Factors Influencing the Adoption of Barley Production Technology in Central Ethiopia, North Shoa Zone, *Amhara* Region

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Abstract

Barley is one of the most important cereal crops widely produced in the highland areas of Ethiopia. This study examined factors influencing the adoption of barely production technology in Ankober, Basona, and Angollela districts, in North Shoa Zone, Amhara Region. Nine barley producing rural *kebeles*, three from each study district, and a total of 812 respondents (604 males and 208 females) were selected randomly. To triangulate and explain the survey results, three focus group discussions each with 12 purposively selected participants (thus involving 36 participants in the three districts) were conducted. The data were analysed using multivariate probit model, descriptive statistics, opinion and concept analyses and interpretations. The study findings revealed that frequent ploughing, fertilizer and manure compost were commonly adopted by more than 50%; and herbicide, frequent weeding, improved barley seed varieties, and farm land drainage practices were adopted by less than 50% of the farm households. The joint adoption and rejection probability of all technologies and practices by all farmers were 2% and 5% respectively. Farmers' decisions of adoption of purchased technologies were influenced by factors external to farmers, and those are credit, input supply, extension and farmers' freedom of choosing technologies and preferences which need attention by policy- and decision-makers as well as by development practitioners.

Keywords: Barely production, Adoption, Influencing factor, North Shoa, agricultural technologies

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1. Introduction and Objectives

1.1. Introduction

Agriculture is a way of life that began around 10,000 years ago with the domestication and cultivation of barley, and was later followed by wheat production (Zohary and Hopf, 1993; Yusuf, et. al., 2011; Abimbola and Oluwakemi, 2013). Barley cultivation began from wild progenitors (*Hordeum spontaneum*) in the Fertile Crescent areas of the Near East (Zohary and Hopf 1993; Diamond 1998)). According to Atkins *et al.* (1998), Asfaw and Shiferaw (2010), FAO (2003) and World Bank (2011), agriculture was the basis for the early stages of human civilization; and it is still the most important sector for economic growth, food security, poverty reduction and rural development for less developed countries of the world (Datt and Ravallion, 1996). Hence, without adoption of improved agricultural technologies, improving the livelihoods of farm households via agricultural production remains a challenge for many developing countries. Adoption of improved agricultural technologies is thus critical to eradicating poverty, achieving food security, and improving rural people's quality of life. (Doss and Morris, 2001).

On the other hand, the characteristics of agricultural technologies and innovations, their profitability, the risks associated with them, the capital requirements, policies, and the socioeconomic characteristics of farmers are critical for adoption (Ajayi *et al.*, 2003). Improving crop productivity and crop technology can be an option for rural farmers to get rid of hunger and food insecurity by increasing production, reducing food price and making food more accessible to the poor (Just and Zilberman, 1988). Developing and promoting the adoption of high-yield crop varieties in a sustainable manner helps improve livelihood of rural farmers (Asfaw *et al.*, 2012). However, in sub-Saharan Africa, adoption of improved agricultural technologies remains low (Ogada *et al.*, 2010). According to Doss and Morris (2001) and Quisumbing and Pandolfelli (2010), agriculture in Africa, particularly in Sub-Saharan Africa, generates 33 percent of GDP on average. It is an important source of livelihood for the majority of rural people, since it provides around 72% of the employment in less developed countries and to 50% of the rural people worldwide (World Bank, 2007; FAO, 2011). However, the low productivity of agriculture creates a challenge on female farmers due to low access to land, market information, extension services, and credit compared to male farmers.

Agriculture in Ethiopia is dominant in terms of stimulating economic growth and development in the country (IMF, 2016). In Ethiopia, the majority of people rely on agriculture, especially on crops and livestock production (Dercon and Gollin, 2014). It provides employment for more than 85% of the people, and covers 50% of exports, and 47% of GDP. The growth and productivity of agriculture in the country is fundamental for the development of other sectors and for poverty alleviation and sustainable economic development. Adoption of improved technologies can improve agricultural productivity (Sahu and Das, 2015).

Low technology adoption, low use of improved farm inputs, traditional farming, and dependence on rain are the main bottlenecks for low performance of agriculture in Ethiopian (Lulit *et al.*, 2012). Barley is one of the five major cereal crops grown in Ethiopia. It is basically used as human food in the form of the various traditional recipes. The straw is used as animal feed, for house wall construction and roof thatching (McFarland *et al.*, 2014; Firdissa *et al.*, 2010). More than four million farm households cultivate barely on more than one million hectares of farmland (CSA, 2013). According to Bekele *et al.* (2005) and Yigezu, *et al.* (2015), barley is produced during *Meher* (the long rainy season) and *Belg* (small rainy season). In Ethiopia, barley production is lower than the global average due to low adoption of improved technologies, socioeconomic factors, credit, extension, agro-ecologies, institutions, policies, information, perception and farmers' risk aversion behaviours, market linkage, low value additions and chains, backwardness of technologies, and diminished cultivated land size (CSA, 2014; Aman and Tewodros, 2016).

In the study areas, some farmers adopted at least one improved technology for barley production. In addition, no previous study was conducted on factors affecting farmers' adoption of at least one technology for barley production. This study was conducted to identify factors influencing adoption of multiple barley technologies in three districts of North Shoa Zone, Amhara Region.

The conceptual framework for this study was developed as suggested by Svinicki (2010) and Miles and Huberman (1994), which outlines the key predictors and outcome variables (dependent variables) as well as their interaction and relationships as shown in the (Figure 1).

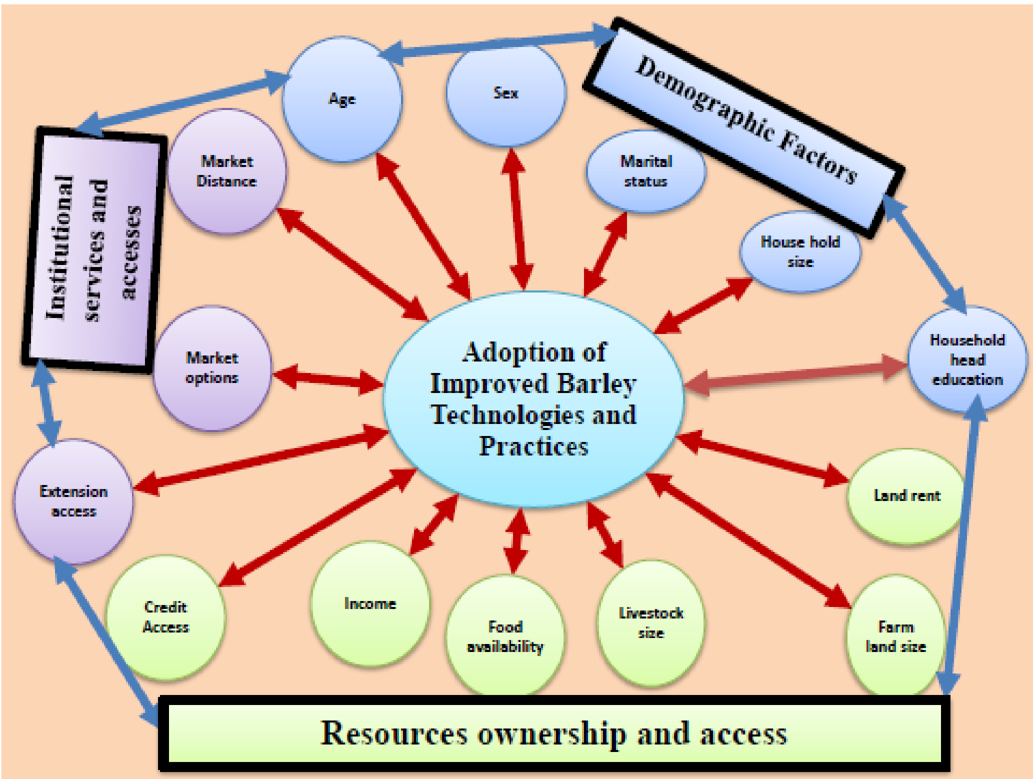

Figure1. Conceptual framework of the study

Source: *Researcher's drawing based on understanding of the conceptual literature*

The Framework assumes that farmers' adoption of improved barely technologies and practices is influenced by a complex bi-directional interaction of demographic factors, household head education level, resource ownership, extension services, and institutional services, all of which have specific observable predictor variables that directly influence adoption of improved technologies and practices.

2. The Study Area and Research Methods

2.1. The Study Area

This study was conducted in Ankober, Basona Worena and Angollela Tera districts, North Shoa Zone, Amhara Region located in the central highlands of Ethiopia (Figure 2). The districts for this study were selected purposively based on accessibility, barley production potential, presence of barley technologies and practices, and the available research budget. In this study, a total of nine barley producing *kebeles*, three rural *kebeles* from each of the three study districts, were randomly selected. Farmers in the study areas used one or more type of recommended and improved technologies and practices in their barley production, although some farmers produced barley without using recommended improved technologies and practices, called non-adopters.

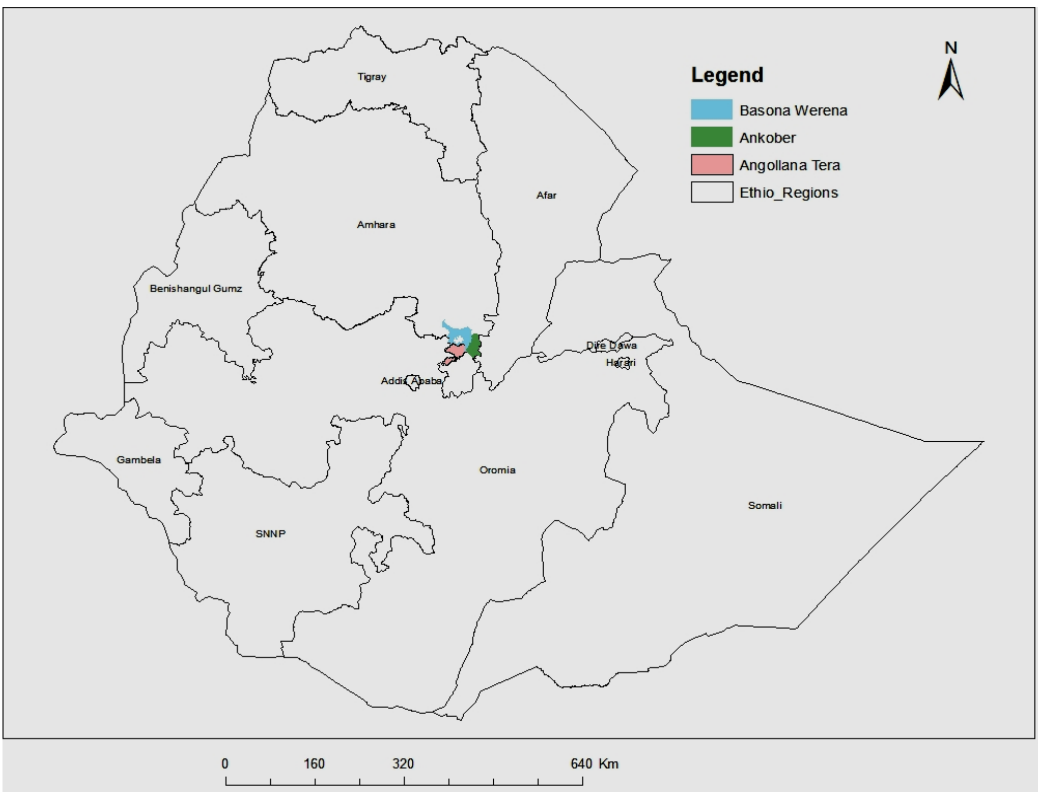

Figure 2. The map of the study area

2.2. Farmland Use in the Study Area

Official reports from the North Shoa Zone Agriculture Office and those of the districts indicate that out of 209,564 ha of total land area, the farmland occupies 48%, grazing land 18%, forest 28%, and others 6%. Out of (100, 590.72 ha) total farm land, 66% was used for cereal crop production, 31% for pulse crop production, 1.7% for oil crop production, and 1.3% for vegetable production. Much of the farmland in the study area was, thus, used for cereal crops production, followed by pulse crops production. Furthermore, out of the total farm land (100,590.72ha) used for cereal crops production (50,194.77ha), 49.9% was allocated for barley production, followed by wheat production (31,786.67ha), 31.6% and the other cereal crops cover (18,106.33ha), 18.6% of the total farm land area. These indicate that barley and wheat together cover 80.50% of the total farm land in the study area.

2.3. The human and livestock population

2.3.1. The human population

The human population in the study area is summarized in Table 1 by study district and by rural and urban dwellers (CSA 2013).

Table1. Human population in the study area

Study Districts' Human Population						
Human population		**Ankober**	**Angollela Tera**	**Basona Worena**	**Total**	
					Number	**%**
Rural	Male	42,173 *(26.76%)*	45,017 *(28.56%)*	70,420 *(44.68%)*	157,610 *(100%)*	-
	Female	41,112 *(26.95%)*	43,577 *(28.58%)*	67,844 *(44.48%)*	152,533 *(100%)*	-
	Total	**83,285** ***(26.85%)***	**88,594** ***(28.56%)***	**138,264** ***(44.58%)***	**310,143** ***(100%)***	**94%**
Urban	Male	3,679 *(39.05%)*	4,724 *(50.14%)*	1,019 *(10.51%)*	9,422 *(100%)*	-
	Female	3,985 *(39.11%)*	5,100 *(50.06%)*	1,103 *(10.83%)*	10,188 *(100%)*	-

	Total	**7,664** ***(39%)***	**9,824** ***(50%)***	**2,122** ***(11%)***	**19,610** ***(100%)***	**6%**
Total	Male	45,852 *(27.45%)*	49,741 *(29.78%)*	71,439 *(42.77%)*	167,032 *(100%)*	-
	Female	45,097 *(27.715%)*	48,677 *(29.915%)*	68,947 *(42.37%)*	162,721 *(100%)*	-
	Total Human Populat ion	**90,949** ***(27.58%)***	**98,418** ***(29.85%)***	**140,386** ***(42.57%)***	**329,753** ***(100%)***	**100%**

Source: CSA (2013) population projection for 2017

As indicated in Table1, the rural population in the study area was 310,143, out of which, 26.85% lived in *Ankober*, 28.56% in *Angollela Tera* and the rest (44.58%) in *Basona Worena* District. In addition, out of the 329,753 total population, 94% were rural dwellers, and only 6% were urban dwellers (Table1).

2.3. 2. The livestock Population

The types of livestock in the study area includes cattle, sheep and goat, chicken/poultry, equine/pack animals, such as horse, mule and donkey, as well as honey bee colonies counted in hive. Table 2 summarizes the types of livestock by the study districts.

Table2. The livestock population of the study districts

No.	**Livestock type**	**Livestock population by district**				
		Ankober	**Angollela Tera**	**Basona Worena**	**Total**	
					Number	**%**
1	Cattle	62,940 *(23.61%)*	111,061 *(41.66%)*	92,592 *(34.73%)*	**266,593** ***(100%)***	**26.80%**
2	Sheep and goats	90,215 *(25.48%)*	129,480 *(36.57%)*	134,381 *(37.95%)*	**354,076** ***(100%)***	**35.60%**
3	Equine/pack animals (mules, horses and donkeys)	10,456 *(12.33%)*	42, 429 *(50. 05%)*	31, 884 *(37.61%)*	**84,769** ***(100%)***	**8.52%**

4	Chicken/ poultry	62,300 *(22.58%)*	97,019 *(35.16%)*	116, 629 *(42.26%)*	**275948** ***(100%)***	**27.74%**
5	Honey bee colonies in bee-hive	5,518 *(41.11%)*	1,758 *(13.10%)*	6, 146 *(45.79%)*	**13,422** ***(100%)***	**1.34%**
Total		**231429** ***(23.26%)***	**381747** ***(38.37%)***	**381632** ***(38.36%)***	**994808** ***(100%)***	**100%**

Source: Offices of Agriculture of the study districts

As shown in Table 2, the population of sheep and goats is the largest population (35.60%), followed by chicken/poultry (27.74%), cattle (26.80%), and equine/pack animals (8.52%). In the study areas, livestock play vital roles in farm households' income and food security, as well as, in the general livelihoods of farm households as confirmed by results from focus group discussions. Livestock are also the major source of farm power for farming (oxen for ploughing), transportation services (pack animals for human and agricultural products transportation services).

2.4. Sampling, Data Collection, and Analysis

Sample selection methods used in this study were both random and purpose sampling. A total of 812 respondents (604 male and 208 female) were randomly selected for the cross-sectional quantitative survey that was conducted around 2015. Qualitative data was collected by conducting three focus group discussions (FGDs) each with 12 participants and one per a study district. The FGDs enabled the researchers to capture farmers' opinions and perceptions towards adopting multiple improved barley technologies.

Secondary data were also collected from respective study District offices of agriculture, administration offices, farmers' cooperative offices, and from Central Statistical Agency/CSA (2013).

2.5. Data Analysis

The quantitative data was analysed using descriptive statistics (mean, frequency, percentage, standard deviation (SD) and coefficient of variation (CV); and econometrics model (multivariate probit model), while narratives from the qualitative data were used to elaborate and explain results and concepts from the quantitative strand. The analyses focused on a list of hypothesized predictors that were expected to affect adoption of barley technologies (Table 3).

Table 3. List of hypothesized predictors expected to affect farmers' adoption of barley technologies

No.	Predictors hypothesized to affect barley technologies adoption	Continuous/or Non-continuous (Dummy)	Expected Coef. sign
1	Household head age in years	Continuous	-
2	Household's Livestock size in TLU	"	+
3	Household's farm land size in Ha	"	+
4	Household size in Adult Equivalent	"	-
5	Household's home distance from market in Km	"	-
6	HH head formal education in years of schooling	"	+
7	Household head sex	Non-continuous	-
8	Household's income status	"	+
9	Household's credit access	"	+
10	HH's access to agricultural extension service	"	+
11	Household's food availability status	"	+
12	HH's participation in barley output markets	"	+
13	HH's participation in land rent-in practice	"	+

Source: Researcher's compilation

In this study, multivariate probit model was employed to test the association between multiple dependent variables and independent variables (predictors). The multiple dependent variables include adoption of fertilizer, compost, weedicide, frequency of ploughing, frequency of weeding, improved barley seed varieties, and land drainage practice. If farm households in the study area adopt one or more among these improved technologies, the farm households are called as adopter and they are represented by (1); otherwise, non-adopter and they are represented by (0) in the multivariate probit model analysis used in this study.

The independent variables used in this study were those expected to influence the farm households' adoption decision. The independent variables , which were hypothesized to have significant association with any of the above-mentioned dependent variable/variables, are summarized in Table 3.

2.5. Model Specification

In the Model, the researchers assumed that households' specific variables that included age, farm experience, gender and income were important factors influencing farmers' decision to adopt the new technology (Feder and Zilberman, 1985). To analyse determinants affecting adoption of multiple improved technologies in barley production, as suggested by Teklewold *et al.*, (2013), multivariate probit model was employed. The multivariate probit model, for observation "i" and equation "j", is specified as:

$$Y_{ij}^{*} = X_i \beta_j + u_{ij} \quad \text{...} \quad (1)$$

$$Y_{ij} = 1(Y_{ij}^{*} > 0) \quad \text{...} \quad (2)$$

$$U_i = [, \ldots, U_{iM}] \sim MVN(O, R) \text{ or} Y_i^{*} = [Y_{i1}, , Y_{iM}] \sim MVN(X_i B, R) \quad \text{...........} \quad (3)$$

Where i=1,... , N indexes observations, j=1,... , M indexes outcomes, X_i is a K---vector of exogenous covariates, the U_i is assumed to be independent across i, but correlated across j for any i, and "MVN" denotes the multivariate normal distribution. (Henceforth, the "i" subscripts will be suppressed). The standard normalization sets the diagonal elements of R equal to 1 so that R is a correlation matrix with off---diagonal elements ρ_{pq}, $\{pq\} \epsilon = \{1, \ldots, M\}$, p≠q·[2] With standard full rank conditions on the X's and each $|\rho_{pq}| < 1$, then B = $[\beta_{1,\ldots\ldots,}\beta_M]$ and R will be identified and estimable with sufficient sample variation in the x's.

3. Results and Discussion

3.1. Descriptive Statistics

3.1.1. Demographic and socio-economic characteristics of the respondents

The total sample size for this study was (812) participants, which include 604(74.40%) male and 208 (25.60 %) female. The demographic and socio-economic characteristics of the sample households are summarized in Table 4.

Table 4. Frequency and percentage (%) of sample households' characteristics

Characteristics		**Districts**			
		Ankober	**Basona**	**Angollela**	**Total**
Gender (Sex) by District	Male	208 *(77.00)*	191 *(70.22)*	205 *(75.93)*	604 *(74.40)*
	Female	62 *(23.00)*	81 *(29.78)*	65 *(24.07)*	208 *(25.60)*
	Total	***270 (100)***	***272 (100)***	***270 (100)***	***812 (100)***
Household Size	1-3HH size	45 *(16.67)*	89 *(32.72)*	82 *(30.37)*	216 *(27.00)*
	4-6HH size	151 *(55.93)*	139 *(51.10)*	151 *(55.93)*	641 *(54.00)*
	7 and above	74 *(27.40)*	44 *(16.18)*	37*(13.70)*	155 *(19.00)*
	Total	***270 (100)***	***272 (100)***	***270 (100)***	***812 (100)***
Marital Status	Married	199 *(33.90)*	179 *(30.49)*	209 *(5.60)*	587 *(72.29)*
	Unmarried	8 *(22.86)*	17 *(48.57)*	10 *(28.57)*	35 *(4.31)*
	Divorced	16 *(21.92)*	40 *(54.79)*	17 *(23.29)*	73 *(9.00)*
	Widow/er	47 *(40.17)*	36 *(30.77)*	34 *(29.06)*	117 *(14.40)*
	Total	***270 (33.25)***	***272 (33.50)***	***270 (3.25)***	***812 (100)***
Educational status	Illiterate	143 *(33.26)*	144 *(33.49)*	143 *(33.26)*	430 *(53.00)*
	Read and write	56 *(33.00)*	59 *(34.00)*	56 *(33.00)*	171 *(21.00)*
	Formal education	71 *(33.65)*	69 *(32.70)*	71*(33.65)*	211 *(26.00)*
	Total	***270 (33.25)***	***272 (33.50)***	***270 (3.25)***	***812(100)***
Ownership of ploughing oxen	No oxen	39 *(31.20)*	57 *(45.60)*	29 *(23.20)*	125 *(15.40)*
	One ox	49 *(49.98)*	38 *(33.33)*	27 *(23.68)*	114 *(14.00)*
	two oxen	165 *(35.03)*	139 *(29.51)*	167 *(5.46)*	471*(58.00)*
	Three and above	17 *(16.67)*	38 *(37.25)*	47 *(46.08)*	102*(12.60)*
	Total	***270 (33.25)***	***272 (33.50)***	***270 (33.25)***	***812 (100.00)***

Mean and Std. Dev. results of the household characteristics

Characteristics	**Estimation**	**Ankober**	**Basona**	**Angollela**	**Mean total**	**CV**
Age (in years)	Mean	55.19	48.50	48.64	50.77	**27.18**
	Std. Dev.	14.52	13.14	12.65	13.80	
Formal education (years)	Mean	1.14	1.72	0.95	2.50	**51.00**
	Std. Dev.	2.52	2.67	2.21	1.27	
Farm land size (ha)	Mean	0.38	0.90	1.02	0.76	**74.08**
	Std. Dev.	0.25	0.61	0.53	0.56	
Grazing land (ha)	Mean	0.13	0.17	0.43	0.25	
	Std. Dev	0.11	0.20	0.34	0.21	**87.35**
Livestock (TLU)	Mean	5.37	6.36	7.06	6.27	
	Std. Dev.	3.08	4.45	4.25	4.03	**64.35**
Household size (Adult equiv.)	Mean	3.93	4.27	4.14	4.11	**41.25**
	Std. Dev.	1.58	1.76	1.73	1.70	

Source: Survey data (2015)

Sample respondents selected for this study have multiple demographic and socio-economic characteristics, mainly age, education, marital status, household size, and resource ownership. As indicated in Table 4, the Coefficient of Variation (CV) values showed that there are variations among respondents age (years), formal education (years), farmland size (Ha), grazing land size (Ha), livestock size (TLU), and household size (in Adult Equivalent).

3.1.2. Adoption of Improved Barley Technologies

In this study, sample farm households varied in their adoption by the number of improved barley technologies and practices as indicated in Table 5. Out of the total respondents, 738 (90.89%) were adopters of one or more improved agricultural technologies in their barley production (Table 5). The rest 74 (9.11%) were non-adopters. The number of adopters of more than one technology was the highest in Basona compared to the other two study districts. In all of the study sites, larger numbers of farm households adopted 3 - 5 technologies.

Table 5. Barley technologies adopted and adopters by districts

No.	Number of barley technologies adopted by farm households	Number of adopters of improved barley technologies			
		Ankober	***Basona***	***Angolela***	***Total adopters N (%)***
1	One –technology adopters	14	10	16	40 *(4.9)*
2	Two –technologies adopters	25	27	48	100 *(12.3)*
3	Three technologies adopters	38	57	38	133 *(16.4)*
4	Four-technologies adopters	64	69	45	178 *(21.9)*
5	Five-technologies adopters	41	31	46	118 *(14.5)*
6	Six-technologies adopters	30	24	37	91 *(11.2)*
7	Seven and above-improved barley technologies adopters	19	41	18	78 *(9.6)*
Total adopters by study district		231	259	248	738 *(90.89)*
Total non-adopters by study district		39	13	22	74 *(9.11)*
	Total	270	272	270	812 *(100)*

Source: Computed from the household survey data

3.1.3. Adoption of multiple barley technologies and adopters' characteristics

In this study, adoption of multiple barley technologies and practices, including ploughing the farm land at least three times, fertilizer adoption, manure compost adoption, two or more rounds of hand weeding, weedicide adoption, barley farm land draining practice, use of improved barley seed varieties, summarized in (Table 6 and Appendix Table 1), were employed as dependent variables to analyze the number and types of improved barley technologies and practices.

In this study, the number/proportion of adopters is summarized by the adopters' sex (Gender) and study districts. As a result, ploughing the field at least three times is adopted by the larger number/proportion of farm households as compared to the other improved barley technologies and practices, followed by fertilizer adopters, manure compost use, frequent hand weeding, weedicide use, farm land drainage practice adopters and by improved barley seed varieties adopters number/proportion.

Table 6. Improved agricultural technologies adopted by barley producers

Improved barley technologies and practices	**Adopters by gender**			**Adopters by study district**		
	Male	***Female***	***Total***	***Ankober***	***Basona***	***Angollela***
Ploughing the land at least three times	450 (75.50)	146 (24.50)	596 (100)	193 (32.38)	226 (37.92)	177 (29.70)
Fertilizer adoption	441 (75.64)	142 (24.36)	583 (100)	136 (23.33)	210 (36.02)	237 (40.65)
Manure compost adoption	348 (76.82)	105 (23.18)	453 (100)	131 (28.92)	193 (42.60)	129 (28.48)
Two or more hand weeding	278 (72.80)	104 (27.22)	382 (100)	169 (44.24)	121 (31.68)	92 (24.08)
Weedicide	259 (75.51)	84 (24.49)	343 (100)	145 (42.28)	125 (36.44)	73 (21.28)
Barley farm land drainage practice	172 (71.13)	51 (22.87%)	223 (100)	33 (14.80)	63 (28.20)	127 (57.00)

Improved barley seed adoption	123 (76.88)	37 (23.125)	160 (100)	49 (30.63)	73 (45.63)	38 (23.75)

*Figures in brackets are percentage values

Adoption of improved barley technologies showed variation with sex (gender), district, extension contacts and farm households' perception level (Table 7). Results from the FGDs confirmed that farmers' adoption practices were influenced by different socio-economic, environment and technology-related characteristics, such as respondents' resource ownership, demographic factors, the accessibility, quality, quantity, and prices of improved barley technologies and practices, and credit service.

Table 7. Adopters and non-adopters' sample HHs' characteristics

Respondents' characteristics and their distribution		**Number and percent (%) of respondents**		
		Total	***Adopters***	***Non-adopters***
Gender (Sex)	Male	604	552	52
	Female	208	186	22
	Total	**812 (100)**	**738 (90.89)**	**74 (9.11)**
District	Ankober	270	231	39
	Basona	272	259	13
	Angollela	270	248	22
	Total	**812 (100%)**	**738 (90.90)**	**74 (9.11)**
Farmers' perception of extension services	Low	196	169	27
	Medium	53	43	10
	High	563	526	37
	Total	**812 (100)**	**738 (90.87)**	**74 (9.11)**
Contacts with extension worker	No contact	72	54	18
	Once/month	626	577	49
	Twice/month	103	98	5
	≥Thrice/month	11	9	2
	Total	**812 (100)**	**738 (90.90)**	**74 (9.11)**

*Figures in brackets are percentage values

As indicated in Table 7, the proportion of male adopters is higher than the proportion of female adopters. In Basona district, higher number of farm households adopted barely technologies followed by farmers in Angollela and Ankober districts. High proportion of adopters had high positive perception towards extension service and thus more frequent contact with extension agents. Male farm households have better opportunities to adopt improved barley technologies and practices as compared to female farm households. It is deduced that farm households' favourable perception and good attitude towards extension service and extension contacts has played a conducive and facilitation role for higher level of adoption of improved barley technologies and practices (Table7).

3.2. Determinants of adoption of improved technologies in barley production

The result of multivariate probit model analysis showed that, among 13 predictors considered in this study, the two predictors, which include (farm household's level of formal education and land rent-in participation) did not show significant association with dependent variables (see Appendix Table2). The remaining 11 predictors showed significant association with at least one dependent variable. The dependent variable "fertilizer adoption" showed positive associations with predictors (farm land size, income status, and access to agricultural extension service) as was hypothesized and it was affected those predictors at 1% significance level, and at 5% significance level by participation in barley selling options. These findings were in line with the findings of Akudugu *et al.* (2012), and Ghimire *et al.* (2015). However, disagree with the findings of Mengistu *et al.* (2016), Lugandu (2013), and Awotide *et al.* (2013).

The dependent variable "compost adoption" showed positive association with the predictors (household sex, food availability status, income status, credit service, extension service, and households' participation in barley produce selling options) as was predicted and it was affected at 10%, 5%, 10%, 5%, 5% and 1% significance levels, respectively. However, market distance, measured in Km, showed negative association with compost adoption as was presumed and it was affected at 1% significance level. These findings showed consistency with the findings of Ghimire *et al.*

(2015), Lugandu (2013), Awotide *et al.* (2013), Mengistu *et al.* (2016), Sisay (2016), and Bahadur and Siegfried (2004).

The dependent variable, “weedicide adoption” was associated positively with the predictors credit access, extension service, and participation in barley selling options as was hypothesized and it was affected at 5%, 1% and 1% significance levels, respectively. However, contrary to what was hypothesized, weedicide adoption showed negative and significant association with farm land size (Ha), at 5% significance level. These findings agreed with the findings of Ghimire, *et al.* (2015); Mengistu *et al.* (2016), Lugandu (2013), Awotide *et al.* (2013), although the predictor, farm land size showed inconsistence with the findings of Akudugu *et al.* (2012), Mariano, *et al.* (2012), and Ghimire *et al.* (2015).

The dependent variable, “frequent (at least three times) ploughing of barley farmland” showed positive associations with predictors (livestock size in TLU, households’ income status, credit service, extension service and farm households’ participation in barley output selling options) and was affected at 5%, 5%, 5%, 1% and 1% significance levels, respectively. These results are consistent with the findings of Ghimire, *et al.* (2015), Simtowe, *et al.* (2016), Sisay (2016), Mignouna, *et al.* (2011), Mmbando and Baiyegunhi (2016), Toma *et al.* (2016); and Mengistu, *et al.* (2016).

The dependent variable “adoption of frequent hand weeding of barley (two or more times) practice”, showed negative significant association with the predictors (household head’s age and farm land size) and it was affected at 5% and 1% level, respectively. However, it showed positive and significant associations with credit access and HHs’ participation in barley selling options at 5% and 1% significance levels, respectively. The negative association of farm land size with adoption of frequent (two or more times) hand weeding of barley fields was unexpected. That negative association may be due to labour scarcity to practice frequent hand weeding on large farm lands. These findings were in line with the findings of Akudugu *et al.* (2012), Mariano *et al.* (2012), Yishak and Punjabi (2011), Ghimire *et al.* (2015), Mengistu *et al.* (2016), Lugandu (2013), Awotide *et al.* (2013).

Adoption of improved barley seed varieties was negatively and significantly associated with household size in adult equivalent at 5% significance level, but showed positive significant association with credit access and households' participation in barley output selling options at 1% level of significance level with each of these predictors. These findings showed consistency with the findings of Akudugu *et al.* (2012), Ghimire *et al.* (2015), Ombe *et al.* (2014), Ogada, *et al.* (2014), Iheke and Nwaru (2013), and Mariano *et al.* (2012). but the results, however, disagreed with the finding of Martey, *et al.* (2014). Furthermore, adoption of barley farm land drainage practice, was associated positively with livestock size, farm land size, household size, agricultural extension service, and households' participation in barley output selling options at 1%, 5%,, 10%, 1% and 1% significance levels, respectively. However, contrary to what was assumed, adoption of barley farm land drainage practice was negatively associated with credit access at 1% significance level. That negative association of adoption of barley farm land drainage practice with credit access may be due to high interest rate of credit and farmers' desire to averse the risk of taking credit in a group. Except credit access, the results about the association of adoption of barley farm land drainage practice with the other predictors were in with the findings of Ghimire *et al.* (2015), Aman and Tewodros (2016), Simtowe *et al.* (2016), Leake and Adam (2015), and Berihun *et al.* (2014). But, the positive association of farm land with drainage practice disagreed with the findings of Mengistu *et al.* (2016), Lugandu (2013), and Awotide *et al.* (2013).

The likelihood estimation on adoption of multiple barley technologies, including adoption of improved practices, assumed to improve the production and productivity of barley, and thereby, improve the livelihoods, including income and food security, of farm households.

The different barley technologies and improved practices adopted by farm households in the study area include frequent (at least three times) ploughing of barley farm land, fertilizer, compost, weedicide, frequent hand weeding, barley farm land drainage, and improved barley seed varieties. Among these technologies and practices, adoption of frequent ploughing of barley farm land, fertilizer, and compost were 74%, 72% and 56%, respectively. On the other hand, the likelihood adoption estimation of frequent hand weeding, weedicide, barley farm land drainage and improved barley seed were 47%, 42%, 28% and 20% (see Appendix Table 3). These findings of the present study were in line with the findings of Beyan (2016) which indicated that the likelihoods estimation of adopters to adopt soil conservation practices, improved seed, line planting and fertilizer ranged between 61% and 80%. The likelihoods of barley technologies estimation in this study range from 20% to 74% (Appendix Table 3). Furthermore, the likelihood estimation of the joint adoption and the joint rejection of improved barley technologies and practices in this study were 22.8% and 36%, respectively (Appendix Table 3).

4. Conclusions and Recommendations

4.1. Conclusions

Farmers in the study area adopt different technologies and practices to increase barley production and, thereby, improve their food security and income. In this study, the majority of the respondents adopted at least one improved barely production technology or practice. Larger proportions of farm households in the study districts adopt four different types of improved barley technologies and practices to maximize their barley production.

However, adoption still remains low. Extension workers, cooperatives and input supplier organizations and institutions (governmental and non-governmental) are engaged in efforts to promote barley technologies and practices.

4.1. Recommendations

Drawing on the findings of the study, the authors make the following recommendations. As adoption of barely technologies proved beneficial in many ways, such as improving income and food security, and poverty alleviation and improve overall livelihoods of farm households, there is need to promote and support adoption and utilization of appropriate improved barley technologies and practices. The concerned governmental and non-governmental organizations have to improve availability and provision of services such as credit, extension, and market access.

Acknowledgements

This article is part of the first author's PhD thesis. The budget for this study was obtained from the International Centre for Agricultural Research in the Dry Areas (ICARDA). The authors duly acknowledge the assistance of Dr. Seid Ahmed (ICARDA) to secure the fund for this study.

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Appendix Table 1. Summary of the types of improved barley technologies by adopters and non-adopters, by study districts, and respondents' sex

No.	Improved technologies and practices in barley production	District			Gender		Respondents by adoption behaviour: Total adopters		Total non-adopters		Total respondents (both adopters and non-adopters)
		Ankober	Basona	Angollela	Male	Female	Number	% from total respondents	Number	% from total respondents	
1	Ploughing with oxen at least three times	193	226	177	454	146	600	73.89%	212	26.11%	812 (100%)
2	Fertilizer adoption	136	210	237	441	142	583	71.80%	229	28.20%	812 (100%)
3	Manure compost adoption	131	193	129	348	105	453	55.79%	359	44.21%	812 (100%)
4	Weedicide	145	125	73	259	84	382	47.04%	430	52.96%	812 (100%)
5	Two or more times hand weeding	169	121	92	278	104	343	42.24%	469	57.76%	812 (100%)
6	Barley farm land drainage practice	33	63	127	172	51	223	27.46%	589	72.54%	812 (100%)
7	Improved barley seed adoption	49	73	38	123	37	160	19.70%	652	80.30%	812 (100%)

Source: Survey data (2015)