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ADOPTIONOFIMPROVEDDAIRYCOWSANDIMPLICATIONSFORHOUSEHOLDFOODSECURITYEVIDENCEINCENTRALHIGHLANDOFETHIOPIA

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Wuletaw Mekuria [α], Workneh Negatu [σ] & Kindu Mekonnen [ρ]

Abstract- Crop-livestock production is the main livelihood strategy for rural households of Ethiopia. However, it is constrained by low level of adoption for agricultural technologies. The objectives of this study are, therefore: analyzing adoption of dairy cow technology and examining the contribution of the technology to household food security. The study is conducted in Gudo Beret watershed, North Shewa, Ethiopia. Primary and secondary data were collected from different sources. In the watershed, 211 respondents were selected through systematic random sampling. Expert consultation, household interview, key informants, focused groups, and personal observation were the main data collection methods. Descriptive statistics, inferential tests, multivariate tools, and econometric models have used for data analysis. The results showed that the rate of adoption for improved dairy cows is low and slow in terms of proportion of households and size of cows, respectively. Binary Logit model indicated that hired labor, social responsibility, and livestock size influenced the adoption of improved dairy cows significantly and positively while land holding size affected the technology significantly and negatively. Production of improved dairy cows contributes for household food security. Although the correlation of improved dairy cows and food security is positive, it is very low and insignificant.

Keywords: adoption, dairy cow, food security, logit model.

I. Introduction

About 80% of the population in Ethiopia is dependent on rain-fed agriculture (World Bank, 2013). In the highlands of the country, the dominant agricultural activity is crop and livestock (mixed) farming system (Belay *et al*., 2012). The contribution of crops and livestock to the national growth domestic product is 27.4% and 7.9%, respectively (NPC, 2016). The total livestock population is estimated to be 53.99 cattle, 25.98 sheep, 21.8 goats, 1.91 horses, 6.75 donkeys, 0.35 mules, 0.92 camels, 50.38 chickens, and 5.2 beehives in million numbers (CSA, 2014). Adoption of agricultural technologies is required to enhance agricultural productivity and sustain agriculture in developing countries. Sustainable agriculture is a function of wise management of natural resources and orientation of institutional and technological changes (Titus and Adefisayo, 2012). Livestock production serves as a means of food security (Iiyama *et al*., 2007a; Messay, 2010). Households with large herd sizes have better chance to ensure food security at household level (Arega, 2012; Mesfin, 2014).

Many countries in Sub-Saharan Africa (SSA), including Ethiopia, could not produce adequate food for the rising population and exhibited large rates of malnutrition (Herrero *et al.,* 2012). In spite of the percentage of the population living below the poverty line has declined from 45.5% in 1995/96 to 29.6% in 2010/11(WFP, 2014), undernourishment remained high (35%) between 2012 and 2014 (FAO, IFAD and WFP, 2014). Soil and pasture degradation is the potential threats of crop-livestock system as long as increasing pressure over the land and growing demand for income, food, and feed. Crop and livestock productivity is limited and attributed by low level of adoption for agricultural technologies (IFPRI, 2011). Although a number of improved livestock breeds have increased, its productivity is low (NPC, 2016).

Plenty of evidences confirmed that several problems are getting worse in the highlands of Ethiopia. These include malnutrition, declining of productivity, excessive land fragmentation, and land degradation (Demese *et al.,* 2010; IFAD, 2013; Nigussie *et al.,* 2015). Climate change is also expected to exacerbate situations by increasing water stress, soil erosion, soil acidity, landslides, feed shortage, and incidence of animal diseases (Tongul and Hobson, 2013). Although various technological interventions have been introduced to the study area, land degradation, feed scarcity, and population density are adversely affecting the landscape situation (Kuria *et al*., 2014). Low considerations and poor management practices of livestock are identified research gaps (Demese *et al*., 2010; EPCC, 2015). The objectives of the study are therefore to analyze determinants of adoption of improved dairy cows and examine the contribution of improved dairy cows to household food security among smallholders.

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II. Methods

a) The study area

The study is conducted in *Gudoberet* watershed of *Basona Worana Woreda*, *North Shewa* zone, *Amhara* national regional state, Ethiopia. It is located between latitudes 9°76' and 9°81' North, and longitudes 39°65' and 39°73' East at a distance of 162 km Northeast of Addis Ababa and 32 km from *Debre Berehan* in the same direction of the town. The watershed covers 2425 ha of land in the upper part of Blue Nile basin in Ethiopia. The catchment lies between an altitude of 2828 and 3700 meters above sea level (masl). Agro-ecology has classified as below 500, 500-1500, 1500-2300, 2300-3200, 3200-3700, and above 3700 masl for *Bereha*, *Kolla*, *Woina Dega*, *Dega,* high *Dega*, and *Wurch,* respectively (MoA, 2016). About 1074 ha of land in the watershed lies in the high *Dega*[1] agro ecology while the remaining 1351 ha lies in *Dega,* agro ecology.

b) Data and sampling procedures

This study is designed to be field survey in quantitative and qualitative approaches. The study watershed is selected purposively in consultation of agricultural experts that have the knowledge of the study area and preliminary diagnostic field assessments. The selected watershed is delineated and demarcated with the help of topographic map, Geographic Positioning System (GPS) and Geographic Information System (GIS). The sample size is determined after the study population who are living in the study watershed is listed. Finally, respondents are selected within the sampling frame of the study population using the following formula derived from Yamane (1967) in Israel (2013).

$$n = \frac{N}{1+N(e)^2} \Rightarrow n = \frac{447}{1+447(.05)^2} \approx 211$$

Where: *n* is the required sample size. *N* is the study population in the watershed, *e* is an acceptance error at a given precision rate. In the watershed, 19 small villages (5 at high *Dega* and 14 at *Dega* agro-ecologies) are identified. A total sample size of 211 respondents (155 in *Dega* and 56 in high *Dega*) are applied for the study through systematic random sampling in probability proportional to size.

c) Methods of data collection and analysis

i. *Methods of data collection*

Both qualitative and quantitative data types are collected from primary and secondary sources. Four data collectors and one facilitator are selected, trained, and they have collected data through interview. Moreover, preliminary field survey, expert consultation, and key informant interview are carried out. On top of this, one focused group discussion, and personal observation are used. Socioeconomic, institutional, demographic, and biophysical data are collected through direct household survey.

ii. *Methods of data analysis*

Descriptive statistics and inferential tests are employed in this study. The socioeconomic and other determinants of adopters are explained both in quantitative and quantitative terms. The rate of adoption is calculated in terms of dairy cow technology users and number of dairy cow breeds. Several studies have used different types of econometric models for dairy technology. Ordinary least square, Probit, Logit, and Tobit are the most commonly used models for adoption studies. Explanatory variables are derived from the theory of innovation diffusion and other empirical studies. In this study Binary Logit model is used. The model helps to describe the relationship between the outcome variable and a set of explanatory variables. Binary Logit is preferred to others because it gives standard result for discrete choice estimation (Gujarati, 2003; Greene, 2007, p.588).

$$Logit(P_i) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_n X_{ni} + e_i \quad (1)$$

Where: $P\,(_i)$ is the probability that the i^{th} value of the dependent variable, X is the i^{th} value of the independent variable, e_i is the "error" variability of the dependent variable not explained by the independent variable; *n* is the number of independent variables.

$$Odds = \frac{P_i}{1-P_i} \quad (2)$$

Odds ratio is the way to present the probability of an event. The odds of an event happening (adoption of crossbred dairy cow) indicates the probability of that event will happen divided by the probability of that event will not happen. Thus, the Logit (Natural log of odds) of the unknown binomial probabilities are modeled as a linear function of the X_i:

$$Logit(P_i) = Ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \sum_{j=1}^{n} \beta_j X_{ji} \quad (3)$$

The Logit model assumes that underlying stimulus index *Logit* (P_i) is a random variable, which predicts the probability of crossbred dairy adoption. P_i is the probability of adopting crossbred dairy cows, while $(1-P_i)$ is the probability not adopting the technology.

[1] 3200 masl is a cut-off point between *Dega* and high *Dega* agro ecologies (MoA, 2016).

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$$\text{Probability of adoption, } P_i = \left(\frac{1}{1+e^{-Logit(p_i)}}\right) = \left(\frac{e^{Logit(P_i)}}{1+e^{Logit(P_i)}}\right) = \left(\frac{e^z}{1+e^z}\right) \quad (4)$$

Where Z is cumulative function, $\beta_1 + \beta_2 X_i$ that ranges from $-\infty$ to $+\infty$, while P_i ranges between 0 and 1. The maximum likelihood estimation approach is used to estimate the equation. SPSS Version 20 software is employed to compute estimates.

III. Results and Discussion

a) Dairy cows production in the study watershed

Almost 74.6% of the cattle population was indigenous breeds while 25.4% was improved breeds. The total livestock population of sample households was 3327 (841.1 TLU). Of the total size, the highest number was for sheep, while the highest size in TLU was oxen. Big animals had large body size and high TLU equivalent. Sheep, chicken, and oxen were the three most common livestock types in number while oxen, sheep, donkey, and cow were high populations in TLU. About 16.1% of households owned improved dairy cows of which 13.7% and 2.4% of households owned 1 and 2 improved dairy cows per household, respectively.

Agriculture is said to be sustainable once adequate agricultural inputs and technologies are available to the farming system. Smallholders, development agents, agricultural experts, and previous empirical studies were consulted in technology selection for the study of adoption. Crossbred cows were selected for this study, which had direct implication for household food security. Cows were the second population (23.2%) in cattle husbandry after oxen in the study watershed. About, 60.2% of households owned cows. Households have introduced the technology since 1998. The size of local and crossbred cows was 1.21 and 1.15 per household respectively, 1.19 in average. Gryseels (1988) reported that 80% of households had an average of 1.5 cows per household in the 1980s near to *Debre Berehan*. It implied that the number of households and the size of cows per household in the 1980s around *Debre Berehan* were higher than the study watershed.

b) Characteristics of dairy cattle households

Table 1: Descriptive results of explanatory variables between adopters and non-adopters

Variables	Adopter (N=34) Mean	Non-adopter (N=177) Mean	t-value/χ^2	Sig. value
Age of household heads in years	42.74 (11.76)	44.04 (11.48)	-2.540**	0.023
Total household size in AE	4.53 (1.61)	3.81 (1.51)	-2.512**	0.013
Farming experience in years	24.50 (12.08)	25.31 (12.41)	0.359	0.721
Hired labor in number	0.23 (0.43)	0.07 (0.26)	-2.118**	0.041
Household labor in number	2.91 (1.02)	2.86 (1.38)	-0.232	0.818
Total land holding in ha	1.41 (0.57)	1.32 (0.58)	-0.829	0.411
Farm income ('000 ETB)	6.16 (6.44)	3.45 (39.19)	-2.370**	0.023
Manure applied in kg	119.26 (70.03)	81.27 (73.58)	-2.873***	0.006
Total livestock in TLU	6.44 (3.00)	3.52 (2.39)	-5.352***	0.000
Non-farm income ('000 ETB)	1.19 (2.47)	0.89 (1.76)	-0.661	0.513
Fertilizer applied in kg	94.85 (73.02)	54.83 (59.37)	-3.010***	0.004
Irrigation land in ha	0.025 (0.07)	0.029 (0.06)	0.261	0.795
Market distance in minutes	25.29 (24.16)	17.10 (18.98)	-1.499	0.141
Road distance in minutes	25.29 (24.16)	17.10 (18.98)	-1.868*	0.069
Kebele distance in minutes	34.20 (27.46)	26.83 (24.92)	-1.455	0.122
Contact of DAs	1.50 (1.05)	1.05 (1.06)	-1.189	0.241
Sex of household head+			5.150**	0.023
Educational status+			5.272**	0.022
Land tenure security+			2.369	0.124
Social status of household head+			13.277***	0.000
Membership in cooperatives+			0.074	0.786
Slope class+			0.007	0.934
Access to credit+			0.042	0.838

, **, * indicates 10%, 5% and 1% significant level respectively.*

Figures in parenthesis refer to std. dev; "+" refers to discrete variables. The mean values for adopters and non-adopters are computed using independent t-test for continuous variables and χ^2 for discrete variables.

i. *Demographic characteristics*

The mean ages of adopters and non-adopters were 42.74±2.01 and 44.04±0.93 years, respectively. There was a significance difference in age between adopters and non-adopters at t-value of -0.254 (p=0.023). The average household size of adopters and non-adopters was 4.53±0.28 and 3.81±0.11, respectively. The average number of years of farming experience for adopters was 24.5±2.07, whereas that of non-adopters was 25.31±0.93. The female heads distribution among adopter and non-adopter groups was 14.7% and 34.5%, respectively. Majority of adopters (38.2%) and non-adopters (43.5%) have had read and write educational status. The χ^2-test result indicates sex and educational level of household heads were significant at 5% probability level. About 50% of adopters and 20.3% non-adopters had social status. Social status was also significant at 1% probability level (Table 1).

ii. *Socio-economic characteristics*

The mean of hired-labor for adopters and non-adopters was 0.23±0.07 and 0.07±0.01, respectively and significant at t-value of -2.118 (p=0.041). The size of household labor for adopters (1.41±0.17) was greater than that of non-adopters (1.32±0.10). The mean farmland size of adopters was 1.41±0.09, while for non-adopters was 1.32 ±0.04. The farm and non-farm household income was better for adopters than their counter parts. It was estimated to be 6.16±1.10 and 3.45±0.29 of farm income for adopters and non-adopters, respectively; while 1.19±0.42 and 0.89±0.13 of non-farm income for adopters and non-adopters, in thousand values. The mean value of farm-income was significant at t-value -2.37 (p=0.023). Households for crop production apply inorganic and organic fertilizers. In average, adopters and non-adopters have applied 119.26 ±12.01 and 81.27±5.53 kg of manure, respectively, while 94.85 ±12.52 kg of inorganic fertilizer was supplied by adopters and 54.83±4.46 kg by non-adopters. The mean difference among adopters and non-adopters was significant both for organic and inorganic fertilizers. Adopters owned more livestock than non-adopters. The mean livestock size for adopters was 6.44±0.51 and 3.52±0.18 for non-adopters which is statistically significant at t-value of -5.352 (p=0.000). Adopters and non-adopters had almost the same size of irrigation lands, 0.02 ha in average.

iii. *Institutional, topographic, and infrastructural characteristics*

The average frequency contact of development agents with adopters for extension service was 1.5±0.18 while for non-adopters was 1.05±0.07 days per month. Households in the watershed travel to the nearest market, asphalt road and the centre of the *Kebele* for various purposes. The nearest market and *Kebele* centre had almost the same average distance among adopter and non-adopter groups, respectively. Although non-adopters travelled less hours in average than adopters, it was statistically insignificant (P-value >0.10). Households travelled to the nearest asphalt road within few minutes compared to the distance to the nearest market and *Kebele* centre. The mean time taken to the nearest road was 25.29±4.14 and 17.10±1.42 minutes for adopters and non-adopters, respectively. Households who reside close to the market, *Kebele* centre and asphalt road were non-adopters who engaged mainly in non-farm activities compared to adopters.

c) *Rate of adoption for improved dairy cows*

The rate of adoption for improved dairy cows was computed in two ways: (i) the ratio of number of crossbred dairy cows to the total number of cows (Adeogun *et al*., 2008). Thus, the rate of adoption was estimated to be 25.8%. (ii) The relative speed with which members of a social system adopts an innovation. In this scenario, adoption rate refers the number of individuals who adopt new technology within a specified period (Roger, 2003). The number of households who adopt crossbred dairy cows to the total number of farmers who own local and crossbred cows was 26.8%, 1.6% per year. In both scenarios, the rate of adoption was low and slow as well. Bikal *et al* (2015) stated that the level of technology adoption was calculated as the total score obtained by households to the maximum possible score then categorized into low, medium, and high. Adopters, in the study watershed, did not have well-designed strategy and defined packages for crossbred cows. Moreover, all adopters except five of them owned only one crossbred cow.

d) *Determinants of adoption of improved dairy cows*

A number of factors influence households' decision either to adopt or reject a new technology. VIF and χ^2 were used to test multicollinearity for continuous and discrete explanatory variables, respectively. There was no multcollinearity among discrete explanatory variables in χ^2–test so that all discrete variables were entered in Logit model for analysis. However, age, farming experience, market distance, and centre of the *Kebele* were multicollinear in VIF value of greater than 10. Some hypothesized variables such as access to crossbred cows, veterinary service, and training were not included in model, because only smallholders who held crossbreds were accessible to improved dairy breeds and veterinary services. All non-adopters respond that they were not accessible to crossbred technology. In addition, only a single person in a year have participated in training on crossbred dairy technology. Thus, age, farming experience, *Kebele* and market distance, access to crossbreds, veterinary services, and trainings are excluded in the model.

Table 2: Descriptions of variables specified in the model

Variables	Measurements and descriptions
Dependent variable (Y_i)	Adoption of crossbred dairy cows which takes the value of 1 if a household is adopting and 0, otherwise.
Independent variables	
Sex (X_1)	Sex of the household head, 1 if a farmer is male and 0, otherwise
Household size (X_2)	Number of household members in households in AE
Education (X_3)	Educational level, 1 if a household head is literate and 0, otherwise
Hired labor (X_4)	Number of wage labor in households
Household labor (X_5)	Number of active labor force in households
Land (X_6)	Total size of land in ha
Farm income (X_7)	Total annual gross on-farm income measured in ETB
Organic fertilizer (X_8)	Amount of manure used in qt
Non-farm income (X_9)	Total annual gross non-farm income in ETB
Fertilizer (X_{10})	Amount of inorganic fertilizer used in kg
Irrigation land (X_{11})	Size of irrigation land in ha
Cooperative (X_{12})	Membership in cooperatives; 1 if a farmer is a member and 0, otherwise
Land tenure (X_{13})	Tenure security; 1 if land is secured to a farmer and, 0 otherwise
Road (X_{14})	Distance between resident and the nearest asphalt road in minutes
Slope (X_{15})	Topography of farmlands, 1 if it is gentle slope and 0, otherwise
DAs contact (X_{16})	Frequency of contact of DAs with household per month
Credit (X_{17})	Access to credit; 1 if a farmer is accessible and, 0 otherwise
Social status (X_{18})	Social position; 1 if a farmers has position and, 0 otherwise
Livestock (X_{19})	Total size of livestock in TLU

Source: Survey data (2016)

The Omnibus test of Goodness of fit in Chi-square indicated the null hypothesis has determined that the step was justified. When the step is to add a variable (s), the inclusion is justified if the significance of the step is less than 0.05. Had the step been to drop variable (s) from the equation, then the exclusion would have been justified if the significance of the change were more than 0.10. Therefore, the likelihood ratio of Chi-square of 63.12 with a p-value of 0.000 shows that outcome model as a whole fitted significantly. The overall model was significant and good fit.

Table 3: Result of maximum likelihood estimates in Binary Logit model

Variables	β	S.E.	Wald	Significance	$Exp(\beta)$
Sex	0.462	0.671	0.475	0.491	1.588
Household size	0.307	0.219	1.973	0.160	1.360
Education	0.285	0.264	1.168	0.280	1.330
Hired labor	1.806**	0.793	5.195	0.023	6.088
Household labor	-0.471	0.311	2.292	0.130	0.624
Land holding	-1.242**	0.575	4.658	0.031	0.289
On-farm income	0.000	0.000	0.823	0.364	1.000
Organic fertilizer	-0.003	0.005	0.324	0.569	0.997
Non-farm income	0.000	0.000	0.137	0.712	1.000
Inorganic fertilize	0.005	0.004	1.164	0.281	1.005
Irrigation	0.761	3.665	0.043	0.836	2.140
Coop member	-0.092	0.559	0.027	0.869	0.912
Land tenure	0.044	0.609	0.005	0.942	1.045
Road distance	-0.004	0.015	0.077	0.781	0.996
Slope	0.078	0.173	0.205	0.651	1.081
DA's contact	-0.427	0.298	2.046	0.153	0.653
Access to credit	-0.078	0.608	0.016	0.898	0.925
Social position	1.344**	0.596	5.091	0.024	3.834
Livestock holding	0.525***	0.151	12.019	0.001	1.690
Intercept	-4.190	1.342	9.745	0.002	0.015

*Source: Model output of SPSS version 20; ** and *** 5% and 1% indicates significance level*

Note: Wald = $(B/SE)^2$ and odds ratio in terms of log of odds i.e. ln [exp (B)] = B

The purpose of beta coefficients in the above table is to describe the direction of relationships and its significance. Among nineteen explanatory variables, hired labor, land holding, social position, and livestock were significant variables. Hired labor, social position, and livestock had positive relationships with adoption of dairy cow technology while land holding had negative relationships with the technology. The probabilities of changes for explanatory variables on the dependent variable are presented in Table 4.

Table 4: Binary Logit model result for marginal effects using Stata Version 11.9

		Delta-method				
	dy/dx	Std. Err.	z	p>|z|	[95% conf. Interval]	
Sex	0.0352	0.0495	0.71	0.478	-0.0620	0.1323
Household size	0.0233	0.0163	1.43	0.153	-0.0087	0.0553
Education	0.0217	0.0202	1.07	0.285	-0.0181	0.0614
Hired labor	0.1372	0.0625	2.19	0.028	0.0146	0.2598
Household labor	-0.0358	0.0231	-1.55	0.122	-0.0812	0.0096
Land holding	-0.0941	0.0435	-2.16	0.031	-0.1795	-0.0087
On-farm income	0.0000	0.0000	0.91	0.364	-0.0000	0.0000
Organic manure	-0.0002	0.0004	-0.57	0.569	-0.0009	0.0005
Non-farm income	-0.0000	0.0000	-0.38	0.707	-0.0000	0.0000
Inorganic fertilizer	0.0004	0.0003	1.09	0.277	-0.0003	0.0010
Irrigation	0.0589	0.2760	0.21	0.831	-0.4820	0.5999
Coop member	-0.0071	0.0425	-0.17	0.868	-0.0904	0.0763
Land tenure	0.0033	0.0461	0.07	0.943	-0.0872	0.0939
Road distance	-0.0003	0.0011	-0.28	0.780	-0.0025	0.0018
Slope	0.0059	0.0132	0.45	0.653	-0.0199	0.0319
DA's contact	-0.0324	0.0223	-1.45	0.146	-0.0761	0.0113
Credit access	-0.0058	0.0462	-0.13	0.900	-0.0964	0.0847
Social position	0.1021	0.0475	2.15	0.032	0.0090	0.1952
Livestock	0.0398	0.0125	3.18	0.001	0.0152	0.0644

Source: Model result

i. *Hired-labor*

The result of descriptive statistics showed that the mean difference of hired-labor for adopters was greater than non-adopter and statistically significant at 5% significant level. The result of Logit model was also statistically significant at 5% (p=0.023) showing a positive relationship with adoption of dairy cows at coefficients value of 1.806. The odds ratio of 6.088 for hired-labor implied that, for each unit increment in hired-labor while fixing the values of other independent variables, the likelihood of crossbred dairy adoption increases by fivefold. As hired-labor increases by one, adoption of crossbred dairy cows increases by 13.7%.

ii. *Land holding size*

Land size influenced adoption of crossbred dairy cows. The result of descriptive statistics showed that the mean difference of total land holding size for adopters was greater than non-adopter. The result of Logit model was statistically significant at 5% (p=0.031) showing a negative relationship with adoption of crossbred dairy cows at a negative coefficient of -1.242. As land size increases by one ha, the probability of adoption of crossbred dairy cow declines by 28.9% holding all other variables are constant. As land size increases by one ha, adoption of crossbred dairy cow declines by 9.4%. The possible reason for negative relationship between land holding and adoption of dairy cows could be as households involved in crop production, the adoption of improved dairy cows held less attention. Another probable reason, in many studies, grazing lands and farmlands have contrasted trends, as cropland and livestock size increases; rangeland decreases (McIntire *et al.,* 1992; Iiyama *et al.,* 2007b; IFAD, 2010). In the study of Tesfaye *et al* (2001), farm size has negative relationships with adoption of inorganic fertilizer. Nevertheless, farmland has positive relationship with adoption of improved wheat varieties and sustainable soil management practices (Tesfaye *et al*., 2001; Bikal *et al*., 2015).

iii. *Social responsibility*

Results in χ^2-test showed that social status of household heads was significant at 1% probability level. This variable was also statistically significant in Logit model at 5% (p=0.024) showing a positive relationship between social status and adoption of dairy cows at a coefficient value of 1.344. The odds ratio of 3.834 for social responsibility implied that, a household played a part in socials responsibility while fixing the value of other independent variables, the odds of adoption in crossbred dairy increased by almost threefold. As a household has social responsibility, adoption increases by 10.2%. This result is consistence with the finding of Silva *et al* (2011) studied on mobile phone adoption in six countries of Asia. Social network is an important determinant of technology adoption (Bandiera and Rasul, 2006).

iv. *Livestock size*

According to t-test, the mean difference of livestock size for adopters was greater than non-adopter and statistically significant at 1% significant level. It was also statistically significant in Logit model at 1% (p=0.001) showing a positive relationship between livestock size and adoption of crossbred dairy cows. As expected, livestock increases the odds of adoption, with 1.69. Keeping other things constant, each TLU increased in livestock, the likelihood of crossbred dairy cow have increased by 69%. As livestock increases by one TLU, adoption of crossbred dairy cow increases by 4%. This result is consistence with the study of Bikal *et al* (2015) but in contrast with the finding of Oyekale (2013) that showed the relationship between number of cattle and adoption of improved dairy cattle has correlated negatively and significantly.

e) Implications of improved dairy cows for household food security

Sample households have quantified the amount of food that could satisfy their family's food requirement. An equation is adapted from FAO-WFP (2009) to compute the amount of net available food using the household food balance sheet model. Various studies have used the mean daily per capita food energy value 2100 kcal as a minimum threshold daily energy requirement (FAO-WFP, 2009; WFP, 2009; Demese *et al*., 2010; Messay, 2010; Arega, 2012; Aziz *et al.,*2016). Thus, in this study, the mean daily energy requirement of 2100 kcal /AE /day was used as the lower limit of food secure households. Households less than 2100 calories were food deprived groups and exposed to undernourishment (WFP, 2009). This cut-off point was the mean per capita energy requirement for the normal population distribution of a developing country (WFP, 2009).

HNAF= (OP+FP+R/G +FA) - (PHL+SR+GS+TO) (Arega, 2012)

Where: HNAF is household net available food, *OP* is own production, *FP* is food purchased, *R/G* is remittance or gift, *FA* is food aid, *PHL* is post harvest loss, *SR* is seed reserve , *GS* is amount of grain sold, and *TO* is transfer to others. The equation enables to calculate dietary energy supply.

The supply side of the equation indicated that sample households produced a total amount of 3826.54 qt. Similarly, 124.25 qt was purchased, and 1.80 qt was obtained through transfer. There was no food obtained through aid. Thus, a total amount of 3952.59 qt of food was supplied. The expenditure side of the equation in the same food balance sheet showed food disposals such as 289.56 qt of food was lost due to several reasons, 552.7 qt of seed was reserved, 429.22 qt of food items were sold, and 9.42 qt of food was given to others. Hence, about 1280.9 qt of food was the annual expenditure of households. Consequently, the total amount net dietary energy supply was 2671.7 qt. The total dietary energy supply was divided by number of persons (i.e. 267170 kg ÷ 832.77 persons=320.8 kg/AE/year). Approximately, 225 kg of cereal is equivalent with 2100 kcal (Guyu, 2015). The second method of calculation was in terms of calories. Food secure, marginally insecure, moderately insecure, and severely insecure households were categorized with a value of greater than 2100, 1800-2100, 1500-1800, and less than 1500 kcal, respectively. This type of food insecurity classification was adapted from FAO-WFP (2009).

Table 5: Households' distribution in terms of per capita food consumption (kcal/AE/day)

Food security status	Proportion of households (%)
Food secure	58.8
Mildly food insecure	6.6
Moderately food insecure	7.1
Severely food insecure	27.5

Source: Survey result (2016)

Crops and animal products were the source of dietary energy supply for 58.8% food secure, 6.6% marginally insecure, 7.1%, moderately insecure and 27.5% severely insecure households. Hence, 58.8% households could attain the minimum food requirements. Households with less than the minimum food requirement were accounted for 41.2%, of which 27.5% are severely food insecure (Table 5). Probably, they were unable to meet their minimum food requirement over extended periods. This result is in agreement with the study of Mesfin (2014) who stated that the proportion of food insecure people in *Amhara* region is 42.5%, which is higher than the national average, 33.6%.

IV. Conclusions

In the study watershed, about 28.9% of household-heads were females. Sample household-heads had an average age of 43.8 with a range of 23 to 82 years. The average family size of sample households was 4.54 a minimum of 1 and a maximum 10 persons per household, with 64.3% of active labor force. About 79.2% of household-heads were literate and 25% of heads were leaders in different socio-economic and political responsibilities. Human and livestock population density was estimated to be 85.4 persons per sq.km and 4.18 TLU per ha, respectively. About 92.4% of smallholders have reared livestock.

More than 70% of the topography had steep landscapes with approximately 22.2% of low fertile soils. The average landholding size was 1.34 ha while the average livestock size was 4.0 TLU per household. Almost, 18.4% smallholders have used 0.06 to 0.25 ha of irrigable lands per household. Nearly, 17.5% and 12.3% of households have rented-in and rented-out lands, respectively. Sales from crop and livestock products accounted for 66.3% of the total annual cash income. Just about 83.9% of households have gained average annual cash income of 3892.6 ETB from on-farm activities and 37.4% households have obtained 944.8 ETB from non-farm activities. Thus, the total annual income of households was estimated to be 4832.7 ETB per household. Livestock have contributed for 37.5% of annual cash income and 2.65% of food calories. Most recently, the annual growth of livestock population was 5.5%. The average productivity of a cow was 1.3 and 2.5 liters of milk per day per cow for local and improved breeds, respectively.

Nearly 26.8% of the cattle population was dairy cows that have been kept by 60.2% of households. However, adoption rate for dairy cattle technology was low and slow because 25.8% of cows were improved breeds while 26.8% of households who reared cows have adopted improved dairy breeds. Adopters had better socio-economic characteristics than non-adopters do. High social responsibilities, more number of family sizes, high amounts of on-farm income, agricultural inputs (such as organic and inorganic fertilizers), high livestock population, and better frequency of extension service were some of the characteristics of adopters. Nevertheless, the mean age of adopters was less than non-adopters. Moreover, the number of literate people for adopters was less than their counterparts. The size of irrigation lands and distance of infrastructures were almost similar for adopters and non-adopters. Binary Logit showed that hired labor, social status, and livestock size have influenced positively and significantly the adoption of dairy cow technology, while land holding size has affected the technology significantly but negatively.

About 41.2% of households were food insecure in food availability aspect of food security. Adoption of improved dairy cows has important implications for household food security. The mean daily per capita was estimated to be 2960.63 and 3084.73 kcal/AE/day for non-adopters and adopters, respectively. Household food security per capita and improved dairy cows have positive relationships but in very low correlation coefficient (0.016). Thus, food security per capita in kcal is insignificant (p=0.766) between adopters and non-adopters with t-values (-0.299). Therefore, the production of improved dairy cows should be supported with dairy packages.

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