The Dynamics of the Central Ethiopian Farming Systems

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Foreword

In GTP II, agriculture has been indicated as one of the economic sectors that continued to be the main source of economic growth. When we refer to agriculture, it encompasses several sub-components, out of which farming is the biggest one and sub-set of the sector. Farming in turn is not just a single entity, but it includes individual farming system components and intertwined activities with similar resource bases, patterns and constraints. In broader context, a farming system is inclusive of biophysical and socio-economic perspectives, such as farm households, crops and livestock systems and natural resources, which transform key resources (land, labor and capital) into usable products.

For a number of reasons, farming system is in a state of change over time. In parts of Ethiopia, there are cases where agricultural production is declining because of frequent drought while in another case productivity is increasing in response to improved technologies. Either positive or negative changes are also evident in the status of natural resources.

Generation, dissemination and use of diverse agricultural technologies is increasing from time-to-time which is largely expected to have influence on farming systems. There are also other factors that influence changes on the linkages of farming systems components and effects on rural livelihoods. Availing information on these change factors and the way farming system components are changing helps as inputs to future research design and policy considerations. In an attempt to generate this plausible information, Agricultural Economics Directorate of Ethiopian Institute of Agricultural Research (EIAR) designed a "Farming Systems Characterization and Dynamism Project", to assess and analyze the way the farming systems components are changing over time and identify the factors that influenced the changes.

The vast range of the findings has been presented in this research report, which has also highlighted a number of factors that have influenced changes to farming systems components. In the study, 87% of the farming households have witnessed introduction, dissemination and use of improved crops, livestock and natural resource technologies to positively influence changes to farming systems. It was further provided that many of the low productive local varieties have been replaced with high productive improved ones while the vast large area of farm land that used to be covered with low productive local varieties have been replaced by improved ones.

In the livestock sector, the research report presents that better productive crossbred cows have replaced low productive local cows. Even though still very less, 19% of the rural households have already owned crossbred cows. Because of promotion of NRM technologies, improved soil and water conservation practices have also made good progresses in positively influencing farming systems.

Apart from agriculture-based technologies, the research report has also revealed other factors that played substantial roles in contributing to changes in farming systems. For instance, 80% of the farming households have witnessed expansion of public infrastructure to influence rural livelihoods and the way the farming systems has appeared now. Schools have expanded in rural areas providing literacy for 73% of rural households and ample education opportunities to rural male and female children. The findings have also if expansion of vehicle roads and provision of better transportation services played key roles in urban-rural interface.

The research report has also indicated access of rural households to communication media and its contribution in technology use and easy access to information. It was witnessed that 67% of the rural household heads had access to mobile phones that largely boosted their market orientation and bargaining power. Many of the farming households have started producing for markets and even some of them are on the way of growing to semi-commercial farms.

The study has also revealed some factors that have imposed negative effects to the farming systems. For instance, climate change, which effects to frequent drought and consequent occurrences of new pests and diseases has appeared to affect the farming systems negatively. The growth of human population and inability of creating new jobs for the large numbers of unemployed youth has appeared to be a threat on the environment, which could turn forests, grazing, and reserve lands to farmlands and unproductive avenues. Expansion of new crop varieties has also deteriorated bio-diversity that used to be characterized with diverse types of local plant flora and fauna.

Overall, the research report provides diverse information on farming systems components and the way they are evolving over time. It also provides some key recommendations to reinforce positive influences and minimize negative effects to the farming systems components and the environment.

I hope the findings in the research report will provide research directorates in the institute and other development partners' useful information and inputs that help design agricultural technologies, improved practices and innovations for sustained food security and economic growth.

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Executive summary

Nowadays, biophysical and socio-economic determinants of farming system are in a state of rapid change. Natural resources are depleting from time to time and climate change is a current big issue in the field of agriculture. Science and technology is also growing from time to time at alarming rate. These technologies and many other factors are believed to influence changes to the existing farming systems at different dimensions and extents. However, there is no adequately documented and up-to-date information illustrating dynamism of farming systems over time. The general objective of the study was to explore and characterize the changes of farming systems over time and identify the factors that contributed for the change especially in the highland agro-ecology. The study was conducted in the central highland agro-ecology through interviewing 1074 randomly selected households (96 were female headed households - FHH) selected from 8 zones and 16 districts.

According to the findings, 95% of the sample households have perceived that farming systems changes are evident in the highlands that were either positive contributing to growth of agriculture and farmers' livelihoods or negative affecting the environment. As recognized by 82% of the households, substantial changes in the farming systems have taken place especially in the recent decade. This was largely associated with massive government interventions on agriculture sector through designing and implementing GTP, AGP and other programs, and climate change. Tens of driving factors to changes in farming systems were identified in the study. As perceived by 87% of the households, the major factor that has influenced changes to farming systems was identified to be introduction, promotion and dissemination of agricultural technologies including crops, livestock, natural resources and others. Other major driving factors included expansion of public infrastructures, such as schools (80%), roads and transportation (76%), health centers, potable water points, rural electrification, communication media (e.g. mobile phone) (74%) and others. Farmers' use of transportation services and market participation has also influenced positive changes to farming systems. Climate change, human, and livestock population growth haveimposed threats to the environment.

As the major driving factors, various technologies have been adopted despite the extent varies from one type of technology to another. For instance, among cereals, adoption rate of improved wheat varieties was 77%, maize (74%), tef (50%) and barley (47%). Among pulses, adoption rate of lentil was 71%, chickpea (49%) and field pea (29%). In the highland agro-ecology, 24% of the farmers have also adopted improved varieties of linseed. On the aspect of dynamism, nearly 90% of highland households started adopting of improved varieties of various crops mainly in the last decade while others before a decade. Adoption of inorganic fertilizer on crops was in the range of 22% – 94% while crop protection chemicals in the range of 27– 92%. Row planting adopters was 6% for tef, 18% for wheat and 19% for barley. Overall, nearly 50% of the highland households have adopted improved crop technologies. This implies that another 50% of the farming community have not yet adopted the use of improved technologies. According to 57% of the households, the major factor that restricted crop

technology adoption was limited availability of improved variety seeds while the other factor was unstable performance of improved varieties compared to locals. Other factors were economic reasons, such as limited affordability of packages of technologies. Among the livestock technologies, adoption rate of crossbred cows were 19% and improved forage varieties (12%). Adoption rate of water harvesting structures in the highlands was 8%. Overall, women (married and FHH) and youth had limited access to technology use and capacity enhancing opportunities.

Climate change (drought) was also evidently occurring in the highlands, because of which farmers are using various coping mechanisms, such as asset depletion (40%), borrow money (25%), and engage in IGAs (20%) and others. Adaptation mechanisms included changing variety type (61%), adjusting planting time (55%) and many others. Women were more affected with climate change than men.

In spite of all that technology adoption and development interventions, 33% of the highland households (36% for male-headed households and 46% for female-headed households) were still food insecure. The major problems in the farming systems were identified to be limited integration of different farming systems components, inadequate and unsustainable supply of improved technologies and many others.

Introduction

Although agriculture is a broad sector encompassing several activities, farming is one of the biggest activities and sub-set of the agriculture sector. Farming is a system rather than a single entity, which is continuously changing depending on the technological advancement (Schiere *et al*, 1999). The working definition of farming system is contextual and depends on the point of analysis. According to Dixon *et al* (2001) a farming system is defined as "a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate". Similarly, Pasquet (2007) defined the farming system as "a group of intertwined activities and lines of production that a farmer and farm household conduct according to their objectives and needs, depending on changing environmental, economic, technical and cultural conditions and constraints". Moreover, Fresco and Westphal (1988) have defined farming systems as a decision-making unit comprising the farm household, cropping and livestock system that transform land, capital and labor into useful products that can be consumed or sold. Lal and Millar (1990) have also defined farming systems as a resource management strategy to achieve economic and sustained production to meet diverse requirement to farm household while presenting resource bases and maintaining a high-level environmental quality. They interact adequately with environment without dislocating the ecological and socio-economic balance on the one hand and attempt to meet the national goal on the other. Therefore, almost all of the definitions share commonalities in that farming system is a complex interrelated matrix of different natural, environmental and social components. The system is intertwined in such a way that the product of one enterprise is an input for another.

Biophysical dimensions like soil nutrient and water balance, and socio-economic aspects such as gender, food security and profitability are also taken in to consideration in the farming system approach (Dixon *et al*, 2001). The biophysical and socio-economic aspects are used as the basis for farming system analysis and grouped into five categories as natural resources and climate; science and technology; trade liberalization and market development; policies, institutions and public goods; information and human capital.

Nowadays, all of the above biophysical and socio-economic determinants of farming system are in a state of rapid change. Natural resources are depleting from time to time and climate change is a current big issue in the field of agriculture. Science and technology is also growing from time to time at alarming rate. The National Agricultural Research Systems (NARS) has been endeavoring to boost agriculture sector through generation and development of agricultural technologies since the last five decades. Scores of agricultural technologies from various sectors of agriculture, such as crops, livestock, natural resources, social science, climate change and others were released and disseminated to beneficiaries in collaboration with development partners. These technologies are believed to change the existing farming systems at different dimensions and extents. Parts of the country might have revealed significant change while in the other part might have been limited or not at all. However, there is no adequately documented information illustrating dynamism of farming systems over time. Even if available, they are not only focusing on single commodities or a few districts but also they are too old and obsolete conducted before 15 years (Dixon (1978); Dixon *et al* (2001); Alelign (1994); Alelign *et al* 1994); Beyene (1995). This information cannot, therefore, be used for research and development planning and policy formulation of these days. These gaps, therefore, necessitateand call for characterization of the dynamics of the farming systems in this changing environment. Generation of up-to-date information is especially important in Ethiopia where the success or failure of agriculture directly or indirectly affects the whole economic sector.

The general objective of the study was to explore the changes of farming systems over time and identify the factors that contributed for the change especially in the highland agro-ecology. Specific objectives of the study included to

- characterize existing practices and dynamism of farming systems components in central highlands;
- assess agricultural technology use status of small-holders in the highland agro-ecology;
- Explore gender dynamism in extension services, technology use, resource availability, economic capacities, food availability and other livelihood dimensions;
- Investigate adaptation and coping mechanisms of households to climate change;
- Identify and prioritize major bottlenecks limiting further agricultural production and productivity; and
- Suggest feasible and practicable development, research, extension and policy intervention options that are believed to ensure lasting and sustainable improvements in livelihoods of farming households.

Methodology

Scope of the study

The scope of the study was technically limited to exploring the farming systems, analyzing the changes over time, identifying the factors that contributed for change and identifying the problems that perpetuated in the highland farming systems. Spatially, the study was limited to 8 zones and 16 districts selected from Amhara, Oromia and SNNP regional states.

Data collection and sample size

Blends of tools and techniques were adopted to collect the required information and dataset that addressthe objectives of the study. Three standard data collection techniques and approaches were employed in the study including desk review, qualitative assessments and quantitative survey techniques.

In the first stage of data collection, secondary information was exhausted from published and unpublished documents of EAIR, CSA, MOA and other governmental, non-governmental and international partners. In the second stage, blends of qualitative survey methods (participatory tools and techniques) were adopted to collect primary information from the farming community and others. The most important participatory tools and techniques employed includefocus group discussions (FGD) and key-informant interviews. An exhaustive checklist was designed to help facilitate the discussion.As farming systems studies focus on systems taken as a whole, many of the studies suggest participatory methods as an approach (Mohamed et al.,2014; Bedada et al.,2014).

In the third stage, cross sectional survey was conducted using quantitative data collection techniques to collect quantifiable data from the target groups. A structured questionnaire was designed based on the specific objectives of the study, pretested and administered through enumerators and supervisors. In all the study approaches, gender perspectives were critically considered to address practices and bottlenecks of men and women farmers. The sampling frame of the study was the population of the farming community in the location under consideration. To select sample households, the study employed the following sample size determination formula developed by Yamane (1967).

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

Where "n" is the sample size, "N" is the population size, and "e" is the level of precision. In this study, the level of precision desired was 95% and therefore, "e" was set at 0.05.

Multistage and purposive sampling procedures were used forselection of regions, zones, districts and kebeles. First regions, zones and districts were purposively selected representing the highland agro-ecology while sample households were selected using random sampling techniques.As provided in Table 1, the total sample size of the study was 1074 households, of which 96 were female-headed households (FHH) while 978 were male-headed households (MHH). In this report, Oromia Special Zone has been used interchangeably with Finfinne Zuria Zone. The survey was conducted during 2016/17 cropping season.

Table 1. Sample size of the study, 2016/17

Zone	MHH	FHH	TOTAL
North Shewa	267	22	289
Southwest Shewa	94	5	99
Oromia Special Zone	76	24	100
Gurage	148	27	175
East Shewa	106	5	111
Arsi	94	6	100
West Arsi	98	2	100
Bale	95	5	100
Overall	978	96	1074

Data analysis

The data collected using a questionnaire was coded and entered into a computer for further cleaning, after which data analysis continued using the most common statistical packages, such as SPSS and STATA. Descriptive statistics was mainly adopted to analyze the data and summarize the information. Chi-square, T-tests and F-tests were also applied as required to determine significance of values across groups. Information was presented in tables, figures and descriptions. The findings were also presented on a workshop where further feedback was collected and the report enriched accordingly.

Specification of commercialization index

Before rushing into the specification of the commercialization index, it is important to note that one of the five bases used for farming system analysis presented in introduction part is trade liberalization and market development (that is highly related to commercialization). In output-based commercialization analysis, commercialization index can be calculated for household, crops or a single crop. However, the general formula for each is similar and defined as the ratio of the quantity sold to the quantity produced. Based on Govereh *et al* (1999) and Strasberg *et al* (1999), the household commercialization index can be defined as the ratio of the value of crop sold to the value of the same crop produced by the household. Using this approach, ample empirical information has been generated on smallholder agricultural commercialization (Tadele *et al.*, 2017; Aderemi *et al.*, 2014; Osmani *et al.,* 2014; Agwu *et al.*, 2013; Kirui and Njiraini, 2013; Mutabazi *et al.*, 2013;Hichaambwa and Jayne, 2012; Berhanu and Moti, 2010; Rahut *et al.*, 2010; Moti *et al.*, 2009;). Although most of the previous studies have targeted a single crop at a time, the same analogue can be used to calculate the commercialization index of the two major cereal crops in the central Ethiopian farming system (wheat and barley). The commercialization index of wheat and barley is given as equations 1 and 2, respectively:

$$CIwi = \frac{Vwheatsold}{Vwheatproduced} * 100\% \quad (1)$$

$$CI_{bi} = \frac{Vbarleysold_i}{Vbarleyproduced_i} * 100\% \quad (2)$$

Where *Vsold* and *Vproduced*are the values of wheat and barley crops sold and produced, respectively. CI_{wi} and CI_{bi} = commercialization index of wheat and barley crops of the i^{th} farmer, respectively having a value between zero to one with zero and one indicating totally subsistent and fully commercialized farmers, respectively.

Specification of the Multivariate Tobit model

The dependent variables in Equations 1 and 2 above are censored from below at zero and hence implying the multivariate Tobit model. For simultaneously estimating these two equations, the work of Kamakura and Wedel (2001) can be adopted and specified as follows

$$Y_{ik}^{*} = \beta_k X_{ik}' + \varepsilon_{ik} \quad i=1,2,\ldots,n, \quad k=1,2,\ldots,K \quad (3)$$

$$Y_{ik} = Y_{ik}^{*} \quad if\ Y_{ik}^{*} > 0$$
$$= 0 \ if\ Y_{ik}^{*} \leq 0\ ,$$

WhereY_{ik} is observed index of crop k of the i[th] farmer, in this case k= 2; Y_{ik}^{*} is the latent variable and the solution to utility maximization problem, subjected to classical linear assumptions; [N~ (0, σ^2)].$\mathbf{X}_{ik}$is vector of explanatory variables affecting level of commercialization of the two crops; $\boldsymbol{\beta}_k$ = is vector of unknown parameters to be estimated. ε_{ik} are multivariate normally and independently distributed error terms with zero mean, varianceσ^2, correlation ρ, and covariance matrix (for the two variable case):

$$\sum \varepsilon_k = \begin{bmatrix} \sigma_{\varepsilon_1}^2 & \rho_{\varepsilon_2\varepsilon_1}\sigma_{\varepsilon_2}\sigma_{\varepsilon_1} \\ \rho_{\varepsilon_1\varepsilon_2}\sigma_{\varepsilon_1}\sigma_{\varepsilon_2} & \sigma_{\varepsilon_2}^2 \end{bmatrix} \quad (4)$$

Hypothesized variables

The dependent variable is the commercialization index of wheat and barley taking values between 0 and 1 for both crops.Based on economic theories and empirical literatures, explanatory variables that are hypothesized to determine the level of commercialization can be categorized into: farming household; resource endowment which includes land, livestock, proxy variables for wealth such as house with corrugated roof, access to information, infrastructure; and institutional factors such as access to extension and credit services.

Household background variables play an important role in decision making of farming households. Gender is one of the key variables of household background that influence several decisions in agriculture. In most cases, female-headed households do not have equal footings in accessing, controlling and managing resources and have limited access to information that assist in decision-making. Specific to the role of gender on the commercialization of smallholder households, Justus *et al* (2015) found negative relationship between being female-headed households and level of commercialization in central Africa. Similarly, education enhances the better decision-making process in the commercialization process. Empirical evidences also support this theoretical justification (Agwu *et al*., 2013; Alelign *et al*., 2017; Aman *et al*., 2014; Justus *et al*., 2015; Tadele *et al*., 2017). Therefore, education is hypothesized to have positive relationship with the level of commercialization. The role of age of the household head is case specific most of the time and may have positive or negative impact on commercialization. Age is proxy for experience and expected to have positive effect on one hand. On the other, younger farmers are more eager to try new things and relatively risk takers than older ones and in this case, age may have negative effect on commercialization process, which is relatively new for subsistent farmers. Therefore, age of the household head is hypothesized to have either positive or negative effect on the level of commercialization. Another household background variable is family size. The more family size in the household, the more need for consumption and less for marketable surplus in the rural settings. Previous empirical evidences support this theoretical background (Agwu *et al*., 2013; Aman *et al*., 2014; Tadele *et al*., 2017). Hence, it is hypothesized to have negative effect on the level of commercialization.

Resource endowments such as livestock ownership, total land owned, area allocated to the crop and household wealth which is usually approached using proxy variables (such as ownership of house with corrugated roof in this case) all are hypothesized to facilitate commercialization process. Most of the previous findings indicate that livestock ownership (Aman *et al*., 2014; Tadele *et al*., 2017), land ownership (Agwu *et al*., 2013; Aman *et al*., 2014; Justus*et al.,* 2015; Nepal and Thapa, 2009), land allocated to the crop under consideration, and wealth contribute positively for the level of commercialization. Therefore, resource endowment variables are hypothesized to have positive effect on commercialization.

Institutional and infrastructural factors also play an important role for commercialization process. Among institutional factors, better access to credit and extension services provided by the development agents in most cases are assumed to facilitate the smallholder commercialization. Therefore, both variables are hypothesized to positively influence wheat and barley commercialization. Similarly, rural infrastructure such as road and market places expressed by distance to nearest market and distance to all-weather road are also expected to enhance the level of commercialization. In other words, the shorter the distance to these infrastructures, the higher the level of commercialization would be. Hence, distance is hypothesized to have negative effect. In addition, access to market information through different means is expected to enhance the level of commercialization. One of such means is mobile phone. Ownership of mobile phone of the head of the household is hypothesized to positively influence the level of commercialization. Explanatory variables explained above and their expected signs are summarized in Table 2.

Table 2. Description of explanatory variables included in the econometric model

Variable	Type of variable	Expected sign
Sex of household head (1=male, 0=female)	Dummy	+
Age of household head in years	Continuous	+/-
Education level of household head (grade completed)	Continuous	+
Family size (in adult equivalent)	Continuous	-
Livestock ownership in TLU	Continuous	+
Oxen owned (number)	Dummy	+
Total land owned (ha)	Continuous	+
Wheat area (ha)	Continuous	+
Barley area (ha)	Continuous	+
Credit services (1=Yes; 0=No)	Dummy	+
Contact with DAs (1=Yes; 0=No)	Dummy	+
Distance to all-weather roads (km)	Continuous	-
Distance to nearest market (km)	Continuous	-
House with corrugated roof (Yes=1; 0=No)	Dummy	+
Mobile owned (Yes=1; 0=No)	Dummy	+

Findings

Socioeconomic circumstances

Age, education and family Size

Age is one of socio-economic factors, whichcan influence the use of various types of farming practices. According to the findings, the average age of households was 44 ranging from 20 to 101 (Table 3). Several studies have reported that age has positive effect on adoption of improved farming practices. For instance, the study conducted by Morris and Venkatesh (2000) has reported that younger people are faster, more effective and more efficient in the adoption of new knowledge than elderly.The study by Kebede *et al*. (1990) has also observed a positive relationship between the number of years of experience in agriculture and the adoption of improved agricultural technologies, while a study by Shiferaw and Holden (1998) indicated a negative relationship between age and adoption of improved soil conservation practices. That is, age of the household head has mixed effects on agricultural technology utilization depending on the technology and specific cases.

Table 3. Age of sample household heads in the highlands, 2016/17

Household Type	n	mean	min	max	SD
MHH-M	914	44	20	101	12.81572
MHH-P	64	48	20	70	10.67958
FHH	96	47	21	70	11.05725
Total	1074	44	20	101	12.61828

F=6.63 *P=0.0014*

MHH-M (P)=monogamous (polygamous) male headed household head,FHH=female headed household

Education is also an influential factor for improved agricultural practices. Evidences from various sources indicate a positive relationship between educational level of the household head and the adoption behavior of farmers (Norris and Bati, 1987; Igoden *et al*., 1990; Lin, 1991). Yirga *et al*. (1996) has also reported a positive association between literacy and adoption behavior. These studies underlined that literate farmers with higher levels of education are more likely to adopt different types of agricultural technologies than those who do not.

The government has provided due focus in the establishment of schools and universities across the country, because of which literacy level of households has increased. This study has also figured out that the average literacy level of households in the highlands was 73%. As presented in Table 4, men had significantly higher proportion of literacy (78%) than women (32%) (X^2=111.4360, DF=1, P<0.001).This might be because of the fact that, male had traditionally better access to education than female especially before two decades. Nearly 70% of women are still illiterate in the highland populations of Ethiopia. In now days, however, educational infrastructure has been substantially improved and that education is equally accessible to both male and female school age children.

Farmers mainly depend on family labor for farming operations despite well-to-do households could also depend on hired labor. In the highlands, households on average had six family members ranging from 1 – 20 (7 for MHH and 5 for FHH). Most of the households (57%) had family members in the range of 6 – 10.

Table 4. Educational level and family size of households, 2016/17

	Men		Women		Overall sample		X^2 Test
	n	%	n	%	n	%	
Educational level of households							
Illiterate	210	22	82	68	292	27	X^2=111.4360, df=1, P<0.001
Literate	743	78	39	32	782	73	
Total	953	100	121	100	1074	100	
Family sizes of households							
1 – 5 household members	337	34	57	59	394	37	X^2=24.1609, df=2, P<0.001
6 – 10 household members	573	59	37	39	610	57	
>10 household members	68	7	2	2	70	6	
Total	978	100	96	100	1074	100	

Land ownership and use

Rural land is one of the key resources thathave been distributed to farming households based on family size. Several studies accentuated that farm size is positively associated with technology adoption. Households who own large size of farmlands tend to adopt agricultural technologies faster than those who own small size of farmlands, ceteris paribus. This is because; households with large farm sizes take risks than others with small size of farmlands. The study by Norris and Batie (1987) confirmed that farmers who own and cultivate larger farms are likely to spend more on technologies as it is associated with greater wealth and increased availability of capital, which makes investment more feasible.

The study has figured out that the current average land holding of the highland-farming households was 2.35 hectares (Table 5). It is less by 3% compared to own farm size a decade ago (2.42 hectares) despite not statistically significant (t=1.7654, DF=897, P=0.1174). The apparent decline might be due to the growth of households over time, which at times has been youth. Male headed households (MHH) owned higher size of land (2.40 ha) than female headed households (FHH) (1.85 ha). The farm size in FHH has declined by 14% compared to ownership status before a decade. Pursuant to land distribution based on family size, the average per capita land ownership in the highlands was 0.39 hectare.

Due to leasing in and sharing in practices of farmland among the farmers either through cash or in-kind shares of yield, cultivated land is slightly higher than own land. Over years, the average cultivated land of households has revealed an increasing trend, 2.79 ha currently compared with 2.55 ha a decade ago. Households allocated 33% of land (0.79 ha) for animal feed and forage growth in the highlands and this trend is the same over the last decade.

Table 5. Land ownership and land use dynamism in the highlands, 2017

Land use	MHH		FHH		Overall households		t- test
	10 years ago	Current	10 years ago	Current	10 years ago	Current	
Landownership trends over the last 10 years	2.45	2.40	2.15	1.85	2.42	2.35	t=2.6789, df=1059, P=0.0075
Cultivated land (rainfed)	2.54	2.89	2.17	1.92	2.55	2.79	t=6.7672, df=913, P<0.001
Feed & forage land	0.84	0.81	0.52	0.55	0.80	0.79	t=0.1004, df=434, P=0.9201
Tree land	0.27	0.26	0.16	0.14	0.26	0.25	t=1.1940, df=240, P=0.2337

Communication materials and power sources

In recent years, mobile phone ownership has become popular in almost all parts of the country including rural areas. The study has figured out that 70% of monogamous male-headed households (MHH-M) and 80% of polygamous male-headed households (MHH-P) have owned mobile phones at the time of the study (Table 6). It was also noted that 26% of female household heads (FHH) and 22% of rural married women have also owned mobile phones. Farmers are using mobile phones not only for personal communication and for social interaction, but also for sharing information about improved farming practices, input and out prices, and others. They not only make calls but also listen to radios on mobile phones with radio facility. Because of these, mobile phone ownership is becoming a common phenomenon in rural households.

Rural households also owned other electronic communication tools. According to the findings, 55% of rural households in the highlands owned functional radio while 8% of the households with access to electric power (Table 7).The proportion of female household heads who owned functional radio and TV was also 37% and 8%, respectively. The use of electronic materials, which used to be limited in urban centers, is also becoming popular in rural areas especially since the last decade following expansion of mobile networks and rural electrification. Apart from using as entertainment, rural households also obtain information on improved farming practices and farmers' best practices from radio and TV display. This has also increased their awareness and exposure to improved farming technologies and new life styles.

In recent years, the use of solar power is also becoming a common phenomenon in rural areas for use as source of electric light. According to the findings, 30% of the households (31% for MHH and 15% for FHH) in rural highlands are using solar poweras source of electric light. Energy saving stove has also become a common source of cooking energy for 9% of rural households. Theuse of such light and cooking energy sources is also indications of better-off life styles for well-to-do households. The implication, therefore, is that livelihoods of the highland rural households are improving from time to time following expansion of various technologies in the country.

Even though traditional means of transport, such as transporting humans and items on the back of equines, is still popular in rural areas, it is also becoming common for 34% rural households to use equine carts. Equine cart service, which can be horse-cart, donkey-cart or mule-cart, is becoming popular in rural areas to transport not only agricultural products to markets but also humans to and from town centers. This is becoming widespread in rural areas following expansion of vehicle roads and transportation services not only in the highlands but also in most parts of the country. Equine cart based business has also appeared to be one of employment opportunities where youth are usually engaged.

Table 6. Mobile phone ownership by household type and gender (%)

Household Type	HH Heads	Married women	Youths
MHH-M	70	22	44
MHH-P	80	24	59
FHH	26	-	64
Overall	67	22	47
Significance test	chi2(2) = 78.7841 P<0.001	chi2(2) = 2.0191 P= 0.364	chi2(2) = 17.3516 P< 0.001

Table 7. Households' durable asset ownership status (% of households), 2016/17

Types of assets	MHH-M	MHH-P	FHH	Overall	Significance test
Functional radio	58	45	37	55	chi2(2) = 17.6287 Pr = 0.000
Functional TV	7	14	8	8	chi2(2) = 3.6057 Pr = 0.165
Solar power	32	31	15	30	chi2(2) = 12.1077 Pr = 0.002
Energy saving stove	9	9	14	9	chi2(2) = 2.6143 Pr = 0.271
Bicycle	2	3	0	2	chi2(2) = 2.4824 Pr = 0.289
Motorcycle	12	1.7	1.1	1.2	chi2(2) = 0.0855 Pr = 0.958
Equine cart	35	34	27	34	chi2(2) = 2.1143 Pr = 0.347
Knapsak sprayer	37	48	14	36	chi2(2) = 25.2375 Pr < 0.000

Residential house status of rural households

Quality of residential house is perceived to be one of the wealth indicators in rural areas. As provided in Table 8, 72% of the households owned corrugated roofed house. In earlier days, such as before two decades, households who owned thatched roofed house were perceived to be resource poor while those with corrugated roofed well-to-do farmers. However, in recent years, corrugated roofed house per se is no more an indicator of wealth status unless quality of wall is considered. Households with wall painted corrugated roofed main house are perceived to be well to do in rural areas. Accordingly, 46% of the households in the highlands owned wall painted corrugated roofed main house.

Another livelihood indicator in rural areas was also perceived to be ownership of pit latrine for the household, which was not common before two decades. Ministry of Health has made robust promotion and sensitization of rural community to use pit latrine. Because of this, construction and use of pit latrine is becoming prevalent in rural areas. According to this study, 96% of the rural households in the highlands have constructed their own pit latrine (Table 9). More than 75% of these households constructed and used family pit latrine in the last decade while only 13% of the households started experiencing pit latrine use before 15 years.

Table 8. Type of residential house owned by farming households (%), 2017

Type of household	Thatched roofed	Corrugated roofed	Painted wall for corrugated roofed
MHH-M	79	72	46
MHH-P	80	84	53
FHH	75	65	38
Overall	78	72	46
Chi-square test	chi2(2) = 0.7231 P = 0.697	chi2(2) = 7.4827 P = 0.024	

Table 9. Access of rural households to own family latrine, 2017.

Access to own latrine	n/%	MHH-M	MHH-P	FHH	Overall
No own latrine	n	37	1	10	48
	%	4	2	10	4
Owned since 1 - 5 yrs	n	383	28	41	452
	%	42	44	43	42
Owned since 6 - 10 yrs	n	309	21	31	361
	%	34	33	32	34
Owned since 11 - 15 yrs	n	65	8	4	77
	%	7	13	4	7
Owned since more than 15 yrs	n	120	6	10	136
	%	13	9	10	13
Total	n	914	64	96	1,074
	%	100	100	100	100

Crop production

Major crops grown in the central highland farming system

Table 10 presents the top crops having received at least one per cent of the total crop area share andproduced by nearly four per cent or more households in the central highland farming systems. Cereals dominate the farming system with wheat, barley and Tef cereal crops receiving the top three ranks. In addition, pulses and root and tuber crops (especially potato) are widely grown following the cereal crops. Therefore, all the subsequent sections and subsections of this chapter make its focuses on these crops.

Table 10. Major crops grown(%HH and %)

Crop	Producers/growers		Area	
	n	%	ha	%
Wheat	797	78.7	753.17	34.5
Barley	498	48.8	294.72	13.5
Tef	482	47.6	425.70	19.5
Faba bean	324	30.3	135.35	6.2
Potato	188	17.6	65.49	3.0
Chickpea	187	18.3	93.87	4.3
Maize	162	15.3	82.96	3.8
Grass pea	124	11.6	52.39	2.4
Lentil	123	11.8	58.94	2.7
Field pea	76	7.1	32.75	1.5
Onion	62	5.8	32.75	1.5
Fenugreek	46	4.3	21.83	1.0
Linseed	41	3.8	37.11	1.7
All other crops	252	23.5	96.06	4.4
Total			2183.10	100.0

N=1074

Crop production seasons

Households in the highlands make crop production using two seasons and supplementary irrigation despite the extent varies. The first and main is “meher” season, which is long season taking place in the main rainy season, which extends from May to October. The second is “bleg” season, which is short season extending from January/February to April. As illustrated in Table 11, 88% of the highland households depend on main season “meher” cropping. Moreover, 97% of cropped area is devoted to “meher” season production. Belg season used to be a substantial practice before two decades. However, consequent to climate change, mainly frequent drought occurrence, and short season cropping has declined substantially. According to the findings, only 9% of the households in the highlands practice short season or “belg” season cropping. Still, belg season production has appeared to a common practice inGurageZone (27%) followed by North Shewa Zone (10%). It is almost none in other study zones. If a farmland is not utilized either for “belg” or for irrigation-based production, it will be utilized for main season (meher) production.

Decline of “belg” season production consequent to frequent drought occurrence has imposed influences on food security and resilience of farming households. Households who have been producing in both short and long seasons used to make relatively larger grain supply for household consumption and sale. Irrigation farming also makes additional contribution to main season production. The trend, therefore, seems to be a shift from “belg” season to irrigated based production. This is because; the use of irrigation has become obviously necessary to enhance resilience to climate change.

Table 11. Proportion of households and crop area by seasons and study zones, 2016/17

Zone	Belg (%)		Meher (%)		Irrigation (%)	
	HH	Area	HH	Area	HH	Area
North Shewa	10	3	88	97	11	1
Southwest Shewa	3	1	96	99	2	0.3
Finfinne Zuria	9	3	80	95	30	3
Gurage	27	13	70	86	13	0.7
East Shewa	1	0	96	99	12	1
Arsi	0	0	100	100	11	1
West Arsi	1	0	97	99	12	1
Bale	1	1	99	99	15	2
Overall	9	2	88	97	13	2

Crop protection

Farmers grow diverse crops in the highlands including cereals, pulses, oilseeds, vegetables and others. The most essential agronomic practice farmers experience is either weeding by hand or using chemicals. For small plot of land, weeding is often practiced manually with hand. As provided in Table 12, 70% of the overall households practice hand weeding for wheat (69% for MHH and 84% for FHH). It was also figured out that 63% of wheat field (area) has been weeded manually (62% for FHH and 72%). Tef field is also the most weeded crop where 84% of the households practiced manual weeding (84% for MHH and 86% for FHH). The area of Tef field that has been weeded has also accounted for 83%. The findings also indicate that 74% of the households practice hand weeding for barley, and 90% for potato including cultivation. Weeding practices and proportion of crop area weeded has been illustrated in the table.

Extent of weeding has been revealed in Table 13. Frequency of weeding has appeared to be more than once for all the crops ranging from 1.3 to 2.8. For instance, the average frequency of weeding for wheat was 1.6 (1.5 for MHH and 1.7 for FHH). In earlier days, hand weeding has often been practiced once. But in recent years, weeding practice has been provided due emphasis through supports of agricultural extension services. This could be one of the reasons why households practiced more than once hand weeding.

Table 14 provides the gap of farmers' hand weeding practices from recommended practices. In almost all of the cases, farmers' practice of hand weeding is lower than recommended. For instance, frequency of weed management recommended by research for wheat fields was twice hand weeding while the farmers practice only 1.5, which is less by 20%. Moreover, research recommends three times hand weeding to obtain good yields from Tef, but farmers practice 1.7 times hand weeding, which is less by 43% than recommended. The only crops for which farmers' hand weeding practice is in line with recommendation are maize and field pea. The findings unveil that farmers' weed management practice is still lower than research recommendations. This has an implication that a certain proportion of yield could be compromised for adopting less crop management practices

Table 12. Hand weeding (% HH and % area weeded) of major crops grown by gender, 2016/17

Crop	MHH		FHH		Overall	
	HH (%)	Area (%)	HH (%)	Area (%)	HH (%)	Area (%)
Wheat	69	62	84	72	70	63
Barley	73	74	89	82	74	74
Tef	84	84	86	79	84	83
Faba bean	84	82	89	91	84	82
Potato	91	89	78	86	90	89
Chickpea	55	59	33	16	55	58
Maize	91	94	95	97	91	94
Grass pea	31	34	0	0	30	33
Lentil	80	82	40	27	78	81
Field pea	42	29	100	100	46	32
Onion	95	93	0	0	95	93
Fenugreek	76	86	50	25	74	84
Linseed	55	58	100	100	56	58

Table 13. Frequency of hand weeding, 2016/17.

Crop	MHH		FHH		Overall		T-value
	n	Mean	n	Mean	n	Mean	
Wheat	539	1.5	58	1.7	597	1.6	-1.298
Barley	351	1.5	40	1.7	391	1.5	-2.096**
Tef	395	1.7	37	1.6	432	1.7	0.190
Faba bean	260	1.5	24	1.7	284	1.5	-1.159
Potato	158	2.2	14	2.3	172	2.2	-0.506
Chickpea	104	1.4	2	1.5	106	1.4	-0.161
Maize	134	2.1	18	2.1	152	2.1	0.243
Grass pea	37	1.3	0	0	37	1.3	-
Lentil	99	1.6	2	2.0	101	1.6	-0.836
Field pea	30	1.4	5	1.8	35	1.5	-1.071
Onion	59	2.8	0	0	59	2.8	-
Fenugreek	32	1.5	2	1.5	34	1.5	-0.058
Linseed	22	1.5	1	2.0	23	1.5	-0.641

Table 14. Farmers' practices and recommended weeding frequency of highland crops

Crop	Farmers' average weeding frequency (a)	Research recommended weeding frequency (b)	Discrepancy (gap) in % =(a-b)/b*100
Wheat	1.6	2	-20 (less)
Barley	1.5	2	-25
Tef	1.7	3	-43
Faba bean	1.5	2	-25
Potato	2.2	2.5	-12
Chickpea	1.4	2	-30
Maize	2.1	2	5 (over)
Lentil	1.6	2	-20
Field pea	1.5	1	50
Linseed	1.5	2	-25

Source: EIAR/HARC/DZARC and ARARI training manual and leaflets (2007 and 2008 EC)

Apart from hand weeding, farmers also use herbicides to control some of the weeds, especially grassy species. For instance, 90% of the households applied herbicides on wheat. Moreover, farmers used herbicides on 94% of wheat area (Table 15). It was also figured out that 85% of the farmers have applied herbicides on 87% of Tef fields. Famers applied herbicides to most of the crops grown in the highlands as revealed in the table. Using herbicides in addition to hand weeding is most probably the possible reason why farmers were practicing below the recommended frequency of hand weeding for most crops.

Not only herbicides farmers have been using, but also fungicides and insecticides. For instance, 44% of the farmers applied fungicides on potato especially for late blight disease. Out of the total potato field, 53% of it has received fungicide spray. The other crop that received fungicide spray is wheat where 36% of the farmers applied this chemical on 50% of wheat fields. Head smut and rust are common fungal diseases on wheat, which require the fungicide spray for control. Fungal disease is also common on onion, the reason for 58% of the farmers to use fungicides on 60% of onion fields. Insecticide spray is also reported to be common on pulse crops especially for control of aphids. As indicated in the table, 68% of the farmers applied insecticide on lentil on 71% of lentil fields. Chickpea is also another pulse crop on which 63% of the farmers applied insecticide. The chickpea field area that received insecticide spray was 67%.

As to the extent of application, farmers applied various rates of chemicals to crops. For instance, farmers on average applied 0.9 kg/ha of herbicide on wheat, 1.1 kg/ha of fungicide and 0.9 kg/ha of insecticide (Table 16). In the same way, farmers applied various rates of herbicides, such as 1.1 kg/ha on barley and 0.8 kg/ha on tef. Farmers commonly applied 1.9 kg/ha of fungicide on potato and 2.1 kg/ha on onion. On chickpea, farmers applied insecticide at a rate of 1.3 kg/ha while it was 1.1 kg/ha for lentil. On potato, farmers applied 2.7 kg/ha of insecticide. Since the last decade, extension service has been strengthened to enhance production and productivity of crops. Development agents (DAs), agriculture experts, agricultural researchers, NGOs and other actors have been supporting farmers through various development initiatives. The support has been introducing and promoting technologies, such as improved varieties, improved management practices and other packages. Because of this, farmer's use of improved technologies including crop protection chemicals is increasing from time to time.

Table 15. Farmers' chemical use practices for crop protection, 2016/17.

Crop	n	Herbicide		Fungicide		Insecticide	
		HH (%)	Area (%)	HH (%)	Area (%)	HH (%)	Area (%)
Wheat	797	90	94	36	50	10	14
Barley	498	69	76	11	14	5	7
Tef	482	85	87	13	12	9	10
Faba bean	324	12	15	13	16	11	12
Potato	188	11	13	44	53	1	1
Chickpea	187	26	30	10	19	63	67
Maize	162	16	19	7	10	9	12
Grass pea	124	17	23	6	9	37	37
Lentil	123	54	59	39	43	68	71
Field pea	76	12	13	5	6	11	8
Onion	62	39	43	58	60	63	66
Fenugreek	46	57	39	37	53	59	69
Linseed	41	29	36	5	14	15	26

Table 16. Application rates of crop protection chemicals (kg/ha), 201617

Crop	Herbicide		Fungicide		Insecticide	
	n	Mean	n	Mean	n	Mean
Wheat	721	0.9	285	1.1	76	0.9
Barley	343	1.1	56	1.4	24	0.8
Tef	412	0.8	64	1.4	45	0.8
Faba bean	39	1.3	41	1.0	36	1.0
Potato	21	2.0	82	1.9	2	2.7
Chickpea	48	1.2	19	1.3	117	1.3
Maize	26	0.8	12	1.4	14	0.7
Grass pea	21	1.1	7	1.3	46	1.2
Lentil	67	1.2	48	1.5	84	1.1
Field pea	9	0.9	4	1.1	8	1.3
Onion	24	1.5	36	2.1	39	1.8
Fenugreek	26	1.9	17	1.5	27	1.4
Linseed	12	0.7	2	0.4	6	0.4

Fertilizer use practices in the highlands

Pursuant to extension services to farmers to boost agricultural production and productivity, agriculture experts and DAs strongly advise to use chemical fertilizers on crops. Since the last two decades, fertilizer use has become poplar for almost all the crops to increase productivity. The findings have also witnessed that fertilizer use is very common especially in cereals. For instance, among the wheat growers, 80% of them applied UREA on 78% of wheat fields (Table 17). Moreover, 83% of the farmers applied DAP on 82% of wheat fields while 14% of wheat growers applied NPS on 18% of wheat fields. Tef is also another cereal crops on which chemical fertilizers are applied. According to the findings, 86% of the farmers applied UREA on 86% of Tef fields, 78% of the farmers applied DAP on 77% of Tef fields, and 14% of the farmers applied NPS on 14% of Tef fields. Potato, maize and onion are also other crops on which farmers commonly apply fertilizer.

Farmers have developed the perception that crops do not provide good yields without application of especially inorganic fertilizers. It was also recognized that fertilizer application enhanced productivity more than 2 – 3 folds. This was the reason why farmers’ use of chemical fertilizers has become widespread in the highlands where is there is also relatively better moisture content even though the rate of application might be lower than recommended. For instance, farmers applied UREA on wheat at a rate of 108 kg/ha, DAP at a rate of 130 kg/ha and NPS at a rate of 131 kg/ha (Table 18). The rate applied on Tef is a bit higher than other crops, where farmers applied 112 kg/ha of Urea, 133 kg/ha of DAP and 151 kg/ha of NPS. They may not necessarily use three types of fertilizers at a time. They may use DAP alone, NPS alone or Urea and DAP in combination. The reason why they apply lower rates than recommended is due to high purchase cost. However, they recognize that using lower rates reduces productivity.

Table 17. Proportion of HHs who use various types of fertilizers and area under fertilizer, 2016/17

Crop	n	UREA		DAP		NPS	
		HH (%)	Area (%)	HH (%)	Area (%)	HH (%)	Area (%)
Wheat	797	80	78	83	82	14	18
Barley	498	60	56	73	73	9	12
Tef	482	86	86	78	77	14	14
Faba bean	324	19	17	30	25	7	6
Potato	188	70	63	87	83	5	11
Chickpea	187	6	9	10	11	5	7
Maize	162	67	73	78	82	3	5
Grass pea	124	7	10	7	11	3	4
Lentil	123	28	29	47	46	10	11
Field pea	76	22	17	34	28	3	2
Onion	62	73	76	77	81	16	13
Fenugreek	46	59	73	63	79	9	7
Linseed	41	5	15	15	23	0	0

Table 18. Fertilizer rates (Kg/ha) applied to crops in the highlands, 2016/17.

Crop	UREA		DAP		NPS	
	n	Mean	n	Mean	n	Mean
Wheat	634	108	661	130	113	131
Barley	299	95	364	110	45	108
Tef	413	112	378	133	66	151
Faba bean	61	91	97	106	21	83
Potato	132	134	164	154	10	175
Chickpea	12	98	19	121	10	81
Maize	108	113	126	103	5	119
Grass pea	9	81	9	134	4	100
Lentil	35	115	58	111	12	127
Field pea	17	118	26	137	2	203
Onion	45	165	48	296	10	267
Fenugreek	27	98	29	112	4	122
Linseed	2	55	6	81	-	-

Farmers could exploit potentially achievable yields of crops only when they apply recommended management practices. Even though farmers' experiences of using inorganic fertilizers date back to more than three decades, most of them still apply the rate below recommended levels. For instance, the findings indicate that the recommended rate of Urea on wheat is 150 kg/ha, but farmers apply108 kg/ha, which is lower by 28% than recommended rate (Table 19). Farmers have also applied lower rates of Urea than recommended for other major cereals. On the other hand, research does not recommend application of Urea on pulse crops since they are nitrogen fixers by themselves. However, farmers were observed to apply Urea on pulses. For instance, farmers applied 91kg/ha of Urea on faba bean and 98 kg/ha on chickpea. The implication is that farmers will only add cost of production for applying Urea on crops, which do not necessarily require nitrogen application externally.

The case of DAP is inspiring in that farmers' application is even higher than recommended rate. For instance, research recommends 125 kg/ha of DAP to be applied on wheat while farmers applied 130 kg/ha on average. It is also recommended to apply 100 kg/ha of DAP for Tef, but farmers used a higher rate (133 kg/ha) than this. The recommended rates used to be feasible at times, but the reason why farmers opt to go for higher rates might be that earlier rates are no more adequate. Otherwise, applying higher rates than recommended might only increase cost burden of farmers. Therefore, there is a need to increase farmers' knowledge of appropriate fertilizer rates. The other option might be that research should revise and determine why farmers' added more rates of DAP than recommended. Perhaps, extent of soil infertility might have increased over time and that the use of higher rate of DAP might have appeared to be evident. Therefore, agronomists might need to revise recommended rates of fertilizer and come up with economically feasible rates to the farmers.

Table 19. Farmers' Vs recommended fertilizer rates (kg/ha)

Crop	Urea		DAP		NPS	
	Farmers' rate	Recommended rate	Farmers' rate	Recommended rate	Farmers' rate	Recommended rate
Wheat	108	150	130	125	131	125
Barley	95	100	110	100	108	100
Tef	112	100	133	100	151	100
Maize	113	200	103	200	119	200
Faba bean	91	0	106	100	83	100
Potato	134	163	154	196	175	196
Chickpea	98	0	121	100	81	100
Lentil	115	0	111	100	127	100
Field pea	118	0	137	75	203	75
Linseed	55	30	81	50	-	50

Source: EIAR/HARC/DZARC and ARARI training manual and leaflets

Farmers use not only inorganic fertilizers but also organic substances, such as compose, manure and others. Compost preparation and use is considered as one of the technologies for ameliorating soil fertility. Extension agents, agriculture experts, agricultural researchers and other development partners have been promoting and supporting farmers on techniques of compost preparation and application. The findings have witnessed that 43% of the highland farmers have used compost on faba bean (Table 20). The area of faba bean field on which compost was applied was 46%. Similarly, 35% of the highlanders have applied compost on 29% of potato fields. Field pea is also another pulse crop, which received treatment with compost with 32% of the farmers. In the highlands, cases are common that pulses, such as faba bean and field peas are grown around homesteads. Potato is also one of the garden crops grown in the highlands. It also seems that crops that receive fewer amounts of inorganic fertilizers get better chance of being fertilized with compost. Farmers normally use less quantity of inorganic fertilizers for pulses and oilseeds, while they used compost instead.

Table 20. Compost use practices on crops in the highland farming systems, 2016/17

Crop	MHH		FHH		Overall	
	HH (%)	Area (%)	HH (%)	Area (%)	HH (%)	Area (%)
Wheat	21	17	29	22	22	18
Barley	29	29	31	33	30	29
Tef	17	16	28	18	18	16
Faba bean	43	47	48	35	43	46
Potato	35	29	33	34	35	29
Chickpea	5	4	0	0	5	4
Maize	18	16	16	8	18	15
Grass pea	4	5	14	7	5	5
Lentil	9	8	0	0	9	8
Field pea	31	36	40	22	32	36
Onion	16	13	0	0	16	13
Fenugreek	5	1	0	0	5	1
Linseed	18	25	0	0	17	25

Crop productivity

One of the features of improved crop varieties is high productivity compared to locals. The study has also witnessed that most of the improved crop varieties have appeared to be significantly higher yielders than locals. For instance, improved wheat varieties yielded 21.4 q/ha compared to 16.4 q/ha for local wheat (Table 21). The productivity of improved barley variety (20.1 q/ha) was also significantly higher than local variety (15.8 q/ha). Improved variety Tef yielded 11.8 q/ha, significantly higher than local yield (9.2 quintal). Yield comparison of improved and local crop varieties has also been revealed in the table. On the other hand, improved potato variety yielded 81.7 q/ha, which is also closely similar to yield of local variety (80.8 q/ha). This might be because, the farmers that perceived potato variety as local might be improved one. When the farmers purchase seeds from the market or other farmers, they perceive it is local variety even though it might be improved one.

Even though improved varieties yielded higher than locals did, their productivity at the farmers' management levels is still far lower than achievable yields. For instance, achievable yield of improved wheat variety on the farmers' fields is more than 30 q/ha while improved Tef varieties yield more than 18 q/ha. The achievable yield of maize is also higher than 50 quintals per ha, higher by two folds than recorded in this study. The achievable productivity of potato is higher than 300 quintals per ha, which is more than three folds than farmers' yield in the highlands. In all the cases, the achieved yield of improved varieties was lower than achievable potentials. This implies that farmers of the highlands are losing more than one folds of yield for some known reasons. One of the major reasons is limited use of recommended inputs for improved varieties. While research recommendations suggest the use of packages of technologies along with improved varieties, farmers did not adequately adopt package-based use of agricultural technologies. As witnessed in the preceding sections, farmers have opted to apply less than recommended rates of fertilizer, chemicals and weeding frequencies.

Table 22 illustrates yield gap of crops when compared with achievable on-farm yields with research support. For instance, the achievable yield of improved varieties of wheat on farmers' fields with research support, such as demonstrations, is 42.5 q/ha. However, this same variety yielded 21.4 q/ha, which is lower by 50%. This implies that 21 q/ha of achievable yield has been compromised for unknown reasons. The same is true for Tef where improved varieties at farmer's field with research support yielded 23 q/hawhile this same variety yielded 11.8 q/ha, which is lower by 49%. This also implies that 11 q/ha of Tef yield has been compromised. The same trend holds true for other improved varieties as presented in Table. One of the reasons for less performance of improved varieties on farmers' fields and compromising substantial yields could be inadequate management practices applied by farmers, such as less than recommended rates of inorganic fertilizer, weeding frequency, land preparation and other agronomic practices. The other possible reason could be unstable performance of improved varieties on farmers'fields. Some of the improved varieties could be locationspecific while others could have broad adaptability.

In any case, that high yield gap needs to be narrowed down and tapped on the already inadequate production for the country. For instance, if the possible challenges for yield gap are addressed and if yield gap of wheat can be minimized at least by 50%, it means that the country can add about 1.1 million tons of wheat in to available production. This also implies that the national wheat production will be enhanced by 24%. For Tef, 0.7 million tons of production could be saved by narrowing down yield gap by at least 50%. The same also holds true for other crops and the cumulative production increment at country level would be substantial by addressing the problems that contribute to yield gap between on-farm achievable and actually achieved by farmers.

Table 21. Yield (q/ha) of local and improved crop varieties in the highland agro-ecology, 2016/17

Crop	Overall		local		Improved		T-value
	n	Mean	n	Mean	n	Mean	
Wheat	845	20.0	233	16.4	612	21.4	4.67***
Barley	524	17.7	291	15.8	233	20.1	4.46**
Tef	511	10.4	270	9.2	241	11.8	4.25***
Faba bean	325	10.9	244	10.0	81	14.0	3.67***
Potatoes	189	81.4	62	80.8	127	81.7	0.08
Chickpea	197	14.7	105	13.0	92	16.6	2.4**
Maize	164	22.7	44	16.4	120	25.0	2.77***
Grass pea	125	11.3	102	9.4	23	20.0	5.1***
Lentil	127	12.3	40	10.4	87	13.1	2.1***
Field pea	76	8.7	54	8.3	22	9.6	0.8
Onion	62	127.5	8	52.1	54	138.7	2.1**
Fenugreek	46	15.0	19	14.5	27	15.1	0.18
Linseed	41	7.3	31	7.5	10	6.7	-0.5

Table 22. Gap of on-farm Vs achievable yield of improved crop varieties

Improved crop varieties	National average yield (q/ha)*	Farmers' achieved yield (q/ha)	On-farm achievable yield with research support (q/ha)**	Yield gap of on-farm achievable from national average (%)	Yield gap of on-farm achievable from farmers' achieved (%)
Wheat	26.75	21.4	42.5	-20	-49.6
Barley	21.11	20.1	34.5	-4.8	-41.7
Tef	16.64	11.8	23	-29.1	-48.7
Faba bean	20.53	14	43.5	-31.8	-67.8
Potatoes	137.68	81.7	365.5	-40.7	-77.6
Chickpea	19.69	16.6	30.5	-15.7	-45.6
Maize	36.75	25	72.5	-32.0	-65.5
Lentil	14.63	13.1	26	-10.5	-49.6
Field pea	16.38	9.6	41	-41.4	-76.6
Linseed	10.94	6.7	16	-38.8	-58.1

*Source: *CSA, 2016/17; **EIAR/HARC/DZARC and ARARI training manual and leaflets*

Access of households to irrigation

In the face of frequently occurring climate change and subsistence oriented rain fed agriculture, irrigation farming is anticipated to be one of mitigation measures and the way out of poverty. However, limited capacity to establish irrigation structures and facilities has become detrimental factor to harness the potential. At the time of the study (2017), only 13% of the households in the highlands had access to irrigation (Table 23). As figured out in the findings, having access to irrigation was a recent phenomenon in the highlands in which 9% of the households started irrigation farming since the last 10 years. Only 4% of them had irrigation access before a decade. From the point of view of resource potential, the highland agro-ecology is believed to be endowed with ample water resources despite the capacity is still limited to harness the potential. In terms of the trend of households with access to irrigation, only 4% of highlanders had access to small-scale irrigation a decade ago while this proportion has increased to 7% after 10 years. In spite of increased proportion of households with access to irrigation, the area allocated for irrigation farming did not reveal a significant growth over time (only 0.42 ha per household) implying that efforts being made to expand irrigation structures and facilities is still inadequate. It was also recognized that households allocated only 18% of their farmlands to irrigation. At national levels, households allocated less than 10% of farmlands to irrigation farming (http://awm-solutions.iwmi.org/ethiopia-1.aspx).

Assessment of irrigation access across the study zones reveals that households who had access to irrigation ranged from 2% - 30% (Figure 1). Relatively better access was observed in Oromia Special Zone where 30% of the households depend on small-scale irrigation. This might be because of the fact that Oromia Special zone is located in a radius of 50kmsurround the city of Addis Ababa that provides an opportunity of easy access to markets. These households mainly produce vegetables with irrigation for sale in the city of Addis Ababa. On the other hand, Southwest Shewa households had the least access to irrigation (2%) perhaps due to limited availability of water sources that can be arrested for irrigation purposes. Other zones had closely similar status of access to irrigation in the range of 11% - 15%. Almost all of these households had access to traditional type of irrigation, which was constructed with limited resources. Not only that traditional irrigation facility is often exposed to ample water loss in the canals, the amount of water it can divert from main supply is also limited in quantity. Because of this, it cannot accommodate several households in providing access to irrigation. In recognition of this challenge and in the interest of addressing food security on sustainable basis, the government along with its development partners, such as NGOs, has launched robust initiatives to expand irrigation facilities for rural households using available ground or surface water potentials.

Table 23. Exposure of households to irrigation access, 2016/17

Exposure of households to irrigation	MHH		FHH		Overall households	
	n	%	n	%	n	%
No access to irrigation	854	87	83	86	937	87
Access since 1 – 5 years	54	6	9	9	63	6
Access since 6 – 10 years	32	3	4	4	36	3
Access since >10 years	38	4	0	0	38	4
Total	978	100	96	100	1074	100

X^2=6.1593 df=3 P=0.104

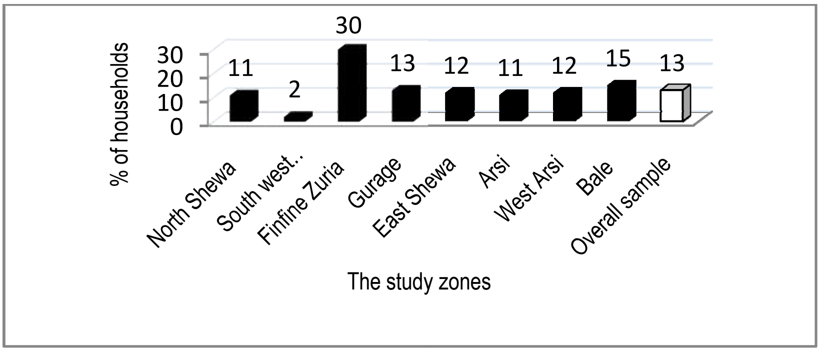


Figure 1. Access of household to irrigation across the various study zones, 2016/17

Awareness and crop technology use

Awareness on improved crop technologies

Technology awareness precedes adoption. Consequent to several years of efforts to raise awareness of agricultural technologies for the farmers through various channels of extension services, an average of 72% of the highland households were aware of improved varieties of different types of crops (Table 24). Among the cereals, the highest proportion of farmers were aware of improved varieties of maize (92%) and wheat (91%) followed by barley (75%) and Tef (70%). Among the pulses, improved varieties of lentil were well known by 83% of the farmers followed by chickpea (78%) and faba bean (54%). Improved varieties of linseed have also been relatively well known among oilseeds by 38% of the farmers.

Assessment of dynamism of improved crop varieties indicates that 84% of the farmers have an opportunity to learn about improved crop varieties in the last decade. This might be because of the fact that the government has provided due focus in promotion of agricultural technologies since the last decade. Only 10% of the highland farmers have learnt about improved crop varieties before 15 years.

Table 24. Awareness status of highland households to improved crop varieties, 2016/17

Crops	% aware of	Dynamism of awareness trends over time (% of aware households)				
		1-5 years	6-10 years	11-15 years	16-20 years	Before 20 years
Wheat	91	36	43	12	5	4
Barley	75	48	42	4	4	1
Teff	70	41	41	8	7	3
Faba bean	54	59	35	3	2	0
Maize	92	44	33	14	8	1
Chickpea	78	37	44	9	6	3
Potato	81	55	37	6	2	1
Lentil	83	46	34	13	4	3
Onion	88	56	33	7	2	2
Field pea	50	57	39	2	2	0
Grass pea	26	42	45	3	6	3
Fenugreek	59	55	34	7	3	0
Linseed	38	75	25	0	0	0
All crops	72	44	40	9	5	2

Adoption rates of improved crop varieties

Adoption rate of improved crop varieties has demonstrated a progress despite it varies from one type of crop to another. The most widely adopted cereal crop was improved varieties of maize with 74% of adopters followed by wheat with 69% of adoption rate (Table 25). Adoption rate of improved Tef varieties was 43% while that of barley 47%. The implication is that 57% and 53% of Tefand barley producers, respectively, have not yet started growing improved varieties. Good progress of improved variety adoption was also observed among the pulse crops. The highest proportion of adopters was reported for improved varieties of lentil (65%) followed by chickpea (49%) and field pea (29%). In the highland agro-ecology, 24% of the farmers have also adopted improved varieties of linseed. It was also recognized that 68% of highland households have also adopted improved varieties of potato. Overall, the findings have figured out that nearly 50% of the highland households have not yet started using improved varieties of various types of crops.

On relative terms, improved crop variety adoption has taken place mainly in the last decade. For instance, 83% of wheat adopters started growing improved varieties in the last decade while 7% of the farmers have access before 15 years. Similar trend holds true for adoption of improved maize and Tef varieties. Adoption of improved varieties of some crops, such as linseed, potato and pulses was a recent phenomenon, mainly in the last five years. Overall, nearly 90% of highland households have access to adoption of improved varieties of various crops mainly in the last decade. This could be attributed to design and implementation of growth and transformation plans (GTP-GTP-II and I) of the government on agriculture sector, which made more investments than ever in technology multiplication, introduction and dissemination. Intensive agricultural extension program has provided due focus for demonstration and scaling-up of various agricultural technologies.

Table 25. Adoption rates of improved crop varieties, 2016/17.

Crops	Adopters (%)	Dynamism of adoption trends over time (% of adopters)				
		1-5 years	6-10 years	11-15 years	16-20 years	Before 20 years
Wheat	69	46	37	10	5	2
Barley	47	55	35	3	6	1
Tef	43	47	35	10	6	2
Maize	74	56	27	13	3	1
Chickpea	49	43	39	12	4	2
Lentil	65	41	37	17	4	1
Faba bean	25	66	28	3	1	1
Field pea	29	40	56	4	0	0
Grass pea	19	68	26	5	0	0
Linseed	24	100	0	0	0	0
Potato	68	61	37	1	1	1
Onion	87	57	36	5	2	0
Fenugreek	59	88	8	4	0	0

When viewed from the perspective of gender on variety adoption status, it was inspiring to notice that female-headed households (FHH) have also made substantial strides in adopting improved varieties of various crops. As witnessed in Table 26, the cumulative adoption rate of various improved variety crops was 47% for FHH and 51% for male-headed households (MHH), which is not significant difference. This implies that the agricultural extension service has strengthened its supportiveness to involve women in technology demonstration, capacity building and various other extension events, which eventually contributed to enhanced utilization of technologies. From the perspective of area occupied by improved crop varieties, the findings have figured out that 55% of the area has been covered by improved crop varieties, out of which 56% accounts for MHH and 50% for FHH. According to the findings, 74% of wheat area was occupied by improved varieties while this proportion is 49% for Tef and 63% for potato. Out of cereal crops, the largest proportion of area (76%) was occupied by improved varieties of maize. Among the pulse crops, lentil (69%) and chickpea (49%), which are dominant cash crops, occupied the largest proportion of area. Among oilseeds, adoption rate (25%) and area occupied by improved varieties (29%) was higher for linseed than others were. Even though the area coverage should have been higher than this, it is still encouraging amid climate change and various other challenges, such as limited distribution of improved technologies.

According to crop wise assessment, it was also recognized that adoption rate of improved potato varieties was higher for FHH (82%) than MHH (66%). Similarly, the proportion of improved barley variety adopters was higher for FHH (49%) than MHH (44%). On the other hand, adoption rate of improved wheat varieties was higher for MHH (73%) than FHH (65%), and that of improved Tef varieties was higher for MHH (48%) than FHH (37%). The study has also observed that adoption rates of pulse crops were higher for MHH than FHH. The study clearly seems to indicate that adoption rate of cash crops is higher for MHH than FHH. This might be because, MHH are relatively food self-sufficient and that they are striving to go for small-scale commercialization by focusing on cash crops which bring better incomes. On the other hand, FHH are more concerned on food self-sufficiency, because of which adoption rate of food crops is higher for FHH than MHH. Because of limited resource status, FHH are striving to meet their food demands from own production.

Table 26. Adoption rates and area occupied under improved varieties by gender, 2016/17

Crop	MHH			FHH			overall		
	n	HH (%)	Area (%)	n	HH (%)	Area (%)	n	HH (%)	Area (%)
Wheat	569	73	74	43	65	72	612	69	74
Barley	210	44	45	23	49	48	233	47	45
Tef	226	48	50	15	37	36	241	43	49
Faba bean	77	26	23	4	15	9	81	25	22
Potato	113	66	61	14	82	90	127	68	63
Chickpea	90	47	49	2	33	22	92	40	49
Maize	105	72	75	15	79	86	120	74	76
Grass pea	22	19	21	1	14	2	23	19	20
Lentil	85	70	70	2	40	33	87	65	69
Field pea	21	30	25	1	20	9	22	29	25
Onion	54	87	86	-	-	-	54	87	86
Fenugreek	26	62	77	1	25	41	27	59	75
Linseed	10	25	29	-	-	-	10	24	29

Farmers have adopted more than one improved varieties of crops. When improved varieties get obsolete due to frequent recycling, low productivity, disease and other reasons, it is being replaced by new ones. Agricultural research is also a continuous process generating tens of improved crop varieties. For instance, there are more than 100 improved varieties of both bread and durum wheat that have been generated through research in the last four decades. Some of these have become out of production due to low productivity for various reasons. According to the findings, farmers on average have adopted three improved wheat varieties, two improved barley varieties and more than two Tef varieties (Table 27). It was noticed that farmers have experienced growing more than one improved varieties of various crops. Even though research system has generated tens of improved varieties of each crop, the number adopted in the highlands has appeared to be very limited. This might be because of limited capacity of agricultural extension systems, seed enterprises and other development partners to multiply distribute and avail improved variety seeds to the farmers on time and with adequate quantities on sustainable basis. Therefore, many of the improved varieties have not been made accessible to farmers on time. There are even many cases where farmers discontinued use of improved varieties due to prolonged recycling and consequent low productivity.

Table 27. Number of improved varieties of crops adopted by farmers

Crop	MHH		FHH		Overall		T-value
	n	Mean	n	Mean	n	Mean	
Wheat	791	3.1	52	2.3	843	3.0	3.211***
Barley	317	1.9	26	2.2	343	1.9	-0.845
Tef	310	2.2	15	1.8	325	2.2	1.312
Maize	132	3.0	18	2.5	150	2.9	1.262
Potato	125	2.6	15	2.4	140	2.6	0.677
Chickpea	107	1.8	2	2.0	109	1.8	-0.221
Faba bean	95	1.4	4	2.3	99	1.4	-1.188
Lentil	87	1.7	2	1.0	89	1.7	1.275
Onion	51	1.4	-	-	51	1.4	-
Grass peas	31	1.0	-	-	31	1.0	-
Field pea	26	1.6	-	-	26	1.6	-
Fenugreek	25	1.4	1	2.0	26	1.5	-0.771
Linseed	9	1.2	-	-	9	1.2	-

Sources of improved variety seeds

Farmers obtained seeds of improved varieties from various sources. According to the findings, 66% of the farmers on average sourced improved variety seeds through supplies of Office of Agriculture either free supports or through cash purchases (Table 28). Office of Agriculture in turn obtains improved variety seeds especially from public seed producer companies, such as Ethiopian Seed Enterprise, Oromia Seed Enterprise and Amhara Region Seed Enterprise. Even though limited in supply capacities, there are also private seed growers including individual enterprises and farmer cooperatives.

The second most important source of improved variety seeds for 16% of the households was informal seed growers that received trainings on seed production and management practices. Agriculture experts, agricultural researchers to provide advises, and inputs are also making close monitoring for the seed growers on issues related to seed management. Other sources included farmer-to-farmer seed exchange, supplies by research centers through extension demonstrations, formal seed producer companies, informal seed producers and others. For instance, 25% of wheat growers sourced improved variety seeds from seed producer cooperatives while 18% accessed through Office of Agriculture. Farmer-to-farmer seed exchange was also a source of improved variety wheat seeds for 14% of the farmers. Even though the extent varies, the trend holds true for other cereals. According to the findings, 30% of Tef growers obtained seeds of improved varieties through Office of Agriculture while 22% obtained from seed producer cooperatives. Farmer-to-farmer seed exchange has also been a source for 13% of Tef growers.

The practice is, however, different for potato where all of the growers obtained improved variety seeds of potato from farmer seed growers. Agricultural research centers have also appeared to be the sole source of improved chickpea varieties for all of the growers. In addition to supplies through Office of Agriculture, market (traders) has also become essential source of improved varieties of maize, cash crops, such as faba bean, lentil, and field pea.

Table 28. Sources of improved variety seeds for the households (%)

Improved variety crops	n	Recycling from own saved	Gift from family/neighbors	Farmer to farmer seed exchange	Provided by Research centers	Extension demo plots	Farmer groups/ Coops	informal seed producers	Market (trader)	Provided free by MOA	Purchased from MOA through extension
Wheat	847	5	5	14	1	2	25	4	6	18	8
Barley	339	3	2	15	5	2	24	1	4	26	7
Tef	332	2	4	13	10	2	22	0	7	30	5
Maize	148	0	0	0	0	0	0	0	43	29	14
Potato	139	0	0	0	0	0	100	0	0	0	0
Chickpea	108	0	0	0	100	0	0	0	0	0	0
Faba bean	92	0	0	0	0	0	0	0	25	50	25
Lentil	91	0	0	13	0	0	0	0	38	50	0
Field pea	26	2	3	14	11	3	11	0	10	33	7
Fenugreek	26	2	2	12	10	0	34	3	9	8	8
Grass pea	21	5	0	24	0	0	24	0	0	19	5
Linseed	8	0	4	15	12	0	15	0	4	38	4

Reasons for non-adoption of improved crop varieties

As revealed in the study findings, ranges of reasons have been identified why farmers of the highlands did not yet had access to growing of improved crop varieties. The major factor has been that the farmers could not get access to seeds of improved varieties. For instance, the reason why 53% of the non-adopter farmers of wheat did not yet adopt improved varieties is due to inability to get seeds. The same is true for 49% of Tef, 55% of barley and 64% of maize growers (Table 29). Overall, 57% of the farmers have prioritized lack of access to seeds as the major reason why they did not yet start growing improved varieties of crops. The second reason where about 23% of the farmers reported was associated with economic reasons where some of the farmers could not afford to purchase packages of recommended technologies that go along with improved varieties, such as inorganic fertilizer, pesticides and others. Even though they apply, they use less than recommend a rate, which does not help to exploit the achievable yield. The third essential reason identified by 10% of non-adopters was unstable performance of improved varieties on farm conditions despite it performed well in the research stations. The farmers described, “improved varieties could not perform well compared to locals”. One of the reasons could be that the farmers may not have applied all the recommended packages along with improved varieties, such as recommended fertilizer type and rate, weeding and other agronomic practices. The other reason could be that the varieties might have required specific adaptability conditions and failed to perform well under diverse on-farm conditions.

Adoption rate of inorganic fertilizers

Inorganic fertilizer use on crops is one of the packages of improved varieties. As witnessed in Table 30, in the range of 83% - 94% of the highland farmers have appeared to be adopters of inorganic fertilizers. Fertilizer use has appeared to be very common in wheat (94%) followed by Tef and barley (91% each). 22% - 52% of the farmers have also adopted inorganic fertilizer application on pulses. Among oilseeds, 26% of the farmers have also applied inorganic fertilizers on linseed. On the other hand, inorganic fertilizer application has not yet become a common practice for pulse crops. Farmers in the range of 36% - 78% have not yet started application of inorganic fertilizers on pulses. The same is true for oilseeds where 74% of the farmers have not yet applied inorganic fertilizers on linseed. This might be because of the fact that pulses and oilseeds are perceived to be break crops in their ability to ameliorate soil fertility for subsequent rotation crops. Farmers believe that pulses and oilseeds do not require addition of inorganic fertilizers as they are the crops which can add fertility to the soils.

On the dynamism of use, more than 50% of the adopters have started applying inorganic fertilizer on cereal crops before 10 years. Even 20% of these farmers have already started fertilizer application on cereals long time ago before two decades. Even though nearly 60% of pulse growers have not yet started application of fertilizer, 24% of those adopters have experienced application in the last decade. The proportion of pulse growers who have started fertilizer use before a decade was not more than 17%.

Table 29. Reasons why highland households did not yet adopt improved crop varieties

	n	Not yet aware of	Could not get improved seeds	Not performing well	High input demanding	No money to purchase associated input packages	No market for its product	Not paying (not economical)	Improved seeds/seedlings expensive	Not tasty for consumption	Others (specify)
Wheat	183	7	53	8	12	8	1	2	5	1	3
Tef	147	3	49	16	7	7	3	2	4	0	9
Barley	139	5	55	12	4	14	1	2	3	0	5
Faba bean	128	5	57	7	10	4	1	4	2	0	10
Chickpea	49	8	65	10	2	2	0	4	0	2	6
Field peas	23	4	48	22	0	9	0	4	0	0	13
Maize	22	5	64	5	5	14	0	0	5	0	5
Potato	22	9	86	0	5	0	0	0	0	0	0
Lentil	21	0	62	5	24	5	5	0	0	0	0
Grass pea	19	11	58	5	0	5	0	0	0	0	21
Linseed	9	0	100	0	0	0	0	0	0	0	0
Fenugreek	2	0	100	0	0	0	0	0	0	0	0
Onion	2	0	100	0	0	0	0	0	0	0	0

Table 30. Adoption rates of inorganic fertilizers, 2016/17.

Crops	Fertilizer adopters (%)	Dynamism of fertilizer use trend (% of households)					
		Not yet started using fertilizer	Started using since the last 1-5 years	6-10 years	11-15 years	16-20 years	Before 20 years
Wheat	94	6	11	23	16	18	26
Barley	91	9	9	31	18	14	19
Tef	91	9	11	22	13	17	28
Maize	83	17	33	20	11	14	5
Faba bean	41	59	14	13	4	4	5
Grass pea	22	78	4	5	1	5	8
Chickpea	27	73	12	5	3	3	4
Field pea	52	48	13	13	8	9	8
Lentil	64	36	20	21	6	9	8
Linseed	26	74	7	10	-	5	5
Potato	87	13	16	36	13	11	11
Onion	91	9	43	20	5	9	14
Fenugreek	78	22	51	6	6	10	4

Adoption rates of agro-chemicals

It has become a common practice for the farmers to apply agro-chemicals, such as herbicides, fungicides and insecticides. As presented in Table 31, 78% - 92% of the farmers have adopted chemical use on three major cereals, including wheat, Tef and barley, commonly herbicides to control weeds. However, chemical use was not a common practice on maize where only 30% of the farmers have claimed to use chemicals, especially insecticides to control stalk-borers. On the other hand, close to 50% of pulse growers have adopted the use of chemicals, especially insecticides on aphids and other insect pests. Adoption rate of chemicals on linseed was also recorded to be 38%, which is mainly insecticide. The use of chemicals is also a common practice on potato where 46% of the farmers have claimed to adopt chemicals, especially fungicides on late blight and other diseases.

In all the cases, chemical use has not appeared to be an old practice. 60% of chemical adopters on cereals and 41% on pulses started the use in the last decade that might have been associated with GTP periods. GTP I and II plans have provided due focus on input use along with improved varieties.

Table 31. Dynamism of adoption rates of chemical, 2016/17

Crops	Adopters of agro-chemicals (%)	Dynamism of chemical use over time (herbicide, fungicide and pesticide) (%)					
		Not yet used	1-5 years	6-10 years	11-15 years	16-20 years	Before 20 years
Wheat	92	8	28	34	13	9	9
Barley	78	22	18	33	12	8	8
Tef	91	9	33	32	10	8	9
Maize	30	70	13	8	5	2	2
Faba bean	30	70	15	10	2	1	1
Chickpea	65	35	29	24	10	1	0
Lentil	83	17	35	36	7	4	1
Grass pea	40	60	30	8	2	-	-
Field pea	27	73	6	13	5	3	-
Linseed	38	62	19	14	-	5	-
Potato	46	54	20	19	3	4	1
Onion	80	20	43	31	3	3	-
Fenugreek	84	16	63	14	2	4	-
All crops	68	32	24	25	8	6	5

Adoption status of row planting

Row planting is one of the technology packages that go along with improved varieties. It is believed that row planting brings substantial yield increment over broadcasting. As provided in Table 32, only 6% of the farmers have started planting Tef in rows. This also implies that 94% of the farmers still depend on broadcasting of Tef. The adoption rate of row planting is relatively better for wheat (18%) and barley (19%). On the other hand, some of the crops, such as maize, potato and onion are commonly planted in rows. Because of this, adoption rate of row planting for these crops is relatively high in the range of 79% - 94%. Among the pulse crops, it has appeared that row planting is becoming a common practice for faba bean (24%) and field pea (22%). Overall, 26%

of the farmers in the highlands have adopted row planting of various crops, including cereals, pulses, oilseeds and vegetables. On the other hand, more than 70% of the highland farmers have not yet adopted row planting of crops because of the main reason that it is laborious activity. The favorable opportunity is that farmers have recognized substantial yield increment when crops are planted in rows. They also described that row planting makes weeding, cultivation and other agronomic activities easier. In spite of this, it requires a lot of labor and time during busiest period of planting. They suggested that row planting should be accompanied with multipurpose row planters, which can fit for planting different types of crops.

The findings have also indicated that nearly 85% of row planting adopters started the practice in the last decade. Out of these, 63% of the adopters started row planting in the last five years. This might also be associated with GTP plans which gave due focus for application of packages of technologies including row planting.

Table 32. Adoption rates of row planting

Crops	Adopters (%)	Dynamism of row planting over time (%)				
		1-5 years	6-10 years	11-15 years	16-20 years	Before 20 years
Wheat	18	82	13	3	1	2
Barley	19	79	12	3	3	2
Tef	6	64	16	7	-	13
Maize	79	48	34	11	4	3
Faba bean	24	65	20	4	3	8
Field pea	22	61	21	7	4	7
Chickpea	7	81	19	-	-	-
Lentil	7	80	20	-	-	-
Grass pea	2	60	40	-	-	-
Linseed	2	50	-	-	-	50
Onion	94	72	25	2	-	2
Potato	92	48	26	7	10	10

Trainings in improved crop management

Pursuant to achieving GTP goals and food security, farming households are exposed to ranges of capacity enhancing programs, such as trainings, experience sharing visits and others. The findings have pointed out that 56% of the households had received various types of trainings on improved crop management practices. Both male headed (57%) and female headed (52%) households had similar access to trainings (X^2=1.2424, df=1, P=0.265). Even though considerable proportion of farming households had access to trainings, 44% of them still did not get opportunities to participate on improved crop management capacity enhancing programs. Among the study zones in the highlands, farming households in East Shewa Zone had better to training services (78%) than others while West Arsi had the least access (34%) (Figure 2).

According to assessment of the gender perspectives in male-headed households, men (94%) had better access to trainings while it is still meager (5%) for married women (wives). On the other hand, FHH had better access to trainings as that of men counterparts. Youth, however, had limited chance of participating on trainings in both households (6% in FHH and 1% in MHH).

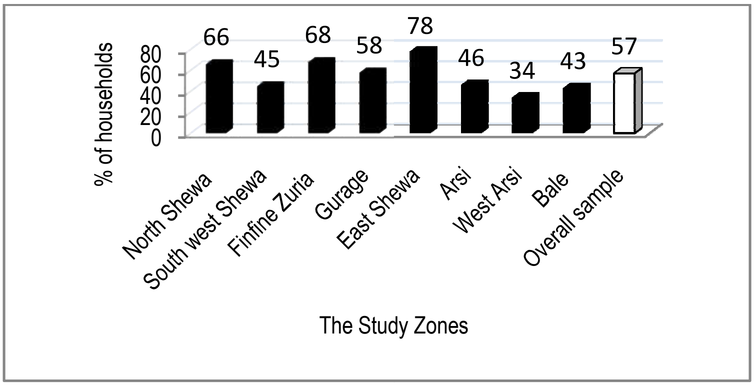


Figure 2. Access of households to trainings on improved crop management, 2017

Out of those households who had the chance to participate on trainings, 49% of them got the chance in the last ten years while others before a decade (Figure 3). This might be because of robust government programs in strengthening agricultural extension services and encouraging farmer-to-farm skill enhancing and training programs. One of such programs could be GTP, which is under implementation since the last decade. According to perception of 42% of beneficiaries, training opportunities were highly useful in enhancing skills on crop production and productivity.As they described, trainings have helped them enrich knowledge on improved practices of crop production apart from being exposed to experience sharing visits of progressive farmers in their locality.

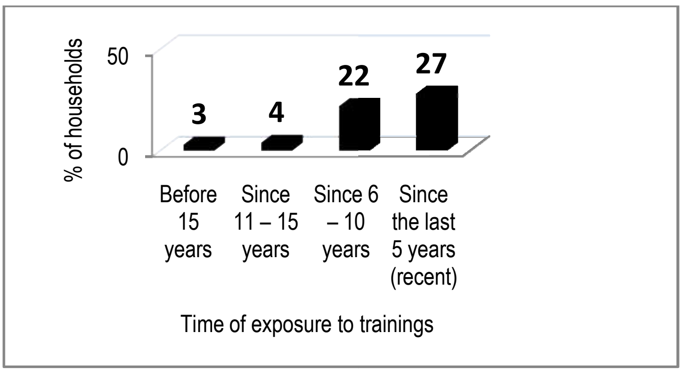


Figure 3. Time of exposure of households to trainings on improved crop management

In rural Ethiopia, all the family members contribute labor to ranges of farming activities. Especially the participation of women in farming is substantial apart from domestic activities. However, training opportunities and other exposures to new technologies is not yet accessible to women. As evidenced in Figure 4, 88% of the households presented that men are the ones who still had access to trainings on improved crop management practices. Even though women provide considerable labor for weeding, harvesting and other crop related farming, their exposure to training opportunities is still petite as reported by 7% of the households. Women need to receive training opportunities and exposure to new technologies for the agriculture sector. As noticed by 75% of the households who received trainings, their farming productivity is highly improving from time to time because of the use of improved technologies as per the knowledge and skills received. Subsequent to trainings, the demand for improved technologies has also increased despite it was not yet possible to meet the demand. Inability to meet the demands of improved crop seeds has appeared to be one of the challenges the farmers are facing in agriculture sector.

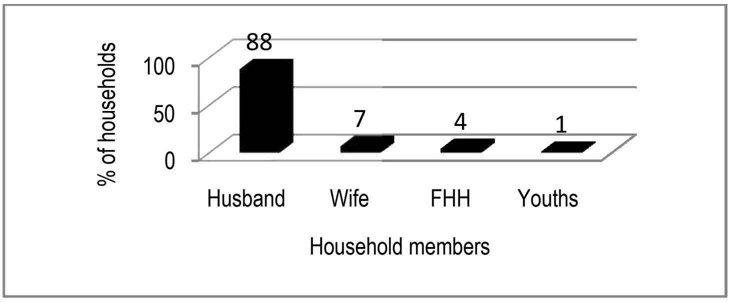


Figure 4. Household members who had access to trainings on improved crop management

Commercialization of wheat and barley

Commercialization index of wheat and barley

According to the findings, commercialization index of what was 0.30 while that of barley 0.17. This implies that on average 30% of the wheat produced was supplied to the market while only 17% of the barley was used for sale. Previous results reported lower figure for wheat commercialization index in Ethiopia. For instance, the level of wheat commercialization reported was 21% by USAID (2010); 25% by Minot *et al* (2015) and 27% by Tadele *et al* (2017). Using nationally representative data, Pender and Dawit (2007) found that 17% of the wheat and 10% of the barley produced was used for sale at the national level.

Distribution of commercialization index is presented in Figure 5. The result reveals that 33% of the wheat and 59% of the barley produced was totally utilized for household consumption implying most of the farmers in the study areas were subsistent. Among the 41% of households participating in barley marketing, the majority fall below 0.5 commercialization index. The sample households are relatively better in terms of wheat commercialization with more than 20% of them selling more than half of the wheat they produced.

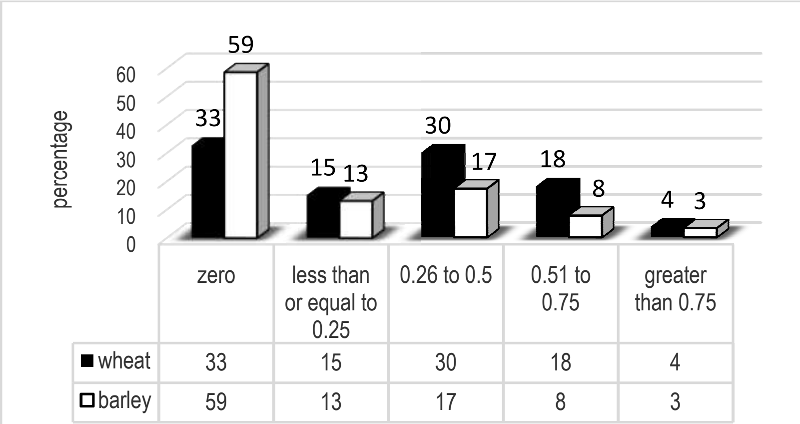


Figure 5: Distribution of commercialization index of wheat and barley (%)

Factors influencing the level of commercialization of wheat and barley

Estimation results of the multivariate Tobit Model for simultaneous decision of commercialization of wheat and barley are presented in Table 33. The overall fit of the model is assessed using Wald Chi square and likelihood ratio tests. The significant Wald Chi square statistic and the significant log likelihood ratio test both at 1% level of significance showed that the variables included in the model explain a significant proportion of the variation in the dependent variables. In addition, the correlation coefficient, rho (ρ) is significant at 1% level implying that there are unobservable factors affecting both decisions and confirming the presence of simultaneity in the decisions on the level of commercialization of the two crops. This implies that estimating a separate Tobit model as univariate to estimate the level of commercialization of each crop would lead to inconsistent and biased estimates and hence using multivariate Tobit for estimating this model is justifiable.

The multivariate Tobit estimation analysis result shows that out of the 16 coefficients, 12 coefficients have a significant relationship with the commercialization level of both crops jointly. Barley commercialization index was found to have a negative effect on the level of commercialization of wheat. This could be explained by the fact that barley and wheat are both cereal crops that have substitute nature and hence in smallholder farming situation where the main objective is not profit maximization but food security, the level of wheat crop sold partly depends on the level of its substitute (barley) that is used for household consumption.

Among the household background variables such as family size (in adult equivalent), sex, age and education of the household head, all of them except age have a significant effect on the level of commercialization of at least one of the two crops. Sex of the household head (being male headed) was found to have a significant positive effect on wheat commercialization at 5% level of significance but no significant effect on barley commercialization suggesting that the role of gender on commercialization seems crop specific. This result is in line with previous findings (Justus *et al.*, 2015).

As expected, education level of the household head was found to have a positive effect on the level of both wheat and barley commercialization at 5% and 10% level of significance, respectively. Therefore, improving access to education in rural areas of the farming community facilitates the way of agricultural transformation process from subsistence towards market oriented commercial farming systems which Ethiopia has been implementing since the past eight years. Previous results are also in line with this finding (Agwu *et al*., 2013; Alelign *et al*., 2017; Aman *et al*., 2014; Justus *et al*.,2015; Tadele *et al*., 2017).

Family size measured in adult equivalent which is relevant to consumption of parts of the crop produced by the farming households, was found to have significantly negative effect on the level of commercialization of both wheat and barley at 1% and 5%, respectively as expected. This is because smallholder farmers who produce crops for both consumption and sale of marketable surplus characterize farming system in central Ethiopia. Large family size implies the need for more crops to consume and less for marketable surplus. However, family size was measured in adult equivalent, which could also be used as proxy for family labor, the result indicates, as the contribution of labor is minimal. The low contribution of family labor (family size in adult equivalent) may be explained with large number of family number with young age, who could not contribute much labor but more on food consumption. The result is consistent with earlier studies (Agwu *et al*., 2013; Aman *et al*., 2014; Tadele *et al*., 2017).

Livestock ownership was found to have a positive effect on the level of barley commercialization at 10% level but not significant for wheat. This is expected as livestock serves as productive asset on one hand and sources of income that can be used to purchase inputs for barley production on the other. Moreover, ownership of oxen (an important for ploughing) was found to have positive effect on the level of commercialization of both wheat and barley at 5% and 10% level of significance, respectively, which is expected a priori. Earlier empirical evidences also support this positive relationship (Aman *et al*., 2014; Tadele *et al*., 2017).

Contrary to expectation, total land owned (ha) was found to have negative effect on the commercialization of both crops, both at 5%. However, land allocated to each crop was found to have a significant positive effect on the level of commercialization of the respective crops at 1% for wheat and at 10% for barley. That is, what matters for the commercialization level of a specific crop is an area allocated for that crop rather than the total land owned by the household that may be allocated for other crops or used for livestock production. Inverse relationship between total land holding and level of commercialization is inconsistent with most of the previous findings (Agwu *et al*., 2013; Aman *et al*., 2014; Justus *et al.,* 2015; Nepal and Thapa, 2009). Cultivable land was found to have negative effect on the level (intensity) of market participation in some literatures (Alelign *et al*., 2017) which implies that the effect of land owned can be case specific. One of the possible reasons for this inverse relationship between total land area and level of commercialization of these crops is that more land is allocated to other cash crops, which have high price than barley and wheat. In this case, barley and wheat are probably sold to solve immediate cash constraints of the poor farmers.

Against the prior expectation and theory of information, ownership of mobile phone of the household head was found to have a negative effect on the level of commercialization of barley but no statistically significant effect on wheat. This contradicts with the effort of the government that started to assist farmers in providing agricultural information based on request from farmers through mobile phone. One of the possible reasons for negative relationship is that farmers gather price information on all crops they produce and sell crops that fetch higher price and use cheaper ones at home. That means, if they have priori information on barley price and other crop price before taking to market, then they decide not to sell barley at low price but sell other crops such as wheat and Tef that relatively fetch better price for farmers. In this case, the negative relationship is expected. Another scenario for the negative relationship between barley commercialization and mobile ownership might be because farmers may not use their mobile for such purposes due to low level of education and lack of knowledge to be benefited from mobile technology. Another scenario for the negative relationship might also be explained by market information of other crops which might be communicated more through phone and less attention was given to barley; hence, households who were not guided by mobile to sale other crops, might supply more barley to market, assuming barley is inferior good to get market information. Therefore, the mobile information designed by the government have to include the commercialization aspects for all crops rather than focusing on the production aspect and market information only for specific crops in the future.

The dummy variable, contact with extension (access to extension services), was found to have negative effect on the level of commercialization of wheat at 5% but has insignificant effect on barley. Nowadays, the contribution of current extension system has been criticized in empirical findings for their less effectiveness and inefficiency. For example, Yigezu *et al* (2015) criticized the way of extension delivery system and suggested for designing new effective extension system after finding statistically insignificant effect of the extension service variable on the adoption decisions of multiple crops (barley and potatoes) in the central highlands of Ethiopia. Similar suggestion is also forwarded from the result of this study which shows even the negative relationship with the level of commercialization despite the main target of the current extension system is on the production side with little focus on the commercialization aspect.

Finally, a dummy variable, access to credit, influenced the level of barley commercialization positively and significantly at 5% but had no significant effect on wheat. This is an expected result as credit has a positive effect in crop production to solve cash problem to purchase inputs that increase yield that in turn enhances commercialization. This result is consistent with previous findings (Agwu *et al*., 2013; Tadele *et al*., 2017).

Table 33. Results of the multivariate Tobit analysis of factors influencing wheat and barley commercialization

Explanatory variable	Wheat commercialization		Barley commercialization	
	Coef.	SE	Coef.	SE
Barley commercialization index	-0.527	0.265**	n.a	n.a
Sex of HHH	0.181	0.081**	0.029	0.104
Age of HHH	0.003	0.002	0.000	0.003
Education of HHH	0.015	0.007**	0.016	0.009*
Family size (AE)	-0.034	0.011***	-0.028	0.014**
Corrugated roof house (%Yes)	0.091	0.060	0.037	0.080
Livestock (TLU)	0.003	0.007	0.014	0.008*
Oxen owned (Number)	0.044	0.021**	0.045	0.026*
Total land owned (ha)	-0.029	0.014**	-0.042	0.017**
Mobile owned (%Yes)	-0.067	0.061	-0.188	0.076**
Contact with extension dummy	-0.161	0.069**	0.032	0.093
Credit service dummy	0.008	0.050	0.129	0.064**
Distance to all-weather roads (km)	-0.003	0.006	-0.005	0.009
Distance to nearest market (km)	0.004	0.005	-0.003	0.007
Wheat area (ha)	0.118	0.023***	n.a	n.a
Barley area (ha)	n.a	n.a	0.102	0.059*
Constant	0.096	0.148	-0.132	0.193
/lnsigma1	-0.950	0.125***		
/lnsigma2	-0.748	0.068***		
/atrho12	0.835	0.229***		
sigma1	0.387	0.048***		
sigma2	0.473	0.032***		
rho12	0.683	0.122***		
Number of observations =336	Censored to left (0) =197 for barley and 110 for wheat			
	Censored to right (1) =5 for barley and 1 for wheat			
Wald chi^2(29)=119.88				
Log likelihood= -348.4483	Prob > chi^2 = 0.0000			
chi2(1) = 4.90636	Prob > chi^2 = 0.0268			
Likelihood ratio test of rho12= 0.000				

*, **and*** means significant at 10%, 5% and 1%, respectively; n.a means not applicable*

Livestock technology introduction and adoption

Households in the central highlands are engaged in mixed farming including both crops and livestock production. Among the livestock, oxen ownership is the most essential factor in farming with substantial contribution to food security. In rural households, oxen ownership is also perceived to be an indicator of wealth. As Table 34 indicates that, 84% of the households in the highlands owned 1 – 8oxen. This also implies that 16% of the households on average did not yet own an ox, which is an indication of poverty.Figure 6 illustrates zonal variability in oxen ownership where more than 85% of the households in all the zones owned ox except GurageZone where oxen ownership is the least, only 44% of the households. This is because of the fact that Guragefarming system is perennial crop based, such as Enset, chat and others covering most plots of the land owned. Any open space between perennials is cultivated with hand using manual tools. Therefore, there is no as such open space that merits oxen plowing in most of the households.

Table 34. Livestock ownership status of households, 2016/17

Types of livestock owned	MHH		FHH		Overall households		X^2 Test
	n	%	n	%	n	%	
Own oxen	837	86	61	64	898	84	X^2=30.9952, df=1, P<0.001
Own a single ox	*121*	*12*	*22*	*23*	*143*	*13*	X^2=50.8080, df=4, P<0.001
Owned a pair of oxen	*419*	*43*	*31*	*32*	*450*	*42*	
Owned 3 – 5 oxen	*263*	*27*	*8*	*8*	*271*	*25*	
Owned 6 – 8 oxen	*34*	*3*	*0*	*0*	*34*	*3*	
Cow	750	77	63	66	813	76	X^2=5.8051, df=1, P=0.016
Heifer	507	52	41	43	548	51	X^2=2.9174, df=1, P=0.088
Bull	336	34	25	26	361	34	X^2=2.7080, df=1, P=0.10
Calves	550	56	44	46	594	55	X^2=3.8281, df=1, P=0.05
Chicken	635	65	52	54	689	64	X^2=4.3925, df=1, P=0.036
Sheep	621	64	45	47	666	62	X^2=10.2528, df=1, P=0.001
Goat	173	18	5	5	178	17	X^2=9.8486, df=1, P=0.002
Donkey	756	77	46	48	802	75	X^2=39.9109, df=1, P<0.001
Horse	357	37	22	23	379	35	X^2=7.0664, df=1, P=0.008
Mule	31	3	0	0	31	3	X^2=3.1334, df=1, P=0.077
Camel	26	3	0	0	26	2	X^2=2.6155, df=1, P=0.106

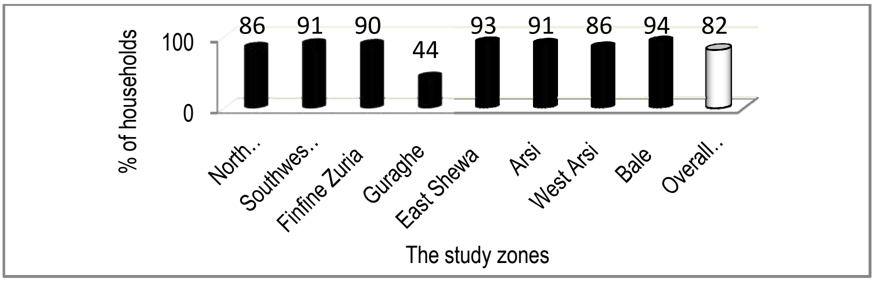


Figure 6. Proportion of households owning ox, 2017

The proportion of households who did not own oxen was higher for FHH (36%) than MHH (14%). This could also be an indication that the poverty level of households is higher for FHH than MHH. On the other hand, 28% of the households owned more than a pair of oxen, which is an indication of better wealth status of households in rural areas. Households who owned a pair of oxen (42%) are perceived to be of medium wealth category while those who owned a single ox represent resource poor households. Those who did not own ox are perceived to be the poorest-of-the poor households. Overall, 70% of the households owned a pair and more of oxen. The implication is that those households who owned two pairs or more of the oxen can cultivate more land and are believed to secure more production than others. In terms of tropical livestock units (TLUs), households of the highlands on average owned 6.7 TLUs (Table 35). MHH owned significantly higher TLUs (6.9) than FHH who owned 4.3 TLUs (t=5.0252, df=1048, P<0.001).

Table 35. Tropical livestock unit (TLU) ownership by household type, 2017

Household type	n	Mean	Min	Max	SD
MHH	962	6.9	0.026	32.04	4.637203
FHH	88	4.3	0.026	14.17	3.073495
Overall sample	1050	6.7	0.026	32.04	4.580035

t=5.0252 *df=1048* *P<0.001*

Adoption of crossbred cows

Research and development interventions have been promoting livestock technologies that mainly include crossbred animals, improved forage crop varieties, multi-nutrient block and milk processing technologies. The findings reveal that 71% of the households in the highlands were aware of crossbred cow technologies, out of which 19% of the households have owned and adopted crossbred cows (Table 36). The proportion of households who adopted crossbred cows was significantly higher for male-headed households (20%) than female headed (10%) (X^2=4.9511, df=1, P=0.026). The study conducted by Agajie *et al.* (2016) in 2014/15 on adoption analysis of smallholder dairy production technologies has reported a higher adoption rate of crossbred cows at 28%. The reason for the decline of adoption rate after three years might be limited sources and consequent high purchase price for replacement of existing crossbred cows. The other reason might be that when the parity of a cow increases beyond 6^{th}, it is no more considered to be a productive crossbred cow. Therefore, the farmers who have at times owned a productive crossbred cow with parity in the range of 1 – 6, could become non-adopters unless there is replacement. The cows after 6^{th} parity are often sold away for beef because of declining productivity. Therefore, there could be declining trend of adoption due to unavailability of reliable sources of replacement crossbred heifers and cows.

When location variability is taken into consideration, the highest proportion of adopters (36%) is from North Shewa zonewhile the least proportion of adopters (9%) is from Southwest Shewa and Bale Zones (Figure 7). North Shewa zone especially in Oromia region is commonly named as Selale plain where several dairy related technologies have been in promotion since the last four decades through various governmental and non-governmental organizations. Some of these included fourth livestock project, Selale Dairy Development Program and others.

Table 36.Farmers' awareness and adoption status of crossbred livestock, 2017

Type of crossbred animal	MHH		FHH		Overall households	
	Aware	Adopters	Aware	Adopters	Aware	Adopters
Ox	67	13	52	7	66	12
Cow	72	20	58	10	71	19
Heifer	65	13	54	7	64	12
Bull	61	7	48	4	60	6
Calves	64	13	49	6	62	12
Chicken	65	23	52	13	64	22

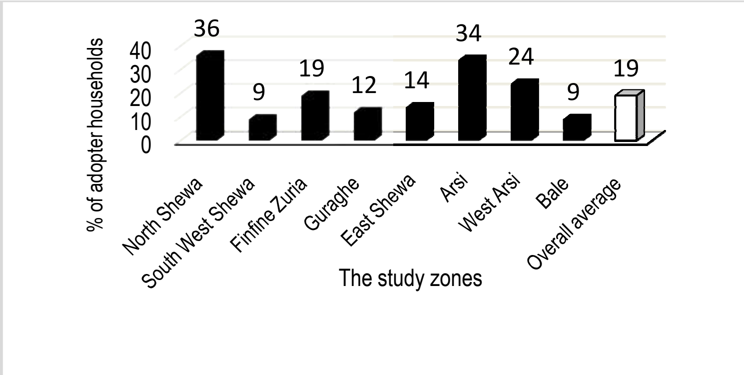


Figure 7. Adoption rate of crossbred cows, 2017

On the aspect of dynamism of adoption, 16% of the households adopted in the last decade while others before a decade (Table 37). This might be associated with the direction of the government to enhance the growth of agriculture sector through designing of Growth and Transformation Plans (GTP) that already completed phase-1 and phase-2 is in progress. The livestock master plan was also prepared and approved within the last decade, which provides directions and recommendations on enhancing the livestock sector in general and dairy sector in particular.

Table 37. Dynamism of crossbred cows adoption, 2016/2017

Time of crossbred cow adoption	MHH		FHH		Overall households	
	n	%	n	%	n	%
None adopters	780	80	86	90	866	81
Adopted since the last 5 yrs	98	10	5	5	103	9
Adopted since 6 – 10 yrs	68	7	4	4	72	7
Adopted more than 10 yrs	32	3	1	1	33	3
Total	978	100	96	100	1074	100

X^2=5.5857, *df=3*, *P=0.134*

Because of unavailability of formal sources of crossbred heifers and cows in the country, the major source has appeared to be a market for 9% of the adopters (Figure 8). When a crossbred cow is purchased from the market, there is no record of its exotic blood level, age, parity, productivity, health status and other reproductive traits. The major factor on which purchasers depend is on body condition that does not necessarily provide indication on either of the reproductive or productive traits. The sellers do not also disclose the real information about the crossbred cow, because of which the purchasers take all the risk in addition to spending high amount of money in the transaction.

The second essential source of crossbred cows and heifers for 4% of the adopterswas farmer-to-farmer transaction at the farm gate. In such cases, the risk of getting wrong information about the crossbred cow is still evident because of either rare or no experiences of record keeping by the farmers. Even the sellers do not appear to be genuine in disclosing the reason why they are selling the cow, which could be either infertility, less productiveness or other sort of defects. Ministry of Agriculture and

Natural Resources (MOANR) has appeared to be the third option of crossbred heifer sources for 3% of adopters. The ministry has its own program of disseminating crossbred cows to farmers through its regular agricultural extension program. It supplies crossbred heifers mainly to progressive farmers to create exposure and a learning opportunity for other fellow farmers.

Out of crossbred cow adopters, 16% of them reported that the economic and nutritional benefits are highly improving from adopting crossbred cows. Crossbred cow adopters basically sale milk, from which they generate economic benefits. They also consume the milk at home because of which nutrition of the family, especially children is believed to improve.

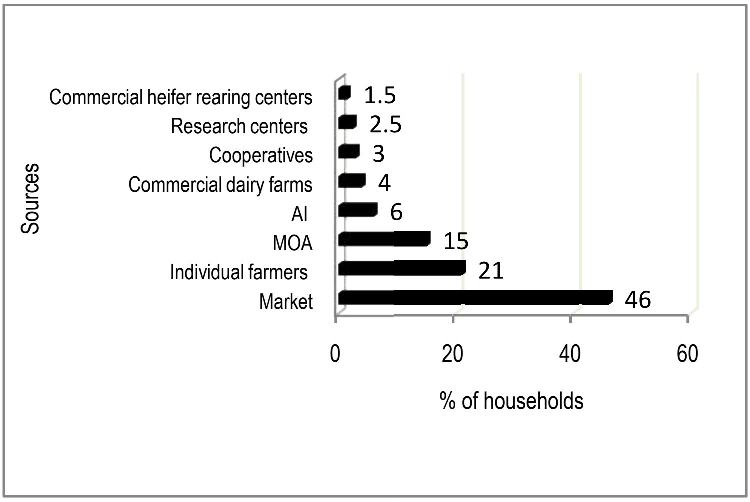


Figure8.Sources of crossbred cows, 2016/17

The study has also figured out that 81% of the households still did not have access to these technologies. According to 44% of the households, unaffordable price of crossbred cows and heifers has appeared to be the major problem that has affected their adoption (Figure 9). The second major factor according to 22% of the households was unavailability of reliable and formal sources of crossbred cows/heifers except a few private companies who are engaged in heifer rearing, but still unable to meet the demand. There is no formal heifer-rearing center in the country, which can meet the demands of dairy farmers and potential new entrants into dairy business. Supply limitation has become the driving factor for unaffordable prices of crossbred dairy cows/heifers that ranges from 30,000 to40,000 birr per cow/heifer. Feed scarcity and consequent high cost has also been the other factor to affect adoption of crossbred cows in the highlands.

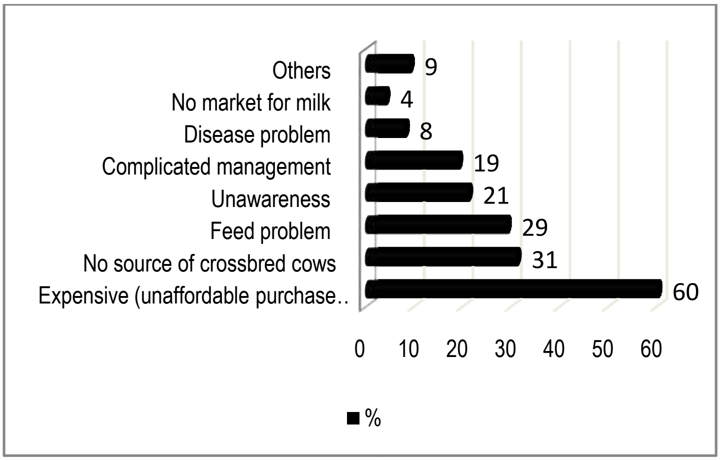


Figure 9.Farmers' reasons for non-adoption of crossbred cows, 2017

Apiculturetechnology adoption

Even though it is largely characterized by traditional management systems, beekeeping is also another enterprise that is being practiced by the highland farmers. Honey, wax and other products are used as source of supplementary incomes to meet cash demands of households for input purchase, consumables and other needs. As evidenced in Table 38, 89% of the households owned traditional beehive that is an indication that beekeeping is still a traditional practice in rural areas. This finding is congruent to Demisew (2016) who reported that 90% of beekeepers in Ethiopia are traditional. The same report has indicated that productivity is by far very low (5.5 kg/colony/annum) when beekeeping is managed on traditional beehive with conventional practices. Instead, productivity can be enhanced by seven folds (33 kg/colony/annum) when apiculture is practiced through improved mechanisms using modern beehives.

However, adopters of modern beehive technologies have appeared to be only 16% of the households, out of which 17% account for male-headed households while 7% female headed households. Even though farmers have noticed the importance of modern beehives, it is not easily accessible at affordable costs. Not only that modern beehive is not easily available at local markets, its price is also very high for smallholder farmers'. For instance, one modern beehive costs more than Birr 2000.00 at the local market. According to the findings, only 3% of beekeepers have obtained beehive from local markets (Figure 10). The common source of modern beehive for 75% of the farmers is Office of Agriculture through Rural Technology sub-sector devoted to construction of technologies and tools, including beehives, for farmers' use.

Table 38. Beekeeping practices

Reasons	MHH		FHH		Overall households	
	n	%	n	%	n	%
Own traditional beehive	153	90	6	85	159	89
Own transitional beehive	9	5	0	0	9	5
Own modern beehive	29	17	0	0	29	16

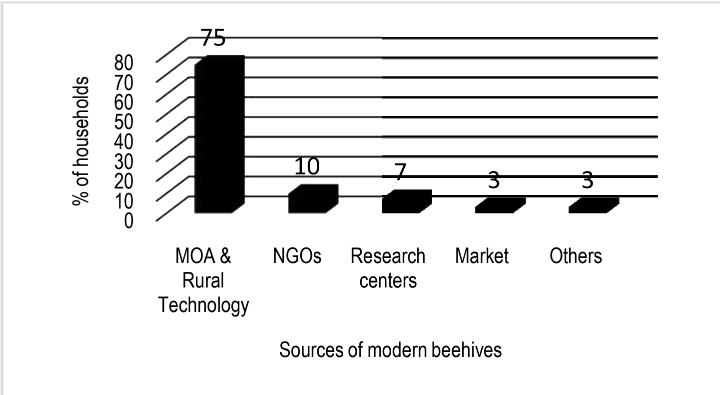


Figure 10. Sources of modern beehives

On the aspect of trend over time, ownership of modern beehives was a recent experience to most of the adopters. For instance, 81% of beekeepers who are using modern beehive owned within the last five years (Figure 11). This might be associated with the plan of the government to introduce technological options and enhance agricultural production and productivity in the GTP-II period.

Adopters of modern beehives owned 2.3 hives on average ranging from 1 – 12. This implies that a beekeeper can obtain about Birr 7500.00 per annum (ranging from Birr 3000.00 – 40,000.00 per household per annum) supplementary income from sales of honey alone. The income would increase when sales value of bee wax is also included. About 52% of apiculture technology adopters owned one modern beehive while 21% owned two, 14% three and 13% more than three.

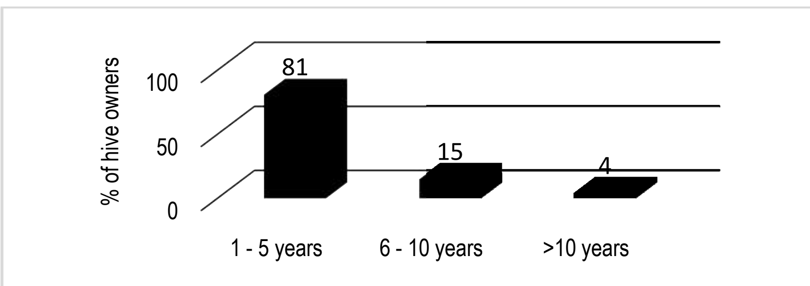


Figure 11. Time since when households started adopting modern beehive technology

Adoption of animal feed technologies

In the highlands, feed is a concern to 70% of the households, out of which it was a serious problem occurring more often for 24% of the households (Table 39).It was noted that consequentto frequent occurrence of climate change in the form of drought and shrinking size of land holding per household over time, feed problem has started becoming a concern to highlander households.

Table 39. Status of feed problem

Status of feed problem	MHH		FHH		Overall households	
	n	%	n	%	n	%
Feed shortage is a serious problem and occurs more often	234	24	24	25	258	24
Feed shortage is a problem, but occurs sometimes	460	48	28	29	488	46
Feed shortage not as such a problem	263	27	43	45	306	29

$X^2 = 15.8577$, $df=2$ $P<0.001$

In the mixed crop-livestock farming systems, livestock feed sources are still conventional in nature. As provided in Table 40, 90% of the households still depend on crop residues as major source of feed followed by grazing (77%). Since the highland agro-ecology is characterized by production of various types of crops, residues have appeared to be major feed sources. Farmers conserve the residues for use especially during a season of feed scarcity. At the time of rainy season, it is common for 52% of the households to practice cut-and-carry system of green feed. They harvest green feeds along boarders of crop fields and weeds to use as animal feed. In earlier days, local beverages used to be disposed away without any uses. Following feed scarcity over time, it has become an essential feed source for 54% of the households. Hay production is also becoming not only livestock feed source for 46% of the farmers, but also a crucial source of income from sales. Concentrate feeding, such as grain and grain by-products, is also becoming a common source of livestock feed for 42% of the households in the highlands.

As one of the packages of livestock technologies, MOANR and national agricultural research systems has been generating, introducing and disseminating improved forage crops to help address feed shortages. So far, the national research system has developed and generated more than 30 improved forage varieties since the last 3 – 4 decades. However, adoption rate of improved forage varieties has appeared to be 12% in the highlands. This also means that 88% of the farmers not still have access to planting of improved forages. This finding is in conformity with the results of the study conducted in 2014 in the same agro-ecology that reported 10% adoption rate of improved forages (Agajie *et al*., 2016). Adoption rate of improved forages has revealed a slight increase in the last 3 - 4 years. This might be associated with extended promotion and dissemination of improved forage varieties. Private enterprises have also been engaged in multiplication and sale of improved forage variety seeds that contributed to increased adoption of forage crops over time.

Table 40. Feed sources, 2017.

Feed sources	MHH		FHH		Overall households		X^2 test
	n	%	n	%	n	%	
Grazing	762	78	70	73	832	77	X^2=1.2578 , df=1, P=0.263
Green feed	504	52	50	51	554	52	X^2=0.0183 , df=1, P=0.892
Hay	448	46	46	48	494	46	X^2=0.1891 , df=1, P=0.664
Crop residues	889	91	80	84	969	90	X^2=5.2703 , df=1, P=0.022
Concentrates	422	43	27	28	449	42	X^2=8.0283, df=1, P=0.005
Improved forages	123	12	12	12	135	12	X^2=0.0002 , df=1, P=0.989
Local beverage products	521	54	55	58	576	54	X^2=0.6098 , df=1, P=0.435
Stubble grazing	415	43	47	49	462	43	X^2=1.5767 , df=1, P=0.209
Others	23	3	1	1	24	3	X^2=1.0053 , df=1, P=0.316

Varietal level adoption of improve forage crop was also assessed in this study. As presented in Table 41, highland households in the range of 9% - 29% were aware of different improved varieties offorage crop. This means, 70% of households in the highlands were not even aware of existence of improved forage crop varieties. Instead, what they know is about improved varieties of food crops. Out of improved forage varieties, relatively better known by 29% of the households was oat-vetch followed by elephant grass (19%). On the other hand, alfalfa is the least known forage crop where only 9% of the farmers were aware of this variety. Even though awareness precedes use, adoption rates of the commonly known forage varieties were recognized to be very low. Relatively better adopted forage variety was oat vetch by 12% of the farmers, which is also most known. Adoption rate of other forage varieties was very low, 4% for elephant grass and 1% for alfalfa, which is also least known. On the aspect of dynamism, forage variety adoption was a recent experience to highland households. For instance, 65% of those adopters started growing and using improved forages within the last five years (Figure 12). This could be associated with growth and transformation programs of the government who have made robust plans to introduce and promote available crops and livestock technological packages and increase agricultural production and productivity.

Overall, even though feed is one of the major constraints to livestock sector, improved forage crops that were generated by research systems have not been adequately promoted and disseminated to the highland households. The agricultural extension system seems to have not provided due focus for promotion and dissemination of livestock technologies.The efforts made by national agricultural research systems which includes research institutions and universities, and international agricultural research institutions in the promotion and dissemination of improved forage technologies have been minimal. Consequent to this, both awareness and adoption rates of these improved forages have appeared to be very low in spite of availability of several options of forage varieties that are tested to be adaptable in the highlands.

Table 41. Awareness status and adoption rates of improved forage varieties, 2016/17

Feed sources	MHH		FHH		Overall households	
	Aware (%)	Adopted (%)	Aware (%)	Adopted (%)	Aware (%)	Adopted (%)
Oat-vetch	30	4	19	11	29	12
Elephant grass	20	4	11	3	19	4
Sesbania	15	3	8	1	14	3
Tree Lucerne	11	3	9	4	11	3
Alfalfa	10	1	6	2	9	1

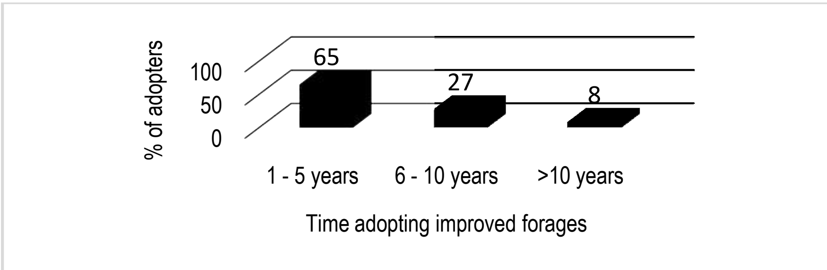


Figure 12. Time of adoption of improved forage crops, 2017

The major reason why a large proportion of the farmers (37%) have not yet adopted improved forage varieties was inability to get seeds of improved forage varieties (Figure 13). Once promotion has been made to the farmers on improved technologies, technologies should have been made available to farmers as per their demands. Even though there are several options of improved forage varieties that have been released by research, there is no organization or company, which is devoted to seed multiplication and supply to the farmers. Because of this, the farmers are not getting the improved seeds they require which could substantially contribute to reduced livestock production and productivity.

The focus so far seems to have been more on promotion of improved crop varieties and natural resource conservation practices than improved forages. Those who are aware could not get the improved forage seeds to grow on their farms. For some of them, the improved forage seeds might have appeared to be expensive. There is also attitudinal problem thatmakes them think that food crops are better helpful for the household economy than forage crops. They tend to provide priority of allocating land for food crops than forage crops. This was the reason why 28% of the dis-adopters reasoned out land shortage as one of the reasons for not yet growing improved forages. Complaints were also reported from the dis-adopters that improved forages have suffered from poor performances.

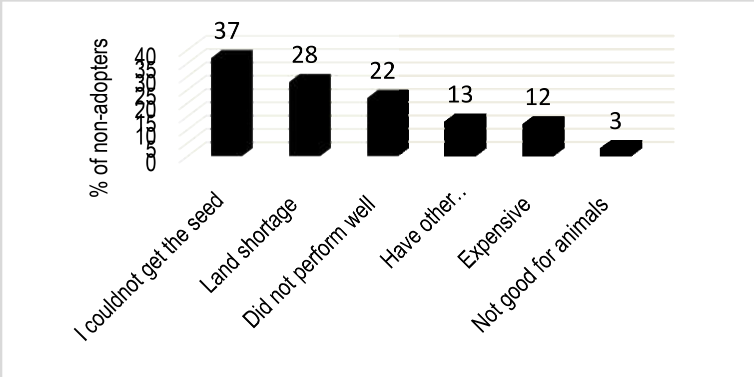


Figure 13. Reasons for non-adoption of improved forage technologies

Livestock health management and breeding

Following feed shortage, livestock health is the second worrisome problem of households in the highlands. As presented in Table 42, 86% of the households have reported livestock diseases as a problem that challenges livestock production, out of which livestock diseases have appeared occasionally for 76% of the households and to 10% of the households, it occurred more often.When the disease takes place, farmers adopted various strategies to manage the diseases. As provided in Figure 14, it has become a common practice for 93% of the farmers to seek treatment of the sick animal at the nearby veterinary clinics. Traditional treatment is also still popular in rural areas being practiced by 29% of the households. When traditional means of attempt fails, the last option is taking the victim animal to veterinary clinic.

Table 42. Livestock disease status, 2016/17

Status of animal health problem	MHH		FHH		Overall households	
	n	%	n	%	n	%
Livestock disease is a serious problem and occurs more often	91	9	15	16	106	10
Livestock disease is a problem, but occurs sometimes	766	78	49	51	815	76
Livestock disease is not as such a problem	121	12	32	33	153	14

X^2 =39.0740, df=2 P<0.001

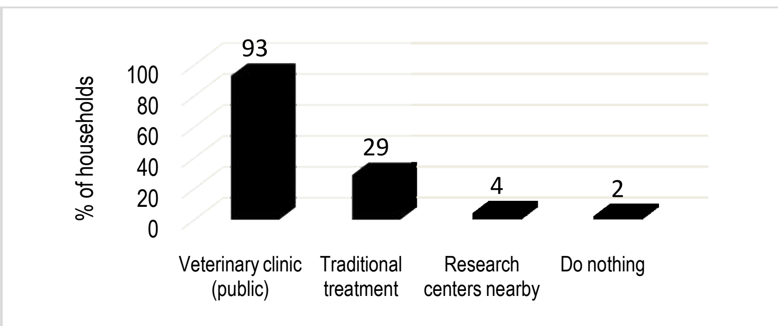


Figure 14. Farmers' livestock health management

As a protection strategy, seeking vaccination service has also become an essential way out in rural households. Ministry of Agriculture and other public organizations make supports and encourage farmers to get vaccination services to their animals. As figured out by the findings, 92% of the livestock owners have vaccination services (93% of MHH and 82% of FHH). As to the trend, vaccination practice has started a bit earlier despite the largest proportion of farmers (78%) intensified the use of vaccination services within the last decade (Figure 15).Public institutions, such as Ministry of Agriculture and others are largely providing vaccination service.

According to assessment of health related problems, inaccessibility and far distance of veterinary clinics was pointed out to be the major by 43% of the farmers (Figure 16). Apart from this, considerable proportion of the farmers (28%) did not have adequate knowledge related to how diseases are caused, protection mechanisms and other features.

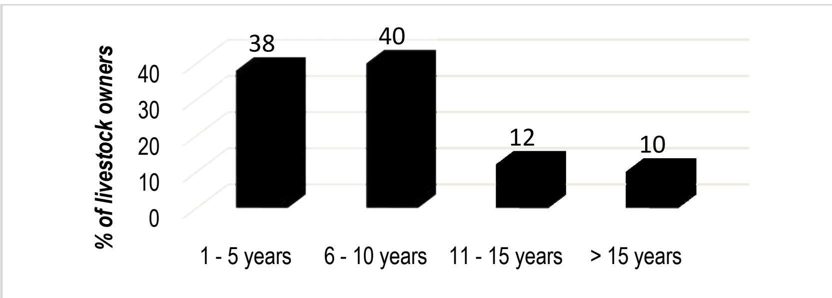


Figure 15. Time started getting vaccination service, 2017.

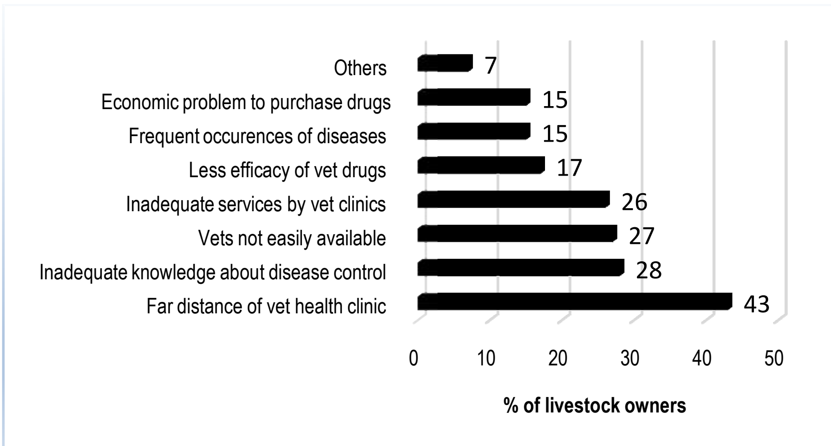


Figure 16. Problems related livestock diseases, 2017.

Livestock breeding

One of the means to get crossbred cows in the farming communities is using artificial insemination (AI) on local cows. However, AI service is not yet a common practice to

80% of the livestock owners. This means, AI service beneficiaries are not yet more than 20% of the households (Figure 17). AI is dominantly public service being provided by Offices of Agriculture (95%) (Figure 18a). Involvement of private sector in the provision of AI service is not yet a common practice where only 1% of the households have AI services from private sectors. As to the trend, 71% of the farmers started getting AI services in the last five years (Figure 18b).

Farmers have described various reasons why they have not yet started getting access to AI services. According to Figure 19, 44% of the households did not have access to AI services. Even 15% of the households claimed that AI service is not effective. In light of severe shortage of crossbred heifers, it is essential to promote AI service and create easy accessibility to farmers' proximity when required.

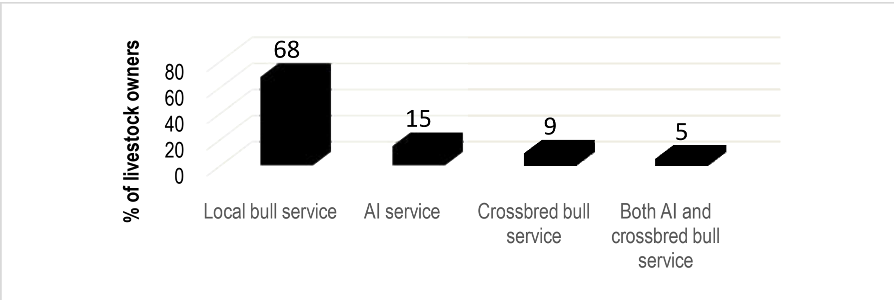
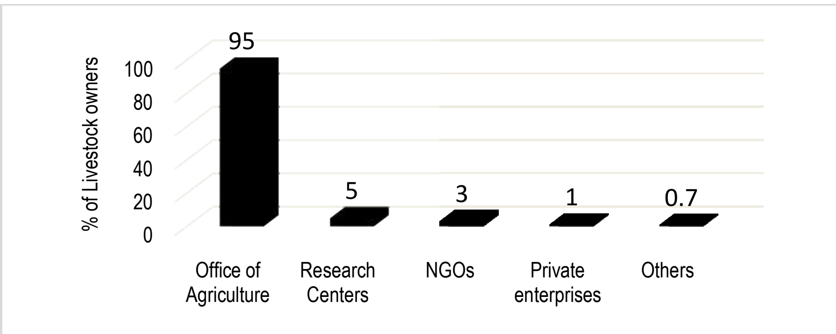
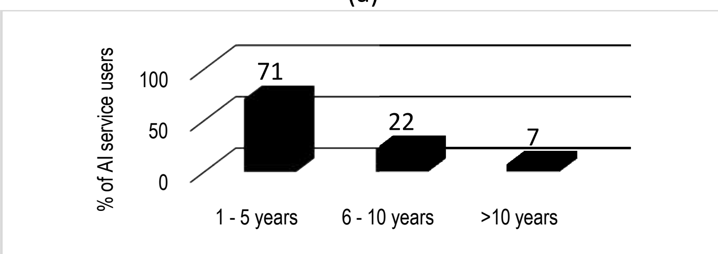


Figure 17. Livestock breeding practices in smallholder farming systems, 2017.



(a)



(b)

Figure 18. AI service providers (a) and time started using AI service (b) by smallholder farmers

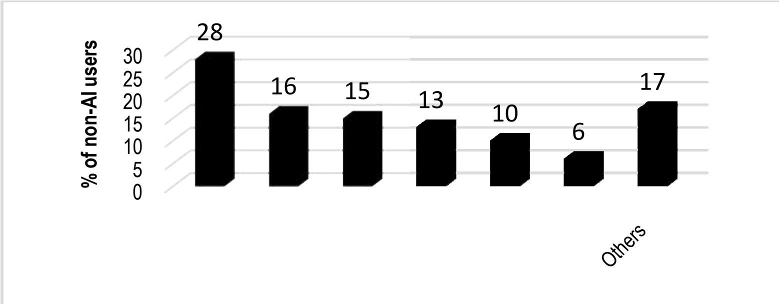


Figure 19. Reasons for not yet using AI service in the highlands

Milk processing technologies

In rural households, selling fresh milk is not yet very strong practice because of inaccessibility of selling points. Households could be located as far as 10km away from roadsides or towns where there could sale fresh milk. Selling fresh milk is largely limited to households located in the outskirts of towns and in close proximity to highways. Because of this, rural households resort to the option of processing milk into other products. According to the findings, 59% of the highland households (61% of MHH and 40% of FHH) processed milk into butter, cheese and yoghurt. Out of these products, 94% of those who process milk produced butter while 73% processed milk into cheese (Table 43). The practice of milk processing is similar to both male and female headed households in rural areas.

However, rural households almost entirely depend on traditional mechanism of milk processing which is believed to be inefficient, time consuming and laborious. Even though there is improved milk churning machine that was designed for rural households to be operated manually, 80% of the households were not even aware of its existence. Only 20% of the households have an opportunity to be aware of the machine that is meant for milk processing in rural areas. Out of these, many of them (57%) got aware only in the last five years (Figure 20).

Technology awareness is succeeded by adoption and use. Accordingly, the findings have figured out that only 3% of the rural households in the highlands have adopted improved milk processing technology, mainly the churning machine. All of these adopters are MHH from North Shewa and Arsi zones and MOA and NGOs supplied the machines. They perceived that the benefit of using milk-churning machine is improving from time to time. They noticed the machine to be not only time and energy saving but also efficient in minimizing fat loses during processing which would have beensubstantial at times of traditional processing practices.

Table 43. Smallholder processing practices of milk and milk products, 2017

Processing of milk & milk products	MHH		FHH		Overall households		X^2 test
	n	%	n	%	n	%	
Butter	557	94	34	89	591	94	X^2=1.5669 , df=1, P=0.211
Cheese	430	73	29	76	459	73	X^2=0.1876 , df=1, P=0.667
Yoghurt	320	55	18	47	338	55	X^2= 0.9656, df=1, P=0.326

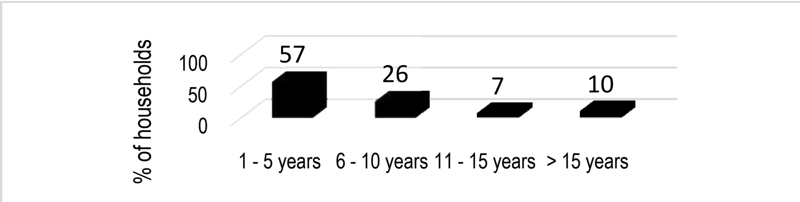


Figure 20. Time when households got aware of improved milk churning machine

In rural areas, many of the households owned local cows that are genetically less productive except a few of them who owned crossbred cows. Consequently, milk production is very limited which stands at only 4.5 liters per day per household (Table 44). Out of this, 35% of the milk is utilized for sale while 29% of the milk produced was utilized for home consumption.

Table 44. Quantity of milk devoted to processing and sale in rural areas

Milk produce and use	MHH		FHH		Overall households	
	n	Av.	n	Av.	n	Av.
Quantity of milk produced	649	4.5	46	4.1	695	4.5
Quantity of milk sold	649	1.6	49	1.6	695	1.6
Quantity of milk processed	649	1.5	49	1.7	695	1.6
Quantity of milk consumed	649	1.3	49	0.8	695	1.3

According to the finding, 35% of the rural households in the highlands did not produce milk at the time of the study (Table 45).Out of those who produced milk, 34% of them produced less than two liters of milk per day while 6% of them produced more than 10 liters of milk per day. Nearly 60% of the households produced less than 10 liters of milk per day. Since milk is perceived to be a cash-generating commodity in rural areas, the quantity consumed at home is often a meager in a year. For instance, Table 46 provides that 44% of the rural households consumed less than five liters of milk per capita per annum. While FAO recommends 200 liters of milk per capita per annum (FAO, 2011), nearly 60% of the households in rural areas consumed 10 liters or less of milk per capita per annum. This could be a typical example to reflect potential existence of malnutrition in rural areas.

Table 45. Smallholders' milk production, 2017

Milk production status	MHH		FHH		Overall households	
	n	%	n	%	n	%
No milk production	329	34	50	52	379	35
Produce < 2 lit/day	338	36	25	26	363	34
Produce 2.1 – 5 lit/day	150	15	13	14	163	15
Produce 5.1 – 10 lit/day	98	10	5	5	103	9
Produce > 10 lit/day	63	6	3	3	66	6
Overall sample	978	100	96	100	1074	100

$X^2 = 14.1648$, *df=4* *P=0.007*

Table 46. Smallholders' per capita annual milk consumption, 2017

Milk consumption status	MHH		FHH		Overall households	
	n	%	n	%	n	%
No access to milk consumption	453	46	67	68	520	48
Consumed <=2 lit/annum	278	28	14	15	292	27
Consumed 2.1 – 5 lit/annum	175	18	11	11	186	17
Consumed 5.1 – 10 lit/annum	53	5	2	2	55	5
Consumed >10 lit/annum	19	2	2	2	21	2
Overall sample	978	100	96	100	1074	100

$X^2 = 20.1075$ *df=4* *P<0.001*

Record keeping

Record keeping is essential to farmers not only engaged in dairy farming but also in any sector. Especially in dairy sector, records should be kept on quantities, types of inputs supplied and used, expenses spent, and incomes received, parity of dairy cows and their daily yields, and many other important features. Maintaining records helps to make informed decisions and monitor the trend of dairy production and productivity.

The problem, however, was that record keeping is not yet a popular practice among rural households. The study has figured out that only 5% of livestock owners had experiences of keeping records. All of record keepers have perceived that keeping information about dairy production has improved especially their dairy improvement practices. As to the timing, 58% of those who keep records started this practice only within the last five years (Figure 21).

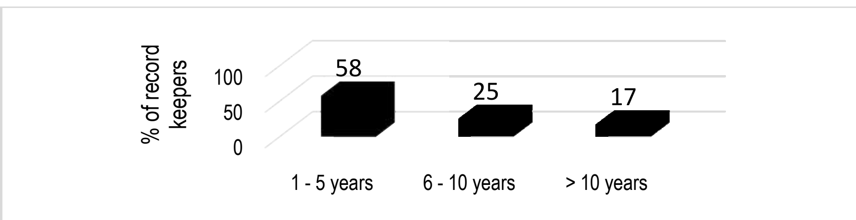


Figure 21. Time since when farmers started record keeping on livestock production, 2017

Fattening practices

Apart from on-farm incomes generated from crops and livestock sale, there are also cases where rural households engage in fattening of animals to generate supplementary incomes. Assessment of fattening practices in the highlands indicates that 52% of the households were engaged in fattening practices of animals, out of which 46% practice it occasionally (Table 47).

Fattening has appeared to be a practice thathas been there since more than two decades. It was noted that 43% of the households who practice fattening started the business since the last five years (Figure 22a). The findings have also revealed that 91% of the households used ox for fattening while 33% used sheep (Figure 22b). At the end of cropping season, it has become a common practice for farmers to fatten oxen which have been plowing the land and sale at attractive prices. At the time of sale of fattened oxen, the household also purchases another ox which is poor in body condition at lower prices. They feed these oxen until the next cropping season commences, use for plowing the land, fatten at the end of the season and then sale. The cycle continues every year in similar fashion. Households who cannot afford to fatten ox, they depend on fattening sheep about three months before a holiday.

Even though fattening is practiced in all the highlands (Figure 23), it has appeared to be a common practice in East Shewa zone (84%) followed by North Shewa Zone (65%) and Oromia Special zone (55%). These locations are close to markets where is huge demand, such as the city of Addis Ababa, and the towns, such as Adama and Bishoftu.

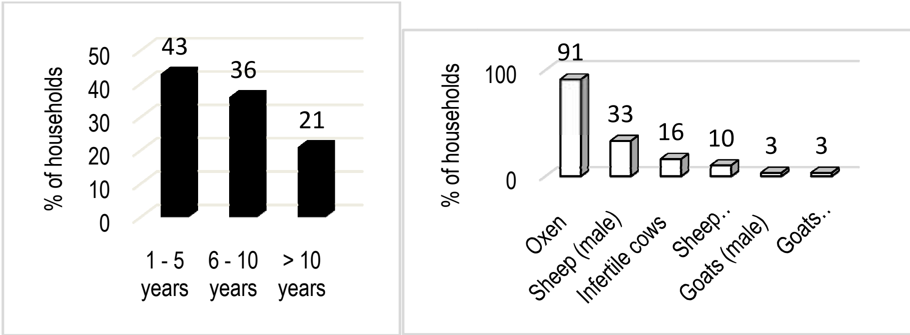
Table 47. Smallholder farmers fattening practices, 2017

Fattening practices	MHH		FHH		Overall households	
	n	%	n	%	n	%
Fattening on regular basis	67	9	2	2	69	6
Fattening on occasional basis	464	48	29	30	493	46
Did not start fattening	443	45	64	67	507	48
Overall sample	974	100	95	100	1069	100

Livestock products marketing

Apart from utilization for consumption, milk and processed milk products are also sold to generate supplementary incomes. As evidenced by 31% of the households, they sale the butter they processed (Figure 24). Even though there is a practice of selling milk products, selling milk itself is not yet a strong practice in rural highlands. It was figured out that only 13% of the highland households sell milk. This is because of the fact that smallholder rural dairy farmers do not have easy access to milk market. The households who have access to milk sales are located in the outskirts of towns and across the highways, which are apparently a few in numbers.

Assessment of gender perspectives in milk selling practices indicates that the involvement of women was noticed to be high. According to 43% of male headed households, married women are involved in selling milk while this proportion is high in female headed households where 75% of FHH women are actively engaged in milk selling (Figure 25). The involvement of men in MHH is also considerable in selling milk as noted by 25% of the households. The reason for involvement of men in this marketing practice is that selling milk has started generating considerable income. Because of this, men have raised interests to control the income.



(a) (b)
Figure 22. Time since when households started fattening practices (a) and livestock types used for fattening (b)

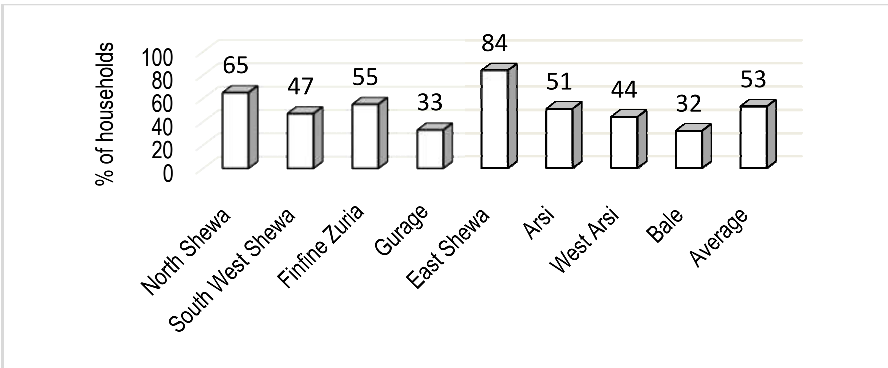
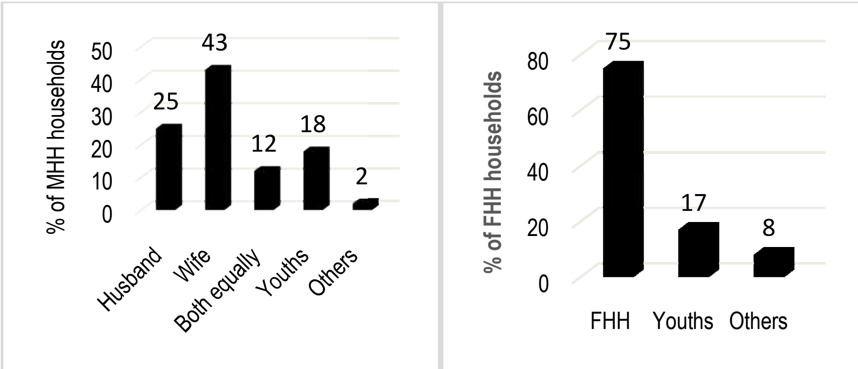


Figure 23. Zones which practice fattening both regularly and occasionally

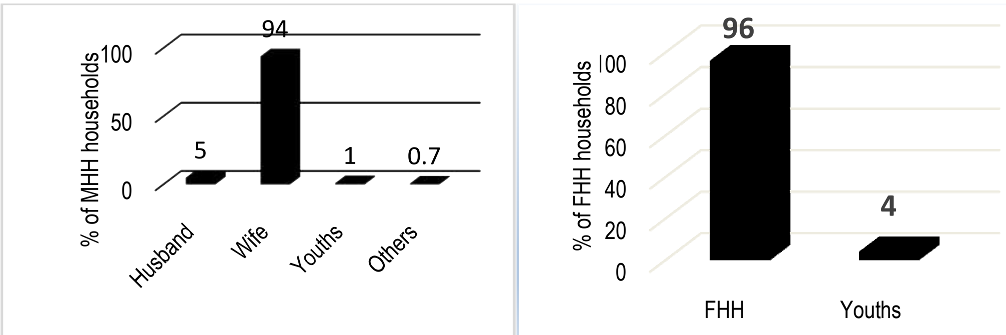
It was also indicated that selling milk products is almost the role of women as illustrated in Figure 26 where close to 95% of both married women and FHH are involved in selling milk products. Since sells of milk products generates meager income, men are not interested in participating to sell these products.

Figure 24. Households market participation practices in selling milk and milk products, 2017



MHHFHH

Figure 25. Gender perspectives to participation in selling milk in MHH and FHH households, 2017



MHHFHH

Figure 26. Gender perspectives to participation in selling butter and cheesein MHH and FHH households, 2017

There are no dependable options of milk markets for rural households. According to the findings, 73% of milk seller households sell their milk to roadside milk collectors while 26% of milk seller households sell to milk collector cooperatives (Figure 27). In the context of Ethiopia, milk traders and processors travel to outskirts of cities and towns to collect milk along roadsides and transport to cities either for direct sale or for processing. For instance, a large quantity of milk supply to the city of Addis Ababa comes from out skirts collected from collection spots across roadsides. Milk producers bring their milk to roadsides every morning where collectors make field level quality testing and either accept or reject depending on quality. The milk produced in the afternoon in rural areas is kept overnight without cooling and is mixed with morning milk for sale. The evening milk starts deteriorating in quality by the time it reaches towns, which is the major problem identified in milk marketing sector. There is no mechanism for rural households to maintain evening milk (the one milked in the evening) overnight without losing its quality. They may think it is still fresh when they mix it with freshly milked morning milk, which is likely to be rejected upon quality check by milk collectors.

Rural households have described their own reasons why they are not selling milk. As provided in Figure 28, 56% of the households justified that they did not produce adequate quantity of marketable surplus milk. They often keep local cows which provide about 1.5 liters of milk per day, which is not even adequate for family consumption. Unless they have too many cows, this meager quantity of milk may not create demand for sale. The second reason provided by 16% of the households was unavailability of market to sell milk. This is especially the case for households who located off the road away far away from the city or towns. Perishability nature of milk does not allow households to travel long distances with fresh milk. This was the reason why they resort to processing of milk and sell butter and cheese.

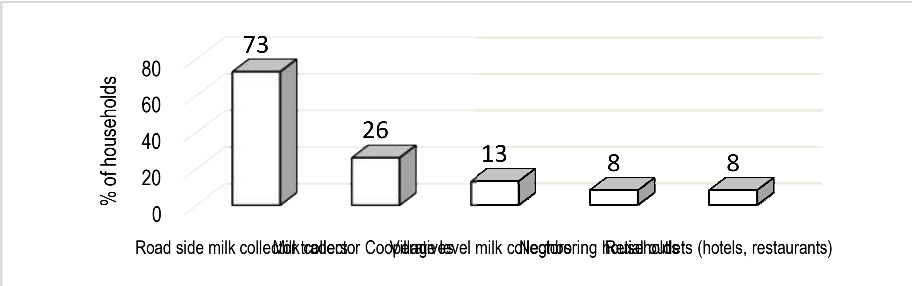


Figure 27. Smallholders' milk supply and selling points in the highlands, 2017

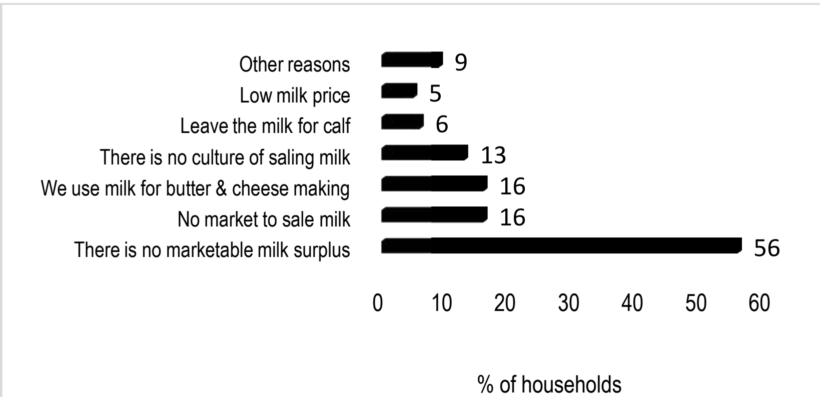


Figure 28. Reasons for not selling milk, 2017

Household and livestock mobility

Even though not as such common in the highlands, livestock mobility is rarely practiced in parts of the country. Out of overall sample, only 4% of the highland households still practiced mobility of their animals from one place to another at times of feed and water shortages (Table 48). It was also noted that 88% of the overall sample households have never practiced mobility from one area to another for longer period for searching feed and water.

Out of the 4% of households who practice mobility, 2.4% of them moved for 1 – 3 months while 1.5% moved for 4 – 6 months and the others for 7 – 8 months away from their villages in search of water and feed. Livestock mobility is practiced in the highlands of Arsi, West Arsi and Bale zones (Table 49). When the sample of these three zones alone is considered, 13% of the households still practice mobility, out of which 8% of them move only their animals while 5% of them move all their family and animals. The reason why these zones practice mobility is seasonal incidence of severe feed and water shortage. At this time, some households move their animals to neighboring locations where there is feed and water, and their relatives are located. They come back to their villages after the harsh season passes and conditions improve in their home village.

Some households (8% of overall sample and 22% of the sample who only practice mobility) have terminated mobility they have been practicing for years. According to Figure 29, 81% of the households who discontinued practicing mobility reasoned out that expansion of croplandsto open grazing lands is one of the factors for termination followed by expansion of state development interventions (60%) and private commercial farms (55%).

Table 48. Livestock mobility in the highlands considering overall sample

Mobility practices	MHH		FHH		Overall households	
	n	%	n	%	n	%
Still practicing mobility	38	4	2	2	40	4
Used to practice, but stopped now	83	5	5	4	88	8
Never practiced mobility yet	837	87	88	93	925	88
Overall sample	958	100	95	100	1053	100

X^2 =2.2568, df=2 P=0.324

Table 49.Locations of livestock mobility

Mobility	Still practicing mobility		Used to practice, but stopped now		Never practiced mobility yet	
	n	%	n	%	n	%
Arsi	13	13	28	28	59	59
West Arsi	12	12	21	21	66	66
Bale	15	15	18	18	67	67
Total	40	13	67	22	192	64

X^2 =3.2870, df=4 P=0.511

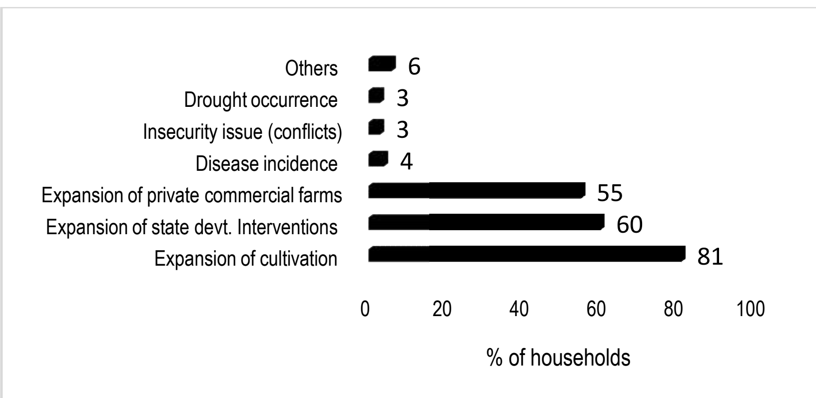


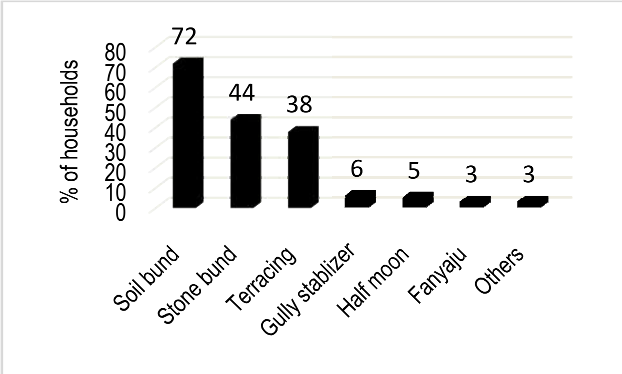
Figure 29. Reasons for termination of mobility practices, 2017

Natural Resources Management

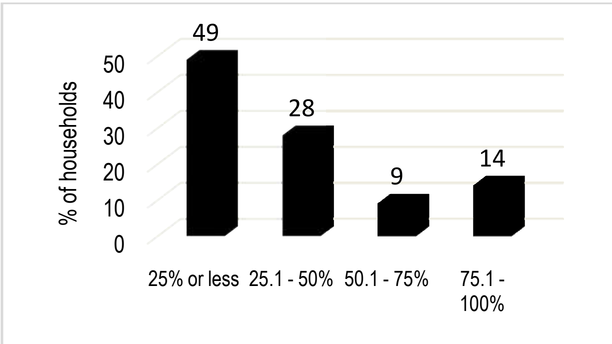
Adoption of physical structures and conservation tillage

One of the packages of agricultural technologies is soil and water management technologies, without which sustainable growth of agriculture sector cannot be achieved. The findings have unveiled that 62% of the farmers on average have constructed physical soil and water management structures in the highlands, out of which 64% accounts for MHH and 47% for FHH (X^2 =9983, df=1, P=0.002). As illustrated in Figure 30a, the common types of physical structures were commonly soil bunds (72%) and stone bunds (44%). On the aspect of dynamism, a large proportion of the farmers (82%) constructed NRM structures in the last decade while the other 18% started constructing before a decade. This might be associated with GTP program, which took-off in the last decade with the purpose of boosting agricultural production and productivity, and ensure food security. However, the proportion of farmland still covered with NRM structures is very less. For instance, the size of land covered by nearly half of the highland farmers is not yet more than 25% (Figure 30b). Only 14% of the farmers who constructed NRM structures in more than 75% of their farmlands.

Even though erosion and low soil fertility are relatively severe problems in the highlands, construction of NRM physical structures was largely limited to communal lands than private farms through campaign programs. Households are advised to make similar structures on their own farmlands despite the progress is limited because of laborious nature of the activity. The other reasons were associated with attitudes. For instance, 56% of the farmers perceived that their farmland is fertile, so that there is no need of constructing physical structures. On the other hand, 15% of the farmers did not construct NRM structures for the reason that they are not adequately aware of its long-term benefits. However, unless both communal and private farmlands are covered with NRM structures, soil and water will not be conserved effectively and anticipated environmental impact will not be achieved. As to the impact, 77% of the households who constructed NRM structures have noticed that soil fertility is highly improving since they constructed the structures while 22% recognized slow improvements over time. Households were asked why they did not construct NRM structures. According to 56% of the households, they believe that their land is fertile, so that they do not need to construct NRM structures (Figure 31). It seems that they are not well aware of the need to depend on NRM structures to maintain soil fertility.



(a)



(b)

Figure 30.Physical structures commonly constructed (a) and proportion of land covered by the structures (b) in the highlands

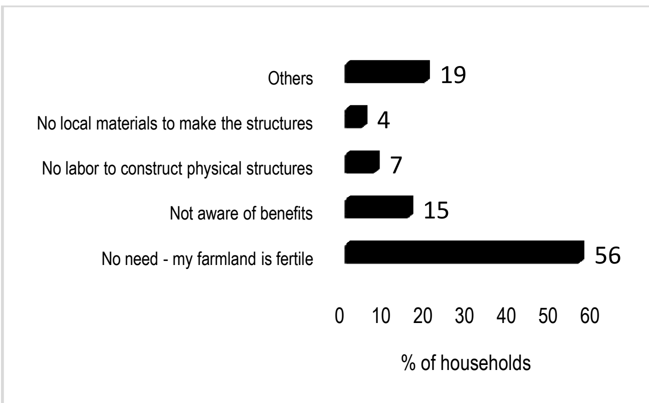


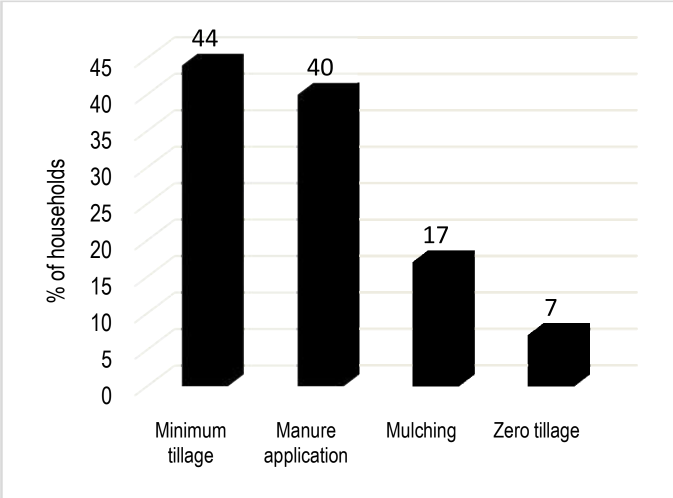
Figure 31. Reasons why some households did not yet construct physical NRM structures, 2017

Apart from physical NRM structures, highland households have also adopted ranges of conservation tillage practices. As revealed by the findings, 44% of the farmers have started experiencing minimum tillage; while 40% adopted manure application on farmlands (Figure 32a). In light of frequently occurring climate change factors, such as drought, farmers recognized importance of minimum tillage and mulching practices to conserve moisture and support crop growth along with early season rain. Manure application has appeared to be essential mechanism of improving soil fertility in long term and helps to minimize the cost incurred for inorganic fertilizers.

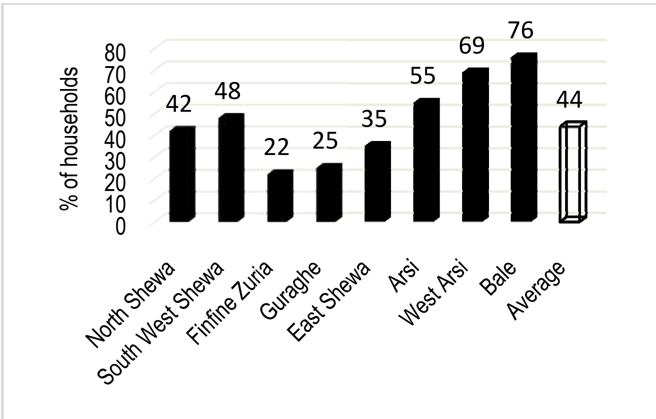
When location variability is taken into consideration, minimum tillage practice is most adopted in Arsi and Bale zones of Oromia region (Figure 32b). The same locations have also practiced zero tillage better than other highlands (Figure 33). This might be because; there areas are affected by moisture stress, as they are also neighboring rift valley agro-ecology that is largely prone to drought. Minimum tillage is minimum soil manipulation without turning the soil cover to protect the moisture from evaporation. In the case of zero tillage, the soil is not being disturbed through tillage. In the highlands that are dominantly characterized by intensive tillage that even changes soil structure, minimum and zero tillage are largely essential to leave crop residues behind to enrich soil organic matter content. These tillage practices also help to control soil erosion which is a feature of highlands washing away of essential soil nutrients and consequently turning the soil acidic. Therefore, it is essential to promote soil conservation practices in the highlands.

Adoption of water harvesting structures

Water harvesting structures were also package of soil and water conservation initiatives introduced to the country to minimize effects of frequent droughts. Households were advised by extension agents and agricultural experts to construct their own pond to collect run-off water for later use. Government has also been supporting the farmers through provision of geo-membrane with subsidy. However, this practice has not gone very well in the highlands. According to the findings, only 11% of the households on average (12% of MHH and 7% of FHH) have constructed their own water harvesting structures in the highlands. Out of these only 8% of them were still using the water harvested in the pond for growing vegetables and fruits around homesteads. However, 2% of them have discontinued using the structure because the pond is not holding water. They give various reasons, such as wild animals damaged geo-membrane and that it does not hold water. Some others have already sold the geo-membrane with expensive price in the towns for it is highly demanded to use it as roof in the shades, toilets, kitchen and even main houses in rural areas. That 1% of the households has never attempted using the pond for holding water and use despite they constructed it. Among those who constructed, 24% of them have been experiencing before a decade while 76% of them in the last decade.



(a)



(b)

Figure 32. Types of conservation tillage practices (a) and locations, whichadopted minimum tillage (b)

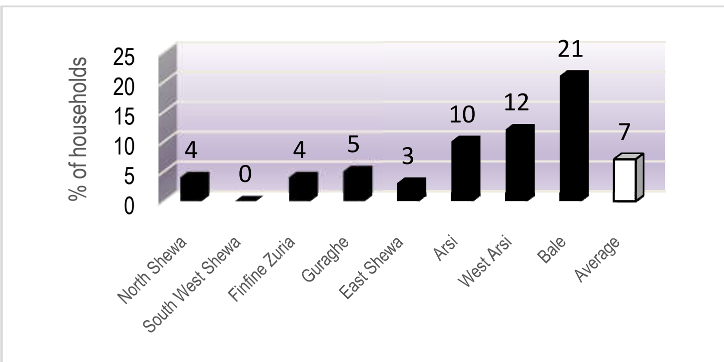


Figure 33. Zero tillage use across the highlands, 2017

Construction and use of water harvesting structures has revealed location variability in the highlands. For instance, the proportion of households who constructed and used water-harvesting structures is high in East Shewa zone (22%) than other parts of highlands (Figure 34). This might be because of the fact that East Shewa is often exposed to moisture stress, as it is neighboring rift valley that is prone to drought. Households conserve water during rainy water in ponds for use at times of moisture stress to cultivate garden crops and for animals drinking. The least proportion of households who used water-harvesting pond was observed from Oromia Special zone, which is a location closer to the city of Addis Ababa.

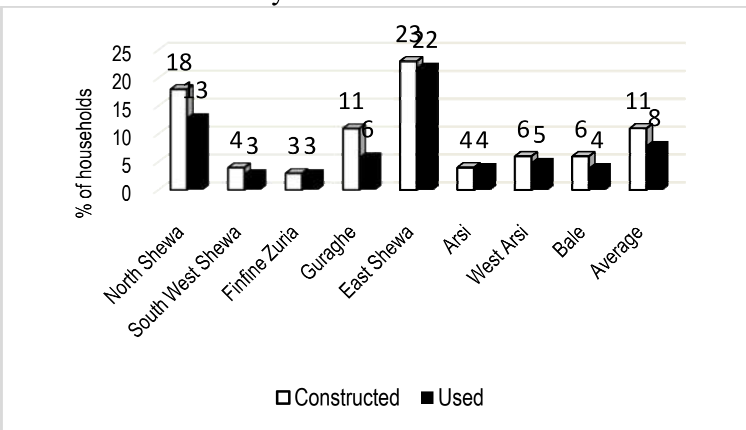


Figure 34. Construction and use status of water harvesting ponds in the highlands, 2017.

Awareness and adoption of agricultural mechanization

Agricultural mechanization tools are also one of the packages of technologies that are used along with improved crop varieties and others to enhance efficiency and ensure increased productivity. For instance, when row-planting practice is introduced as a technology, it is more efficient when practiced with row planter than manual planting. Recommended time of harvesting and threshing should also be accompanied with harvester and thresher machines. These tools save time and minimize drudgery and post-harvest loses. The findings indicate that awareness status of agricultural mechanization tools was not yet more than 30%. This implies that 70% of the farmers in the highlands were not yet aware of importance of improved agricultural mechanization tools. Out of the various tools and machines, moldboard plow and BBM/IBAR are the most known tools by 29% of the highland households (Table 50). Thresher/Sheller is also known by 21% of the households. Even though awareness precedes use, adoption rate of these farm tools was still very low. For instance, adoption rate of moldboard plow was 17% followed by BBM/IBAR, which was adopted by 10% of the households. Even though 12% of the households owned BBM/IBAR, not all of them were using it. The study also indicates that many of the households in the highlands were not yet aware of the importance of row planters. Only 8% of the farmers were aware of row planters. Adoption rate of row planter was, however, almost none in the highlands. This might be because of limited promotion of the importance and operation techniques on the one hand and limited availability on the other. The major problem for less adoption of agricultural mechanization tools was inadequate promotion and limited access to the farmers at affordable prices. The tools are often been supplied through Offices of Agriculture at subsidized prices. However, this approach is not sustainable and it might only help to demonstrate and raise awareness of the farmers.

Table 50. Awareness, ownership and use status of farm tools in the highlands (% of households), 2017

Farm Tools	Aware of (%)	Owned (%)	Used (adopted) (%)
Moldboard plow	29	17	17
BBM/IBAR	29	12	10
Thresher/sheller	21	2	2
Metal garner	7	2	1
Row planter	8	0.4	0.2
Weeder	3	0	0
Hand/animal driven harvester	7	4	4
Feed chopper	2	0.3	0

Climate Change

In the highlands, climate change has appeared to be a common phenomenon and a challenge for agriculture sector. Climate change is often being expressed in various features across the world. In the highlands of Ethiopia, climate change is often expressed in the form of drought as perceived by 81% of the households (Figure 35). Drought has become a common phenomenon in Ethiopia often occurring almost once in three years. Erratic rainfall (52%) and even too much rainfall (43%) are also features of climate change expressing in the highlands of Ethiopia. For rainfall dependent agriculture, rural households often become fragile, face severe food, and feed shortages, because of which they receive food aid and other supports not only from the government but also from international aid organizations and donors.

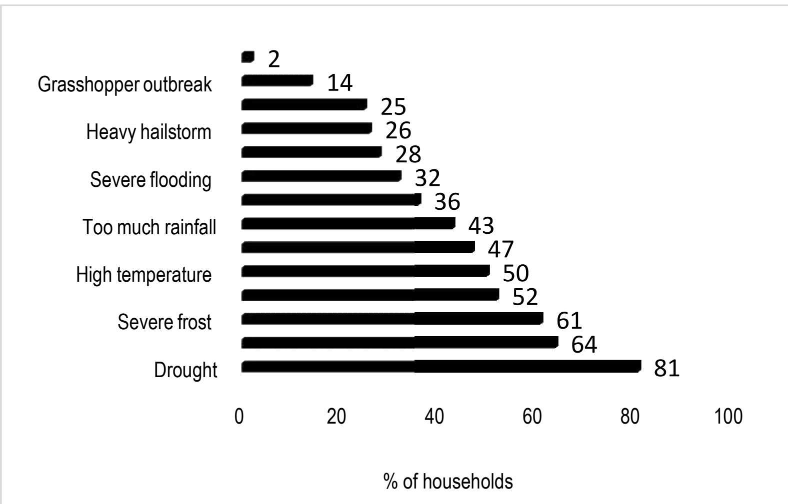


Figure 35. Climate change factors that have prevailed in the highlands of Ethiopia

Since external aid supports are often short-term aimed at lifesaving, farmers have developed their own coping and adaptation mechanisms over time to minimize effects of climate change. Types of coping mechanisms depend on the resource and wealth status of households. The well-to-do and medium wealth category households drought effects through disposing of assets, such as sale of livestock, to purchase food grain (Figure 36). Some of them buy food grain from own savings (31%) while others store and save grain for later use (29%). On the other hand, 26% of the households with limited resources seek food aid as coping mechanism while 25% of them borrow money from friends/relatives and purchase food grain. They also rent-out/share-out land (14%) while some others (7%) migrate to towns in search of daily labor.

In response to frequent occurrence of drought, farmers have also developed their own adaptation mechanisms. Adaptation implies living with a problem through establishing various mechanisms. One of the many adaptation mechanisms practiced by 61% of the farmers is changing crop and variety types that are adaptable to prevailing climatic condition (Figure 37). This includes replacing long maturing local varieties with short maturing improved ones. In earlier days, for instance, there used to be barley varieties, which require nine months of growth period. Such varieties have almost been disappeared in now days. Instead, improved barley varieties that require about six months of growing period and are highly productive are coming up in the farming systems. Low productive local varieties are replaced with high productive ones, such as wheat and potato varieties. Following frequent occurrence of climate change, disease and pest emergence has become a severe challenge for crops. Because of this, disease sensitive crop varieties are replaced with disease tolerant improved ones. Other adaptation mechanisms include adjusting planting time (55%), engaging in off-farm income generating activities (IGAs) and increase savings (30%) and many others.

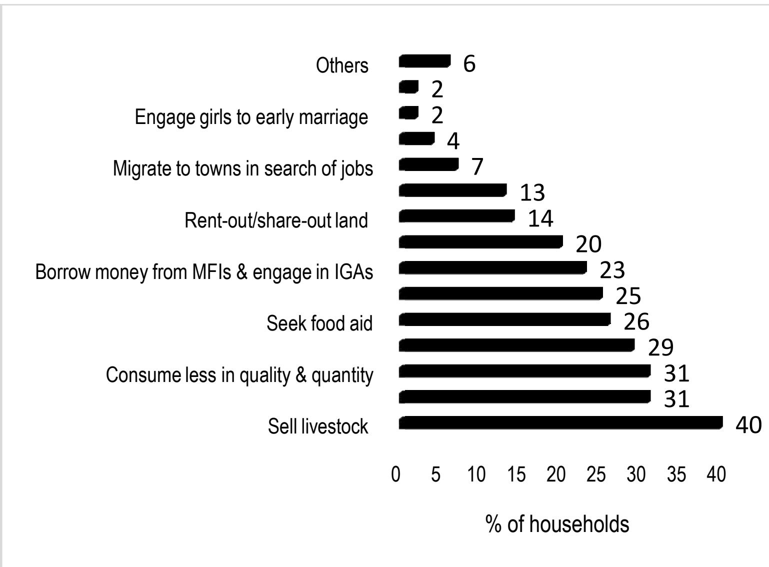


Figure 36. Smallholder farmers coping mechanisms to climate change hazards, 2016/17.

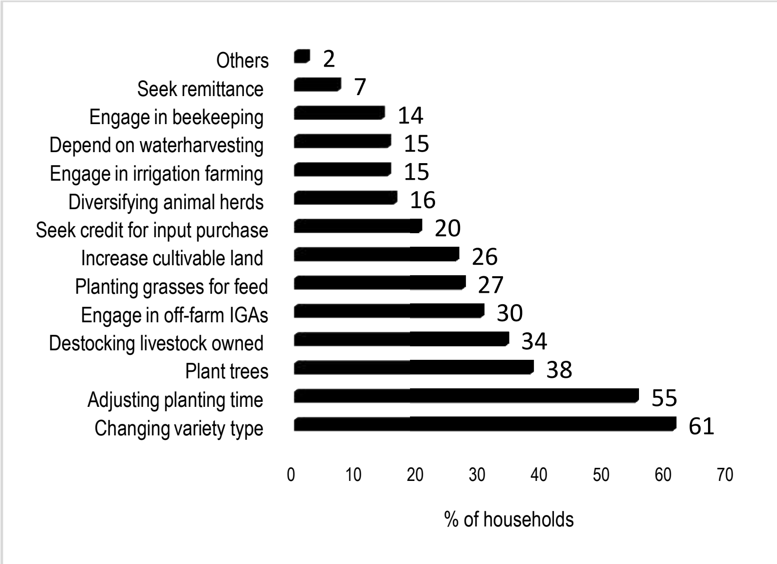


Figure 37. Smallholder farmers' adaptation mechanisms to climate change, 2016/17

Access to credit services

Consequent to introduction and dissemination of agricultural technologies especially since commencement of GTP agricultural programs, the demand for rural credit has grown over time to spend for agricultural inputs. Credit enhances agricultural commercialization for it contributes to the use of technological packages. In recognition of this, the government has established micro-finance institutions at district levels for easy access to credit services. However, it appears that rural households have not yet exploited access to micro-finance institutions and available credit services. According to the findings, 38% of the households (37% MHH and 47% FHH) had access to credit services.Out of these 54% of them got access within the last five years, which could be associated with GTP programs, which encourage credit use for intensive input use and increase agricultural productivity (Figure 38).

Rural households required credit mainly to purchase agricultural inputs, such as fertilizer (for 51% of households), ox for 43% of households, improved variety seeds (29%) and others (Table 51). There are also cases where 5% of the households demanded credit for social services, such as wedding. The main reason why more than 60% of rural households have not yet benefited from credit services is the pre-conditions the farmers are required to fulfill, such as collateral, short credit period and others. Farmers also complained of the interest rate that is as high as 18% per annum. However, the reality seems to be that the attitude that farmers have on credit is distorted. For instance, while credit is required for profitable activities that generate incomes, they tend to utilize it for consumption purposes, such as purchasing food grains, celebrating wedding and other festivities. Because of this, they become defaulters unable to pay the loan. It seems that adequate awareness creation needs to be made for farmers on credit use and indicate options of feasible enterprises to engage with and demand credit.

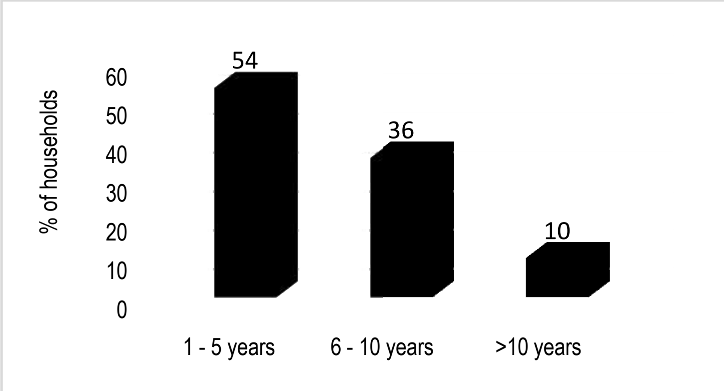


Figure 38. Time since when households started getting access to credit services

Table 51. Purposes to which credit service was required for rural households, 2017

Purposes: To purchase:	MHH		FHH		Overall households		X^2 test
	n	%	n	%	n	%	
Ox	162	45	16	35	178	43	X^2=1.4116 , df=1, P=0.235
Local cows/heifers	34	9	13	29	47	12	X^2=14.8188 , df=1, P<0.001
Improved variety seeds	110	30	9	20	119	29	X^2=2.1173 , df=1, P=0.146
Fertilizer	186	52	23	51	209	51	X^2=0.0027 , df=1, P=0.958
Social services (wedding, etc)	16	4	4	9	20	5	X^2=1.6969 , df=1, P=0.193
Feeds	14	4	5	11	19	5	X^2=4.6926 , df=1, P=0.030
Others	74	20	10	22	84	21	X^2=0.0724 , df=1, P=0.788

A large proportion of rural households (63%) sourced credit services from Micro-finance institutions, which are established by the government to enhance agricultural growth and rural transformation (Figure 39). Farmer cooperatives and unions have also served as sources of credit for 12% of rural households. Cooperative unions provide ranges of supports to its member farmers, one of which is providing credit services to its members for such purposes as input purchase. Apart from formal sources, there are also informal saving and credit groups which were established with facilitation of NGOs and other partners. Households, especially women, save a certain amount on regular basisand draw credit for various personal uses. In cases of informal credit sources, there is no fixed interest rate, but rather it is determined by consensus of its members.

When location variability is considered, some of the administrative zones have provided better access to credit services than others. For instance, South West Shewa zone has provided credit services to 51% of its households while GurageZone has made access to credit services for 48% of the households (Figure 40). On the other hand, the least access of credit to households was created in West Arsi (16%) and Bale zones (20%).

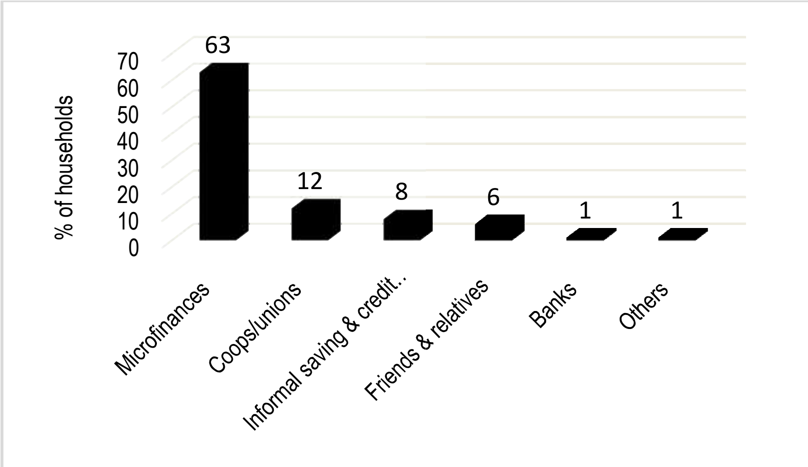
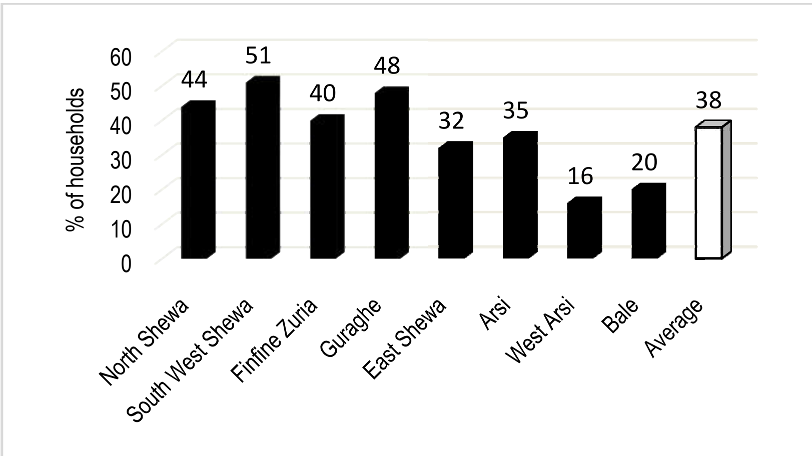


Table 39. Sources of credit services for smallholder farmers, 2017

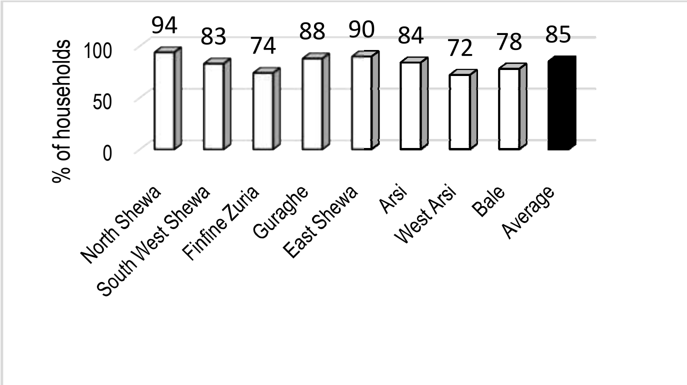


X^2=54.7555, *df=7,* *P<0.001*

Figure 40. Access to credit services, 2017

Access to extension services

Farmers receive extension services on improved crop management, such as improved variety use, recommended weeding, plowing, value addition and other practices through MOANR extension service program. According to the findings, 85% of the households had access to extension services. Access of extension services to male headed households (87%) was however significantly higher than female headed households (73%) (X^2=12.8609, df=1, P<0.001). Even though mainly public institutions, such as Ministry of Agriculture, the national agricultural research systems, NGOs and international organizations, are providing agricultural extension service, there is location variability in the extent of extension service provision. For instance, the largest proportion of farmers (94%) got extension services from North Shewa zone while it was 72% in West Arsi (Figure 41).



X^2=50.0938, df=7, P<0.001

Figure 41. Access of households to extension services in crop production, 2017

Extension service has been there since long time ago despite extensive introduction, promotion and dissemination of agricultural technologies has been intensified and strengthened from time to time. As evidenced in Table 52, 80% of the highland households received intensive and frequent extension services accompanied with technology supply in the last decade. This was largely associated with GTP program which aimed to make agriculture the leading sector of the economy not only as source of food and feed, but also as source of raw materials for agro-processing industries. Ranges of technological packages have been introduced to various agro-ecologies of the country during GTP I period which lasted from 2010- 2015. GTP II is also in progress with strengthened programs to last in 2020.

Table 52. Dynamism of households in access to extension services, 2016/17

Time started extension services	MHH		FHH		Overall sample	
	n	%	n	%	n	%
1 – 5 years	301	36	36	51	337	37
6 – 10 years	365	43	30	42	395	43
11 – 15 years	122	14	2	3	124	13
> years	60	7	3	4	63	7
Total	848	100	71	100	919	100

X^2 =11.4181, df=3 P=0.010

The gender perspective in extension services reveals that men had better access than women. For instance, Figure 42 illustrates that especially married women (24%) had limited access to extension services compared to FHH (40%). Even though youth are also actively involved in agricultural activities, their access to extension services was very limited. So far, there was no specific extension service that was tailored to women and youth. Since women and youth bear special challenges and priorities in the community, they deserve extension programs that address their technology needs.

Extension services are channeled through various development partners and media of communication. For instance, Figure 43 provided that the most essential source of extension information for 81% of households was through on-site advises and follow-up of development agents (DAs) and agriculture experts. Other sources of extension information included demonstration trials (40%) and mass media (39%). Out-reach programs of agricultural research institutions (14%) and NGOs (11%)are essential source of extension services. Having diverse options of extension information sources is helpful for the farmers as it provides opportunities of learning lessons, experiences and best practices among development actors.

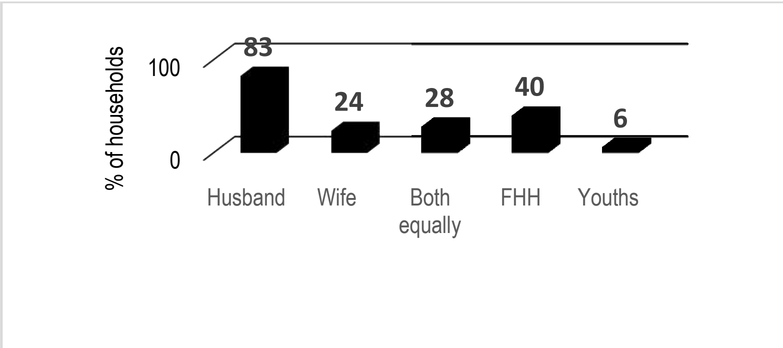


Figure 42. Gender perspectives in access to extension services for improved crop production, 2017

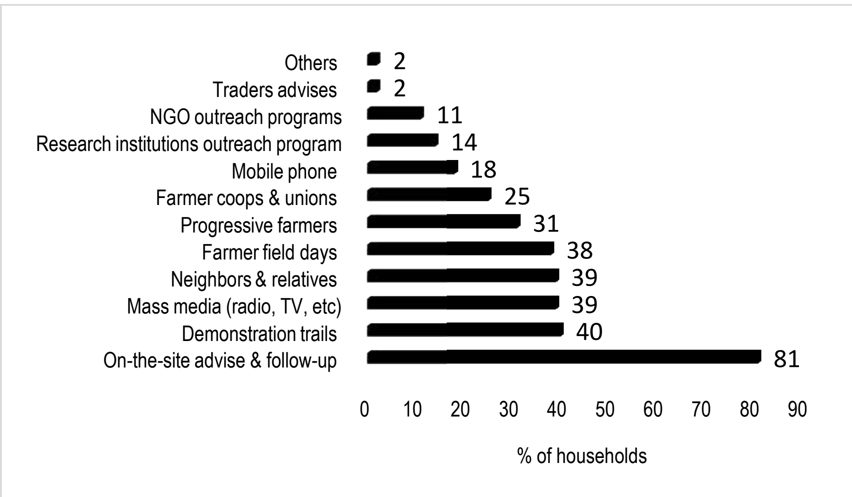


Figure 43. Extension methods and channels through which farmers have been receiving technology messages, 2016/17

Economic benefits of households from agricultural activities

Rural households generate income from various on-farm and off-farm sources. On-farm sources mainly include sales of crops, livestock and livestock products and trees. Apart from these, farming households also generate incomes from off-farm income generating activities. As provided in Table 53, a rural household in the highlands generated an annual income of Birr 28,995.39on average, which is equivalent to USD 1054.38 (this provides about USD 210.00 per capita). Out of this income, 35% of it was contributed from sales of livestock and livestock productsfollowed by crops (33%) (Figure 44). The household income was controlled in consultation with both men and married women (Figure 45). However, income controls by men is still substantial from crop sales (46%) and sales of livestock (51%). On the other hand, women (60%) control income generated from sales of livestock.

Table 53.Rural household incomes generated from various sources

Income source	MHH		FHH		Overall households		t-test
	n	%	n	%	n	%	
Crop sale	661	9,862.36	65	5,645.08	726	9,484.78	t=4.0760, df=724, P<0.001
Sales of livestock & livestock product	706	10,309.19	63	6,841.84	769	10,025.12	t=2.2041, df=767, P=0.0278
Sales of forest products	140	4,432.85	12	3,654.17	152	4,371.37	t=0.3910, df=150, P=0.6963
Off-farm income generating activities	263	5,269.71	39	4,064.89	302	5,114.12	t=1.2095, df=300, P=2274
Average household income	783	29,205.11	88	20,205.98	871	28,995.39	t=4.3610, df=869, P<0.001

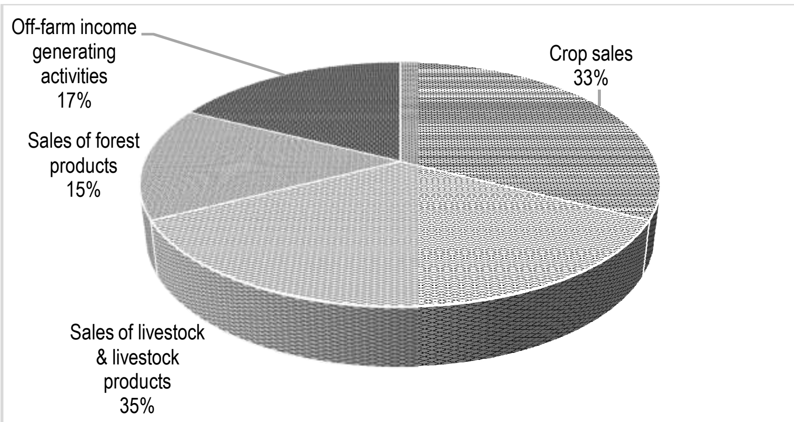


Figure 44. Income sources of rural households and share of incomes

Engaging households in off-farm income generating activities (IGAs)

Apart from on-farm incomes where households generated more than 80% of the income, they also generated supplementary incomes from IGAs that accounts for 17% of total household income. Petty trading and daily labor are the most common off-farm activities where men, women and youth are engaged (Table 54). Since relatively well-to-do households spend most of their time in their own farms, engagement in off-farm activities is commonly a feature of low-income households. This is because; low-income households do not have adequate land to keep them busy the whole season. Once they complete farming activities on small plots of land, they spend the remaining days in a year on IGAs. Women and female youth are also engaged in selling local drinks in their villages.

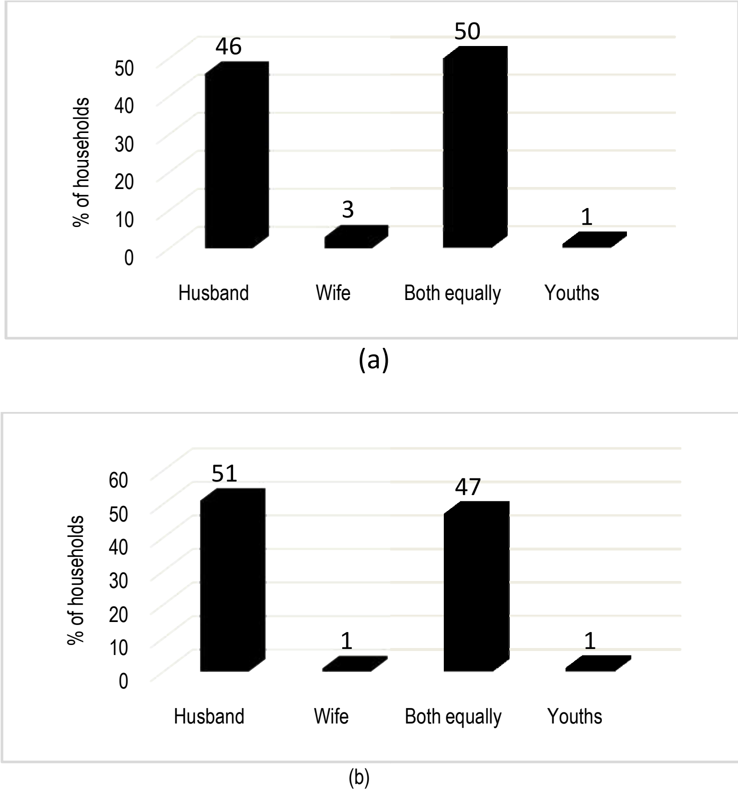


Figure 45. Gender perspectives in control of income from crop sales (a) and sales of livestock (b)

Table 54. Types of IGAs and gender perspectives in IGA participation (% of households), 2017.

Types of IGAs	Husband	Wife	FHH	Male youth	Female youth
Petty trading	22	36	33	12	7
Daily labor	39	13	17	46	27
Selling local drinks		34	33		33
Hand-crafts	5	8	8	4	
Brokering	1			2	
Employment in part-time jobs in institutions	11			20	27
Selling firewood	1	3		2	7
Grinding mills	2	1		2	
Fattening	15	3	8	6	

Development interventions and farming systems dynamism

Since 2 – 3 decades ago, there had been enormous development interventions in the country not only by the government but also by international and national development partners. These interventions included large-scale investments in agriculture sector, infrastructure and many other economic dimensions. These interventions have contributed in bringing substantial changes to the farming systems whether it could be positive or negative. As revealed in Table 55, the highland farming communities have been exposed to scores of interventions. Out of these, as perceived by 86% of the rural households, interventions made in such sub-sectors as veterinary and animal health was the most notable. Interventions related to farmers' training centers (FTC) was also another noticeable program as reported by 80% of the households. Interventions on rural roads, potable water supply and others are interventions among infrastructure, which brought substantial changes in creating access to transportation, communication, health and other services to farming households. Introduction of agricultural technologies to rural areas was also noted to be another intervention that would have impacted agriculture sector in improving food security. There is no significant difference between male and female-headed rural households implying that both households accessed and benefited from the interventions without substantial disparity.

Assessment of changes in farming systems indicates that many changes have taken place in the highlands in the last decades. According to the findings, 95% of the farmers have perceived that changes are evident in the highland farming systems (Figure 46a). The change can be either positive contributing to growth of agriculture and farmers' livelihoods or negative affecting the environment. As recognized by 82% of the farmers, noticeable changes in the farming systems have taken place especially in the last decade (Figure 46b). Even though there have been interventions and various phenomenon in the farming systems since several decades ago, substantial changes were noticeably evident within the last decade. This might be associated with massive government interventions through GTP programs and others to help farming households ensure food security and improve livelihoods

Table 55. Proportion of households benefited from development interventions in highlands

Are you beneficiary of:	MHH		FHH		Overall households		X^2 test
	n	%	n	%	n	%	
Rural land development intervention	101	10	8	8	109	10	X^2=0.3661 , df=1, P=0.545
Forage & pasture development	175	18	8	8	183	17	X^2=5.5932 , df=1, P=0.018
Veterinary & animal health interventions	834	86	82	86	916	86	X^2=0.0188 , df=1, P=0.891
Facilitating better market opportunities	283	29	32	34	315	29	X^2=0.8683 , df=1, P=0.351
Genetic resources conservation	118	12	3	3	121	11	X^2=6.9443 , df=1, P=0.008
Genetic resources improvement	156	16	7	7	163	15	X^2=5.0389 , df=1, P=0.025
Restocking intervention	154	16	10	11	164	15	X^2=1.8811 , df=1, P=0.170
Destocking intervention	109	11	16	17	125	12	X^2=2.6504 , df=1, P=0.104
Improved feed security intervention	164	17	14	15	178	17	X^2=0.2840 , df=1, P=0.594
Settlement program	142	15	8	8	150	14	X^2=2.7537 , df=1, P=0.097
FTC program	780	80	71	75	851	80	X^2=1.7359 , df=1, P=0.188
Community based services intervention	542	56	53	56	595	56	X^2=0.0003 , df=1, P=0.987
Pond construction	235	24	22	23	257	24	X^2=0.0515 , df=1, P=0.820
Control grazing intervention	228	24	20	21	248	23	X^2=0.2913 , df=1, P=0.589
Water development intervention	506	52	56	59	562	53	X^2=1.5970 , df=1, P=0.206
Forage seed multiplication intervention	59	6	8	8	67	6	X^2=0.8027 , df=1, P=0.370
Capacity building intervention	344	35	34	36	378	35	X^2=0.0040 , df=1, P=0.950
Road development intervention	599	62	69	73	668	63	X^2=4.3798 , df=1, P=0.036
Construction of feed lots intervention	78	8	2	2	80	7	X^2=4.3884 , df=1, P=0.036
Livestock credit program intervention	76	8	8	8	84	8	X^2=0.0756 , df=1, P=0.783

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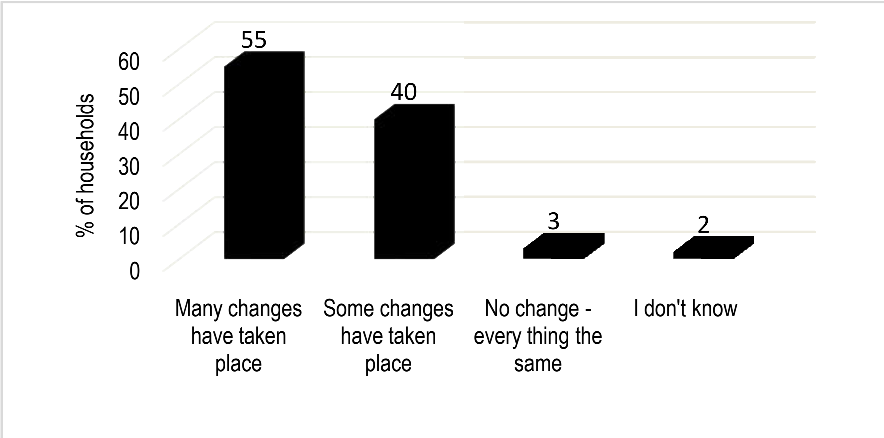

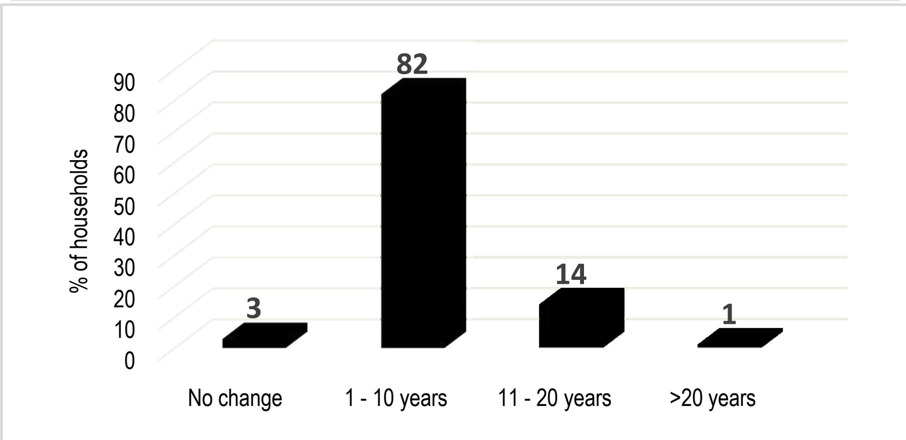

(a) (b)

Figure 46. Perception of dynamism (a) and time since when farming systems started changing

Various driving factors to changes in farming systems were identified in the highlands. These factors were categorized as major, medium and minor factors according to perceptions of farmers on influence to farming systems. As perceived by 87% of the farmers, the major factor that has influenced changes to farming systems was identified to be introduction, promotion and dissemination of agricultural technologies (Figure 47). Development partners, such as MOANR, National Agricultural Research Systems (NARS), International Organizations, NGOs, private companies and others have been contributing in technology generation, promotion, multiplication, demonstration and dissemination in the last decades. The government has also been designing special programs, such as GTP, PASDEP, poverty reduction and others to help enhance growth of agriculture and improvement of rural livelihoods. Focus has been provided on introduction and dissemination of packages of technologies, such as improved varieties, fertilizers, row planting, mechanization, NRM and other technologies. The use of these technologies has made influences to changes in farming systems of the highlands. Fields, which used to be covered with local varieties, have now appeared to be replaced with improved ones. Hills and farmlands are also covered with improved trees, and physical and biological soil and water conservation structures. Other major driving factors included expansion of public infrastructures, such as schools (80%), roads and transportation (76%), potable water points, rural electrification, communication media (74%) and others. Road networks have expanded substantially in the last two decades. Farmers' use of transportation services and market participation has also influenced positive changes to farming systems.

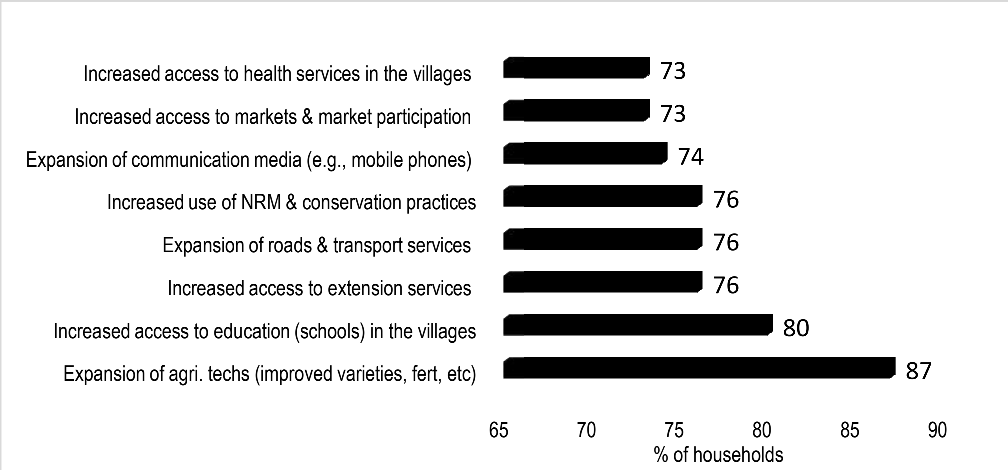

Figure 47. Major factors that have influenced changes in farming systems, 2016/17

Among the medium level driving factors, increasing human population (66%), changes in gender dynamism (63%), expansion of towns and increased rural-urban interaction (60%) and others were also identified to have influenced farming systems of the highlands (Figure 48). Even though growth of human population can contribute for labor availability in agriculture sector, it has also appeared to be a challenge for employment. Farm size per household is declining over time and a pressure has increased on degradation of natural resources, such as forests, plowing of hills and grazing lands in search of farmlands for increased population. In such cases, it can partly impose negative influences on farming systems. Gender dynamism has also revealed changes in the last decades. Women have started engaging in public meetings, technology use and administrative positions. The roles of women have started to be recognized and they are empowered over time. Men have also started recognizing and sharing burdens of women. The other substantial change has been growth of towns and increased rural-urban interaction, which has increased since the last decades. This has increased market participation of the farmers, business orientation and commercial thinking.

Minor but essential driving factors that have imposed influences on farming systems included rural electrification as perceived by 45% of the households (Figure 49). As one of government strategies, rural electrification has started taking-off in the highlands contributing to improvements in livelihoods of rural households. Climate change, which is being expressed in the form of drought (43%), has also appeared to be the other driving factor to changes in farming systems. Frequent drought occurrence has influenced disappearance of some of the crop varieties and emergence of new ones. Increased access to irrigation and expansion of commercial farming has also made their own contributions in influencing changes to farming systems. Along with government and NGO supports, considerable numbers of households are getting access to small-scale irrigation enabling them to make double or triple cropping within a year.

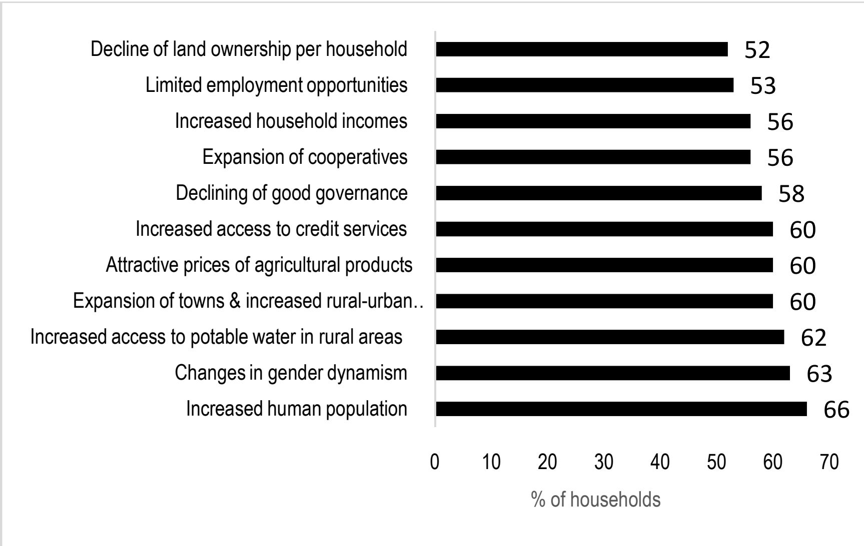

Figure 48. Medium factors that have influenced changes in farming systems, 2016/17

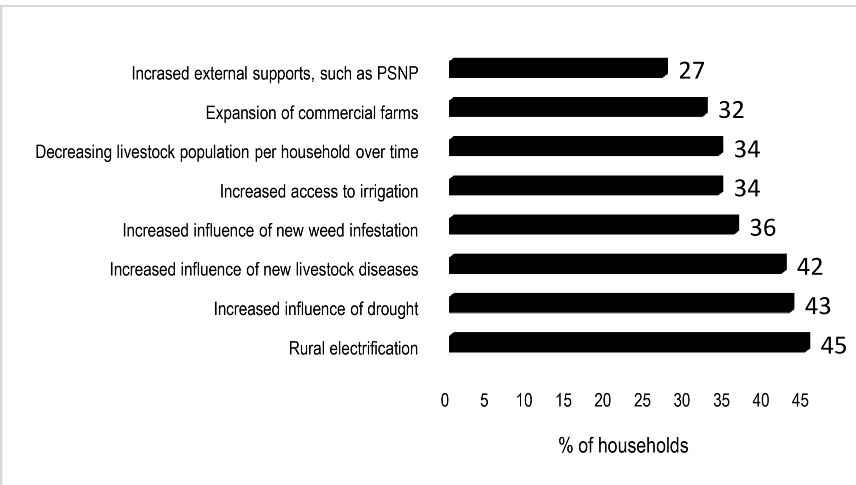

Figure 49. Minor factors that have influenced changes in farming systems, 2016/17

Overall, assessment of driving factors helps to make interventions accordingly to strengthen positive changes and address negative influences to farming systems. It also provides evidence that farming is a system that can be influenced with ranges of driving factors, including social, economic, environmental, political and other factors. Most of the factors are interlinked and the cause of one is an effect of another. The implication is that focus on two or three factors alone does not bring sustainable improvements to farming systems unless integrated approach is set in place.

Food security

According to the assessment of food security status of highland households, 33% of the households on average were identified to be food insecure (Table 56). The proportion of food insecure households was significantly higher for female-headed households (46%) than male-headed counterparts (31%). This category of households faced food shortage for some months in a year for they are unable to make adequate production that can meet their family food demands. For instance, 15% of food insecure households faced food shortages for 1–3 months in a year while 14% faced food shortages for 4 – 6 months in a year. On the other hand, the findings have also figured out that 67% of the highland households were able to secure their food demands through adequate production. The strategy shouldbe reducing the proportion of food insecure households through creating better access to packages of improved technologies and establishing market linkages.

Table 56. Food availability and food security status of households from own production in good seasons, 2016/17.

	MHH		FHH		Overall sample		X^2 Test
	n	%	n	%	n	%	
Food availability status							
Produce surplus	283	29	21	22	304	28	X^2=8.4670, df=2, P=0.015
Produce adequate for the household	389	40	31	32	420	39	
Inadequate production & faced food shortages	306	31	44	46	350	33	
Food security status							
Food secured	672	69	52	54	724	67	X^2=9.2331, df=4, P=0.055
Food insecure for 1- 3 months	140	14	20	21	160	15	
Food insecure for 4 - 6 months	132	14	19	20	151	14	
Food insecure for 7 - 9 months	21	2	4	4	25	2	
Food insecure for 10 – 12 months	13	1	1	1	14	1	

As illustrated in Figure 50, the critical food shortage months were identified to be June – October for these months are periods of planting and crop growth. On the other hand, December – April are relatively food availability months since they are crop harvest seasons. This pattern is believed to be almost common in most parts of the country. Households who could not produce adequate to meet their family's food demands start running out of food as the main season planting is approaching. Cases are common where households with limited resources could not even get adequate seed for planting exacerbating food crisis. It is at this time when they lease-out/share-out their land and migrate to towns in search of daily labor.

Various factors are responsible in causing food insecurity in the highlands. According to 20% of food insecure households, the major driving factor that causes food shortage in the highlands was identified to be drought followed by land shortage (18%) (Table 57). The importance of factors was observed to be different for male and female-headed households. Apart from drought, 25% of female-headed households (FHH) prioritized land shortage to be the cause for food shortage while this proportion is 17% for male-headed households (MHH). Oxen unavailability has also been a cause for 17% of FHH while this proportion is 6% for MHH. Labor shortage is also a problem for 11% of FHH while it is 3% for MHH.

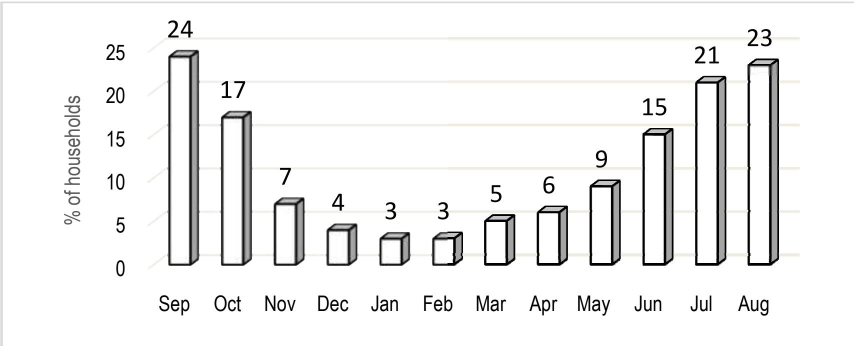

Figure50.Months of food shortage in 2016/17 E.C cropping season

Table 57.Causes of food shortages, 2016/17

Cause	MHH		FHH		Overall households		X^2 test
	n	%	n	%	n	%	
Drought	191	10	26	27	217	20	X^2=7.6294, df=2, P=0.022
Pest outbreak	46	5	8	8	54	5	X^2=8.1278, df=2, P=0.017
Land shortage	164	17	24	25	188	18	X^2=7.7418, df=2, P=0.021
Disease outbreak	69	7	10	10	79	7	X^2=7.6246, df=2, P=0.022
Labor shortage	26	3	11	11	37	3	X^2=23.0848, df=2, P<0.001
Flooding	34	3	4	4	38	4	X^2=7.7447, df=2, P=0.021
Frost	81	8	6	6	87	8	X^2=11.5096, df=2, P=0.003
Oxen unavailability	62	6	16	17	78	7	X^2=15.9453, df=2, P<0.001
Others	54	6	6	6	60	6	X^2=8.0239, df=2, P=0.018

In rural areas of the highlands, households produced not only food but also cash crops. The largest proportion of food crops is meant for household consumption while the cash crops are meant for sale. For instance, 53% of barley and 50% of maize produced are meant for food (Figure 51). On the other hand, the proportion of wheat sold (40%) is higher than the quantity used for household food consumption (28%). Even the proportion of Tef sold (50%) is higher than the proportion used for food (41%). On the other hand, potato, chickpea, grass pea and lentil are cash crops the largest proportion of which is utilized for sale. For instance, 76% of potato produce has been sold while only 20% is used for household consumption at home.

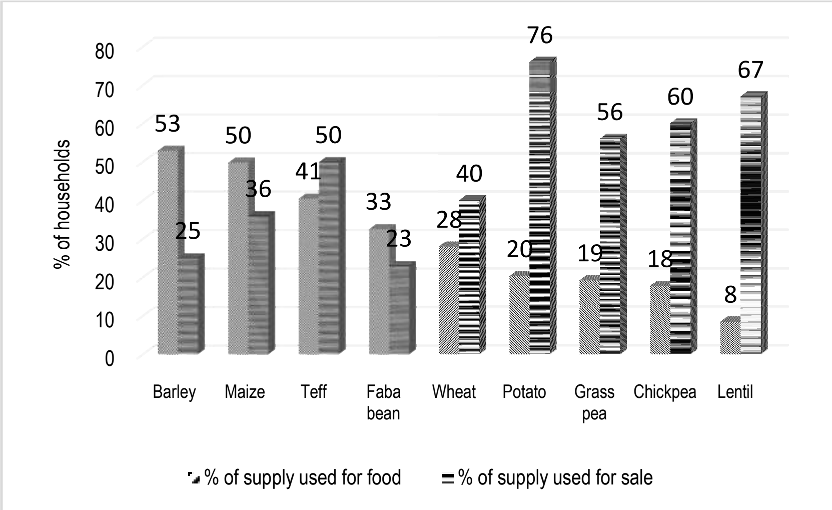

Figure 51. Proportion of grain supply utilized for food and sale

Major problems

The problems that have been drawn from the study are presented in subsequent sections. These problems require integrated interventions of research, development, policy and other sectors. Addressing these problems on sustainable basis means enhancing agricultural production and productivity of the highland farming systems and improving livelihood status and food security of the households.

Limited and unsustainable technology supply

Farmers are not able to get improved seeds and associated packages on sustainable basis. The supply of available technologies is not even adequate not only due to inadequate but also unreliable information on supply and demand for these technologies. When information especially on demand is aggregated from grass root levels, such as Kebele administration, it was often distorted and unrealistic. Because of this, it was not even possible to make proper planning of seed production and other technology supply. There is also limited replacement mechanism of existing technologies with new ones. Technology replacement mechanism is slow when existing improved varieties and other packages get obsolete. Farmers have also noticed that durability of improved seeds has appeared to be very short as seed recycling beyond three years results to yield decline. At this time, most of the producers could not get replacement seedsof either the same or the new improved varieties. Consequently, farmers resort to continuing production of obsolete varieties whose productivities decline every yearand return to local varieties.

Limited agro-ecology specific technologies

Technology generation and dissemination should take into consideration of specific features of agro-ecologies. The same technology may not work well everywhere in the highlands with varying soil and other features. Highlands with adequate moisture and those with moisture stress (dryland) may not require the same technologies. However, the same technology is often being disseminated to everywhere with little consideration of where the technology works better and where not.

Technology introduction and promotion coverage is limited to specific locations

Districts across the highway have better access while those far away have less access. Because of this, technology use has not become accessible to all those who deserve it.

Development interventions are mostly campaign based

The reality is that intensive technology dissemination and scaling up program starts at one time and decreases at other times. Because of this, technology follow-up, introduction and technical back uphave become less sustainable. Once the farmers recognize benefits of improved technologies, they demand to obtain it every year and interventions shall not be one-time event.

Limited availability and use of agricultural mechanization tools

Farmers are recognizing the importance of agricultural mechanization tools. However, initiatives are inadequate to introduce and promote such tools and machines to farmers, such as multipurpose row planters, threshers, shellers, harvesters and others in crops sector. In livestock sector, there is very limited promotion and demonstration of such tools as milk churning machine and others.

Limited coverage of NRM physical structures

NRM physical structures are mainly limited to communal lands, such as hills and hill bottoms. However, such structures are not well constructed on private plots, causing erosion of the soil and consequent decline of soil fertility.

Less extension focus to women and youth

Evidences indicate that most of the technology exposure and use has so far been focusing on men and male-headed households. For various reasons, such as cultural set-ups which discourage public appearance of women, busiest schedules of women in domestic and farming activities and others, the participation of women in trainings, demonstrations, experience sharing and other extension communication media has still appeared to be limited. The participation of youth was also reported to be limited in extension services despite their participation in farming activities is substantial.

Inadequate technology promotion and dissemination to food insecure households

The extent of access to improved technologies was reported to be limited among food insecure households, mainly for economic reasons to afford purchases of packages of technologies.

Limited knowledge of farmers on packages of improved agricultural technologies

Agricultural technologies are often formulated in packages, such as improved varieties and associated packages including recommended fertilizer type and rate, improved weeding and harvesting practices, post-harvest management and others. The same is true with other technologies. However, most of the farmers have limited knowledge of recommended types and rates of these packages, because of which they could not exploit the maximum achievable productivity and benefits of the technologies.

Other problems identified by the study included the following

- Decline of short season belg production in recent decades due to climate change and this has contributed for food insecurity;

- Low level of irrigation practices: Even though there are areas with irrigation potential, this opportunity has not yet been harnessed;

- Farmers fail to follow recommended rates of inputs, such as recommended rates of fertilizer, seed and others. It could be either over-dose, such as seeds, and under dose, such as both organic and inorganic fertilizers. Apart from losing productivity, it also increases production cost;

- Limited knowledge of improved variety names: Farmers often call improved varieties as “new variety” despite each of them have their own names. There are also cases where farmers report improved varieties as local especially when they buy from market. They perceive that unless they receive improved varieties from Ministry of Agriculture or Research Institutions, they call them as local even though they could get from market or other sources. This has created difficulty of determining adoption rates and even impacts of the technologies;

- Low level of adoption of improved varieties of crops (overall 50%) and less than 50% for very important crops such as Tef and barley. This means that still more than 50% of the farming community in the highlands is not beneficiary of improved agricultural technologies. The reasons reported included unavailability or limited supply of improved seeds, and economic reasons where some of the farmers could not afford to purchase packages of recommended technologies that go along with improved varieties, such as inorganic fertilizer, pesticides and others.Unstable performance of improved varieties on farm conditions is also another reason for dis-adoption despite it performed well in the research stations;

- Limited adoption of technologies by female headed households: This was mainly attributed to limited resource ownership to afford purchases of technology packages;

- Low level of crossbred cows adoption: The demand for milk is highly increasing especially in urban centers. However, there is no adequate supply of milk due to limited adoption and use of dairy technologies. The major factors responsible for this included unavailability of reliable sources of crossbred cows/heifers and consequent unaffordable prices;

- Limited access to and use of apiculture technologies: Farmers find engagement in beekeeping as one of the essential incomes sources through sales of honey, wax and other products. However, they could not get reliable access to improved beekeeping technologies, such as modern beehives that appeared to be almost unavailable and its cost unaffordable. There is also limited knowledge and skills of beekeepers on improved beekeeping practices; and

- Weak extension services in livestock sector: Technology adoption and use is worse for livestock sector compared to crops. Technologies on crossbred cows, improved forages, milk churning machine and other technologies are not adequately available and accessible. This has even contributed to limited adoption of improved forage varieties which was constrained by inability to get seeds. Milk processing technique was also observed to be traditional which is believed to be inefficient, time consuming and laborious. Milk production is also very low in rural areas consequent to limited technology use, feed, health and other problems.

Serious feed shortage for livestock: Shrinking of grazing lands consequent to expansion of croplands was reported to be one of the causative factors for feed shortage. Human population pressure has forced communal grazing lands to be provided for youths to use for production of crops and other uses. Expansion of large-scale commercial investment farms has also made its own contribution for decline of grazing lands that used to be source of feed.

- Livestock diseases and low-quality animal health services: The findings have also figured out that animal health services quality is still very low, because of which disease was the other problem reported as high in the livestock sector. According to assessment of health related problems, inaccessibility and far distance of veterinary service centers was also reported to be an issue that should require due emphasis in the livestock sector. For instance, ineffective and low level of AI service has contributed to exacerbate the problem of crossbred heifer's shortage;

- Limited record keeping practices for dairy production: Record keeping practice is almost non-existent (only 5% practice) in rural livestock/dairy production. The reason was reported to be inadequate awareness and knowledge of report keeping practices, which is also one of the factors for limited dairy productivity; and

- Absence of raw milk market options and cooling system for evening milked milk: In rural areas, household who sale milk to nearby towns and road-side milk collectors faced a critical problem of maintaining quality of milk that was milked in the evening. While they sale morning milked milk immediately, the evening milked milk gets sour when trying to sale in the morning. They required any technology or mechanism in which they can keep their milk safe until sale.

Conclusion and Recommendations

Conclusion

The farming systems of the highland agro-ecology have evidently evolved over the last decades through influence of ranges of driving factors. Introduction, dissemination and use of agricultural technologies, expansion of infrastructure, climate change and other factors have influenced changes to farming systems. Many of socio-economic factors have revealed changes over time, such as per household land ownership has declined and access to irrigation has increased. Adoption rate of various agricultural technologies has illustrated an increasing trend over time especially in the last decade, which is mainly attributed to contribution of various government programs, such as growth and transformation plan (GTP), agricultural growth program (AGP) and others. While nearly half of the farming population on average has adopted various improved technologies, another half has not yet started benefiting from the technologies. The major factor that hindered technology use and adoption was limited access to improved technologies, such as improved variety seeds and associated packages. Technology introduction and dissemination initiatives have largely been campaign bases with little consideration of sustainability issues. Timely technology supply and replacement, and associated capacity enhancement efforts were recognized to be inadequate and unsustainable. While technology supply and use have to be package basis and as per recommendations, the reality is below expectation.

Access of women and youths to technology use and capacity enhancement initiatives is still very limited despite their contribution to agriculture sector is substantial. In the mixed farming systems, introduction, dissemination and adoption of livestock technologies has still appeared to be very limited, even far below the use of crop-based technologies. Even though soil and water conservation technologies are getting through well, they have not been well adopted on private farmlands. Climate change which is being expressed in the form of drought is becoming a major threat to the highland farming systems despite farmers try to minimize the effects through various innovations of coping and adaptation mechanisms. In spite of lots of interventions and development initiatives, one third of the highland households are still food insecure. To improve food security status of these households and enhance agricultural growth in the highlands, the following key recommendations are proposed:

Recommendations

Even though ranges of problems and challenges have been identified in the course of the study, the following key recommendations have been suggested:

Ensure sustainable supply and timely replacement of available technologies

Available technologies, both on production and on shelf, need to be multiplied and disseminated to beneficiaries on sustainable basis. Improved varieties of all crops need to be officially multiplied through formal seed producing companies, both public and private. The capacities of public and private seed companies need to be enhanced through special policy supports and incentives, such as credit services, supply of land for seed multiplication, establishing market linkages, tax incentives and others. The improved seeds along with recommended seed and fertilizer rates need to be packaged on 0.25ha basis and should be made available at village levels through cooperatives. After 3 – 5 years of production, improved variety seeds under production need also be replaced with clean seeds either of the variety or with new variety seeds. Technology supply initiative should not be campaign basis that makes intensive efforts at one time and terminate at another. Rather, it should be sustainable with continuous supply as required. The use of modern crop breeding methods and integrated breeding process to generate durable disease tolerant varieties is required.

Provide focus to introducing and disseminating technologies to unaddressed communities

So far, nearly half of the highland community on average has not yet become beneficiary of improved technologies. Most of these households are aware of the technologies, but did not yet get access to improved seeds and associated packages. Technology introduction and dissemination initiative along with robust capacity enhancing should also make a focus to unaddressed highland locations as well.

Focus on introducing, promoting and disseminating packages of technologies

Piece meal basis of technology introduction and use did not bring anticipated impacts. To exploit maximum achievable yield, it should be strengthened on promoting and disseminating packages of agricultural technologies, such as improved varieties along with recommended fertilizer rates, weed control, farm mechanization tools (such as row planters, harvesters, threshers, etc.) and others. This should be supplemented with soil and water conservation technologies, such as physical structures, minimum tillage and others. Livestock technologies, such as crossbreds, improved forages, and others should also be introduced for maximum impact. Market linkages should also be created for both crops and livestock products to ensure sustainability.

Strengthen and exploit available opportunities for expansion of irrigation schemes

In the highland farming systems, there are locations with surface and ground water potentials. However, the proportion of irrigation farming is still below 10%.Government and NGO supports are required to help farmers utilize water sources for irrigation. Farmers should also grow high value commodities, which are demanded at the market. Establishing market linkages are also required to ensure sustainable production.

Strengthen generation of stable and productive technologies to highland agro-ecology

The study has identified that one of the factors for less adoption rate of technologies is their inability to reveal high and stable performance. It was reported that some of the improved varieties could not perform better than locals under the same input levels. This suggests that breeding programs need to provide due focus in generating technologies that sustainably outperform locals. Specific technologies are required for highlands with adequate moisture and highlands with moisture stress (drylands). Highland drylands require short maturing improved varieties of crops along with soil and water conservation technologies.

Focus to women and youths in technology dissemination and capacity building

The study has figured out that women and youths are not yet adequately addressed through extension services, capacity building and overall technology access. This should be given due focus on embrace women (both married women and FHH) and youths in engaging them on extension services, providing capacity enhancing opportunities and exposure to various technology types.

Introduce, promote and disseminate agro-mechanization tools

Households have recognized the importance of agro-mechanization tools in saving time, minimizing drudgery, enhancing efficiency, and minimizing post-harvest loses. However, there is limited access to the tools at affordable prices. It issuggested to introduce, promote and disseminate farmer friendly machines and tools, such as multi-purpose row planters, threshers, milk churners and others. Market linkage should be created between beneficiaries and manufacturers of these tools and machines along with on-the-farm demonstration and training.

Preparation and dissemination of production manuals

Limited knowledge of application and use of the various technologies was also identified to be one of the problems in the adoption process. It ishighly suggested to prepare, publish and disseminate production manuals in an easily understandable and self-explanatory expression in different local languages. This production manual could contain features and recommended packages of a new technology. Thousands of copies should be duplicated and distributed to farmers on improved technologies use and application methods of improved varieties and associated packages, livestock, soil and water, irrigation, and other technologies. When a new technology is generated, it should be accompanied with a user-friendly production manual for the farmers.

Provide local names for new technologies

Once technologies are confirmed to be acceptable and generated for utilization, whether improved varieties or others, it is highly advisable to provide local names to help farmers identify one technology type from another. It also helps for later studies on technology adoption and impact, and other studies.

Establish and strengthen crossbred heifer rearing centers

he demand for crossbred cows and heifers is increasing from time to time. However, there is no reliable supply of crossbred heifers and cows at affordable prices. Therefore, it is highly suggested by either the government or private sectors to establish reliable heifer rearing centers at various regions of the country as that of regional seed enterprises. For instance, there could be Crossbred Heifer Rearing Centers in Amhara, Oromia, Tigray, SNNP and other regions. The government should also provide investment incentives for private sectors in crossbred heifer rearing centers.

Promote apiculture technologies

Sales of honey, wax and other products have appeared to be essential sources of incomes for highlanders. However, there is no reliable supply of modern beehive and associated technologies for the farmers. Therefore, it is highly suggested to promote, support and strengthen new beekeeping technologies. This could include providing investment incentives for private modern beehive manufacturers. Moreover, there is a strong need to raise knowledge and skills of beekeepers on improved management practices. Beekeeping production manuals could also be prepared and distributed to beneficiaries in local languages to build their experiences with improved knowledge.

Strengthen extension services for livestock sector

It has been noticed that extension services largely focus on crops sector. Therefore, public, private and development partners (international and national) should also provide more focus in providing extension services for livestock sector. This could focus on promoting improved technologies on daily management, feed, health, fattening, apiculture, poultry and others. Record keeping practices need also be promoted for the farmers to help them record inputs and outputs, costs and incomes, and many other features. This helps to make informed decisions on farm conditions.

Introduce and promote milk-churning technologies

New milk churning technologies have not been introduced and promoted to rural areas. It is therefore, highly suggested to introduce time and energy saving, affordable and user-friendly milk churning technologies along with manuals that describe how to use and maintain.

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