, few of them are producing wheat with full adoption of this wheat row technology in the district. This shows that it is important to explore thoroughly determinantal factors influencing wheat row planting technology adoption in the district.

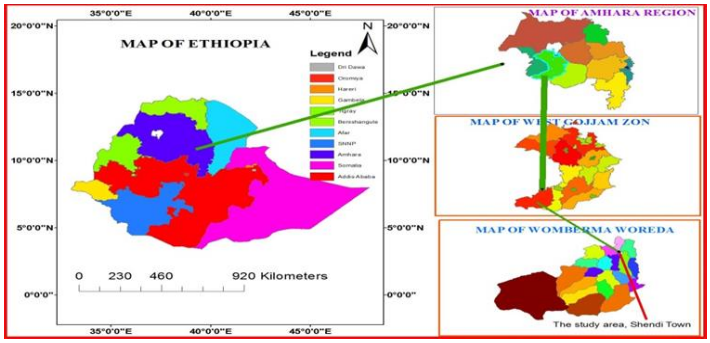

Figure 1. Location Map of the study area

Source; Arc GIS :(2022)

2.2.Sources and Types of Data

Data for the study was gathered from primary source. The primary data was collected through household survey using structured interviews in order to identify factors affecting wheat row planning technology adoption. The interview questions mainly focused on households' demographic factors (sex structure, family size and literacy and others), economic factors (tropical livestock size and cultivated land size,), institutional factors (extension service, market distance, participation in training, participation in filed visit and credit access). Focused group discussion was also used as an additional means of data collection method to triangulate the data collected through the questionnaire. The FGD was conducted with the elders, young, and stripling farmers groups of each having five members. The main aim of FGD was to cross examine farmers perceptions of wheat row planting technology. Key informant interview was also further used using purposively selected knowledgeable respondents to obtain detail information regarding to the current practice and application of wheat row planting technology for the production, the problems that wheat grower farmers face to adopt the row planting technology to increase wheat productivity in the study area. The key informants were development agents and district agricultural and rural development officers from each selected *kebeles*.

2.3.Sampling Technique and Sample Size Determination

Womberma district was selected purposively based on researcher knowledge about the area as the target area of the research. The representative sample households were selected using multi-stage sampling technique. Markuma, Marwoled and Hirate Kebeles were selected purposively from 19 total rural Kebeles of the district in the first stage, since they are high wheat producing kebeles compared to others. In second stage, by using simple random probability sampling technique, a total sample of 337 farmers were selected. These 337 sampled households were selected proportionally from the total number of farmers found in each selected rural Kebeles. Thus, 109, 98 and 130 farmers were the final samples drawn from Markuma, Marwoled and Hirate Kebeles respectivelly.

In Markuma, Marwoled and Hirate Kebeles, there were 689, 617, and 814 farmer household respectively. Yamane (1967), sample size determining formula, $n = \frac{N}{1+N(e^2)}$,was used to determine the total sample size. where N is population size, n is the sample size for the study, e level of precision (value of 0.05 was used). Among the total population of 2120 in three Kebeles, the sample size is approximately 337 households. That is $n = \frac{2120}{1+2120\ (0.05^2)}$ = $= \frac{2120}{1+5.3)}$ = 336.50.

2.4.Method of Data Collection

Structured interview schedule using properly prepared questionnaire was the main instrument used to collect primary data from sample respondents, where interview questions primarily focused on households' demographic factors (sex structure, household family size and literacy), economic factors (tropical livestock size and cultivated land size,), and institutional factors (extension service, market distance, participation in training, participation in filed visit and credit access). In addition, in order to make triangulation with questionnaire data, focused group discussion was used, where one focus group discussion was held at each Kebele. Furthermore, to get detailed information on the problems that wheat growing farmers face to use the technology used in row planting, the prevailing usage of wheat row planting technology in order to increase wheat yield in the study area. District agricultural and rural development officers, development agents from each selected *Kebele* were some of key informants selected to get detail information.

2.5.Definitions of Variables and working hypothesis

The dependent variable is wheat row planting technology adoption by Womberma district wheat producing farmers. It is a dummy variable with a value of 1 if farmers adopted row panting technology and 0 otherwise.

The independent variables which were expected to influence the adoption of row planting technology in wheat production include demographic, economic and institutional factors such as sex of farm household head, literacy, access of credit service, family size, extension services, participation in field visit days, participation in training, livestock ownership in tropical livestock unit, cultivated land size and distance to the nearest market. These variables are defined and hypothesized as follows:

shh: Sex of household head- This variable was included in the model as dummy variable (takes a value of 1 if the household head farmer is male and, 0 otherwise) and expected to have positive relationship with adoption of row planting technology for wheat production. Due to many socio-cultural values and norms, males have access in different extension programs and consequently have greater access to information and thus wheat row planting technology adoption is positively related with male- farmer heads. (Gebre et al., 2019) and Muriithi et al., 2018).

fshh: Family size of the household head- represents the number of family members in a farmer household which is measured in number. The existence of large family size is expected to have positive effect on farmer's row planting technology adoption in wheat production. Therefore, it is hypothesized that row planting technology adoption for wheat production is positively related with farmers' family size (Tamirat & Abafita, 2021).

Edul: Literacy- it was considered as as dummy variable, which takes the value 1 if the household head are literate, 0 for their counterpart, and expected to influence adoption of row planting technology for wheat production positively. This is so because literate farmers will be better to adopt the new row planting technology than those of illiterate, since literate ones may have the chance of getting experience in technology adoption through education. Therefore, it is hypothesized that wheat row planting technology adoption is positively related with farmers' literacy status (Tamirat & Abafita, 2021 and Amare 2018).

accs: Access of Credit service- This variable is treated as dummy variable which takes a value 1 if the household head farmers were getting access to credit and 0 if they did not have access to credit. It was hypothesized to have positive relationship with row planting technology adoption (Dinku&Beyene, 2019).

exs: Extension services- It is a dummy variable taking 1 if the farmers had got extension services; 0 otherwise. Farmers having extension contact knows the source and possible benefit of row planting of wheat crop production and hence expected to be better adopters of row planting technology of wheat crop. It is therefore it is expected to have positive effect on row planting technology adoption in wheat production (Tamirat & Abafita, 2021).

pfvd: Participation in field visit days- It is a dummy variable and takes 1 if farmers were participating in field visit days; 0 otherwise. Farmers who have attended field visit days, visited demonstration plots, to have a positive attitude to the adoption of wheat row planting technology (Mentire & Gecho, 2017).

pitr: Participation in Training- Participation in agricultural training is also considered as dummy variable with taking 1, if farmers participate in agricultural training, 0, otherwise. It one of the extension events where farmers get practical skill and technical information for the new wheat row planting technology. It is hypothesized that row planting technology adoption positively related with participating in training (Dinku & Beyene2019).

tlu: Livestock owner ship in tropical Livestock unit- it is a continuous variable representing the total amount of animals a farming household owned in tropical livestock unit. Besides, using for plowing, threshing, transporting, livestock are used as liquid capital, which are very important and serving as a security when there is crop failure. Therefore, this variable would be hypothesized positive relationship with adoption of row planting of the wheat crop (Birhanu et al., 2017 and Feyisa, 2020).

cls: Cultivated land Size- this variable is continuous that stands for the total amount of cultivated land area of the wheat crop which is measured in hectare. The size of cultivated land positively related with household technology adoption in row planting of wheat. Farmers who have larger cultivated land size increases row planting of wheat crop than those who have smaller area. This is so because farmers with more cultivated land size have greater chance to produce more and earn mor income and thus having the ability to afford and to adopt the technology. Therefore, it is hypothesized that positive relationship expected between land size and adopting wheat row planting technology **(**Tamirat & Abafita, 2021).

dnm: Distance to the nearest market-this variable is continuous that measures distance to the nearest main market in kilometer. There is no high transportation cost incurred by the farmer and further the potential of the farmer to buy input and sell their product is high, when the farm area is near to the market. Therefore, it is hypothesized that row planting technology adoption is negatively related with distance of farm area from the market center (Tesfaye et al., 2016).

2.6.Methods of Data Analysis

Since dependent variable is a dichotomous discrete variable, it is appropriate to use the binary logistic regression model to evaluate the relationships between explanatory variables and the dummy dependent variables, i.e. technology adoption in wheat production. Despite, the dependent variable is dummy, the explanatory variables are both continuous and dummies. The binary logit than the probit model is used for its simplicity of calculation and that its probability lies between zero and one. Moreover, its probability approaches zero at a slower rate as the value of independent variable gets smaller and smaller, and the probability approaches one at a slower and slower rate as the value of the independent variable gets larger and larger (Gujarati, 2003).

Mathematically the logit model is represented in equation as follows (Maddala, 2002):

$$Pi = E\left({}^{Yi}/_{Xi}\right) = \frac{1}{1+e^{-(\beta o+\beta iXi)}} = Pi$$

$$= E\left(\frac{yi}{Xi}\right)$$

$$= \frac{1}{1+e^{-zi}} -----(1)$$

Where the probability of i^{th} household being adopting wheat row planting technology is represented by Pi which ranges between 0 and 1, the functional form of **m** independent variables (X) is represented by Zi which is expressed in equation (2) as:

$$Zi = \beta o + \sum_{i=1}^{m} \beta iXi\,, i = 1,2,3 \ldots\ldots m\,,$$

$$----------(2)$$

Where $\beta 0$ is the coefficient of intercept and βi represents the slope coefficients of the model to be estimated, which indicates how the log-odds in support of a given household using wheat row planting technology adoption status change due to the change in explanatory variables. If the ith wheat producing farmer in the district is being adopter of row planting technology in wheat production, it is represented by the probability of Pi, then, any given farmer to be non-adopter of technology in wheat row planting practice is represented by a probability of $1 - Pi$, which can be written as equation (3): $1 - Pi = \frac{1}{1+e^{zi}} --- (3)$

When we divide equation (1) by equation (3) and after simplification, it gives,

$$e^{Zi} = \frac{Pi}{1+Pi} = \frac{1+e^{zi}}{1+e^{-zi}} ----- (4)$$

Equation (4) clearly shows that the odds ratio for a given farmer using row planting technology in wheat production. It is the ratio of the probability of a wheat producing farmer who adopts wheat row planting practice to the probability that those farmers who will not use the technology in wheat production. Finally, by taking the natural logarithm of equation (4) , the logit model can be specified in equation (5) as follows:

$$Li = l\,n\,(Pi/(1-Pi))$$

$$= \beta o + \beta 1X1 + \beta 2X2$$

$$+ \beta 3X3 + \beta iXi + Ui --$$

$$----- (5)$$

Where Pi = the probability that that a given wheat producing farmer is using row planting technology, which takes a value of 1) and $1 - Pi$ = the probability that a given wheat producing farmer does not adopt wheat row planting technology which takes a value of 0.
The odds ratio in the logit model ,explained

in terms of natural log is represented by Li; the slope parameters measuring, the change due to a unit change in independent variables (X) is represented by βi, while the intercept coefficient, which measures the value of the log-odd ratio, $\frac{Pi}{1-Pi}$ when the independent variables are zero is represented by $\beta 0$ and Ui is random error term.

Finally, the equation of logit model is empirically specified as equation (6):

$$FRP = \beta o + \beta_1 shh + \beta_2 fshh + \beta_3 edul + \beta_4 accs + \beta_5 exs + \beta_6 pfvd + \beta_7 pitr + \beta_8 tlu + \beta_9 cls + \beta_{10} dnm + \mu i \quad ---------- (6)$$

Where FRP is the farmers' probability of adopting row planting technology, the explanatory variables were represented as explained in variables of the study sub section and μi is the random error term.

3. Results And Discussion

3.1.Diagnostic Test in Logit Model

Goodness-of-fit test (Hosmer-Leme show): - Goodness-of-fit of the estimated logit regression model was used for determining how much all the explanatory variables explained the dependent variable. The value of (Probability > chi2) is greater than 0.05(5%), showing that there is better goodness of fit in the logit model. In this case, the p-value (.9907) is greater than 0.05. Therefore, in this study there was no goodness of-fit problem (Appendix 1).

Multicollinearity Test: -The presence or absence of multicollinearity was detected by the most familiar methods of variance inflation factor (VIF) or tolerance of variance (1/VIF) to detect the problem of mutual interdependence among the explanatory variables. If VIF of a variable is greater than 10, it is an indicator that there is a serious problem of multicollinearity. Therefore, in this case, all the VIFs in the model were below 10 implying that multicollinearity among the variables was not a serious problem (Guajarati, 2003) (Appendix 2).

Heteroscedasticity test: -Finally, minimize the problem of hetroscedasticity the robust regression was used.

3.2.Descriptive Analysis

As shown in table 1, out of the total 337 respondents, nearly 81% of them were male an the remaining 19 % were female respondents. Regarding access to credit services, 58% of the respondents did have access to credit, while the remaining 42% did not get credit. Furthermore 78% of them got extension services while 22% of the respondent did not get such services. In relation to farmers participation in training, nearly 51% were participating in agriculture related training, while the remaining,49% did not.

Table 1. The Descriptive Statistics for Dummy variables

Variable	Obs	**No**	**Yes**	Pearson chi2	Pr.
Shh	**337**	**18.69%**	**81.31%**	**0.2760**	**0.599**
Edul	**337**	**32.05%**	**67.95%**	**11.7258**	**0.001**
Accs	**337**	**42.43%**	**57.57%**	**2.4096**	**0.121**
Exs	**337**	**21.66%**	**78.34%**	**20.4313**	**0.000**
Pfvd	**337**	**60.83%**	**39.17%**	**24.2658**	**0.000**
Pitr	**337**	**49.26%**	**50.74%**	**49.7012**	**0.000**

Source: Own computation based on 2023 data

Table 2. The Descriptive Statistics for Continuous Variables

Variable	Obs	Mean	Std. Dev.	Min	Max	T-test
Fsize	**337**	**4.964392**	**1.226654**	**3**	**8**	**3.0862**
Tlu	**337**	**7.114985**	**1.50691**	**4.5**	**14**	**4.1039**
Clh	**337**	**1.988694**	**.5758824**	**1**	**4**	**1.0725**
Dnm	**337**	**6.977003**	**1.068318**	**5**	**9**	**5.0917**

Source: Own computation based on 2023 data

It is clearly shown from table 2, that the sampled respondents farm land located 7 kilometers far to the nearest market on average. It is also shown that, on the surveyed farmers had 5 household members on average. On the average the surveyed sampled farmers had nearly 2 hectares of cultivated land which lies between a minimum of 1 hectare to the maximum of 4 hectares. The t-test statistics clearly showed that there is a significant difference between row planting technology adopters and non-adopters and these differences were statistically significant for family size, distance from the nearest market and total livestock ownership.

Table 3. Distribution of sample respondents by adoption of row planting in heat production

Adoption Category	Freq.	Percent
Non-adopter	215	63.80
Adopter	122	36.20
Total	337	100.00

Source: Own survey data, 2023

Out of 337 sample respondents, 215(63.80%) are non-adopters of wheat row planting technology and 122(36.20) are adopters' technology in wheat row planting.

3.3.Econometric analysis

In order to estimate and identify factors influencing row planting technology adoption in wheat production in Womberma district, this study employed logit regression model. The logit regression result showed that, from 10 explanatory variables included in the model, six of them had significant effect to determine the probability of the farmer to adopt row planting technology for wheat production. These are family size, access to extension service, participation in training, livestock ownership, cultivated land size and distance from market center.

Family size had positive and significant effect on wheat row planting technology at 1% significance level. The odds ratio of 2.92 as shown in table 4 indicates that, the odds of households to adopt row planting technology for households with large families are 2.92 times greater than the odds of adopting row planting technology for households with small family size households. This may be the fact that the row planting technology is so labor intensive, since it demands more individuals for putting seed, organic and inorganic fertilizer in row. This corroborates the findings of Giller (2021) and Dinku and Beyene (2017) who confirmed in their studies that family households with large number of family member is more involved in adopting wheat row planting technologies compared to those who had small family size.

Table 4. Results of the Binary Logit Model

Variable	Coef.	Robust std. Err.	Odds Ratio	Z	P >|Z|
Shh	-1.082773	.7740695	.3386551	-1.40	0.162
Fshh	1.071149***	.3009223	2.918731	3.56	0.000
Edul	.5395687	.6485468	1.715267	0.83	0.405
Accs	-2371016	.5979899	.7889111	-0.40	0.692
Exs	2.375314***	.8498978	10.75439	2.79	0.005
Pfvd	.7625531	.6445443	2.143742	1.18	0.237
Pitr	1.424203**	.6947744	4.154546	2.05	0.040
Tlu	3.113886***	.4858072	22.50833	6.41	0.000
Cls	.913891*	.5121935	2.494008	1.78	0.074
Dnm	-1.782325***	.4058353	.1682466	-4.39	0.000
_cons	-20.86014***	3..504534	8.72e-10	-5.95	0.000

*****, **** and ***** shows the significance level at 1%, 5% and 10% respectively.

Source: Own computation based on data (2023)

As shown in table 4, access to extension service was also another variable positively and significantly influencing wheat row planting technology at 1% level of significance. The odds ratio of 10.75 indicates that, the odds of adopting row planting technology is 10.75 times more likely for those farmers who involved in extension services comparing to their counterpart. This is so because, farmers having extension contact knows the source and possible benefit of row planting of wheat crop production and hence expected to be better adopters of row planting technology for wheat production. This result was similar to the findings of another studies in Ethiopia (Ayenew et al., 2020), in China (Gao, et al.2020) and in Nepal (Suvedi et al., 2017).

Participation in training also affects adoption of wheat row planting technology positively at 5% significance level. As shown in table 4, the odds ratio was 4.15, revealing that, the odds of being row planting technology adopter for farmers participating in training is 4.15 times greater than the odds of adopting row planting technology for those farmers who didn’t participate in training. When farmers participated in training a new practice, they can acquire and gained additional skills and knowledge which helps them to implement the new technology properly. This finding was consistent with the findings of other studies, Jeylan and Fentaw (2019) and Mentire and Gecho (2017), who concluded that participation in training affects wheat row planting technology adoption posistvelly significantly.

The other explanatory variable that had positive effect on adoption of wheat row planting technology at 1% significant level was tropical livestock unit. The odds ratio of 22.51 for tropical livestock unit implies that, the odds of being row planting technology adopter is 22.51 times more likely for those farmers who owned large number of tropical livestock unit (TLU) than farmers with small number of TLU. The main reasons are the farmers that have many TLU will have high wheat crop yields by using his/her oxen for plowing which made easy for them to participate in adopting wheat row planting technology. Therefore, the same relation has been found from other studies (Dinku and Beyene 2017) and (Leake and Adam 2015).
Furthermore, the total cultivated land size had positive and significant effect on technology adoption in wheat row planting at 10% significance level. As clearly indicated in table 4, the odds ratio of 2.49 shows that, for farmers with larger cultivated land size, the odds of adopting row planting technology is 2.4 times greater than, the odds of adopting row planting technology for farmers with small cultivated land size. This positive relation clearly showed that farmers owning more cultivated land size, had greater chance of participating in row planting technology adoption, since they mare produce more and earning more income so that easily accessing the wheat row planting technology. Therefore, the same relation has been found from other study (Abafita 2021).

The only significant variable influencing negatively and significantly wheat row planting technology adoption at 1% level was distance from the market center. Furthermore, the odds ratio from table 4 is 17 showing that, the odds of adopting row planting technology is 17 times less likely for farmers living far from the market center than their counter part. This is because when the farmers farm land is located far away from the market center, it is difficult to get easily agricultural inputs, lower chance to sell out their agricultural outputs and less information access about the row planting technology than their counter parts. As a result, farmer motivation to adopt wheat row planting technology would decline. Therefore, the same relation has been found from other study (Leake and Adam 2015).

4. Conclusion and Recommendation

4.1.Conclusions

This study results revealed that, some demographic characteristics of farming households, economic and institutional factors were the determinantal factors affecting row planting technology adoption in Womberma district. Accordingly, family size and livestock size in TLU, extension service, participation in training and cultivated land size were found to be factors influencing wheat row planting technology adoption positively and significantly. Contrary to this, distances to the nearest market center in km were found to have negatively influence on adoption of row planting technology on wheat production.

4.2.Recommendations

Based on the study results, the following recommendations which would be important for clear agricultural policy design particularly focusing on row planting technology adoption are forwarded:

Stakeholders must involve to arrange a short-term training in order to create awareness on row planting technology adoption on wheat production and also provision of appropriate and modernized extension services should be needed to improve the farmers' adoption of row planting technology on wheat production.

It is also recommended that the extension agent in collaboration with other concerned body must work to support those farmers with low socio-economic status by arranging credit for them to increase their total livestock unit so that increasing the tendency in adopting wheat row planting technology.

Furthermore, concerning bodies need to invest on improving rural road infrastructure and market access through development and maintenances of rural road networking that provide services all year round. Alternatively, emphasis should be given to strengthen the existing rural-urban infrastructure development to improve farmer's access to input and output markets.

Suggestions given to further research

The researcher also recommends that researchers must take in to considerations in conducting their research particularly focusing on row planting technology adoption. Despite the fact that some relevant socio-economic and other factors were included in this particular study, all variables under each factor not included due to time and budget constraints. Therefore, future studies conducted in this particular specific research area must include all variables related to row planting technology adoption. Furthermore, due to budget constraints, the total sample of this study only included 337 respondents. Besides, the scope of this study was also limited only focusing only in three kebeles in Womberma district but excluding other rural kebeles and thus future studies must include other rural kebeles with increasing representative samples in order to get further detailed results on factors affecting adoption of technology in wheat row planting.

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Appendix 1. Hosmer-Lemeshow Goodness of Fit Test

```
. estat gof,group(10)table
```

Logistic model for ahh, goodness-of-fit test

(Table collapsed on quantiles of estimated probabilities)

Group	Prob	Obs_1	Exp_1	Obs_0	Exp_0	Total
1	0.0000	0	0.0	35	35.0	35
2	0.0005	0	0.0	33	33.0	33
3	0.0015	0	0.0	34	34.0	34
4	0.0055	0	0.1	33	32.9	33
5	0.0228	1	0.4	34	34.6	35
6	0.2105	3	2.7	30	30.3	33
7	0.8877	19	19.0	14	14.0	33
8	0.9941	32	32.8	2	1.2	34
9	0.9997	34	33.9	0	0.1	34
10	1.0000	33	33.0	0	0.0	33

```
 number of observations =       337
       number of groups =        10
Hosmer-Lemeshow chi2(8) =         1.61
            Prob > chi2 =         0.9907
```

Appendix 2. Multicollinearity Test

```
. corr sehh fsize edul accrids acces partfv parttra tlu clh dnm
(obs=337)
```

	sehh	fsize	edul	accrids	acces	partfv	parttra	tlu	clh	dnm
sehh	1.0000									
fsize	0.0047	1.0000								
edul	-0.0031	0.0942	1.0000							
accrids	0.0811	0.1074	0.0537	1.0000						
acces	0.0065	0.0965	0.0557	-0.0142	1.0000					
partfv	-0.0362	0.2070	-0.0221	0.0616	-0.0355	1.0000				
parttra	0.0452	0.2621	0.0483	-0.0053	0.0726	0.2070	1.0000			
tlu	0.0948	0.4736	0.1898	0.1105	0.2030	0.1831	0.2814	1.0000		
clh	0.0303	0.2793	0.0501	0.0797	0.1149	0.1321	0.1877	0.3002	1.0000	
dnm	-0.0172	-0.3518	-0.0805	0.0178	-0.1523	-0.2310	-0.1809	-0.4034	-0.2997	1.0000

. vif

Variable	VIF	1/VIF
tlu	1.56	0.640317
fsize	1.41	0.709782
dnm	1.33	0.750281
clh	1.18	0.846221
parttra	1.15	0.869526
partfv	1.12	0.890427
acces	1.06	0.941130
edul	1.04	0.958021
accrids	1.04	0.960983
sehh	1.02	0.978356
Mean VIF	1.19	