Adoption Analysis of Smallholder Dairy Production Technologies in Oromiya Region

Agajie Tesfay
Tadele Mamo
Tesfaye Solomon
Yared Deribe
Wudineh Getahun
Tolesa Alemu
Diriba Hunde
Tamirat Fikadu
Seyoum Bediye

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Ethiopian Institute of Agricultural Research

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ድረ ገፅ: http://www.eiar.gov.et
ስልክ: +251-11-6462633
ፋክስ: +251-11-6461294
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1. INTRODUCTION

Different packages of dairy production technologies have been promoted to beneficiaries since a long period of time with the support and facilitation of several governmental and non-governmental organizations. Despite several efforts made in the dairy sector, adoption and impact studies are generally lacking under Ethiopian situation to guide future research and development endeavors. Considering the current focus of dairy in Ethiopia, assessing adoption and determinants of dairy technology utilization is a strategic concern and take off point in sharpening the focus and ensuring the envisaged impacts at a regional or national level. Therefore, this report intends to fill information gap on the current status of adoption of dairy production technologies. It also presents the various factors that are responsible for adoption or otherwise of dairy technology packages. Therefore, this report presents the findings of adoption analysis of packages of dairy production technologies with reference to Oromiya Region.

2. THE STUDY METHODOLOGIES AND APPROACHES

2.1 Scope of the study

The study mainly focused on Oromiya Region which ranks second (39%) in dairy population in the country next to SNNP region (49%). Zone North Shewa, West Shewa, Southwest Shewa, East Shewa, West Hararghe, Arsi, Bale and West Arsi Zones were selected for the study. These Zones are believed to Zone represent the Region in dairy production. Two districts were again selected based on dairy cows population from each of the target Zones, making a total of 16 districts embraced in the study. From each of the districts, two kebeles were selected based on dairy cows population and this makes a total of 32 kebeles considered in the study. Therefore, multi-stage sampling technique was adopted mainly on dairy cows population. Similar study conducted in Kenya has also selected the study areas based on dairy cow population (Makokha *et al*., 2003).

The study was conducted at a time with networking of Holetta, Melkassa and Kulumsa research centers. A team of researchers drawn from each of these centers took the overall responsibility of data collection and supervision, and data entry. Holetta Research Center was responsible for the overall coordination of the study and collection of data from North Shewa, West Shewa and Southwest Shewa Zones. Melkassa Research Center handled data collection and supervision task from East Shewa and West Hararghe Zones while the team drawn from Kulumsa Research Center was responsible for Bale, Arsi and West Arsi Zones. Data collection and entry instruments, such as a structured questionnaire and data entry templates were centrally designed and shared to implementing centers. This means all the research centers used the same questionnaire and data entry code. The dataset collected from eight of the Zones was merged together, cleaned and analyzed for report synthesis.

2.2 Data collection and team coordination

The required dataset and information was collected by employing blends of standard data collection methodologies. The major stages of data collection included: Desk review, qualitative and quantitative survey techniques. In the first stage, extensive desk review was made from electronic and print sources including published and unpublished materials, websites and others. Information obtained from desk reviews and qualitative approaches has helped to design survey instruments, such as structured questionnaire, at initial stages of the study. In the second stage, supplementary information and further details on specific parameters were collected through qualitative survey techniques, such as focus group discussions and key informant interviews. This approach has largely contributed to understand details of particular issues and learn more about dairy production technologies from contacts with selected farmers, Office of Agriculture representatives, senior livestock research and social science scientists and others. The third stage was devoted to collection of quantifiable data through quantitative survey approaches. This stage was fundamental to collect concrete and measurable data from randomly selected households using a structured and pre-tested questionnaire.

The structured questionnaire was designed centrally with consultation of the study team and different professionals in the livestock sector. To substantiate with additional feedback and finalize the questionnaire, consultative meeting was held with the study team and senior researchers drawn from different fields of livestock sector. This platform has helped establish a common understanding of the team on the whole study processes, data collection instruments especially the questionnaire, sampling frame and sample selection techniques, selection of the study sites, team management and various other issues. This stage was essential to lay a favorable ground and strengthen team spirit across the implementing research centers.

2.3 Sampling frame and sample selection

Since the purpose of the study is to analyze the adoption status of dairy production technologies, the sampling frame of the study was farming households who owned cattle, in general, and cows, in particular, either local or crossbred. Selection of Zones, districts and kebeles was largely based on dairy cows population. For selection of Zones, dairy cow population was taken from CSA (2013) dataset and Zones with the largest population of dairy cows were selected to be included in the study. The information on dairy cows population for districts and kebeles was again retrieved from the respective Offices of Agriculture documentation in each of the Zones. The complete list of households from where samples were drawn randomly was again obtained either from Office of Agriculture or District Office of Finance.

In addition to cattle ownership and dairy cow population, accessibility to milk markets was also considered as additional criterion to select districts, kebeles and households. Given that dairy cow technology is meant for milk production, it is not expected to be disseminated and promoted to areas far away from milk market outlets, such as towns or milk collection centers along the roadsides, which shall basically fall within 10 km radius (about two hours walking distance for the farmers). Therefore, stratification was made in this study that out of the two districts selected from each of the Zones, one was picked from a distance of 5 km radius while the second was selected from a distance of about 10 km radius from milk collection centers or milk markets (towns). Kebele selection has also followed the same trend. Therefore, after stratification by distance from milk selling centers, the sample districts and kebeles were selected randomly. Following identification of kebeles, households who owned dairy cows were selected randomly using systematic random sampling technique.

The sample size selected from each of the sample kebeles was determined through standard sample size determination techniques.

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

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 e was set at 0.05. Sample size was, therefore, reasonably determined taking into consideration of all the above factors. All efforts were made to minimize sampling errors and ensure collection of quality dataset. Accordingly, a sample size of 50 households was selected from each of the sample kebeles and this means 100 households from each of the districts or 200 from each of the Zones even though there can be plus or minus of some samples during the actual data collection. Therefore, the total sample size of the study was 1630 households of which women accounted for 28%. Table 4 provides Zones included in the study and sample sizes selected for interview.

Table 1. Sample sizes selected from each of the study Zones in Oromiya Region, 2014.

Zones	Male	Female	Overall
North Shewa	167	57	224
West Shewa	175	60	235
Southwest Shewa	155	42	197
Arsi	130	42	172
Bale	140	60	200
West Arsi	138	61	199
East Shewa	140	58	198
West Hararghe	125	80	205
Overall average	1170	460	1630

2.4 Statistical analysis tools and empirical models

Options of statistical methods and econometric models were employed to analyze data, synthesize the information and determine technology awareness, adoption decision behaviors of smallholder farmers and adoption intensity of dairy production technologies. The choice of appropriate model in this study was determined based on the nature of dataset, sampling techniques, the level of precision required and other factors. Accordingly, blends of tools and models have been used to generate valid information.

Knowledge index was used to determine the extent of awareness of dairy farmers regarding dairy production technologies. Similar study made by Lemma *et al*. (2012) on adoption of improved dairy husbandry practices in central parts of Oromiya region has also used knowledge index to measure the extent of knowledge of dairy farmers about dairy husbandry practices. The knowledge index was estimated using the following formula:

$$K_i = \frac{X_1 + X_2 + X_3 + \cdots + X_n}{N}$$

Where K_i = *Knowledge index*

$X_1, X_2, X_3, \text{-----}\ X_n$, = *Total number of correct answers/obtained score*
N = Number of items in a test / maximum possible score

Adoption index was also used to determine adoption rates of packages of dairy production technologies. This was also made using the following equation:

$$\text{Adoption index} = \frac{\textit{Total number of scores obtained}}{\textit{Expected maximum score}} \times 100$$

Econometric models including Heckman two-step selection model, probit and tobit models were also employed to analyze the data and synthesize the information. Adoption study of dairy technologies in Kenya made by Makokha *et al*. (2003) has also employed probit model to determine the factors affecting the adoption status. Similar study on adoption rates, means and proportions of selected variables were analyzed through descriptive statistics using Chi-square, F-tests, t-tests, one-way Anova and others for tests of significance between selected group variables.

Probit model was used to determine the factors affecting adoption of certain dairy technologies, such as crossbred dairy breeds and forage technologies. On the other hand, tobit model was employed to analyze adoption intensities of crossbred dairy cows and area of land allocated for forage production.

Heckman's two-step model

Heckman's two-step selection model was used on conditions where there is selectivity bias especially for dependent variables. Therefore, Heckman model is employed to correct for selectivity bias. Selection bias problems are endemic to applied econometric problems, which make Heckman's original technique and subsequent refinements by both himself and others, indispensable to applied econometricians. Heckman's sample selection model is based on two latent dependent variables models and has developed a two step estimation procedures model that corrects for sample selectivity bias (Heckman, 1979). Moreover, Heckman's two steps estimation procedures are appropriate in that there are two decisions involved, such as participation in adoption of crossbred cows and the intensity of adoption. The first step of Heckman two steps model, 'the participation equation' attempts to capture factors affecting participation decision. The selectivity term called 'inverse Mills ratio' (which is added to the second step outcome equation that explains factors affecting the level or intensity) is constructed from the first equation. The inverse Mill's ratio is a variable for controlling bias due to sample selection (Heckman, 1979). The second step involves the Mills ratio to the intensity (level of participation) equation and estimating the equation using Ordinary Least Square (OLS). If the coefficient of the mill's ratio is significant, then the hypothesis of the unobserved selection bias is confirmed. Moreover, with the inclusion of extra term (Mill's ratio), the coefficient in the second step selectivity corrected equation is unbiased (Zaman, 2001). Specification of the Heckman two step procedures, which is written in terms of the probability of participation and intensity, is:

The participation/the binary probit equation

$Y_{1i} = X_{1i}\beta_1 + U_{1i}$ $\quad U_{1i} \sim N(0, 1)$ (1)

$Y^* = 1$ if $Y_{1i} > 0$ (1.1)

$Y^* = 0$ if $Y_{1i} \leq 0$ (1.2)

Where Y_{1i} is the latent dependent variable which is not observed
X_{1i} is vectors that are assumed to affect the probability of participation
β_1 is vectors of unknown parameter in the participation equation
U_{1i} are residuals that are independently and normally distributed with zero mean and constant variance

The observation equation/the intensity equation

$Y_{2i} = X_{2i}\beta_2 + U_{2i}$ $\quad U_{2i} \sim N(0, 1)$ (2)

Y_{2i} is observed if and only if $Y^* = 1$. The variance of U_{1i} is normalized to one because only Y^*, not Y_{1i} is observed. The error terms U_{1i} and U_{2i} are assumed to be bivariate, normally distributed with correlation coefficient ρ, β_1 and β_2 are the parameter vectors.

Y_{2i} is regressed on explanatory variables, X_{2i}, and the vector of inverse Mills ratio (λ_i) from the selection equation by Ordinary Least Square (OLS).

Where, Y_{2i} is the observed dependent variable
X_{2i} is factors assumed to affect intensity equation
β_2 is vector of unknown parameter in the intensity equation
U_{2i} is residuals in the intensity equation that are independently and normally distributed with mean zero and constant variance.

$$\lambda_i = \frac{f(XB)}{1 - F(XB)}$$
(3)

f (Xβ) is density function and 1- F (Xβ) is distribution function.

The software known as STATA Version 13 was used for the estimation purpose.

The Probit model

The probit model was also employed to determine the factors affecting participation of households in the adoption of forage technologies. According to Woodridge (2002), probit model can be specified as:

$$Y^* = Z'\alpha + \varepsilon_1 \quad \text{...(1)}$$

Y=1 if $Y^* > 0$ and Y=0 if $Y^* \leq 0$

Where,

Y^*= latent (unobservable) variable representing farmers' discrete decision whether to participate in a program or not

Z' = vector of independent variables hypothesized to affect farmer's decision to participate in the program

α = vector of parameters to be estimated which measures the effects of explanatory variables on the farmer's decision

ε 1 = normally distributed disturbance with mean (0) and standard deviation (δ) of 1 , and captures all unmeasured variables

Y = dependent variable which takes on the value of 1 if the farmers participate in the program and 0 otherwise.

The maximum likelihood estimate of the probit model is given as:

$$LnL(\frac{\alpha}{Y}, Z) = \sum_{y=1} \ln \Phi(Z'\alpha) + \sum_{y=0} \ln(1 - \Phi(Z'\alpha) \quad \text{..........................(2)}$$

Marginal effect of probit model

$$\frac{\partial E(y^*|x)}{\partial x} = \beta \quad \text{.......................................(3)}$$

The Tobit Model

The Tobit model was also employed in the analysis to determine the intensity of adoption of crossbred cows and improved forages technologies. The Tobit model is a statistical tool proposed by Tobin (1958) to describe the relationship between a non-negative dependent variable and an independent variable. The Tobit model is also known as a censored regression model. According to Tobin (1958), the Tobit model can be specified as:

$$y_i^* = \beta_0 + \beta_i X_i + \mu_i \quad \text{.......................................(1)}$$

$$y_i = w_i^* \text{ if } \beta_0 + \beta_i X_i + \mu_i > 0$$

$$= 0 \text{ if } \beta_0 + \beta_i X_i + \mu_i \leq 0$$

Where:

y_i = is observed index of the i^{th} farmer

y_i^* = is the latent variable and the solution to utility maximization problem, subjected to classical linear assumptions; [N~ (0, σ^2)].

X_i = is vector of explanatory variables affecting level of intensity

β_i = is vector of unknown parameters to be estimated

μ_i = is the error term, assumed to be normally distributed with mean 0 and constant variance, σ^2.

According to Maddala (1992) and Amemiya (1985), the estimates of the Tobit model are based on the Maximum Likelihood estimation (ML) by maximizing the Tobit likelihood function. Based on Sigelman and Zeng (1999), if density function and cumulative density functions of *y** are denoted by *f(.)* and *F(.)*, respectively, then the Tobit model implies that the probabilities of observing a non-zero y and a zero y are *f(y)* and p(y*<0)=F(0), respectively. Therefore, the log likelihood (LL) of the model can be:

$$\ln L = \ln\left(\prod_{y_i > o} f(y_i) \prod_{y_i = 0} F(0)\right) = \sum_{y_i > 0} \ln f(y_i) + \sum_{y_i = 0} \ln F(0) \quad \text{.....................(2)}$$

Since y* is assumed to be normally distributed as error terms are assumed to be normally distributed, f(.), F(.) and hence LL functions can be written in the form of density function and cumulative density function of the standard normal distribution as: $\phi(.)$ and $\Phi(.)$, and the LL function can be rewritten in the usual form as:

$$\ln L = \sum_{y_i > 0}\left(-\ln\sigma + \ln\phi\left(\frac{y_i - x_i\beta}{\sigma}\right)\right) + \sum_{y_i = 0}\ln\left(1 - \Phi\left(\frac{x_i\beta}{\sigma}\right)\right) \quad \text{........................(3)}$$

Unlike the case of OLS coefficients, it is difficult to interpret the estimated coefficients of the Tobit as a marginal effect because there are three main conditional expectations of interest in the Tobit model. These are: 1. the conditional expectation of the underlying latent variable (y*); 2. the conditional expectation of the observed dependent variable (y); and the conditional expectations of the uncensored observed dependent variable ($y|y>0$). Following (Greene 1997; McDonald and Moffitt 1980), the marginal effects of these conditional expectations, respectively, are illustrated as:

1) $$\frac{\partial E(y^*|x)}{\partial x} = \beta \qquad (4)$$

2) $$\frac{\partial E(y|x)}{\partial x} = \beta\Phi\left(\frac{x\beta}{\sigma}\right) \qquad (5)$$

3) $$\frac{\partial \Pr(y>0|x)}{\partial x} = \phi\left(\frac{x\beta}{\sigma}\right)\frac{\beta}{\sigma} \qquad (6)$$

The interpretation of these marginal effects depends on the point of interest based on the focus of the study. For instance, if the interest is to make statements about the conditional mean function in the population despite the censoring, equation (4) is used for the censored data. If a researcher is interested on average value of the population of study, and how those values vary with covariates, equation (5) is used and finally, if one wants to interpret, for example, about the determinants of average values of the dependent variable among those who have already participated in a program, equation (6) is used. However, in literature, all the three marginal effects are interpreted to show the change in the probability of participation, intensity of dependent variable among the whole population and intensity of use among the participants only, respectively.

2.5 Hypothesis and definition of variables

Ranges of socio-economic variables and attributes of the technologies under consideration were employed for modeling the adoption decision of dairy farmers. Several studies have often been considering household and farm characteristics, attributes of the technologies, institutional factors, such as land tenure, access to markets and information, credit and extension, and others (Chilot and Hassan, 2008). As presented in Table 5, household characteristics (age, level of education), household assets (farmland), dairy technology attributes and others were hypothesized to influence adoption decisions of farmers.

Sex, age and educational levels of a household head are demographic characteristics believed to impose influences on adoption decisions of farming households. Different studies have reported either positive or negative influence of age on adoption of agricultural technologies. For instance, in the adoption study of wheat production technologies conducted by Chilot *et al* (2013), it was reported that the age of a household head has a negative influence on adoption. Education of a household head measured in numbers of schooling completed is believed to have a positive influence on adoption decisions of households. Several studies reported the influence of family size to impose either positive or negative impact on adoption of agricultural technologies. Chilot *et al* (2013) have also reported negative influence of family size on intensity of improved wheat production.

The study has also utilized several variables believed to be influencing factors of dairy technologies adoption. Ranges of institutional variables have also been identified to be included in the analytical models to determine adoption behaviors of households and intensity of adoption.

Table 2. Selection and definition of variables hypothesized to influence adoption of crossbred dairy technology, forage crops, milk churning machine, and feeds and nutrition technologies, 2014

Variable	Description	Values	Expected sign of influence
Demographic characteristics			
Sex	Sex of household head	0=female 1=Male	-/+
Age	Age of household head	Years	-/+
Education Educ0 Educ1	Educational level of household head Illiterate Literate	Dummy Variable 1=yes 0=no 1=yes 0=no	+
Family size	Number of family members in a household living for more than 6 months	Number	-/+
Household type	Type of household	0=Female-headedmale-headed 1=Male-headed	-/+
Asset Ownership			
Cows owned	Number of cows (local, crossbred) owned by a household	Number	-/+
Farm size	Total area of land managed by a household	Hectare (Ha)	+
Size of forage land	Area of land allocated for forage production	Ha	+
Income	Household income from agricultural and non-agricultural activities	Birr	+
Institutional variables			
Credit	Access of a household to credit services for purchase of feeds and crossbred cows	1=Yes 0=No	+
Extension	Access of a household to extension services on improved dairy management practices along with its packages	1=Yes 0=No	+

Trainings received	Trainings received by a household head on improved management of crossbred cows, forage and pasture, feeds and nutrition, milk processing	1=Yes 0=No	+
Membership in coops	Membership of the household in milk cooperatives	1=Member 0=Not member	+
Other variables			
Distance to milk market	Distance of the farmers' village from milk selling or collection center	km	-
Perceived crossbred Price	Perceived price of crossbred cows	1=Expensive 0=Not-expensive	-
Perceived source of crossbred cows	Perceived source of crossbred cows	1=Not available 0=Available	-
Perceived feed cost	Perceived cost of feeds	1=Expensive 0=Not expensive	-
Perceived source of feed	Households' main source of feed is grazing	1=Grazing 0=Other sources	+
Perceived knowledge of improved feed management practices	Knowledge of the household head on improved feed management practices	1=Has knowledge 0=Has no knowledge	+
Quantity of milk produced	Total quantity of milk produced from cows	Liters	+
Milk selling experiences	Whether a household ever has experiences of selling milk	1=Has experiences 0=No experiences	+
Proximity of the household to big consumer centers	Proximity of the household from big consumer centers, such as the city of Addis Ababa, in the radius of 100 km	1= Close proximity 0= Far-off location	+

3. RESULTS AND DISCUSSION

3.1 Socio-economic characteristics of the households

Ranges of social and economic factors are anticipated to influence farmers' adoption behavior of improved technologies. Proxy indicators for wealth of farming households, such as livestock ownership, land and the type of house are believed to be the major factors affecting adoption of dairy production technologies. These factors are briefly presented in subsequent sections.

3.1.1 Household Characteristics

Age of Household Head: Age of the household head is believed to be associated with farming experiences which is noticed to have either positive or negative influences on adoption of technologies. The average age of farming households in the study Zones was 43 years ranging from 18 – 90 (Table 6). There is also statistically significant difference between Zones in the average ages of households ($F=15.23$, $df=7$, $P<0.001$). The average age of men was 44 years while that of women was 40 years. This implies that if the average age at marriage is 21 years for males and 18 years for females, both male and female have more than 22 years of farming experiences. If this experience is accompanied by education, skill based trainings, experiences sharing visits and other exposures to improved farming; it is likely to have positive influence on adoption of dairy production technologies.

Table 3. Age of household heads across the study Zones, 2014

Zones	n	Average	Min	Max	SD
North Shewa	222	48	19	90	13.85498
West Shewa	234	44	18	78	12.27761
Southwest Shewa	197	42	23	76	11.92969
Arsi	172	41	22	78	12.12328
Bale	200	44	18	86	13.90629
West Arsi	199	38	18	70	10.54611
East Shewa	198	45	18	73	12.40111
West Hararghe	203	38	18	72	11.71379
Overall average	**1625**	**43**	**18**	**90**	**12.78658**

F=15.23 df=7 P<0.001

Educational status of household head: Education is also another influential parameter in making adoption decisions. It is apparent that a household head with some level of formal schooling is supposed to have positive attitudes towards new technologies and practices. Even though there is significant difference among Zones (X^2=220.2644, df=21 and P<0.001), 72% of the overall households are literate with formal schooling ranging from elementary to high school levels (Table 7). Whilst 28% of the households are illiterate, 44% have attended elementary levels of education. This can be taken as a favorable opportunity for promotion and dissemination of packages of dairy production technologies to the farming community. Provision of extension services can also be facilitated by using various extension media, such as production manuals, leaflets, pamphlets and others. On the other hand, on-the-job types of trainings, skill based demonstrations and farmer field days can be valid approaches to render extension services for households with no formal schooling.

Table 4. Educational status of sample households (%)

Zones	Illiterate	Elementary	Junior secondary	High school
North Shewa	41	45	6	7
West Shewa	28	45	16	11
Southwest Shewa	15	47	18	20
Arsi	14	42	20	24
Bale	11	46	17	25
West Arsi	18	45	16	20
East Shewa	39	46	5	10
West Hararghe	52	36	5	7
Overall average	28	44	12	15

Family size per household: Farming households largely depend on family labor for operations related to livestock management, such as feeding, feed collection, herding, milking, barn construction and cleaning, and other activities. Therefore, family size is an essential resource for farming households. The average family size of households in the study areas was 6.9 with significant ($F=12.26$, $df=7$, $P<0.001$) variations across Zones (Table 8). Chilot *et al*. (2013) in their studies at national levels have also reported similar family size per household. However, these figures are still higher than the national average of family size of 5.1 persons (CSA and World Bank, 2013).

3.1.2 Farm size and proportion allocated to feed production

Own land is the size of farm that is officially allocated to a household on the basis of its family size during land re-distribution. On the other hand, total land cultivated includes own land and additional leased-in or shared-in land. As indicated in Table 9, households owned 2.2 ha of land on average with significant variability across Zones ($F=38.15$, $df=7$ and $P<0.001$). The average total land cultivated per household was 2.3 ha (including leased-in and shared-in land), of which 34% was allocated to feed production including for grazing, pasture/hay making and improved forage development. There is also statistically significant difference among the study Zones in the size of land allocated for feed production ($F=8.59$, $df=7$ and $P<0.001$). North Shewa and Arsi Zones allocated relatively larger area of land (1.1 ha each) while East Shewa (0.4 ha) and West Hararghe allocated the least (0.2 ha) for feed production.

Table 5. Family sizes of households in the study areas, 2014

Zone	N	Average family size	SD
North Shewa	224	6.8	2.5798545
West Shewa	235	7.0	2.7587418
Southwest Shewa	197	7.3	2.7654241
Arsi	172	6.7	3.2323336
Bale	200	6.7	3.5390109
West Arsi	199	8.4	3.6467822
East Shewa	198	6.2	2.2902554
West Hararghe	205	6.1	2.324397
Overall average	1630	6.9	2.9878303

F=12.26, df=7, P<0.001

Table 6. Farm sizes of households and proportion of land allocated for feed production, 2014

	Owned land (ha)	Total land cultivated including leased-in and shared-in land (ha)	Land allocated for feed production	% of land allocated for feed production
North Shewa	3.0	3.4	1.1	32
West Shewa	2.6	2.9	0.9	31
Southwest Shewa	2.3	2.6	0.5	19
Arsi	2.2	2.9	0.8	27
Bale	2.7	2.7	0.9	33
West Arsi	2.4	2.4	1.1	46
East Shewa	2.1	2.7	0.4	15
West Hararghe	0.6	0.6	0.2	33
Overall average	2.2	2.3	0.8	34
Statistical test	F=39.15, df=7, P<0.001	F=35.03, df=7, P<0.001	F=8.59, df=7, P<0.001	

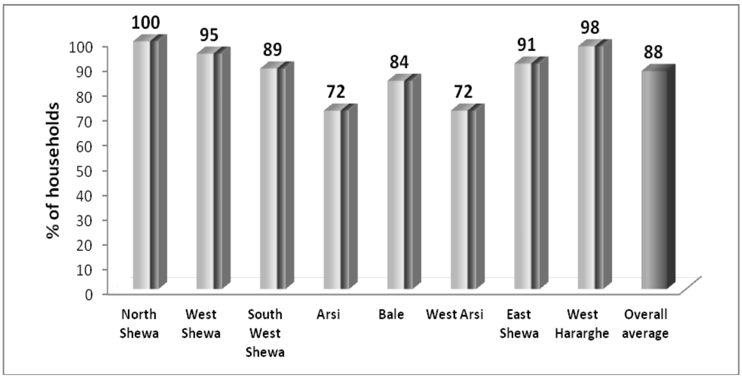
3.2 Awareness and sources of information about crossbred dairy cows

Adoption of a new technology and practice is often preceded by knowledge of its existence. Accordingly, 88% of the overall households were aware of crossbred dairy cows (Figure 5). There is also significant variability across the study Zones (X^2=159.9851, df=7, P<0.001), ranging from 72% – 100%. North Shewa Zone, which is also commonly called Selale plain, has demonstrated complete awareness of crossbred dairy cows technologies. This can be attributed to the fact that this Zone has hosted ranges of development interventions related to dairy since three to four decades. Some of these included the 4th livestock development project (FLDP), Small-scale Dairy

Development Project (SDDP), and others. On the other hand, the awareness level was relatively lower for Arsi and West Arsi Zones (72% each).

As presented in Table 10, 52% of the households in North Shewa Zone were aware of crossbred dairy technologies since more than 10 years. There is also statistically significant difference among the study areas (X^2=253.5771, df=14, P<0.001) in the time Zone that households became aware of dairy technologies. In spite of less proportion of aware households as compared to others, 46% of the households in Arsi Zone have also claimed to have got knowledge of crossbred cow technologies since more than 10 years. This might be because of the influence of CADU (Chilalo Awraja Development Unit) and ARDU (Arsi Rural Development Unit) which have been pioneer development and extension programs in the sixties and seventies to promote improved agricultural technologies in the area. On the other hand, a large proportion of households in West Hararghe (77%), Southwest Shewa (53%) and East Shewa (51%) Zones were aware of improved dairy cow technologies within the last five years. In general, 71% of the overall households got the knowledge of crossbred cows within the last 10 years time. This might be because of the decentralized administrative set up and empowerment of districts with well organized extension programs designed based on the needs of beneficiaries and prevailing development needs.

For 54% of the households, the information and knowledge about crossbred dairy cows was mainly sourced from Office of Agriculture through its channels of extension service provision (Figure 6). The second essential source of information about new technologies was farmer-to-farmer information exchange for about 34% of the households. In this regard, agricultural research centers have also contributed to creating knowledge stock of improved dairy cows for 4% of the households through direct engagements. However, the contribution of the national agricultural research systems and international research organizations is fundamental through awareness creation, outreach programs, capacity building and empowerment means through indirect means as well.



X^2=159.9851, df=7, P<0.001

Figure 1. Awareness and knowledge of households about crossbred dairy cows, 2014

Table 7. Time since when households became aware of crossbred cows, 2014

Zone	Since the last 5 years	In 6 – 10 years	Since more than 10 years
North Shewa	16	33	52
West Shewa	39	40	20
Southwest Shewa	53	23	24
Arsi	29	24	46
Bale	47	24	28
West Arsi	51	17	32
East Shewa	51	27	22
West Hararghe	77	15	7
Overall average	45	26	29

X^2=253.5771, df=14, P<0.001

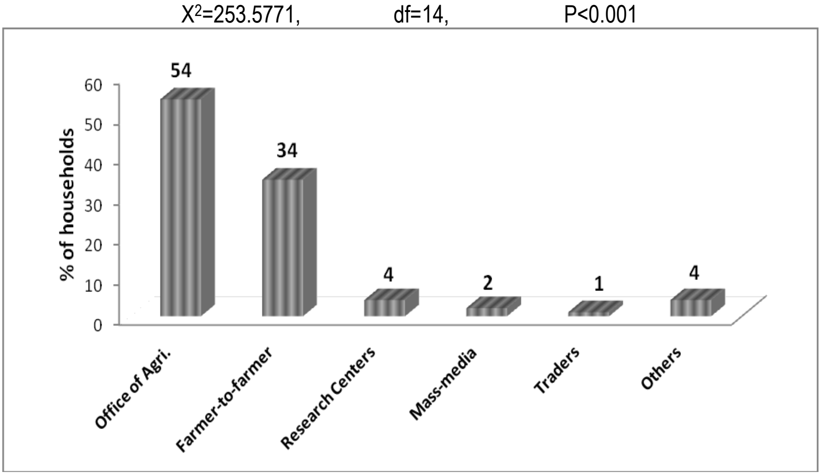


Figure 2. Sources of information about crossbred cows for farming households, 2014

3.3 Adoption of crossbred cows technologies

3.3.1 Contextual framework and definition of adoption

Unfortunately there is no clear definition of technology adoption, in large part due to the tremendous variability in the types of technology and circumstances under which people adopt them. In spite of this, adoption of a new technology basically involves processes of making interrelated decisions. Adoption could be defined as a decision to make full use of a new idea or technology as the best course of action available. Several authors have defined adoption in their own ways even though the contexts of all converge to a closely similar idea. For instance, Feder *et al.* (1985) have defined final adoption at household levels as the degree of use of a new technology in the long run equilibrium when the farmer has full information about the new technology and its potential.

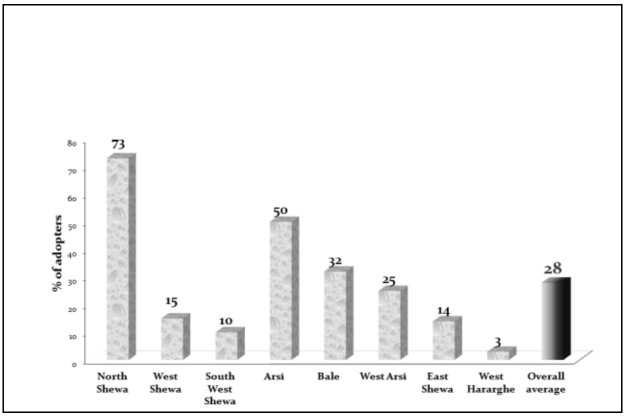
In the context of this study, the adoption concept involves at least three interrelated decisions. The first adoption decision is the choice of whether to adopt the components of the recommended dairy production technological packages, such as crossbred cow, feeds and nutrition, forage and pasture, dairy processing or animal health technology. Households can adopt these technologies in different sequences or combinations, such as crossbred cow only, recommended feeds and nutrition only, improved milk processing only or a combination of these components. The second decision is determining how many crossbred cows to purchase, or the choice of how much land to allocate for the production of improved forages. The third decision could be the intensity of adoption, such as how many crossbred cows to replace in the herd of cows and what size of land to allocate for production of forage crops. The combination of these three decisions composes the technology adoption decision and when this is aggregated to the national scope, it is the diffusion of the technology. In this study, describing the context of adoption by components as described above helps to demonstrate how farmers determine their decisions in choosing either a single or components of technologies to meet their diversified interests and needs.

3.3.2 Adoption rates of crossbred dairy cows

Various studies specifically define adoption in the context of the technologies under consideration. In this study, adopters of crossbred dairy cows can be defined in two conditions. In the first stance, adoption could be defined as the proportion of farmers who owned either milking or pregnant crossbred dairy cows. Among the packages of dairy production technologies, ownership of crossbred cows is considered as the major component technology followed by forage, and feeds and nutrition technologies. Therefore, the first decision made by farmers regarding adoption of dairy technologies is whether or not to own crossbred dairy cows. According to the findings, the overall average adoption rate of crossbred dairy cows in Oromiya region was 28% (Figure 7). A statistically significant difference (X^2=347.3796, df=7, P<0.001) was observed among the study Zones with adoption rates ranging from 3 to 73%. The overall adoption rate in Oromiya Region is perceived to be encouraging as compared to other parts of the country. For instance, the study made in Dejen district of Amhara region has reported very low adoption rate of dairy technologies (Mekonen *et al,* 2010).

North Shewa Zone of the Oromiya Region demonstrated the highest adoption rate (73%) whereas West Hararghe, the least (3%). Given the fact that ranges of dairy technologies have been promoted and introduced through various development programs in the last decades, it is apparently expected that North Shewa Zone could relatively have the highest adoption rate. If North Shewa Zone would have been excluded from consideration, the average adoption rate of other seven Zones could have been 21%. The agro-ecology of North Shewa Zone is also favorable for dairy production, accessibility to highway road, feed availability, and existence of several dairy cooperatives. The Fourth Livestock Dairy Development Project, Stallholder Dairy Development project (SDDP) and various other programs have been implemented in this Zone. Consequent to this, there are several commercial dairy farms and dairy cooperatives along highway from Addis Ababa to Gojam. The commercial farmers in the Zone are believed to have served as sources of crossbred cows or heifers for the smallholder community members around and also to other parts of the country. When making a transect drive on the highway, one could see scores of milk collection centers creating a favorable condition for the farmers to supply their milk easily on regular basis. Additionally, Zones with above average adoption included Arsi and Bale Zones presumably because of their access and proximity to earlier development initiatives of CADU and ARDU. In West Hararghe Zone, the lowest adoption rate of crossbred cows have been noted. This could be largely associated with shortage of farmland and feed resources. In this Zone, farm size per household is 0.5 ha, which is believed to be far less than the average of all the study Zones (2.3 ha). While other Zones have allocated some proportion of their land holding for feed production ranging from 4 – 10%, West Hararghe Zone allocated none. It might be that households give much focus to cash crops, such as *chat*, which is believed to be the main source of their livelihoods along with sorghum.

Farmers have been adopting crossbred dairy cows since decades ago. However, 59% of the adopters owned crossbred cows within the last five years while 14% of them adopted since more than a decade ago (Figure 8). This could largely be attributed to the fact that government extension services made persistent efforts to promote dairy production technologies since the year 2000. Even in the GTP-II period, the livestock sector with particular emphasis on dairy and meat is recognized as a major driver of growth. Given the high gap between supply and demand for milk in the country, there is enormous interest by the government to address the problem and increase per capita milk availability for the population at large. Therefore, more adoption rates of crossbred dairy cows is apparent in the coming decade.



X^2=347.3796, df=7, P<0.001

Figure 3. Adoption rates of crossbred dairy cows in Oromiya Region, 2014.

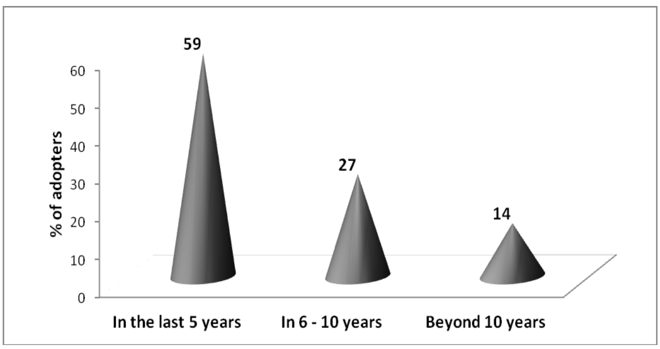


Figure 4. Time Zone since when farmers started adoption of crossbred cows, 2014.

3.3.3 Gender perspectives in the adoption of crossbred cows

The study has also attempted to assess whether there is gender disparity in the adoption of crossbred dairy cows. It was noticed that there was no difference in the adoption rates for male and female-headed male-headed households, the values of both standing at 28% (Table 11). This indicates that female-headed male-headed households, especially, have managed to progress in par with male counterparts in adopting crossbred cow technologies. Within both household types, zonal variability was observed to be statistically significant. For instance, adoption rates of female-headed households ranged from 4 to 62% while it ranged from as low as 2% to as high as 77% in male-headed households. The highest adoption rate was reported in North Shewa Zone while the lowest was recorded in West Hararghe Zone for both household types. Higher adoption rates for females than males were noted in East Shewa, Bale and Southwest Shewa presumably because of strong engagement of the males in crop production and more attachment of females to dairy production in these particular Zones. Proportion of female-headed male-headed adopters particularly in Southwest Shewa and East Shewa Zones were twice that of the male-headed households.

Table 8. Gender perspectives of crossbred dairy cows adoption rates, 2014

Zones	Female-headed household	Male-headed household	Average
North Shewa	62	77	73
West Shewa	10	17	15
Southwest Shewa	20	13	10
Arsi	45	54	50
Bale	45	30	32
West Arsi	9	27	25
East Shewa	26	13	14
West Hararghe	4	2	3
Overall average	28	28	28
Statistical test	X^2=42.1599, df=7, P<0.001	X^2=341.9453, df=7, P<0.001	X^2=403.2277, df=7, P<0.001

3.3.4 Initial sources of crossbred dairy cows

In earlier days, there used to be formal governmental institutions, such as ranches, which have been sources of crossbred heifers for smallholders and commercial farmers in the country. However, these ranch sites have been privatized for some other investment purposes and they are no more serving as sources of crossbred heifers. As a result, there are almost no formal sources of crossbred heifers in the country at the moment except a few private enterprises that just have started heifer rearing, but with enormous capacity limitations to meet the growing demands in the country. Therefore, dairy farmers have to source crossbred cows from elsewhere.

As demonstrated in Figure 9, the findings of this study have shown that market is the common source of crossbred cows for 35% of the adopters followed by farmer-to-farmer trading (20%). Crossbred cows and heifers distributed through arrangements and facilitation of Office of Agriculture is also reported to be essential source for 17% of the adopters. Commercial heifer rearing centers have contributed as source of crossbred heifers to only 8% of the adopters. In spite of other options, the two major sources of either crossbred heifers or cows to smallholder farmers are the market and farmer-to-farmer trading. Farmers depend on these options, because, they do not have a better alternative source. As a result, there is neither information nor knowledge of the exotic blood levels of crossbred cows/heifers when purchased from non-formal sources. Given the fact that open breeding is almost the common practice in the country, it is obvious that exotic blood levels of crossbreds could go in a declining trend over time. In specific locations, however, where the population of crossbred cows is relatively high; such as Selale area in North Shewa Zone, open breeding could have positive contributions in either maintaining or improving exotic blood levels of cows.

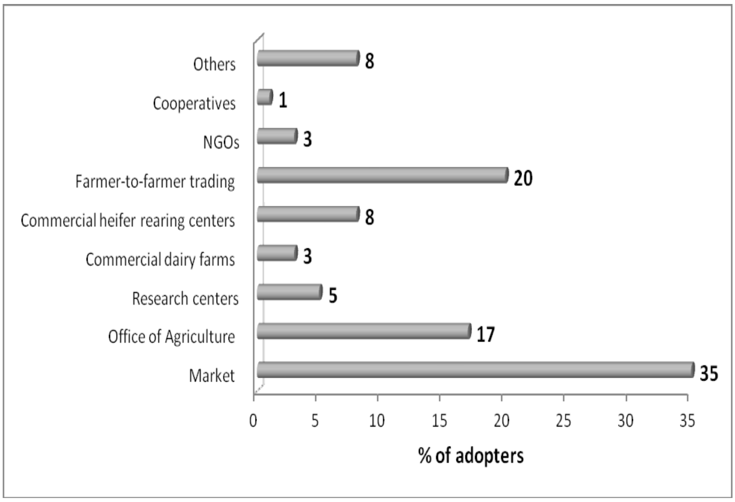


Figure 5. Sources of crossbred cows to the smallholder farmers, 2014.

3.3.5 Intensity of adoption of crossbred cows

In the context of this study, it has been defined that full adopters of crossbred dairy cows are those households who completely replaced their herd of cows with crossbreds. On the other hand, partial adopters are defined to be those households who kept both crossbreds and indigenous cows together in the herd. The findings have attested that out of the 28% of total adopters, 12% of them were full adopters while the other 16% were partial adopters (Figure 10). When viewed across the study Zones, full adopters ranged from as low as 0.8% in West Shewa to as high as 43% in North Shewa Zone (Figure 11). Full adopters might have been becoming business oriented farmers with the purpose of generating incomes from sales of milk and other dairy products. Zones with above average adoption included North Shewa, Arsi and Bale.

The average number of cows owned by the sample households was 2.3 of these 1.8 were crossbred cows. About 85% of the adopters owned crossbred cows in the rage of 1 – 2. As presented in Figure 12, 13% of the partial adopters have replaced 50% of their cow herd with crossbred cows while the other 3% have done this to the extent of 85%. Farmers usually practice stepwise adoption of technologies and replace the existing ones with the improved breeds gradually through time. The range of adoption intensity ranged from as low as 3.5% to as high as 100%.

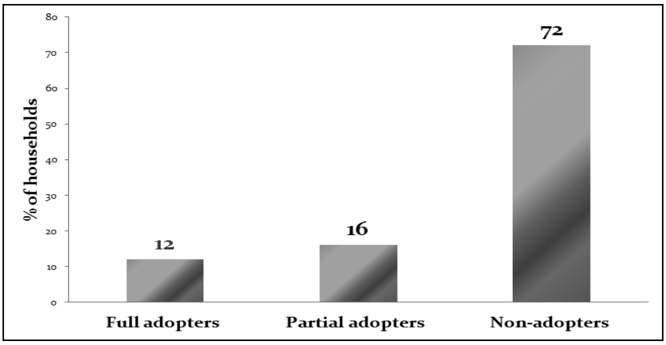


Figure 6. Adoption status of crossbred dairy cows out of the total numbers of cows in the herd, 2014

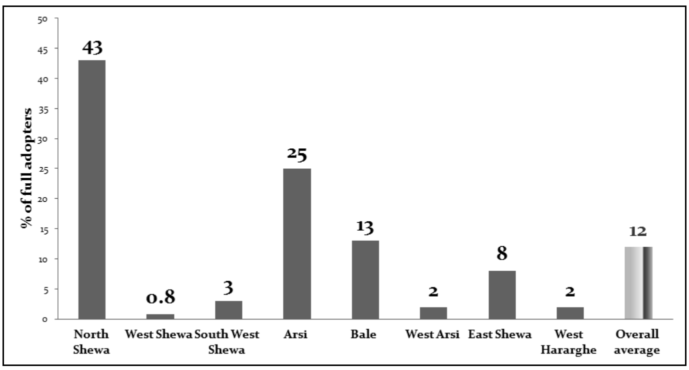


Figure 7. Zonal variability in the extent of crossbred cow adoption, 2014.

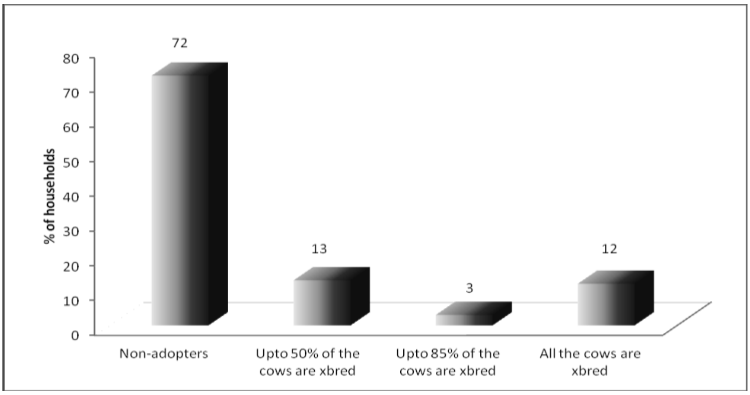


Figure 8. Ranges of intensity of crossbred cows adoption, 2014.

3.3.6 Reasons for farmers not adopt crossbred cows

Even though limited proportions of households have already started using, large proportions of them have not yet started adopting crossbred cows. There are key factors behind this dis-adoption. As indicated in Figure 13, the three major reasons described by farmers included high and unaffordable prices of crossbred cows as reported by 49% of the households, unavailability of sources of crossbred cows (26%) and unawareness of crossbred cows technology (16%). The first two reasons are interrelated in that unaffordable price charge is the effect of supply shortage and the consequent increase in demand. Crossbred cows are usually sold in the range of Birr 20,000.00 – 60,000.00 per cow depending on the age, condition and parity of a cow, which is apparently unaffordable for smallholder farmers. Not only that the price is high in the informal sources, but also that the exotic blood levels of these cows/heifers is not known. Farmers feel that it can also be a risky decision to invest that much high money just on a single cow. The fundamental cause of this phenomenon is acute supply shortage due to unavailability of reliable and capacitated formal heifer rearing and distribution centers in the country. The government has given a due focus for the establishment of seed multipliers of improved crop variety both at Federal and Regional levels, but almost no attention has been given to establish rearing and distribution centers for crossbred heifers.

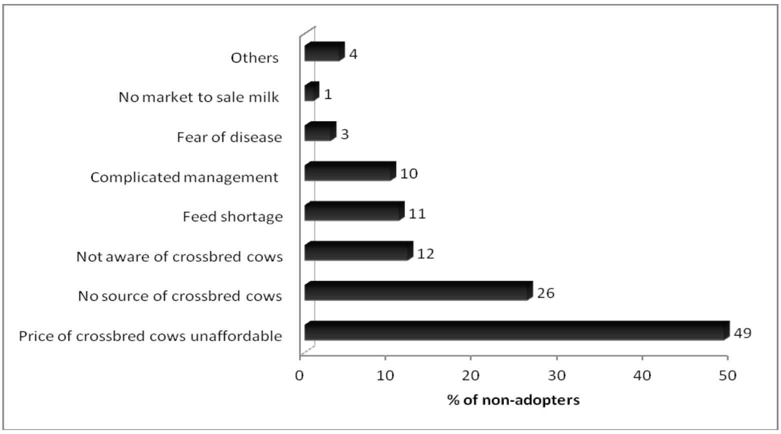
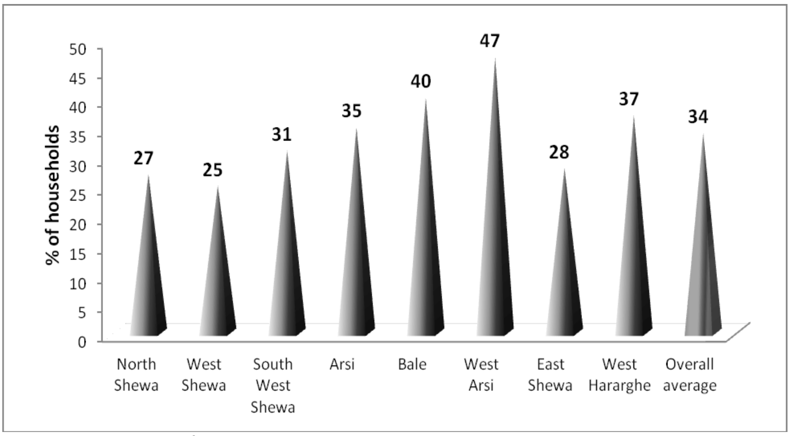


Figure 9. Reasons for not adopting crossbred cows 2014

3.3.7 Farmers` access to trainings on crossbred cows t

One of the mechanisms through which knowledge of new technologies is conveyed to the farmers is tailor made trainings. Farmers could receive trainings through different development organizations, such as Offices of Agriculture, NGOs, Agricultural Research Institutions, farmer-to-farmer action oriented trainings, higher learning institutions and others. It is noted in this study that 34% of the overall sample households have received trainings on the general perspectives of crossbred cows and improved management practices (Figure 14). This means that some of the non-adopters have also received training even though they did not yet adopt crossbred cows.

Across the study Zones, training recipient households ranged from as low as 25% in West Shewa Zone to as high as 47% in West Arsi Zone. Even though the adoption rate of crossbred cows was the highest in North Shewa Zone, only 27% of them have received trainings related to crossbred cows. It means that apart from receiving formal trainings, a large proportion of adopters had access to information mainly through informal mechanisms, such as farmer-to-farmer information exchange and other means. Even out of crossbred cow adopters, only 48% of them were reported to receive formal trainings through Office of Agriculture and other development institutions.



X^2=37.5427, df=7, P<0.001

Figure 10. Access of households to trainings on crossbred cows technologies, 2014

Even though the involvement of women in dairy production and management is considerable, they are men (62%) who took more advantage of participation in trainings as compared to women (11%) in male-headed households (Figure 15). Among the development partners, Office of Agriculture is reported to be the major provider of trainings on crossbred cows as reported by 79% of the households (Figure 16). NGOs also play considerable roles in facilitating trainings for 18% of the overall respondents.

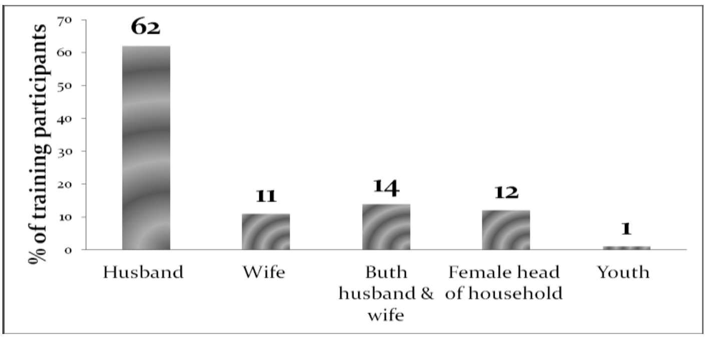


Figure 11. Gender perspectives of participation in trainings, 2014

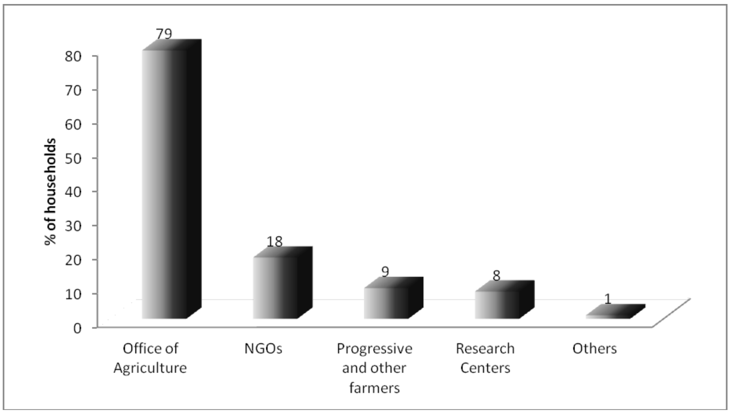


Figure 12. Sources of trainings for the farmers on improved management of crossbred cows, 2014

Basically, trainings focus on improved management practices of crossbred cows as demonstrated in Figure 17. Emphasis was particularly given to trainings on improved feeding (88%) followed by improved health care practices (57%) and housing management (56%). The issue of feed availability and efficient management practices is the key factor that determines whether to adopt crossbred cows or not. This is because; feed scarcity is acute problem not only in the study areas, but also in the country as a whole. It is also believed that knowledge of these practices motivates farmers not only to adopt crossbred cows but also to enhance their productivity and ensure sustainable economic benefits.

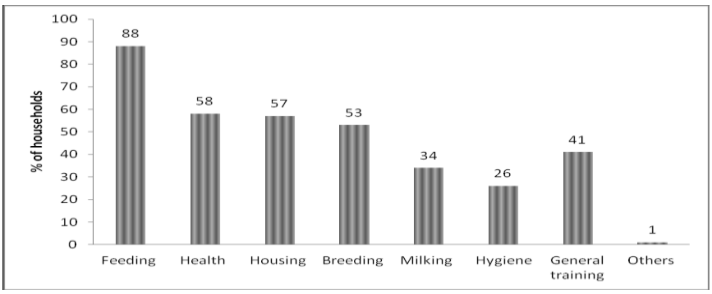


Figure 13. Focused training areas related to promoting crossbred cows technologies to farmers, 2014.

3.3.8 Experience sharing visits on crossbred cows technology

In addition to trainings, experience sharing visit is also another source of information and skill for dairy farmers. Even though there was zonal variability in the exposure of households to experience sharing ranging from 8% - 25%, the overall average was 12% (Figure 18). Such a program is usually organized to places with ample experiences and skills, and lessons and best practices to share. Since it provides opportunities for direct contacts, observation and discussions, it is believed to be one of the effective extension approaches to promote new technologies. Farmers often get motivated and take advantages of the exposure to try the same practice in their own right.

As the case for trainings, they are men (75%) who had exposure to experience sharing visits despite the considerable involvement of women in dairy management (Figure 19). Training and experience sharing organizers assume that once the household head (often the man) is trained, he would share the knowledge and skills to his family members. However, this assumption does not hold true in most of the cases. It has apparently been recognized that it is not a common practice for men to share what they learnt to their family members. Moreover, there is a kind of culture barrier that discourages women to participate in trainings and experience sharing visits. Therefore, trainings and experience sharing visits shall be organized not only for men but also for women at a time. Appropriate timing and favorable conditions shall be arranged in consultation with households when providing opportunities for both the husband and wife to participate in trainings and experience sharing visits.

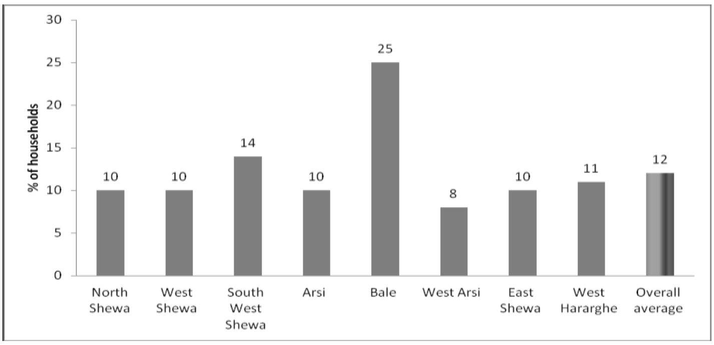


Figure 14. Exposure of households to experience sharing visits, 2014

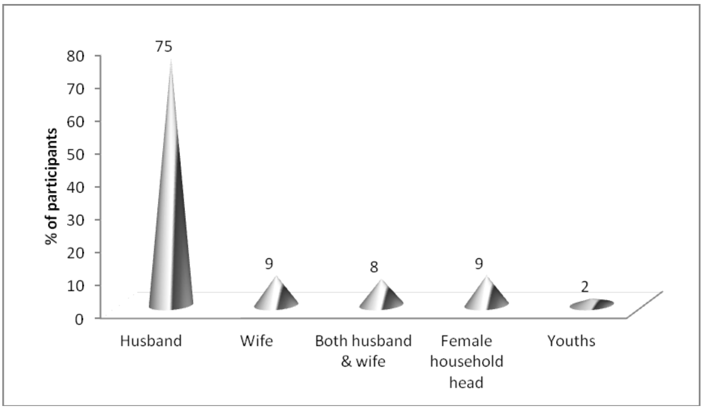


Figure 15. Gender perspectives in experience sharing visits, 2014

3.3.9 Milk productivity of local and crossbred cows

As presented in Table 12, the average milk productivity of crossbred cows was 4.8 liters per day per cow which is about three folds higher than that of the local cow (1.6 liters/day/cow). Even though the productivity of crossbred cows is by far higher than that of local breeds, it is still much lower than their potential average productivity of about 8 liters/day/cow. The reason behind this could be attributed to low management practices given for crossbred cows, such as low feeding, poor housing and even poor health care. In almost all of the study locations, crossbred cows are observed grazing in the field along with the locals which consequently led them to poor body conditions, emaciated and then poor milk yields. In other words, milk productivity would be enhanced by more than 65% if the management practices of crossbred cows are improved further than the current practice.

Table 9. Milk productivity of crossbred and local cows across lactation periods, 2014

Lactation stages	Local cows		Cross-bred cows	
	n	Average milk yield (lit/day)	n	Average milk yield (lit/day)
Early lactation	1242	2.4	419	6.7
Mid lactation	1214	1.5	414	4.9
Late lactation	1058	0.8	398	2.8
Average		1.6		4.8

3.3.10 Empirical analysis of adoption of crossbred cows

The Heckman Two-Stage Model

In view of the nature of dataset and sampling procedures, the Heckman's two-step selection model was employed to take care of sample selection bias for dependent variable. The first step of Heckman procedure captures factors affecting participation decisions in the adoption of crossbred cows while the second step explains factors affecting the level or intensity of adoption. The intensity of adoption was attributed to the number of crossbred cows owned by adopters. The mills ratio or lambda of the model reveals a statistically significant value (P<0.001) implying appropriateness of the choice of Heckman model for the analysis. The analytical findings of the study are presented in subsequent sections.

The Heckman two-step analysis results in Table 13 illustrate the coefficient estimates for the factors affecting participation of households in adoption of crossbred cows along with marginal probabilities. Moreover, the results of the second function present intensity of crossbred cows adoption and the corresponding marginal effects. In both cases, most of the coefficient estimates are statistically significant with the expected sign. The Wald Chi-square test of the Heckman model was highly significant (P<0.001) affirming a strong explanatory power.

It was hypothesized that level of education of the household head positively contributes to adoption of crossbred cows and the findings have also supported this. Both elementary and junior secondary levels of education for the household head have positively and significantly (P<0.001) influenced the likelihood of adoption of crossbred cows. The likelihood of owning crossbred cows would be higher by 12% for a household with primary level of education while it is 16% for the household with junior level of education. Enhancing educational access to households is believed to facilitate adoption of crossbred cows technologies.

In the rural setup, adoption of crossbred cows is highly associated with ownership of farm lands. The study has revealed that farm size has a statistically significant and positive association (P=0.039) with adoption of crossbred cows. The marginal probability indicates that a one hectare increase in farmland would rise the likelihood of adoption of crossbred cows by 2%. This is because, the farmers are supposed to allocate a certain proportion of land for grazing, and production of improved forage crops. Moreover, a farmer can produce crop residues that are essential sources of animal feed in the study areas.

The two fundamental factors that hamper adoption of crossbred cows technology are unavailability of reliable sources for crossbred cows/heifers and the resulting high price which is hardly affordable by smallholder farmers. The model has also depicted the negative and statistically significant influence of both of these factors on the adoption of crossbred cows, which is expected. There are no formal sources of crossbred heifers unlike the case of seeds of improved crop varieties in the country. As the price of crossbred cows gets unaffordable to smallholder farmers, the likelihood of adoption of crossbred cows decreases by 4%. The source is especially more critical in that as the problem of unavailability of crossbred cows persists, the likelihood of adoption decreases by 27%.

Grazing is believed to be the major source of livestock feed in the farming community and it has also illustrated a highly significant ($P<0.001$) and positive association with adoption of crossbred cows. As the farmers strengthen the choice of grazing as the main source of feed, the likelihood of adoption of crossbred cows increases by 23%. Even though crossbred cows are not supposed to depend on grazing as source of feed, farmers are still practicing it and that is one of the reasons why grazing is positively and significantly associated with adoption of crossbred cows. The knowledge of improved feeding practices has also imposed a significant and positive influence on adoption of crossbred cows. As the farmers acquire more knowledge on improved feeding techniques, the likelihood of adoption of crossbred cows increases by 0.2%. The main product in dairy farming is milk mainly for sale. Therefore, the quantity of milk and selling experiences of households are significantly and positively associated with adoption of crossbred cows. As the experience of selling milk increases, the likelihood of further adoption of crossbred cows increases by 3%.

The second equation of Heckman model presents the intensity of adoption for the households who already are adopters of crossbred cows. Several of the factors were observed to influence adoption extent of crossbred cows significantly. Among the factors was the type of household which favored female-headed male-headed households compared to male counterparts. The findings indicate that for female-headed male-headed households, the intensity of owning crossbred cows would be higher by 8% as compared to male-headed households. This is mainly because, crossbred cows are often herded around the household and women are the ones who have close attachments to manage these cows. Moreover, milk selling experience is higher for female-headed male-headed households (they sale 49% of the milk produced) compared to male-headed households who sold about 39% of the milk produced. The average quantity of milk sold was also higher for female-headed male-headed households (1.7 liter per day) than male counterparts (1.5 liters per day). This might be due to limited options of income sources for female-headed male-headed households (FHH). Moreover, FHH are perceived to generate less amount of income from crop sales than MHH.

The level of education which significantly affected the likelihood of adoption of crossbred cows did not have significant influence on the intensity of adoption. This is because, once the household is an adopter, the number of crossbred cows to purchase is not determined by level of education, but by some other factors such as price and financial capacity. The age of the household head was observed to have a negative association with the adoption intensity of crossbred cows. This might be because of labor shortage to manage crossbred cows at the later ages. Even though farming households often depend on family labor, the family size declines at later ages of the household head due to marriage, employment and various other factors. Moreover, the income of the household declines at later ages due to sharing away of part of the properties and assets for adult children to support them start their own life.

Other factors that significantly and positively influenced the intensity of crossbred cow adoption included farm size, exposure to trainings, knowledge of improved feeding practices, quantity of milk produced and milking selling experiences of the household. The variables which affected intensity of crossbred cow adoption negatively included high cost of crossbred cows, unavailability of reliable sources of crossbred heifers/cows, high feed cost and proximity of the dairy farm to big cities, such as Addis Ababa. The reason why proximity to the city of Addis Ababa influenced adoption intensity (the number of crossbred cows owned) might largely be due to displacement of households due to expansion of urbanization. When urbanization exerts a pressure on the households around, the first action is disposing their assets, such as crossbred animals, due to lack of grazing and pasture lands and herding space for the animals. In earlier discussions, the practice of grazing was reported to have influenced adoption of crossbred cows significantly and positively. Other authors in different African countries (Kenya, Cameroon and Tanzania) have identified gender, educational level, access to capital, farm inputs and access to market as determinants to adoption of dairy technologies (Baltenweck *et al*., 2006; Nchinda and Mendi 2008).

Table 10. Parameter estimates of the Heckman Two-step model, 2014

Variable	Coefficient	SE	P>|Z|	Marginal effect	
Stage one: Participation in the adoption of x-bred cows				**dy/dx**	**x**
Elementary level of education	0.1362***	0.0476	0.004	0.1198	0.4302
Junior and secondary level of education	0.1401***	0.0496	0.005	0.1625	0.3086
Household type	0.0567	0.0529	0.284	0.1545	0.8477
Age of household head (years)	0.0023	0.0017	0.170	0.0077	41.6321
Family size	0.0019	0.0049	0.701	0.0023	6.8868
Farm size (ha)	0.0192**	0.0093	0.039	0.0187	2.0500
High price of crossbred cows	-0.1177**	0.0527	0.026	0.0442	0.3319
Unavailability of crossbred cow sources	-0.3446**	0.1739	0.048	0.2731	0.1913
Participation in trainings	0.0479	0.0350	0.171	-0.0028	0.3657
Main source of feed is grazing	0.2535***	0.0609	0.000	0.2316	0.8805
High feed cost	0.0131	0.0348	0.706	0.0804	0.7230
Knowledge of improved feeding practices	0.0629**	0.0330	0.057	0.0020	0.4608
Quantity of milk produced (liters)	0.0202***	0.0062	0.001	-0.0221	2.1572
Access to credit services	0.0491	0.0576	0.394	-0.0243	0.0655
Access to extension services	0.0019	0.0347	0.956	0.0405	0.4556
Membership in milk cooperatives	-0.0014	0.0473	0.976	-0.0683	0.0803
Household income (Birr)	-0.6770	0.3470	0.845	0.2250	2.5713
Experiences of selling milk	0.1079***	0.0408	0.008	-0.0272	0.1987
Distance of the village to milk market (km)	0.0496	0.0492	0.314	0.0169	0.0961
Access of the study Zones to Addis Ababa city	-0.0217	0.0662	0.743	0.1208	0.2938
Stage two: Number of crossbred cows owned				**dy/dx**	**SE**
Elementary level of education	0.0720	0.1651	0.663	0.0109	0.0254
Junior and secondary level of education	-0.0982	0.1718	0.568	-0.0144	0.0244
Household type	-0.4378***	0.1672	0.009	-0.0810**	0.0376
Age of household head (years)	-0.0237***	0.0046	0.000	- 0.0035***	0.0008
Family size	-0.0020	0.0200	0.919	-0.0003	0.0030
Farm size (ha)	0.1667***	0.0340	0.000	0.0251***	0.0066
High cost of crossbred cows	-0.7046***	0.1681	0.000	- 0.0917***	0.0231
Unavailability of crossbred cow sources	-2.5785***	0.5370	0.000	- 0.1833***	0.0201
Participation in trainings	0.2238*	0.1337	0.094	0.0352	0.0221
Main source of feed is grazing	0.0961	0.1915	0.616	0.0137	0.0260
High feed cost	-0.2982**	0.1328	0.025	-0.0493**	0.0249
Knowledge of improved feeding practices	0.2683**	0.1254	0.032	0.0411**	0.0200
Quantity of milk produced (liters)	0.1861***	0.0170	0.000	0.0280***	0.0044
Access to credit services	0.3285	0.2341	0.160	0.0599	0.0511
Access to extension services	-0.1695	0.1346	0.208	-0.0253	0.0200
Membership in milk cooperatives	0.2984	0.2335	0.201	0.0532	0.0487
Household income (Birr)	-1.2900	1.5600	0.411	-194.0	0.0000
Experiences of selling milk	0.6073***	0.1493	0.000	0.1170***	0.0387
Distance of the village to milk market (km)	0.1447	0.2168	0.504	0.0236	0.0385
Access of the study Zones to Addis Ababa city	-0.6193***	0.2106	0.003	- 0.0791***	0.0252
Mills Lambda	0.2703	0.0658	0.000		

rho	1.0000
sigma	0.2703
Number of observations	946
Censored observations	728
Uncensored observations	218
Wald chi2 (20)	1390.61
Prob > chi2	0.000

Tobit model estimates

There is an assumption that factors that affect adoption of technologies have similar association to the dependent variables both with Heckman second-step selection model and Tobit model. To investigate this and substantiate model based analysis factors, the Tobit model was used to estimate the intensity of adoption of crossbred cows' technologies. Moreover, Tobit model was used to estimate the other perspective of adoption intensity, which is the extent to which the number of crossbred cows will be affected as a result of adopting the technology. Table 14 presents the Tobit model coefficient estimates and marginal probabilities. Most of the coefficient estimates are significant with the expected signs as that of the Heckman two-step procedure. The likelihood function of the Tobit model was also highly significant ($P<0.001$) revealing a strong explanatory power.

Most of the variables significant in Heckman second step equation are also significant in the Tobit model with similar coefficients. For instance, farm size, participation in trainings, knowledge of improved feeding practices, quantity of milk sold and milk selling experiences have illustrated a significant and positive effects on intensity of crossbred cows adoption in both Tobit and Heckman models. Moreover, unavailability of reliable sources of crossbred cows and the consequent high price have negatively affected the intensity of crossbred cows adoption as indicated in both Tobit and Heckman models. However, only few variables significant in Heckman model were insignificant in Tobit, such as household type and age of the household head. In general, most of the factors in both Heckman and Tobit models have demonstrated similar influences on the intensity of crossbred cows' adoption.

Based on the Tobit model, a one hectare increase in farmland will increase the proportion of households owning a crossbred cow by 2.6% and the number of crossbred cows to be owned by 2.3%. As the problem of unavailability of crossbred cow sources persist, 19% of the households will not go for herd replacement and the numbers of crossbred cows in the herd will eventually decline by 16%. Consequent to participation of the farmers on trainings related to improved management practices, the proportion of farmers getting into the business of dairy farming will increase by 4% and the numbers of crossbred cows in the herd will also increase by 4%, keeping other factors constant. As the problem of high feed cost continues to prevail, the proportion of dairy farmers is likely to decline by 2.5% and that of the numbers of dairy cows will continue decreasing by 2.3%, ceteris paribus. It was also interesting to note the proportion of farmers engaged in dairy farming within 100 km radius of Addis Ababa city will decline by about 11% annually as compared to those far-off farmers located beyond this bound and the proportion of crossbred cows will also continue declining by about 9%.

Table 11. Parameter estimates of the Tobit model for the intensity of crossbred cows' adoption, 2014.

Variable	Coefficient	Robust SE	Adoption Index		Expected ownership	
			Marginal effects (% of dairy farmers)	SE	Marginal effects (% of crossbred cows)	SE
Elementary level of education	0.4706**	0.2090	0.0625**	0.0287	0.0562**	0.0272
Junior and secondary level of education	0.4358*	0.2330	0.0602*	0.0344	0.0549*	0.0330
Household type	-0.2307	0.2089	-0.0317	0.0303	-0.0288	0.0283
Age of household head (years)	-0.0093	0.0067	-0.0012	0.0008	-0.0010	0.0008
Family size	0.0027	0.0248	0.0003	0.0032	0.0003	0.0028
Farm size (ha)	0.2021***	0.0354	0.0261***	0.0053	0.0230***	0.0055
High cost of crossbred cows	-0.7731***	0.2274	-0.0903***	0.0257	-0.0778***	0.0239
Unavailability of crossbred cow sources	-2.7501***	0.7499	-0.1934***	0.0188	-0.1619***	0.0184
Participation in trainings	0.3272**	0.1681	0.0438*	0.0238	0.0394*	0.0226
Main source of feed is grazing	0.6213**	0.2975	0.0659**	0.0268	0.0546**	0.0221
High feed cost	-0.1935	0.1715	-0.0258	0.0239	-0.0232	0.0218
Knowledge of improved feeding practices	0.4049***	0.1481	0.0530**	0.0206	0.0473**	0.0193
Quantity of milk produced (liters)	0.2132***	0.0255	0.0275***	0.0055	0.0243***	0.0056
Access to credit services	0.4780**	0.2393	0.0723*	0.0414	0.0689*	0.0426
Access to extension services	-0.1278	0.1686	-0.0164	0.0218	-0.0145	0.0193
Membership in milk cooperatives	0.3828	0.2609	0.0560	0.0430	0.0524	0.0428
Household income (Birr)	-8420000	157000	-109000	0.0000	-961000	0.0000
Experiences of selling milk	0.8899***	0.1928	0.1405***	0.0355	0.1389***	0.0403
Distance of the village to milk market (km)	0.3648	0.2465	0.0528	0.0399	0.0492	0.0395
Access of the study Zones to Addis Ababa city	-0.9844***	0.2668	-0.1085***	0.0264	-0.0924***	0.0248
Constant	-2.2801***	0.5147				
Number of observations	949					
F(20, 926)	18.58					
Prob > F	0.0000					

3.4 Adoption status of improved forage technologies

3.4.1 Feed resources

Farmers depend on various sources of animal feed, most of which are obtained in their locality and from their own farms. As shown in Figure 20, 95% of the farmers depend on crop residues as source of animal feed. The types of residues fed to animals often depend on the types of crops grown in different parts of the country. For instance, straws of tef, wheat and barley are common in the agro-ecology ranging from mid altitudes to highlands while stalks of maize and sorghum are common feed types in the lowlands. Wherever it is, residues of crops are often stored for use in the later season especially when feed scarcity is encountered. Grazing (89%) and green feeds (76%) are also major sources of feeds for animals in the study Zones. Green feed supply is usually practiced as cut and carry systems especially during rainy season. Concentrate was also reported to be a common source of animal feed by 63% of the households. These concentrates mostly include noug seed and linseed cake, and by-products of grains and local beverages.

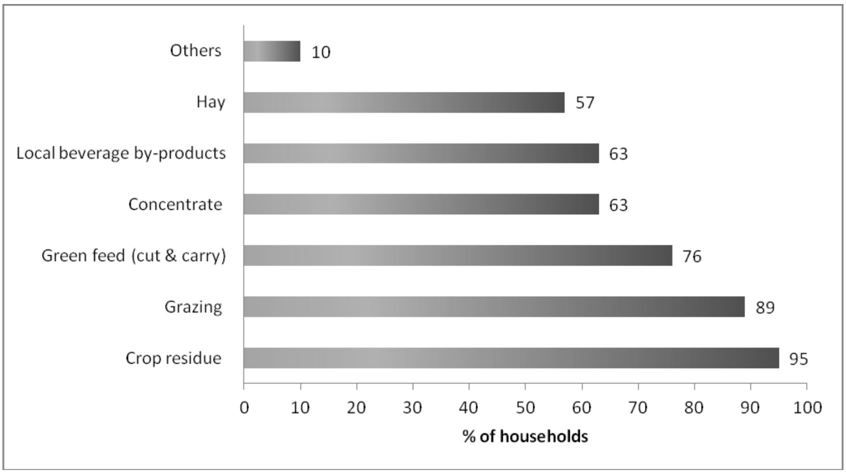


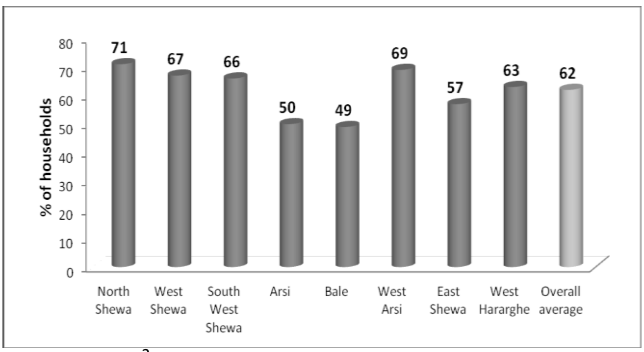
Figure 16. Major feed resources used for feeding dairy cattle, 2014.

3.4.2 Awareness of improved forage technologies

Awareness precedes adoption of improved feed technologies and these technologies could have been generated and disseminated to the farmers through various routes of extension. Based on findings of this study, 62% of the overall households in the study areas were aware of feed technologies (Figure 21). Statistically significant Zonal variability was also observed (X^2=41.5992, df=7, P<0.001) ranging from as low as 49% in Bale Zone to as high as 71% in North Shewa Zone. Such an awareness usually facilitates adoption and utilization of the technologies in the succeeding years.

The study has also shown that 72% of the overall sample households became aware of improved feeds and forage technologies almost recently, since the late 1990s (Table 15). The other 20% of the households were exposed to knowledge of feed technologies since the early 1990s. There is also statistically significant difference between the study Zones (X^2=104.2891, df=14, P<0.001) in the time horizon since when households became aware of feed technologies. The proportion of households who became aware in the last five years ranged from 51% in North Shewa Zone to 93% in West Arsi Zone. It has become apparent that some Zones, such as Wes Arsi (93%), Bale and West Hararghe (each 83%) were exposed to knowledge of improved feed technologies since the late 1990s. On the other hand, some other Zones got prior information beyond 10 years ago and these included North Shewa (28%), West Shewa (27%) and Arsi (26%) Zones. Earlier exposure in some Zones might have been a combined effect of tailor made projects specifically designed and implemented on dairy and presence of research centers who positively influenced zonal offices of Agriculture through farmer-extension advisory council and trainings offered to the farmers.

The study has also identified that different organizations have put their efforts in creating awareness of feed technologies to the community. The most noticeable recognition goes to Office of Agriculture as attested by 64% of the households (Figure 22). Next, farmer-to-farmer information exchange has been the most important approach (19%) through which technological information is conveyed easily to beneficiaries.



X^2=41.5992, df=7, P<0.001

Figure 17. Awareness status of improved feeds and forage technologies in the study areas, 2014

Table 12. Time since when farmers became aware of improved feed technologies, 2014

Zones	Within the last 5 years	In 6 – 10 years	Beyond 10 years	Total
North Shewa	51	28	20	100
West Shewa	67	27	6	100
Southwest Shewa	67	22	10	100
Arsi	66	26	7	100
Bale	83	10	7	100
West Arsi	93	3	4	100
East Shewa	64	24	11	100
West Hararghe	83	15	1	100
Overall average	72	20	8	100
X^2 Test	X^2=104.2891 df=14, P<0.001			

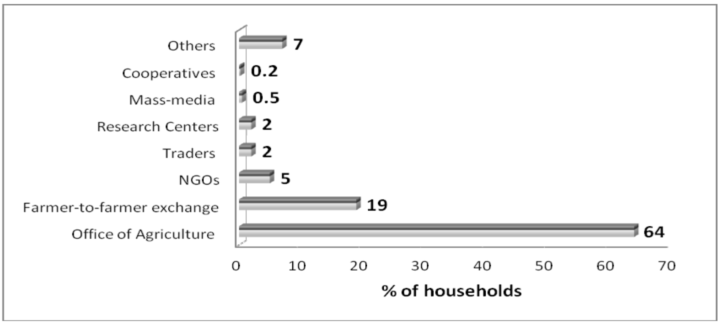
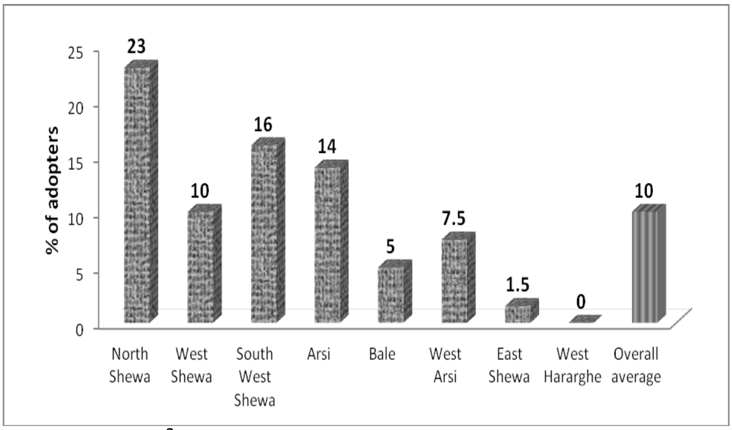


Figure 18. Sources of information about improved forage technologies, 2014

3.4.3 Adoption rates and intensity of forge technologies

Next to crossbred cows, improved feeding and forage is recognized to be the second most important component of dairy technology packages. Improved forages of various types have been released for utilization since decades ago. The findings, therefore, present how these technologies have been adopted and utilized by dairy farmers in the study areas.

In this study, adopters of forage technologies are defined to be farmers who have allocated a plot of land to grow forage crops. Accordingly, the overall adoption rate of forage crops in Oromiya region has been found to be 10% (Figure 23). There is statistically significant difference among the study Zones (X^2=98.6106, df=7, P<0.001) in the rate of adoption of forage technologies ranging from none in West Hararghe Zone to about 23% in North Shewa Zone. In West Hararghe Zone, farm sizes of households is the least of all the study Zones and this might be the reason why they did not give focus to allocate a plot of land for forage production. This might also be one of the reasons why the adoption rate of crossbred cows is the least in West Hararghe Zone. North Shewa Zone, on the other hand, is high adopter of forage technologies (23%) followed by Southwest Shewa (16%) and Arsi (14%) Zones. North Shewa is also highest adopter of crossbred cows and this might have contributed to give a focus for adoption of forage technologies.



X^2=98.6106, df=7, P<0.001

Figure 19. Adoption rates of improved forage crops, 2014.

Extent of adoption of improved forage technology depicts that only 8% of the farmland (0.31 ha on average) was allocated for production of forage crops (Table 16). The actual area allocated for feed could be more than this if we take into consideration of the area allocated for grazing and hay making. There is also statistically significant difference (F=3.09, df=6, P=0.0072) among the study Zones ranging from none in West Hararghe to 10% in Arsi Zone. Among the study Zones, the farmers of North Shewa (0.44 ha) and Arsi (0.36 ha) allocated large area of land for forage production than others. Conventionally, farmers tend to allocate more area of farmlands for the production of food crops than forage crops. This is partly because of limited land holding or farm size and attitudinal perception of the farmers that animals can get feed freely from elsewhere and that it is a waste of land to allocate for forage crops. Limited awareness on the importance of forage crops is also another factor that hindered wider use of forage technologies.

Table 13. Adoption intensity of improved forage crops in Oromiya Region, 2014

Zones	Total area (ha) of land cultivated (sample mean)		Total area (ha) of land cultivated (forage growers mean)			
	n	Total sample average (ha)	n	Growers' average (ha)	Area allocated for forage (ha)	% of area allocated for forage production
North Shewa	224	3.3	51	5.1	0.44	8.6
West Shewa	235	2.7	23	3.6	0.25	6.9
Southwest Shewa	197	2.6	32	3.1	0.15	4.8
Arsi	172	2.8	24	3.5	0.36	10.3
West Arsi	199	2.4	15	3.5	0.23	6.6
East Shewa	198	2.5	3	2.8	0.16	5.7
West Hararghe	205	0.5	0	0	0	0
Overall average	1630	2.3	159	3.8	0.31	8
	F=40.63, df=7, P<0.001		F=3.93 df=6 P=0.0011		F=4.96 df=6 P<0.001	F=3.09 df=6 P=0.0072

3.4.4 Varietal level adoption rates of improved forage crops

Until 2014, a total of 24 improved varieties of forage crops have been officially released for different agro-ecological Zones of Ethiopia (Fekede *et al*., 2015). Various stakeholders were engaged in the promotion of these forage crops, such as Office of Agriculture, Agricultural Research Institutions, Higher Learning Institutes, special purpose projects (such as 4th Livestock Project, ILRI (the then ILCA) projects, Smallholder Dairy Development Projects and others). According to the findings, the different varieties of forage crops have varying levels of adoption rates. As presented in Table 17, the two major forage crops that have relatively been expanded and grown in the study areas included oat-vetch (35%) and elephant grass (15%). On the other hand, pigeon pea (0.2%), cow pea and Leucanea (1% each) were the least adopted forage crops. The major reasons behind the less adoption rates of forage crops is associated with shortage of farmlands and the consequent interest of the farmers to give priority for food than forage crops.

Table 14. Varietal level adoption rates of improved forage crops in the study Zones, 2014

Improved feed packages	% of aware households N=1630	No. of years since awareness	Adoption rates (%) N = 1630
Oat-vetch	53	9.5	35
Elephant grass	43	4.7	15
Tree Lucerne	19	8.3	7
Sesbania	14	5.1	6
Alfalfa	11	4.6	2
Fodder beet	9	6.0	2
Rhodes grass	7	8.7	1.3
Leucanea	5	6.4	1
Cow	4	4.4	1
Pigeon pea	2	5.6	0.2

3.4.5 Quantity of concentrates fed to crossbred cows

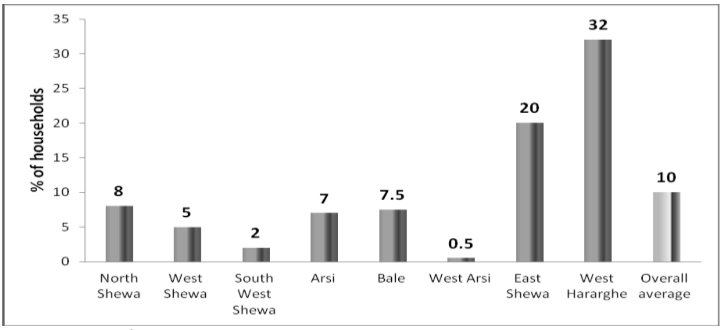
Even though quantity of feed required for cows depends on their body size and physiological stages, almost all of the farmers are not aware of this. Instead, they supply mainly based on feed availability, the more the supply the more quantity offered to feed even though this practice eventually leads to loss of feed and consequent shortage in later seasons. They feed large quantities when the feed is available in ample amounts while less at times of scarcity. They are also not aware of the recommended quantity of feeds that need to be fed to crossbred cows. The findings provided in Table 18 have indicated that crossbred cows were fed an average of 2.0 kg/day/cow of various concentrate types. This basically varies based on the reproductive stage of cows. For instance, milking cows were fed an average of 2.4 kg/day/cow concentrates while pregnant cows were fed 1.7 kg/day/cow and dry cows 1.6 kg/day/cow. In this study, pregnant cows refer to those cows in the later months of their pregnancy (after seven months) while dry cows refer to those which are not pregnant. Dry and green feeds are supplied to cows adlib depending on availability.

Farmers often depend on traditional practices in feeding crossbred cows. Even weighing of concentrate feed is uncommon practice as reported by 90% of the households. On the other hand, only 10% of the overall respondents reported to practice weight based supply of feed to their crossbred cows ranging from 0.5% in West Arsi to 32% in West Hararghe Zone (Figure 24). Farmers often use local units of roughly estimated quantity (such as 1.0 kg or 5.0 kg basis) for measuring the weight of feed.

Research recommends that a milking cow should be fed an average of 0.5 kg of concentrate per liter of milk production. In view of the average milk productivity, this means that they have to feed 2.4 kg of concentrates per day. However, milk productivity of crossbred cows has already been constrained by limited feed supply. For instance, the required quantity of feed to secure an average milk yield of 8.0 liters per day was 4.0 kg of concentrate. The implication is that farmers have lost more than 65% of milk productivity by not feeding an additional 1.6 kg of concentrate feed per day per cow over that of 2.4 kg which is already being fed. It was recognized that farmers are not as such aware of the recommended concentrate rates required to exploit the maximum possible milk yields of crossbred cows. Coupled with this is also inadequate availability of concentrate feeds and the consequent high price that has restricted farmer level milk productivity to be below 5.0 liters/day/cow.

Table 15. Average quantities of concentrate feed ingredients fed to crossbred cows per day in Oromiya region, 2014

	Milking cows		Pregnant cows		Dry cows	
	N	Average (kg/day)	N	Average (kg/day)	N	Average (kg/day)
Oil seed cake	207	2.8	103	1.8	40	1.8
Wheat bran	259	2.7	129	1.9	36	1.6
Wheat middling	74	2.4	33	1.7	9	1.8
Molasses	9	0.8	5	1.1	2	3.0
Multi-nutrient block (MNB)	16	2.1	12	2.5	5	1.3
Grain	106	1.6	56	1.3	19	1.4
Ye ehil bitari	114	1.9	77	1.3	24	1.3
Ye awdima gird	71	2.0	30	1.4	13	1.7
Overall average concentrate intake per day		2.4		1.7		1.6
Overall average concentrate intake per day per cow	2.0 kg/day/cross-bred cow					

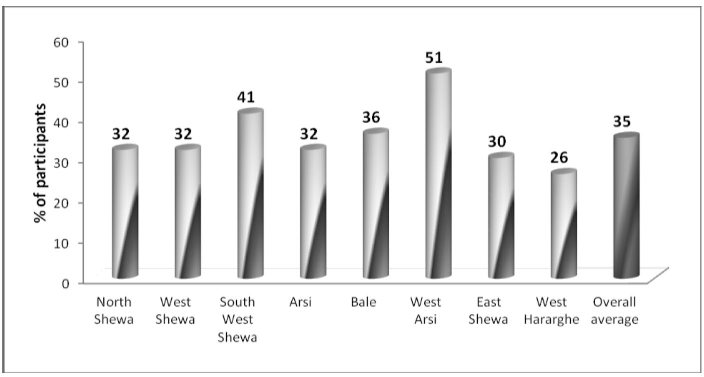


X^2=169.5990 df=7, P<0.001

Figure 20. Households practicing weighing of concentrate feeds when supplying to crossbred cows, 2014

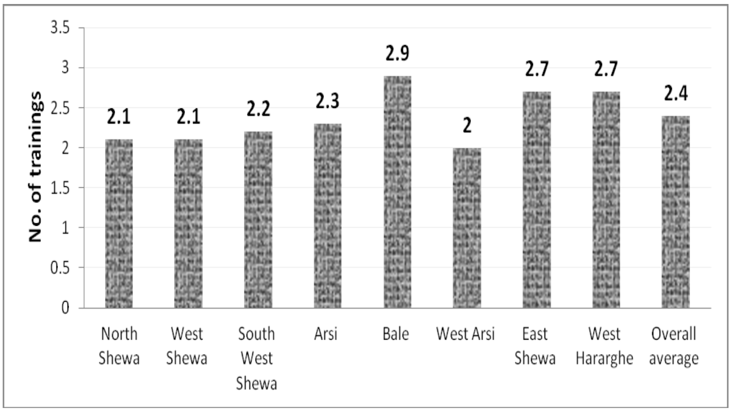
3.4.6 Trainings on improved feed technologies

Irrespective of adoption status of forage and feed technologies, awareness raising trainings were given for the farmers by different types of development actors. Based on the findings of this study, 35% of the households have reported to receive trainings on feed technologies (Figure 25). Statistically significant difference (X^2=36.8343, df=7, P<0.001) was also noticed among the study Zones ranging from as low as 26% in West Hararghe to as high as 51% in West Arsi Zone. The average frequency of trainings was also reported to be 2.4, ranging from 2 in West Arsi to 2.6 in Bale Zones (Figure 26). However, men (13%) are still major beneficiaries in receiving trainings as compared to women (8%) in spite of the extent of their contributions in dairy cows management (Figure 27). It is believed that women are the ones who are largely responsible for feeding and management of dairy cows even though they are not adequately recognized in capacity building initiatives.



X^2=36.8343 df=7, P<0.001

Figure 21. Proportion of farmers who have attended trainings on improved feed technologies, 2014



X^2=36.8343 df=7, P<0.001

Figure 22. Frequency of participation in trainings related to improved feed technologies, 2014

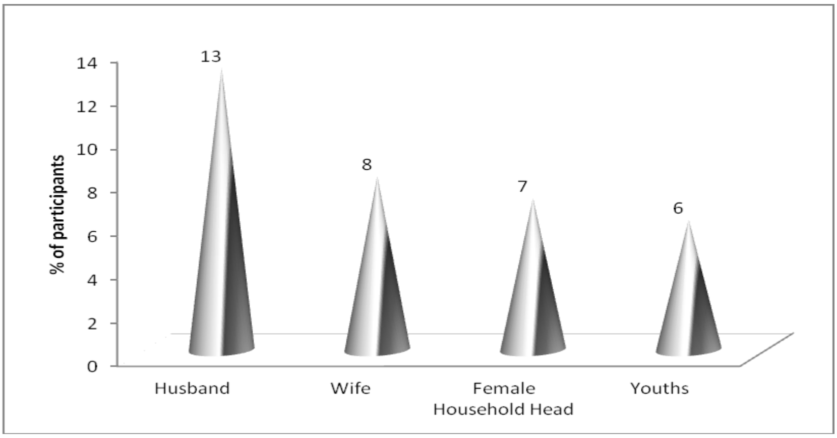


Figure 23. Participants of trainings on improved feed technologies, 2014.

3.4.7 Empirical analysis of forage technology adoption

Determinants of forage technology adoption

The probit model was used to estimate the factors that influence adoption of forage technologies while the Tobit model was again used to investigate intensity of forage technology adoption. In probit model estimation, the Wald X^2 test indicates a statistically highly significant estimate (P<0.01) signifying the fitness and explanatory power of the model (Table 19).

Among the factors considered in the model, the size of farmland, the use of grazing as the major feed source, quantity of milk produced, experience in adoption of improved crop technologies and trainings received on improved forage technologies have positively and significantly affected adoption of improved forage crops along with expected signs. As the size of farmland increases by one hectare, the likelihood of adopting improved forage technologies increases by 1.6%. Increments in the quantity of milk produced will also increase the likelihood of adoption of improved forage crops by 0.2%. Access of a household to credit services was observed to have a negative association with adoption of improved forage crops. As a household gets access to credit services; the likelihood of adoption of improved forage crops declines by 5.6%. This might be because of dependence of households on purchased feed resources rather than planting and managing of forage crops. With increased access to money, they would like to deepen on purchased feeds, such as green and dry feed, or concentrates.

Earlier experiences of a household in the adoption of improved crop varieties have positively contributed to adoption of improved forage crops. The likelihood of adoption of improved forage technologies increases by 6% for households who have earlier experiences of growing improved crop varieties compared to those with no such experiences. This is because; households have already developed exposure to technologies and also realized the importance. Therefore, they would intend to give a try for new technologies such as improved forage crops. It was also noted that the likelihood of adopting forage technologies declines by 6% for households with no exposure to extension services as compared to those who have exposure. On the other hand, participation in trainings on improved feeding practices has positively contributed to the adoption of forage technologies. The likelihood of adoption of forage technologies increases by 4% in households with exposure to trainings on improved feeding practices as compared to those who did not have such an opportunity.

Table 16. Parameter estimates of the probit model for factors affecting adoption of improved forage technologies, 2014.

Variable	Coefficient	Robust SE	P>|Z|	Marginal effect	
				dy/dx	SE
Adoption of crossbred dairy cows	0.1729	0.1216	0.155	0.258	0.157
Number of crossbred dairy cows	-0.0077	0.0216	0.738	-0.001	0.003
Elementary and Junior level of education	0.0795	0.1112	0.475	0.011	0.016
Household type	0.1973	0.1455	0.175	0.029	0.021
Total farm size (ha)	0.1100***	0.0187	0.000	0.016	0.002
Main source of feed is grazing	0.4478**	0.2030	0.027	0.066	0.030
Quantity of milk produced (liters)	0.0194**	0.0083	0.019	0.002	0.001
Access to credit services	-0.3772*	0.2087	0.071	-0.056	0.031
Membership in milk cooperatives	0.1350	0.1612	0.402	0.020	0.024
Access of the study Zones to Addis Ababa city	0.2181**	0.0979	0.026	0.032	0.014
Adoption of improved crop technologies	0.4163**	0.1681	0.013	0.062	0.025
Availability of feed problem	0.0630	0.1433	0.660	0.009	0.021
No forage extension services	-0.4250***	0.1225	0.001	-0.063	0.018
Training on improved feeding practices	0.2704***	0.0941	0.004	0.040	0.014
Constant	-2.9298***	0.3173	0.000		
Number of observations	1619				
Wald chi2(14)	146.96				
Prob > chi2	0.000				

Intensity of Forage Technology Adoption

The Tobit model was also used to estimate the intensity of forage technologies adoption. As presented in Table 20, the model was found to be statistically significant ($P<0.001$) indicating strong explanatory power. Most of the factors considered were statistically significant with expected signs. It is apparently expected that the size of farmland positively influences the adoption intensity of improved forage technologies. For a one hectare increment in farmland, the proportion of improved forage growers will increase by about 2% and the size of land allocated to forage crops will also increase by 0.5%. Access to credit services has, however, a negative association not only with adoption rate, but also with intensity of adoption. A household may not allocate farm land for to grow improved forage crops when credit service is available. With access to credit, improved forage growers will decline by 3.5% and the area allocated to improved forages will decrease by 1%. Similarly, household income is negatively associated with adoption intensity of forage crops. This might again be because of the preference of households to depend on purchased feed types, such as concentrates, dry feed and green feed.

As expected, unavailability of opportunities to participate in the extension services influenced adoption intensity of forage technologies negatively, as expected. On the other hand, participation in trainings enhances improved forage growers by 2.6% and the area allocated to forage production by 0.8%, ceteris paribus.

Table 17. Parameter estimates of the Tobit model to estimate adoption intensity of improved forage technologies, 2014

Variable	Coefficient	Robust SE	Adoption Index		Expected ownership	
			Marginal effects	SE	Marginal effects	SE
Adoption of crossbred dairy cows	0.0624	0.0658	0.0147	0.0163	0.0043	0.0048
Number of crossbred dairy cows	-0.0134	0.0137	-0.0030	0.0031	-0.0008	0.0009
Up to Junior level of education	0.0336	0.0609	0.0075	0.0133	0.0021	0.0038
Household type	0.0971	0.0823	0.0202	0.0154	0.0057	0.0043
Family size	0.0214**	0.0094	0.0048**	0.0021	0.0014**	0.0006
Farm size (ha)	0.0792***	0.0128	0.0180***	0.0030	0.0052***	0.0009
Main source of feed is grazing	0.2888	0.1141	0.0487	0.0130	0.0133	0.0036
Knowledge on feed technologies	0.1044**	0.0500	0.0241**	0.0118	0.0070**	0.0034
Quantity of milk produced (liters)	0.0169***	0.0044	0.0038***	0.0010	0.0011***	0.0003
Access to credit services	-0.1960*	0.1187	-0.0356**	0.0165	-0.0098**	0.0044
Membership in milk cooperatives	0.0695	0.0880	0.0170	0.0232	0.0051	0.0071
Access to Addis Ababa city	0.0985*	0.0531	0.0223*	0.0120	0.0065**	0.0034
Experiences in adoption of food crop technologies	0.2164**	0.0969	0.0409***	0.0144	0.0114***	0.0039
Household income	-1.5500**	6.9500	3.5200***	0.0000	-1.0300**	0.0000
No exposure to forage extension services	-0.1954***	0.0699	-0.0393***	0.0119	-0.0111***	0.0034
Training on improved feeding practices	0.1091**	0.0515	0.0259**	0.0125	0.0077**	0.0038
Constant	-1.8001***	0.2259				
Number of observations	1619					
F(16, 1603)	7.52					
Prob > F	0.000					

3.5 Adoption feeds and nutrition technologies

3.5.1 Awareness and adoption of improved feed technologies

In addition to improved forages, various research efforts have also been made to recommend appropriate feeds and nutrition technologies for smallholder farmers. In this study, adopters of feeds and nutrition technologies are defined to be those farmers who used urea treated straw and multi-nutrient block (MNB). As demonstrated in Figure 28, research recommends 0.5 kg of concentrate feed per each liter of milk for crossbred cows. By coincidence, farmers' rate is also closer to this level, 0.4 kg per liter of milk, which is only 25% less than the recommended rate. This is because, farmers are not as such aware of recommended rate of concentrate and the quantity supplied was largely determined by the availability of supply. The farmers only feed 2 kg of concentrate per day to produce 4.8 liters of milk. However, they should have fed about 4 kg/day to secure 8 liters of milk, at least.

According to the findings, 19% of the farmers are aware of urea treated straw while its adoption rate is only 5% (Table 21). This means that only 5% of the overall sample households in all the study Zones were able to utilize their crop residues efficiently through urea treatments. Since crop residue is a product that is available in almost every household, the practice of treating it with urea should have been largely adopted by the farmers. Limited promotion and demonstration of the practice might have hindered further adoption of urea treated straw.

On the other hand, only 10% of the overall sample households were aware of what MNB is all about, out of which only 2% were adopters. It has apparently become evident that MNB is yet an unknown technology to about 90% of the farmers and not yet utilized by 98% of the dairy farmers even though it is the most essential feed ingredient. Limited promotion and demonstration could still be one of the responsible factors for the low adoption rate of MNB. Researchers suggest that missing the essential feed ingredient means compromising productivity. On the other hand, other concentrate types are commonly supplied to crossbred cows including wheat bran (59%), oil seed cake (55%) and grain (46%) even though these are not as such considered as new technologies. However, farmers do not adequately know the recommended quantities of these feed ingredients supplied to cows of different physiological status, milking, pregnant or dry.

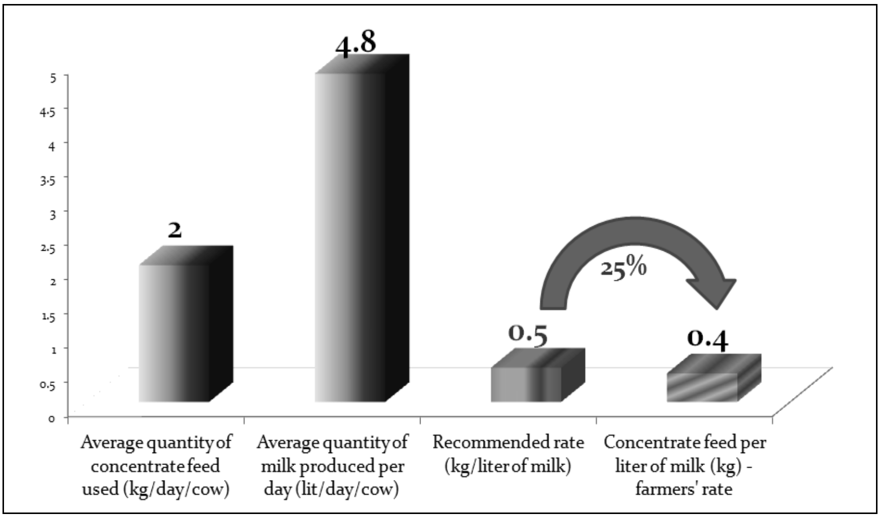


Figure 24. Recommended rate of concentrate feed Vs farmers' rate, 2014.

Table 18. Awareness and adoption status of concentrate feeds in Oromiya region, 2014

Feed	% of aware households N=1629	No. of years since awareness	Adopters (%) N = 1629
Urea treated straw	19	4.1	5
MNB	10	4.4	2
Oil seed cake	82	7.9	55
Wheat bran	85	7.2	59
Grain	66	9.6	46
Wheat midlings	42	7.1	25

3.5.2 Trainings on improved feed and nutrition technologies

Development partners usually strive to create awareness of technologies through various extension approaches, and one of these is trainings. An average of 35% of the farmers, whether adopters or non-adopters, have received trainings on improved feed management (Figure 29). Across the study Zones, the proportion of farmers who had access to trainings ranged from 26% in West Hararghe to 51% in West Arsi Zone. The training is usually given to all the farmers in the community with the purpose of creating awareness and motivating them to adopt and use new feeds and nutrition technologies.

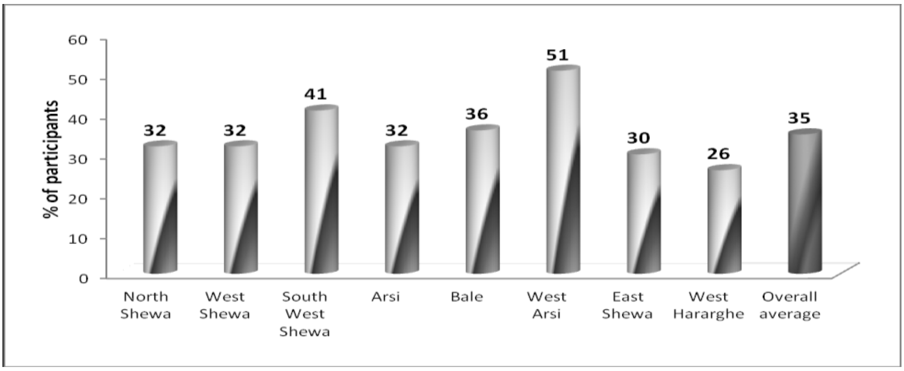


Figure 25. Proportion of farmers who received trainings on improved feeds and nutrition, 2014.

3.5.3 Factors influencing the use of forages, feeds and nutrition technologies

In spite of efforts made to create awareness and promote utilization of the various types of forages, feeds and nutrition technologies, the adoption rates were very low. Various factors are believed to be responsible for the low adoption and utilization. As provided in Figure 30, high cost of feeds was reported to is the major factor (75%) followed by lack of adequate knowledge on improved feeding techniques (55%). Shortage of land to plant forage crops (38%) was also the third most important factor that hindered adoption of improved forage technologies. It was also evident that the lack of adequate knowledge and skills on how to prepare MNB (28%) and urea treated straw (28%) has limited adoption of feeds and nutrition technologies. To enhance adoption and utilization of forage, feeds and nutrition technologies, these problems need to be addressed through building the capacities and creating further awareness.

3.5.4 Indoor feeding of crossbred cows

Along with promotion of dairy management practices, dairy farmers are advised to practice indoor feeding of crossbred cows. This practice is believed to minimize energy loss and enhance milk production efficiency of crossbred cows. However, it was recognized that only 14% of the crossbred cow adopters were able to adopt full indoor feeding while 69% practiced partial indoor feeding (Figure 31). In almost all parts of the study areas, it is common to see crossbred cows grazing in the field along with local cows. Consequent to this, the crossbred cows were observed to have lost body conditions and most of them looked emaciated. This practice can be one of the reasons for declining productivity of crossbred cows at smallholder levels. This is partly because they would not get adequate feed from grazing, not only in quantity but also in quality.

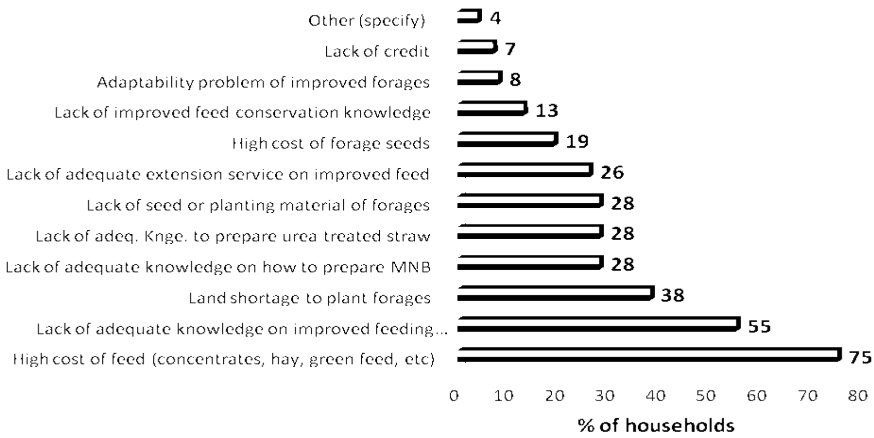


Figure 26. Factors that hindered adoption and use of forage, feeds and nutrition technologies, 2014

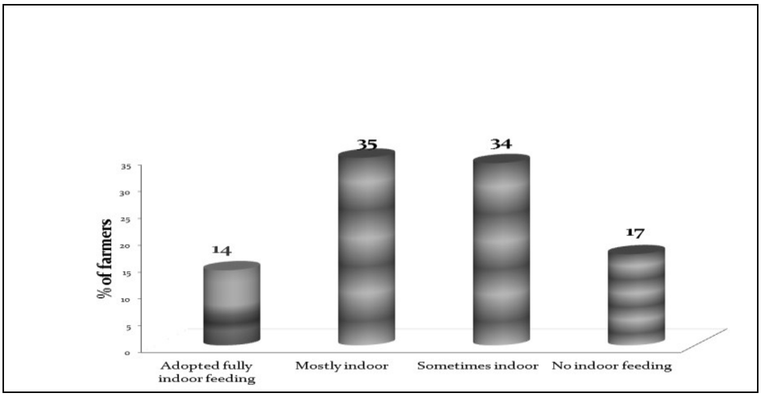


Figure 27. Indoor feeding practices of crossbred cows, 2014.

3.6 Awareness and adoption of animal health services

3.6.1 Extent of animal health problems and farmers' health management practices

The two key problems of dairy production are shortage of feed and animal health. Table 22 provides that animal health is still a problem to 86% of the farmers even though 78% of them said that the diseases occur less often. This might be because of the fact that almost all of the farmers (98%) used vaccination services to their animals. Access of dairy farmers to vaccination services is higher in the study areas than the national average of 52% (CSA, 2014). On the other hand, feed is reported to be a problem to 88% of the farmers, of which 37% said feed problem is a serious concern in livestock production. This justifies that feed and animal health problems require research interventions to be strengthened further and promote available technologies for wider exposure and adoption.

Animal health service is provided by Veterinary Department of Office of Agriculture (80%) which is often located at woreda levels (Figure 32). Farmers are expected to bring the sick animal to health service station for possible diagnosis and treatment. Private veterinarians accounted for only 5% of the service providers. This indicates that adequate efforts have not been yet made in terms of creating alternative service delivery by encouraging the establishment of private veterinarians not only at woreda, but also at kebele levels.

Table 19. Problem status of feeds and animal health in the study areas of Oromiya Region, 2014

Problem status	Feed		Animal health	
	n	%	n	%
It is a serious problem and it still occurs more often	595	37	136	8
It is still a problem, but occurs less often	832	51	1,270	78
It is not a serious problem as such	187	12	214	13
Overall sample	1,614	100	1,620	100

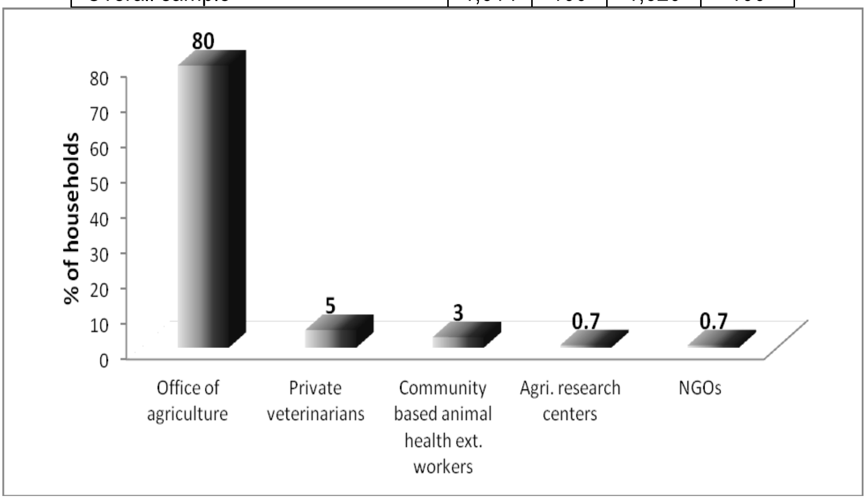


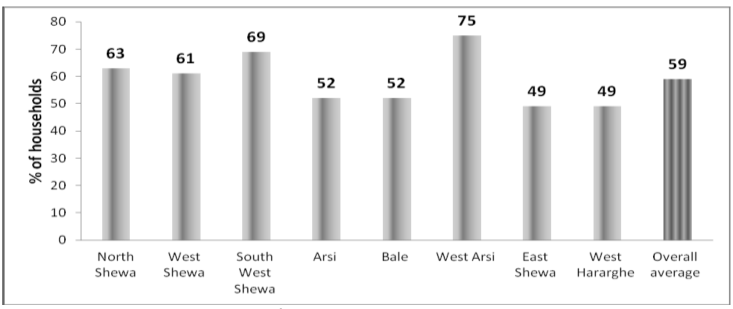
Figure 28. Animal health service providers, 2014

3.6.2 Awareness and adoption of animal health technologies

Along with the trainings on general practices of animal production, the issue of animal health technologies could certainly be one of the focal areas. It has been reported that 59% of the farmers were aware of improved animal health management practices (Figure 33). Variability among the study Zones is statistically significant (X^2=56.4678, df=7, P<0.001) ranging from 49% in East Shewa and West Hararghe Zones to 75% in West Arsi Zone.

According to 86% of the households, the source of information on improved animal health management practices was Office of Agriculture (Figure 34). Farmer-to-farmer information exchange mechanism was also another essential source (8%). As direct source of information about improved health management, the contribution of research centers appears to be 2.3%. However, the major source of information on improved livestock technologies could be the national agricultural research systems and international research organizations, in general.

Whenever disease incidence occurs, farmers in the first instance make efforts to cure the animal by their own through ethno-vet medicines followed by taking the sick animal to traditional healers. When these attempts fail, then the last option is taking the sick animal including crossbred cows to veterinary clinic as evidenced by 94% of the households (Figure 35). In this study, the practice of ethno-vet mechanism of treating the sick animals is believed to be among the health care practices that have so far been promoted. Therefore, adoption rate of this practice is 26% in the study areas of Oromiya Region. Apart from this, trainings have been provided to farmers on improved animal health management practices.



X^2=56.4678 df=7, P<0.001

Figure 29. Awareness of farmers on improved health management practices, 2014.

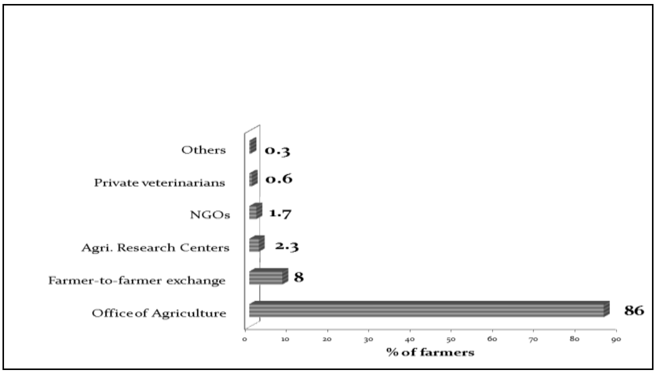


Figure 30. Sources of information for the farmers on improved animal health practices, 2014

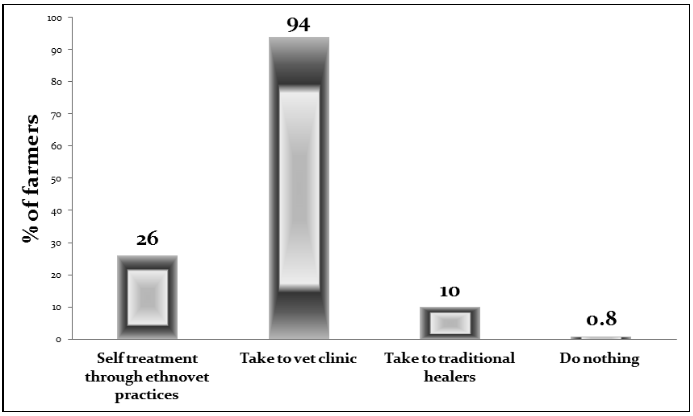


Figure 31. Animal health management practices and adoption rates, 2014.

3.6.3 Problems influencing animal health management practices

Even though it has become a common practice to take the sick animal to veterinary clinic, farmers have reported several problems related to animal health management practices. Lack of adequate knowledge about diseases and control mechanisms was reported to be the major problem for 33% of the farmers (Figure 36). Along with this, far distant location of veterinary clinic from their villages has been the major problem for 32% of the farmers. About 24% of the farmers are not also satisfied with the services they obtain from veterinary clinic.

3.7 Animal breeding practices

Animal breeding practice is also among the major packages in dairy production technologies. This is because, exotic blood levels of crossbred cows is expected to be maintained at certain threshold level. For instance, if the exotic blood level of a crossbred cow is set at 50% for smallholder management conditions, it could decline from this level if breeding is left to happen uncontrolled. Therefore, farmers have been supported through trainings and various other mechanisms on how to maintain exotic blood levels of crossbred cows. The two common options are bull service and the use of Artificial Insemination (AI).

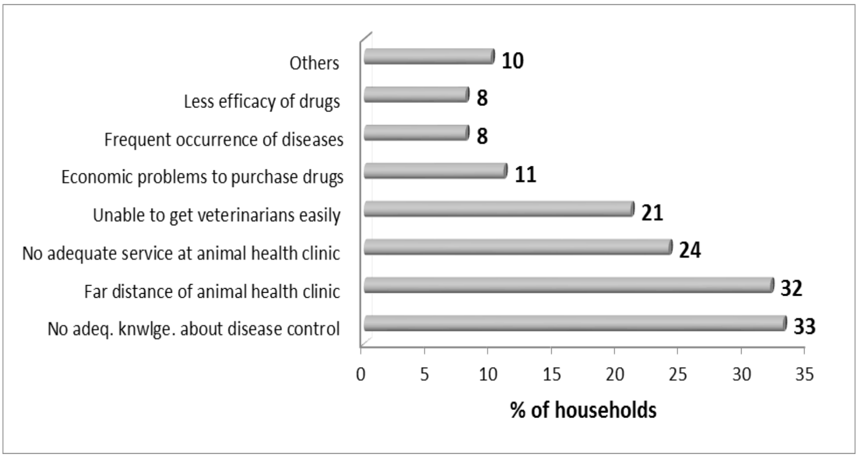
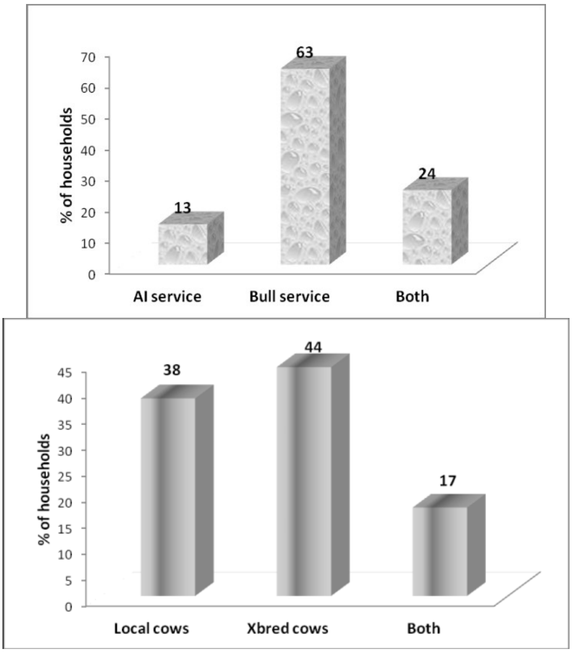


Figure 32. Farmers' problems related to animal health management, 2014.

According to the findings, the largest proportion of farmers (63%) still depend on bull service (Figure 37), of which only 10% used crossbred bulls while others depend on local bulls. Despite limited, there are also cases where farmers use local bulls for crossbred cows. Even AI beneficiary farmers were reported to be only 13%. This proportion seems to be higher than the African AI coverage of less than 2%, but closely similar to the average AI coverage of Asian countries which stands at 12% (Chencha and Kefyalew, 2012). Even though there is no reliable information on the AI coverage of Ethiopia, it has been estimated to be less than 1% even if all the exotic and crossbred cows are inseminated. AI service is being given not only to crossbred cows (44%) but also to locals (38%). However, farmers are not as such contented with AI service (Figure 38) and their complaints on the one hand is that it is not effective while on the other AI is not easily available (26%). This finding is in conformity with various studies which reported in-effectiveness of AI service in Ethiopia on account of managerial, infrastructural and financial constraints as well as poor heat detection, improper timing of insemination and embryonic death (Desalegn *et al*., 2008.). The same source has also concluded that AI service in Ethiopia is not a success and proposed for urgent corrective measures to be taken. Consequent to this, farmers tend to depend on traditional breeding practices, which is open breeding. This is believed to be the major factor that makes exotic blood levels of crossbred cows decline every time and it is not even possible to recognize how far it has deteriorated.



(a) (b)

Figure 33. Breeding practices at farm levels (a) and cow breeds which receive AI services (b), 2014.

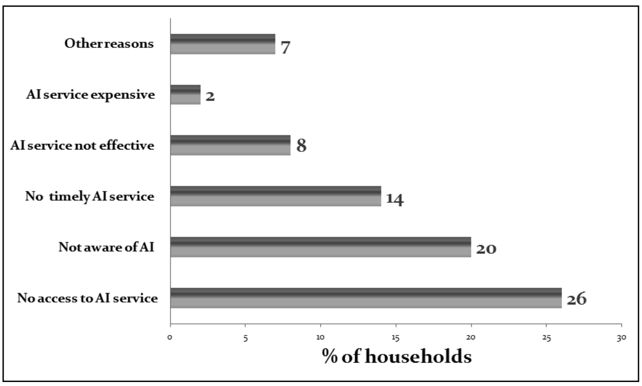


Figure 34. Factors that restrict the use of AI services, 2014

3.8 Awareness and adoption of dairy processing

3.8.1 Overview of milk processing practices and value addition

Rural households utilize milk in various ways. Some part of the whole milk is either consumed at home or sold at the market while the other part would be processed into different products. The study showed that 19% of the overall sample households had experiences of processing milk (Figure 39). Only 2% of the households had experiences of processing milk in West Hararghe Zone while it is higher in Arsi (43%) and North Shewa Zones (37%). As presented in Figure 40, products processed from milk are often butter (19%) and cheese (16%). Quite considerable proportion of farmers (49%) feel that they lack knowledge and skills on improved practices of milk processing and value addition (Figure 41). The other complaint is that traditional milk processing practices are time and labor consuming (32%).

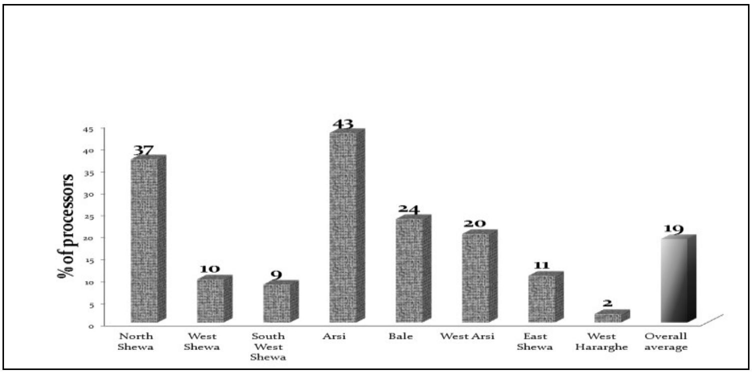


Figure 35. Milk processing and value addition experiences of the farmers in the study Zones, 2014.

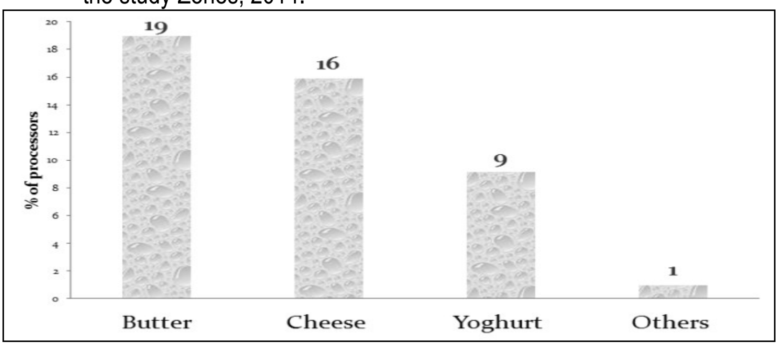


Figure 36. Products processed from milk in the study areas, 2014.

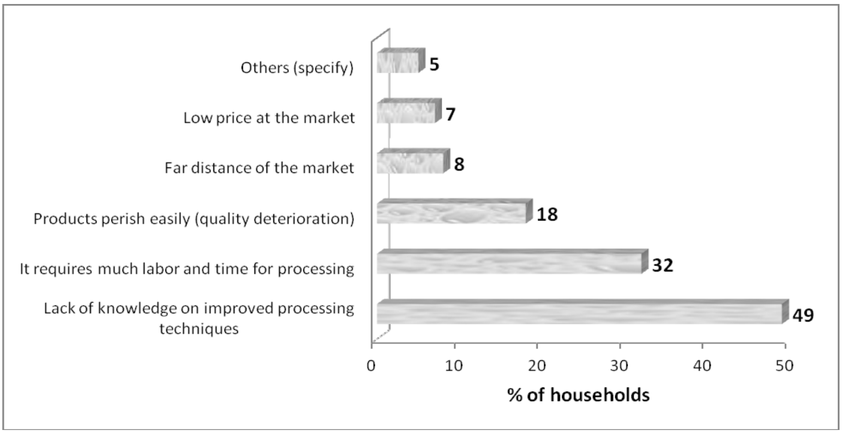
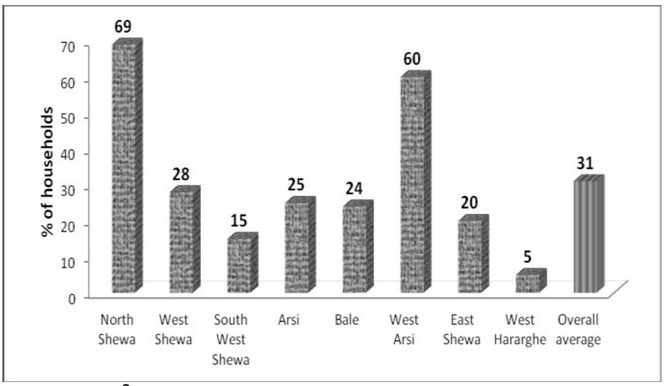


Figure 37. Problems related to milk churner technology, 2014.

3.8.2 Awareness of dairy processing technologies

Dairy production cannot bring expected impacts unless it is accompanied with processing technologies. Research has been pursuing in generating and promoting dairy processing technologies not only through national research but also through international research institutions. Governmental development partners, such as Office of Agriculture, have also been engaged in technology promotion and dissemination since decades ago. As a result of these efforts, 31% of the overall sample households were aware of improved dairy processing technologies (Figure 42). Zonal variability was statistically significant (X^2 = 331.8806, df = 7, P < 0.001) ranging from 5% in West Hararghe Zone to 69% in North Shewa Zone.

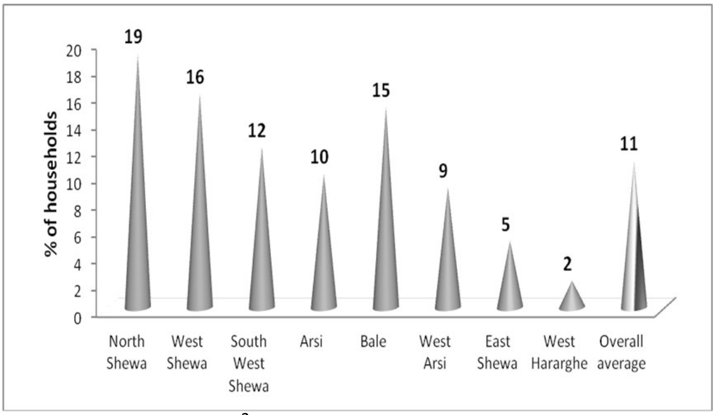


X^2 = 331.8806 df = 7 P < 0.001

Figure 38. Farmers' awareness status of dairy processing technologies, 2014

3.8.3 Trainings for the farmers on milk churner technology

Milk churner is one of the dairy processing technologies promoted to farmers in different parts of Ethiopia. Along with the introduction and dissemination programs, trainings were also given for the beneficiaries to create awareness and motivate adoption. The findings depicted that 11% of the overall sample households have received trainings on milk churner technology (Figure 43). Statistically significant difference was also observed among the study Zones (X^2 = 46.8259, df = 7, P < 0.001). Only 2% of the households in West Hararghe received trainings on milk churner technology while it is relatively higher in North Shewa Zone (19%). In general, it could be recognized that a large proportion of households did not receive trainings on milk churner technology.

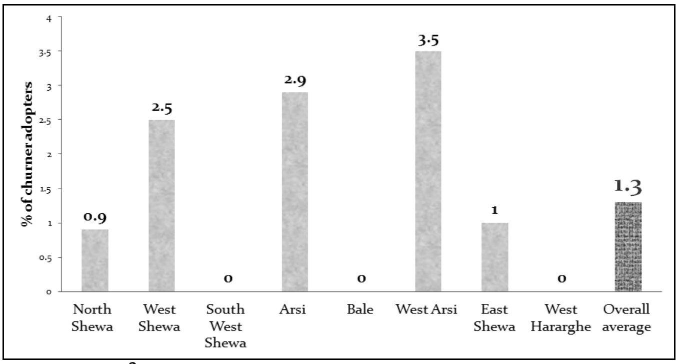


X^2 = 46.8259 df = 7 P < 0.001

Figure 39. Households who received trainings on milk churner technology, 2014.

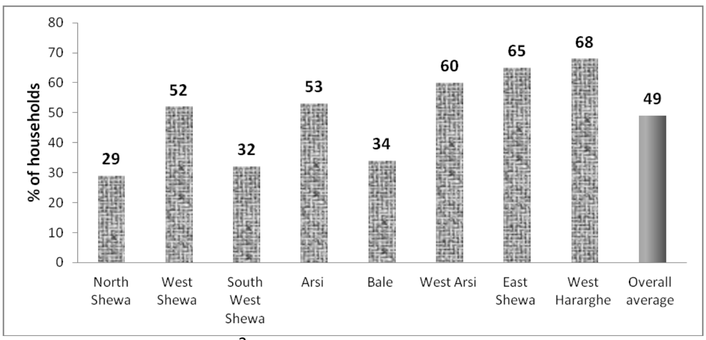
3.8.4 Adoption rate of milk churner technology

Rural households practice traditional milk processing mechanisms which are often inefficient, time consuming and cumbersome. Since milk processing is almost the sole responsibility of women, they usually face stress in processing and spend lots of time that could have been spent in caring for children, elderly and other productive activities. In response to this hurdle, research has generated and disseminated milk churner technologies which are believed to be time and energy saving, efficient and easy to operate. Efforts were also made to promote and disseminate it through demonstrations, trainings and other extension approaches. In this study, an adopter of milk churner technology is defined to be a household who owns and uses the milk churning machine. Accordingly, the study has indicated that the overall adoption rate of milk churner technology in the study Zones was only 1.3% (Figure 44). This means that only less than 2% of the households are using milk churner machine. Zonal variability was quite divergent with statistically significant difference (X^2 = 331.8806, df = 7, P < 0.001) in that adoption rate is nil in Southwest Shewa, Bale and West Hararghe Zones while it is 3.5% in West Arsi and 2.9% in Arsi Zone. It was astonishing to realize that in North Shewa Zone where adoption of crossbred cows is highest, milk churner technology adoption is meager (only 0.9%). This might be because of easy access to markets and focus on selling the whole milk. The major reasons for either nil or less adoption of milk churner technology was attributed to lack of knowledge and skills as reported by 49% of the households (Figure 45). There was also statistically significant (X^2 = 89.1035, df=7, P<0.001) variability among the Zones with respect to farmers knowledge and skill on milk churner technology. Lack of knowledge and skills was highly noticeable in West Hararghe (68%) and East Shewa Zones (65%) as compared to North Shewa (29%) and Southwest Shewa Zones (32%).



X^2 = 331.8806 df = 7 P < 0.001

Figure 40. Adoption rate of milk churner technology in the study Zones, 2014



X^2 = 89.1035 df = 7 P < 0.001

Figure 41. Proportion of households who have reported lack of knowledge on improved milk processing techniques, 2014

3.9. Record keeping

Record keeping is highly essential to enhance smallholder dairy commercialization. Farmers need to keep records of their dairy cow particulars, such as parity, milk yields over lactation periods, breeding history, exotic blood levels, milk prices and costs, feed quantities and prices, and various other details. This helps to make informed decisions not only for managing efficient farm but also for research, extension, development and policy interventions required to improve the dairy sector. Unfortunately, record keeping practice is not common or almost non-existent in rural areas. The study has shown that only 7% of the overall sample households had record keeping experiences ranging from as low as 3% in Bale Zone to as high as 10% each in Southwest Shewa and West Arsi Zones (Table 23). The practice was much less in female-headed male-headed households where only 3% of women claimed to have started record keeping of details about crossbred cows (Table 24). It was also reported that record keeping practice is a recent experience (not more than the last five years). In such circumstances, it is hardly possible to improve the dairy sector through breeding and other practices. Even those who started record keeping has indicated that they started the practice very recently as a result of trainings and advises gave to farmers through extension agents and other development partners. As presented in Figure 46, farmers mainly record dairy production details, such as quantity and costs of feeds purchased (13%) and incomes obtained from sales of milk and other products (10%). The practice of recording exotic or local blood levels of crows was only 3%. This might indicate that there is no well structured record keeping experience even in households who already have started.

Table 20. Record keeping experiences of households in the study areas, 2014

Zone	Keep records		Do not keep records		Overall sample	
	N	%	n	%	n	%
North Shewa	16	7	208	93	224	100
West Shewa	11	5	224	95	235	100
Southwest Shewa	20	10	177	90	197	100
Arsi	11	6	161	94	172	100
Bale	6	3	194	97	200	100
West Arsi	20	10	179	90	199	100
East Shewa	13	6	185	94	198	100
West Hararghe	14	7	191	93	205	100
Overall average	111	7	1519	93	1630	100

$X^2 = 13.11815$ df = 7 P =0.069

Table 21. Record keeping experience by household type, 2014

Household Type	Keep records		Do not keep records		Overall sample	
	N	%	n	%	n	%
Female-headedmale-headed	6	3.2	183	96.8	189	100
Male-headed	102	7.4	1268	92.6	1370	100
Overall average	108	7	1451	93	1559	100

$X^2 = 4.6981$ df = 1 P =0.030

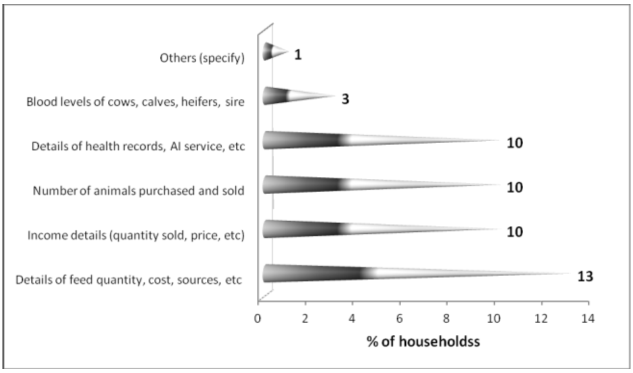


Figure 42. Types of information farmers keep in records, 2014.

3.10. Milk marketing and hygiene

In rural areas, milk selling is not as such a common practice as that of grain. This is largely because of inadequate milk production and also limited milk markets at accessible locations. This study has revealed that 29% of the households have experiences of selling whole milk (Table 25).This might also mean that all the adopters of crossbred cows sale milk. On the other hand, 64% of the overall households did not yet start selling milk. There is also divergent variability among the Zones in experiences of selling milk. It is apparently evident that North Shewa Zone has a well-established experience of selling milk. The study has confirmed that 75% of the households in north Shewa sale milk, which is the highest proportion followed by 44% in West Arsi Zone. Farmers in North Shewa Zone usually depend on milk sales as source of on-farm incomes and most of them are also accessible to several milk collection centers across the road-sides, on the highway from Addis Ababa to Gojam. On the other hand, the farmers of Southwest Shewa Zone did not have experiences of selling milk except the 2% of them. The proportion is still the least for West Shewa Zone where only 7% of the farmer’s sale milk.

Farmers have scores of reasons for not yet engaging in milk selling. One of the major reasons 59% of dairy farmers is that households did not produce adequate amount of milk for sale (Figure 47). The already limited quantity produced is often used for home consumption. About 20% of the households preferred to process milk and sale butter and cheese rather than selling whole milk. Unavailability of milk markets in close proximity might have been the reason why some farmers took the option of milk processing.

Milk hygiene and handling is also the most crucial issue to maintain and supply quality product for the market. Office of Agriculture, national and international research institutions, and other development actors have been offering trainings to the farmers, both men and women, on improved mechanisms of milk hygiene and sanitation. However, men are still the ones who took the lead in taking trainings (16%) as compared to 12% for women while this operation is largely the responsibility of women (Table 26).

Table 22. Milk selling practices of rural households in the study areas, 2014

Zone	Sold milk more often	Sold milk sometimes	Never sold milk	Total
North Shewa	75	4	21	100
West Shewa	7	2	91	100
Southwest Shewa	2	2	96	100
Arsi	28	16	55	100
Bale	27	6	67	100
West Arsi	44	12	44	100
East Shewa	23	1	76	100
West Hararghe	28	17	54	100
Overall average	29	7	64	100

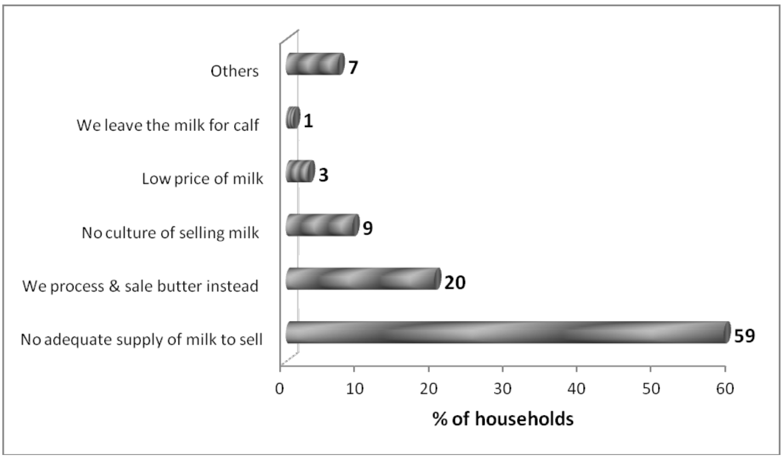


Figure 43. Reasons why households did not sell milk, 2014

Table 23. Participation of household members in milk hygiene and handling, 2014

Zone	Participated in milk hygiene and handling training	Never participated in milk hygiene and handling training	Total
Husband	16	84	100
Wife	12	88	100
Female Household Head	15	85	100
Youths	16	84	100
Overall average	15	85	100

3.11 Perceptions of households on price of milk and feed

At the time of this study (which is 2014), an assessment was made on the perception of the community about the prevailing milk prices. It was reported that 80% of the milk producers and sellers did not have complaints on the price of milk (Table 27). Out of these, 38% of them expressed that the price is very good while 42% said it is fair. It was only 20% of the dairy farmers who complained that milk price is not attractive. Especially the study Zones surrounding Addis Ababa (North Shewa and West Shewa) have complained that the price is not fair in view of the high feed cost. It was reported that the price gap between the price farmers receive (farm gate price) and the price consumers pay at the city of Addis Ababa is sometimes as high as 100%. This means that the beneficiaries are the middlemen at the expense of producers, which is an indication of market irregularities in the milk value chain.

The perception of households on the price of feed is quite different than milk. It has been firmly underlined by 87% of the households that feed price is very expensive (Table 28). The perception is similar in all the study Zones that feed in fact is scarce and consequently expensive resource. It could also contribute to restricted adoption of crossbred cows technology. Only 12% of the farmers said that the price of feed is fairly good, especially in East Shewa (21.5%) and Arsi (18%) Zones. This might be because of relatively better supply of feed as compared to other Zones.

Table 24. Perception of households on the price of milk, 2014.

Zone	It is attractive (very good)	It is fair (good)	It is low (not paying)	Total
North Shewa	8	38	54	100
West Shewa	16	41	43	100
Southwest Shewa	47	24	29	100
Arsi	25	44	31	100
Bale	40	57	3	100
West Arsi	59	37	5	100
East Shewa	54	41	5	100
West Hararghe	60	36	4	100
Overall average	38	42	20	100

Table 25. Perception of households on the price of feed, 2014

Zone	It is fair	It is expensive	It is low	Total
North Shewa	3.2	96.3	0.5	100
West Shewa	11	89	0	100
Southwest Shewa	12	87	1	100
Arsi	18	75	7	100
Bale	11	88.5	0.5	100
West Arsi	14.4	85.1	1.5	100
East Shewa	21.5	78	0.5	100
West Hararghe	9.5	90	0.6	100
Overall average	12	87	1	100

3.12. Impacts of adopting dairy production technologies

Even though adoption rates of crossbred cows and other packages of dairy technologies is very low, there are still some positive and promising impacts that are brought up by the adopter households. The impacts are versatile ranging from economic benefits to livelihood improvements. According to the findings, 55% of the beneficiary households witnessed that their on-farm income has increased since they started adopting crossbred cows technologies (Figure 48). Households generated enormous incomes from sales of milk and milk products (butter and cheese) and also from sales of crossbred heifers and calves. As presented in Figure 49, adopters of crossbred cow technologies generated 44% more income than non-adopters. This is just in addition to other food and non-food related benefits accrued to adoption of crossbred cows technologies. The income generated has helped families to meet various types of family needs and obligations as given in the figure.

Apart from income benefits, 39% of the households have confirmed that their household consumption has been diversified and their nutrition improved since they started producing milk and milk products at home. They described that milk availability has especially improved the health and growth of children. Availability of butter, cheese, yoghurt and whey at home has also improved nutrition and health of the whole family members and they are overwhelmed with these changes in their livelihoods due to crossbred cows technologies.

The other tremendous impact, as expressed by 18% of the farmers, was that resilience of the household has increased more than ever since they started adopting and benefiting from crossbred cows technologies. This could be achieved through increased savings and food availability. Moreover, ownership of crossbred cows is considered as keeping prestigious asset at home which can be easily liquidated at high values whenever the need arises to do so. The regular income that could be generated from sales of milk and milk products can also strengthen resilience of households at times of unexpected crisis.

The income generated from sales of milk and milk products has also contributed in strengthening other sectors, such as crop production, through purchases of inputs. Farmers often purchase seeds of improved crop varieties, inorganic fertilizer and labor from incomes generated through crossbred cows technologies. This by itself helps farming families to diversify income sources, increase food availability and eventually strengthen resilience and livelihoods of households.

Even though these impacts are brought up through limited households who adopted and benefited from crossbred cow technologies, more other households could have also been benefited the same way had the technologies been disseminated, adopted and utilized at larger scales. This can be achieved through addressing the problems that have restricted adoption of various components of crossbred cows technologies including problems related to crossbred cows, feeds and nutrition, animal health, milk processing and hygiene, marketing of milk and milk products, and others. Above all, ensuring adequate supply of crossbred heifers shall be placed at higher development agenda. Moreover, awareness creation and capacity building efforts need to be strengthened further accompanied with practical and skill based demonstrations.

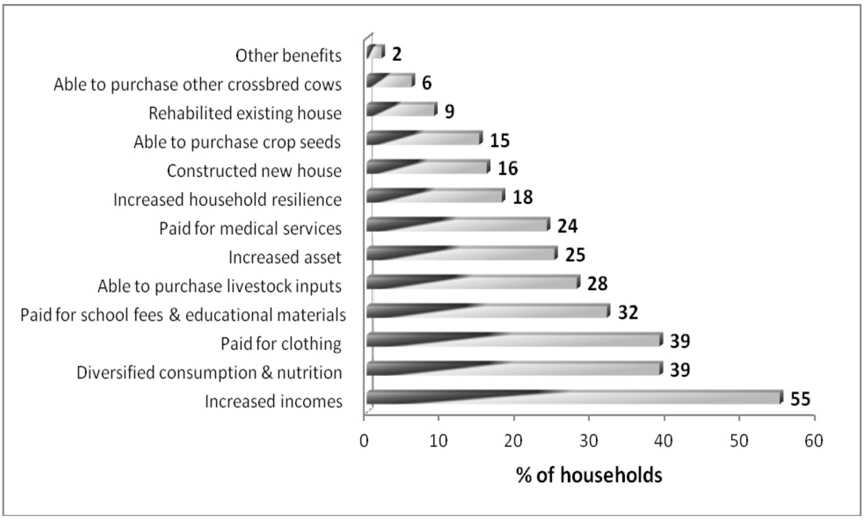


Figure 44. Impact areas and impacts of using crossbred dairy technologies on farmers' livelihoods, 2014

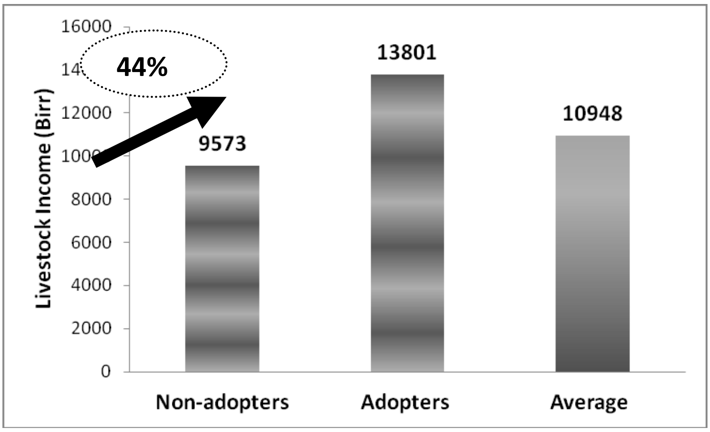


Figure 45. Income benefits from adoption of crossbred cow technologies, 2014.

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

Considerable proportions of households were at least aware of dairy production technologies which are the first step to inspire adoption and utilization of technologies in subsequent stages. Trainings and experience sharing visits facilitated by Office of Agriculture, national and international research institutions, NGOs and other development actors have made enormous contributions in improving farmers' knowledge on improved dairy technologies. It was also apparently recognized that awareness and adoption of dairy production technologies was largely of a recent phenomenon probably associated with massive development programs that have been designed to facilitate the promotion, dissemination and utilization of integrated agricultural technologies. Information sharing mechanism established among the community has largely facilitated farmer-to-farmer technology exchange mechanisms.

The adoption rate of crossbred cows in Oromiya region was 28%, which is perceived to be an encouraging status. Adopters mainly sourced these crossbred cows from the market where it is hardly possible to know the exotic blood levels, parity status, productivity and other reproductive traits. It can sometimes happen that cows with certain defects and unproductive ones are sold at the markets without disclosing the reality. Therefore, purchasing a crossbred cow from the market without knowledge of its reproductive traits could impose high risks on the purchaser.

The major factor that restricted farmers from adoption of crossbred cows was high price which is often unaffordable to smallholder farmers. The price could range from ETB 20,000.00 – 60,000.00 (equivalent to USD 1000.00 – 3000.00) without considering the productive and reproductive traits of crossbred cows. The highest ever price could be attributed to supply shortages and the consequent mounting of demand. While there are formal seed multiplication enterprises for improved crop varieties both at Federal and Regional levels, there is almost no formal heifer rearing and distribution center in the country except a few private enterprises with limited capacities to respond to the escalating demand.

Apart from crossbred cows, adoption of other packages of dairy production technologies was also very low. For instance, adoption rate of improved forage crops was only 10% while adoption intensity was 8%. This means that households allocated only 8% of their farmlands for forage production while the other proportion is often allocated to production of food crops. It is not that forage crops are less important but farmers' perception and preference is for food production in view of farmland shortages. Compared to crossbred cows and forage technologies, introduction of MNB and urea treatment are relatively new to the farmers and are not yet included as component of regular extension package. Thus adoption rate of MNB was only 2% while that of urea treated straw was 5%. Owing to availability of crop residues, the very low adoption rate of urea treated straw could especially be regarded as a missed opportunity in dairy development initiatives. Extensive use of MNB is often constrained by poor availability of molasses and access by rural community. With the current initiative of the mega project on sugarcane industry, availability and access to molasses shall be substantially improved soon when the 17 sugarcane factories become fully operational. This is because, almost every farming household produces crop residue even though the type varies from one agro-ecology to another and the types of crops grown. Urea is also a nutrient that is not very difficult to obtain. However, it was awareness and capacity gap that has been a responsible factor. Farmers were not trained skillfully on how to prepare urea treated straw and MNB. While feed scarcity is getting worse from time to time, there is no better option other than strongly promoting improved knowledge and skills on how to utilize available feed resources efficiently.

Among the dairy processing technologies, milk churner machine was promoted to beneficiaries even though its adoption rate is only 1.3%. Unawareness of knowledge and sources of the machine were the responsible factors for limited adoption rate. Processing technologies generally did not receive adequate focus in promotion, demonstration and dissemination in the study areas.

In sum, dairy production technologies have not been well adopted as a package along with crossbred cows. This was witnessed with limited levels of adoption rates of the components, which is likely to compromise milk productivity. Consequent to this, milk yields of the cows remained far below their potential. Farmers have at least lost 65% of milk production by failing to use recommended packages along with crossbred cows, such as forages, feeds and nutrition technologies and health care.

In spite of limited adoption of crossbred cows and associated technological packages, beneficiary households have recorded certain economic and livelihood impacts. The notable one is that adopter households have generated 44% more income than non-adopters from sales of milk and milk products. Farmers were able to meet various needs and obligations with the increased incomes. It was also noted that the income from utilization of dairy technologies has contributed to strengthen other sectors, such as crop production, in helping to purchase seeds, fertilizers and labor. In addition to this, household food diversification and nutrition has been improved, and this has largely contributed to improvements in the health and growth of children. It has also contributed to building of assets, because, ownership of crossbred cows is perceived to be keeping of prestigious asset that could be liquidated at times of acute problems. Cumulative effect of all these has contributed to strengthening resilience of households at times of unexpected life crisis. However, these impacts apply to only limited proportions of beneficiary households. Therefore, dairy technology should be promoted and disseminated further to large numbers of households in different agro-ecologies to ensure that the large proportion of households is beneficiaries of the technologies and the consequent impacts.

4.2 Recommendations

Taking into consideration of the problems identified and opportunities available, the following recommendations are suggested to enhance the dairy sector further.

1. Ensure reliable sources and supplies of crossbred heifers

One of the problems fundamentally recognized during the study was unavailability of reliable sources of crossbred heifers at affordable prices. On the one hand, farmers require crossbred heifers with known exotic blood level while also demanding prices to be affordable. Literally, there are no formal heifer rearing centers in the country as there are seed multiplication enterprises for crops. Only limited private enterprises have started the initiative even though they are not still able to meet the growing demands. As a result, the farmers tend to depend on markets to acquire crossbred cows, a place where farmers could not get reliable information about reproductive traits, such as their parity, milk yielding potential, age and other essential merits. In addition to this, the prices of crossbred cows is so high and quite unaffordable for smallholder farmers. Even those who can afford could not get crossbred cows in the required numbers with known records of reproductive traits. Therefore, addressing this problem requires not only development but also policy intervention to establish heifer rearing centers at regional levels to create easy access to farmers. Moreover, private enterprises need to be supported and strengthened to invest in this business venture. In the short term, additional options can be taken to produce crossbred calves from local cows through effective promotion of AI and purebred bull services including synchronization techniques. All other possible options need to be exhausted to ensure reliable supply of crossbred heifers for the farming community. Beyond policy and institutional issues, enhancing supply of crossbred heifers also requires a serious engagement in technical back up by harnessing the state of the art of reproductive biotechnology (Multiple ovulation and embryo transfer, sexed semen technology and *in vitro* fertilization)

2. **Further awareness creation and capacity building of households on dairy technology packages**

Dairy farmers could remain productive if they apply packages of available technologies along with crossbred cows. The packages included improved feeding management practices, improved health care and housing, recommended processing technologies, milk hygiene and value addition, and others. It was recognized that most of the farmers are not well aware of these packages. Whenever they get chance to own a crossbred cow, they keep on managing through traditional practices, such as open grazing, poor housing, feeding, health management and other practices. This is largely because of limited awareness on packages of dairy technologies. Therefore, further initiatives are required to raise awareness of households on improved management practices of crossbred cows along with practical demonstrations and skill based trainings. Experience sharing visit is also an essential approach to learn lessons and best practices.

Knowledge and skills of improved dairy management practices need to be raised through relentless capacity building programs. Farmers need to be trained on how to prepare urea treated straw and other concentrate feeds at home using locally available materials. It is also essential to encourage them grow improved forage crops in their backyards to ensure reliable supply of green feed.

3. **Creating easy access to packages, such as forage seeds, milk churner machine and others**

Even though some farmers are aware of and willing to invest on dairy technologies, such as improved forages, milk churner machine and others, they could not get starter materials. For instance, they could not get a milk churning machine and seeds of improved forage crops on time at affordable prices. There is also a need to establish linkages with local industries of farm implements to make milk churner machines and then with dairy farmers to purchase and use the apparatus and thereby establish reliable markets. The manufacturers are willing to receive orders of making milk churner machine as far as there is demand and market guarantee.

Forage seed producing farmers could be organized and trained to ensure easy access to and availability of forage seeds to start with. This could also create an opportunity of income generation for seed producers.

4. Give due focus to gender perspectives

Dairy management fundamentally requires involvement of women for various operations, such as feeding, milking, cleaning, health care and others. In spite of this, participation of women in trainings, experience visits and other capacity building initiatives is very limited as compared to men. Men were mostly given priority advantages in receiving trainings and other programs. Therefore, there should be fair consideration of men and women in capacity building programs, technology promotion and demonstration initiatives, and others. Targeting of either men or women shall depend on the basis of the type of task they are mainly responsible in dairy management. This could be identified through gender analysis study disaggregating the various practices and activities as managed by men, women and youths. Based on this, designing gender responsive programs and development initiatives would contribute to enhancement of the dairy sector.

5. Introduce and promote record keepking practices

Dairy commercialization will not be effective without maintaining appropriate recording of the management practices, cost and benefit flows, reproductive traits of cows, health records, parity and other details. Exotic blood level of crossbred cows is hard to maintain unless breeding strategy is made controlled. The information on the breeding history of dairy cows, such as bull and AI services shall be recorded over time. Moreover, the feed type, combination and amount fed daily as per the cow's parity and across seasons, health status by type of disease, the parity, age of the cows, daily milk yield across lactation periods, market information, such as milk prices and trends over time, cost of feed and all other relevant particulars need to be recorded. At the outset, dairy farmers need to receive adequate trainings on how to keep records, record formats, and how to synthesize information. Experience sharing visits shall also be organized to dairy farms with best practices in record keeping.

6. Promote indoor feeding practices

Outdoor feeding and open grazing are becoming a common practice for crossbred cows. However, these breeds of cows are not meant to find their main feed through grazing. On the one hand, exposing them to outside environment for prolonged time might make the cows lose body conditions while on the other hand they cannot get adequate feed from grazing. The eventual effect is loss of milk productivity and other good traits. Therefore, there is a need to promote indoor feeding practices with restricted roaming in the backyards to improve and modernize dairy commercialization and management practices.

Capacity building trainings could be given to dairy farmers on how to construct shades, the barn design, feed storage techniques and all other particulars. Experience sharing programs could be effective here to demonstrate the best indoor feeding practices.

7. Prepare and distribute dairy production and management manuals

In addition to extensive capacity building programs on the whole dairy management practices, knowledge can be conveyed through printed materials. Production and management manuals could be prepared for smallholder farmers in an easily understandable descriptions and demonstrations. For instance, separate manuals could be prepared on improved feed management practices, health care and ethno-vet, dairy processing and value addition, improved housing and indoor management, milk hygiene and handling, calve rearing and management, breeding and exotic blood maintenance, record keeping and others. Once the manuals are prepared in one of the common languages, it could be translated into other languages of interest. The manuals should also be published in large numbers and disseminated to all over the country not only for the farmers, but also for development partners, such as Agriculture Offices, NGOs and others. This approach is believed to have significant contributions in creating awareness, knowledge and skills of the farmers on various types of dairy management practices. It will also motivate and sensitize farmers to adopt and utilize improved dairy production technologies.

8. Improve service delivery

Service delivery in AI, animal health and other inputs required for modern dairy production should be thought from perspectives of market orientation and transforming smallholder dairy. Alternative service deliveries in AI and animal health should be strengthened to respond the needs of smallholder farmers so that they can access the service at their vicinity at affordable prices. Fundamental move towards privatizing some of the services like AI and animal health would help to support Ethiopian dairy along the path of market led economy and commercialization.

5. References

Abebe B, Zelalem Y, Ajebu N. 2012. Hygienic and microbial quality of raw whole cow's milk produced in Ezha district of the Gurage Zone, Southern Ethiopia. Wudpecker J. Agric. Res. 1(11):459

Amemiya, T., 1985. Advanced Econometrics. T.J. Press, Pad Stow Ltd., Great Britain.

Baltenweck I, Yamano T and Staal S J 2006. Dynamic Changes in Dairy Technologies Uptake in the Kenya Highlands. International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18

Benson HJ .2001. Microbiological Applications Laboratory Manual. Laboratory Manual for General Microbiology. Eighth Edition. The McGraw-Hill Companies, New York.

Biruk H, Samson W, Zelalem Y. 2009. Microbial properties of milk and traditionally produced Ethiopian fermented milk products.

Chencha Chebo and Kefyalew Alemayehu. 2012. Trends of Cattle genetic improvement programs in Ethiopia: Challenges and Opportunities, from http://www.lrrd.org/lrrd24/7/cheb24109.htm

Chilot Yirga, Moti Jaleta, Bekele Shiferaw, Hugo de Groote, Menale Kassie, Takele Mebratu and Ali Mohammed. 2013. Analysis of Adoption and Diffusion of Improved Wheat Technologies in Ethiopia: Research Report 101. Ethiopian Institute of Agricultural Research and International Maize and Wheat Improvement Center. ISBN: 978-99944-53-93-1.

Chilot Yirga and RM Hassan. 2008. Multinomial logit analysis of farmers' choice between short and long-term soil fertility management practices in the Central Highlands of Ethiopia. Ethiopian Journal of Agricultural Economics, 7(1):83-102.

CSA (Central Statistical Authority). 2003 - 2014. Agricultural Sample Survey: Report on Livestock and Livestock Characteristics. Addis Ababa.

CSA (Central Statistical Agency) and the World Bank. 2013. Ethiopia Rural Socio-Economic Survey Report (ERSS).

Dawit Alemu, Seyoum Bediye and Yirdaw W/Semayat. 2012. Feed Marketing and quality issues. In (Adugna Tolera, Alemu Yami and Dawit Alemu eds. Livestock Feed Resources in Ethiopia: Challenges, Opportunities and need for transformation. PP.74-89.

Heckman, James J. (1979): "Sample Selection Bias as a Specification Error", Econometrica 47, 153-161.

Desalegn G/Medhin, Merga Bekana, Azage Tegegne and Kelay Belihu. Status of Artificial Insemination Service in Ethiopia, from: https://cgspace.cgiar.org/bitstream/handle/10568/27942/ESAP_Proceedings_17.pdf?sequence=1

FAO. 2010. Status and prospects for smallholder milk production – A global perspective, by T. Hemme and J. Otte. Rome.

Fekede Feyissa, Getnet Assefa, Gezahegn Kebede, Alemayehu Mengistu and Driba Geleti. 2015. Cultivated Forage Crops Research and Development in Ethiopia. *In*: Alemu Yami, Getnet Assefa and Lemma Gizachew (eds) Pasture and Rangeland Research and Development in Ethiopia. Ethiopian Society of Animal Production. Addis Ababa.

Greene, William. 1997. *Econometric Analysis*, 3rd ed. New York: Macmillan. Johnston, J. and J. Dinardo, 1997. Econometric Methods. 4th Edn., Mac Graw-Hill, New York.

Heckman, James J. (1979): "Sample Selection Bias as a Specification Error", Econometrica 47, 153-161.

Kurt, Davis. 2014. Top 5 opportunities for investment in Ethiopia. http://www.africa.com/blog/top-5-opportunities-for-investment-in-ethiopia-part-ii/. Accessed on December 18, 2014.
Lemma Fita, M. M. Trivedi and Bekele Tassew. 20**12.** Adoption of improved dairy husbandry practices and its relationship with the socio-economic characteristics of dairy farmers in Ada'a district of Oromia State, Ethiopia. Journal of Agricultural Extension and Rural Development Vol. 4(14), pp. 392-395, 8 August, 2012. ISSN: 2141-2154 ©2012.
Machira Gichohi. 2014. Status of the Kenyan Dairy Industry. Kenya Dairy Board Belgscopebusiness. 2014. Will
Maddala, G.S., 1992. Introduction to Econometrics. 2nd Edn., Macmillan Publishing Co., New York.
Makokha, S.N., J. Karugia, S. Staal and.O.Kosura. 2003. Adoption of dairy technologies: lessons learnt from case study in Western Kenya.
McDonald and Moffitt's 1980. The Usefulness and Uselessness of the Decomposition of Tobit Coefficients.
Mekonnen H, Dehninet G and Kelay B 2010. Dairy technology adoption in smallholder farms in " Dejen" district, Ethiopia. Tropical animal health and production, 42(2): 209 – 216.
Mesfin Dejene, Seyoum Bediye, Getu Kitaw, Aemiro Kehaliw, Getnet Assefa and Getaw Tadesse.2014. Livestock feed marketing in Ethiopia: Challenges and opportunities for livestock development. Journal of Agricultural science and Technology A. 4(2):155-168.
MOFED (Ministry of Finance and Economic Development). 2010. Federal Democratic Republic of Ethiopia: Growth and Transformation Plan (GTP) 2010/11 - 2014/15.
Nchinda V P and Mendi S D 2008 Factors influencing the adoption of yoghurt technology in the Western Highlands Agro-ecological Zone of Cameroon. *Volume 20, Article #102.* Retrieved September 28, 2011, from http://www.lrrd.org/lrrd20/7/nchi20102.htm
Oliver SP, Jayarao BM, Almedia RA. 2005. Food borne pathogens in milk and the dairy environment food safety and public health implications. Foodborne Pathog. Dis. 2:115-1129.
Sigelman L and Zeng L (1999). Analyzing Censored and Sample-Selected Data with Tobit and Heckit Models. *Political Analysis,* 8(2):167-182
SNV. 2008. Dairy Investment Opportunities in Ethiopia.
Tsedey Azeze and Asrat Tera. 2015. Safety and quality of raw cow milk collected from producers and consumers in Hawassa and Yirgalem areas, Southern Ethiopia.
Tobin, J. (1958). Estimation on Relationship for Limited Dependent Variables, Econometrica, 26, 26-36. http://dx.doi.org/10.2307/1907382.
Woodridge, J. 2002. Econometric analysis of cross section and panel data. MIT Press, USA.
Yilma. Z., and Faye, B. 2006. handling and Microbial load of Cow's milk and Irgo - Fermented Milk Collected from Different Shops and Producers in Central Highlands of Ethiopia. Eth. J. Anim. Prod. 6(2):67-82.
Zaman H. 2001. Assessing the poverty and vulnerability impact of micro credit in Bangladish: A Case study of BRAC. Office of the chief economist and senior vice president.
Zelalem Yilma, Emmannuelle Guernebleich and Amha Sebsibe. 2011. A review of the Ethiopian dairy sector. FAO. http://www.fao.org/3/a-aq291e.pdf.