

Full Length Research Paper

Adoption of artificial insemination service for cattle crossbreeding by smallholder farmers in Laelay-Maichew district, Tigray, Ethiopia

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Adoption of artificial insemination (AI) in Ethiopia is low and there is paucity of information in documentation. Therefore, the aim of this study is to identify the determinants of smallholder farmers' adoption of AI technology in Laelay-Maichew district. Multi-stage random sampling technique was employed to select 155 sample respondents for the study. The primary data were collected through individual interviews using semi-structured interview and check list. Descriptive, inferential statistics and binary logistic model were employed to describe the study results and identify the determinants of farmers to adopt improved breeding method of AI. The farmers' adoption of AI was influenced by access to credit facilities and mobile phone, social participation, formal training, frequency of extension contact, knowledge about AI practice and perception of AI profit positively and participating in off-farm activities negatively. In conclusion, ownership of information and communication technology (ICT), access to extension services (training and extension visit), knowledge of AI practices and perception of profit determined farmers' AI adoption. There is a need to improve the effectiveness of extension service through strengthening the training, frequent home visit, making credit service accessible, and educating farmers regarding the knowledge and importance of AI technology for its effective dissemination.

Key words: Adoption, artificial insemination (AI), crossbreeding cattle, binary logit econometric model.

INTRODUCTION

The demand for livestock products and by-products is increasing in Ethiopia. This is due to the population growth, improving income and urbanization (Smith, 2013). Dairy farming mostly considered as promising option to improve household income and nutrition in developing countries including Ethiopia (Francesconi et al., 2010; Headey et al., 2014). The large cattle

population, the favorable climate for improved, high yielding cattle breeds, and the relatively animal disease free environment make Ethiopia to hold a substantial potential for dairy development (Zelalem, 2012).

Ethiopia has a huge potential for dairy development with the number of milking cows estimated to be 9.9 million dairy cows. The larger proportion of the milk is

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produced from cattle about 83% nationally and followed by goat and camels. The country milk production estimates 3.3 billion liters (CSA, 2015). However, this milk production could not fill the demand of the country and imported an additional \$10.6 million of dairy products (Reddy and Kana, 2016). Because of the milk yield depends on the indigenous cattle with low yielding and the country is found to be net importer of dairy products (FAOSTAT, 2014).

To meet the ever increasing of milk, milk products in Ethiopia and their enhancing income, ensure households food security and alleviate poverty of households and at national level, adoption of appropriate breeding method is crucial to improve the dairy productivity. Genetic improvement of the indigenous cattle through AI program was proposed as one of the options in Ethiopia.

Governmental and non-governmental organizations have been making efforts to improve the cattle genetic resources through conventional artificial insemination (AI) service, distributing improved bulls, introducing pure exotic and crossbred (F1) dairy cows. Those organizations have been providing AI service in operation for over 50 years. In 1967, an independent service was started in the Arsi Region, Chilalo Awraja (district) under the Swedish International Development Agency (SIDA) with establishment of Chilalo Agricultural Development Unit (CADU) that the technology of AI for cattle has been introduced at the farm level in the country as a tool for genetic improvement (Zewdie et al., 2006).

However, the effectiveness of the program is less successful. As a result, the cattle populations of hybrid and exotic breeds are less than 2% (CSA, 2015).

There are many literatures on adoption of agricultural technology. Views show that adoption technologies are subjected by a combination of personal (demographic), social, economic, physical and psychological factors (Boahene et al., 1999; Edwards-Jones, 2006; Pannell et al., 2006; Ergano, 2015).

Personal or demographic factors affected the adoption decision of agricultural technology positively and negatively. For instance, a research shows that age and sex were found to be influenced positively and negatively whereas education shows positive relationship with adoption of AI, dairy and breeding technologies (Howley et al., 2012; Gillespie et al., 2014; Emil, 2011; Dennis, 2010).

The other factors that influence the adoption on AI, dairy and dairy marketing technologies and other agricultural technologies, socio economic and physical factors are the other important point. Research findings like land holding size, livestock holding, off-farm activities and farm income variables show positively and negatively influenced the aforementioned technologies (Howley et al., 2012; Yohannes, 2014; Kaaya et al., 2005; Tefera and Gebre, 2015; Dehinenet et al., 2014; Sime et al., 2014; Singha and Baruah, 2011). Similarly, physical factors of owning mobile phone and distance of AI

service influenced positively and negatively on adoption of dairy technologies, respectively (Gashaw et al., 2014; Yohannes, 2014; Dehinenet et al., 2014; Ergano, 2015).

Institutional factors specifically, advisory service (extension visit), training participation, credit access and social participation variables were found as positive relationship and influence adoption of AI breeding method and husbandry technologies (Howley et al., 2012; Sime et al., 2014; Umeta and Temesgen, 2013; Asmelash, 2014; Singh and Singh, 2013). In other words, psychological factors of knowledge about improved livestock husbandry practices and perception to profit of AI service indicated positive relationship with adoption of these technologies (Fita et al., 2012; Tefera and Gebre, 2015; Yohannes, 2014).

Therefore, the objective of the study aimed to identify the determinants of farmers' adoption of AI for crossbreeding service in Laelay-Maichew district.

METHODOLOGY

The study was conducted at Laelay-Maichew district which is located in the Central Zone Tigray regional state of northern part of Ethiopia. It is 1080 km far away from capital city of Addis Ababa. Geographical location of the district is found at 14°07'00" to 14°09'20"N latitude and 38°38'00" to 38°49'09"E longitude in semi-arid tropical belt of Ethiopia with mid-highland agro climatic zone (Behailu et al., 2004). The district has area coverage of approximately 53,833.39 ha. According to the Laelay-Maichew district Planning and Finance Office (2015), the total population of the district is 65,296 (32165 males and 33,131 females). The map of the study area is as shown in Figure 1.

Household heads who own dairy cows were used as sample frame for the study. Hence, the sample size for the study was determined by Taro (1967) formula. Multistage sampling technique was used to select sample respondents. First stage, Laelay-Maichew district was selected purposively for its potential of dairy cattle and AI used for crossbreeding dairy cattle. Second stages, five Kebeles were selected from 15 rural Kebeles using random sampling method. Third stage, household's stratified into adopters and non-adopters. Finally, 155 sample households were selected systematically and randomly taken proportional to sample size from each stratum (adopters and non-adopters) of the rural household heads who owns dairy cows. Semi-structured questionnaire employed as data tool and collected data interviewing of households and from key informant group discussion of quantitative and qualitative data in 2016/2017. Stata software version-12 was used to analyze the collected data. A descriptive statistical analysis was employed to discuss the collected survey data using frequency, mean, standard error and percentage. Inferential statistical method of t-test and χ^2 -test was also used to test for significant differences in socio-economic and significant association in socio-economic characteristics of adopters and non-adopters, respectively. Binary logit econometric model was used to see the influence of hypothesized variables on the decision to adopt/or not to adopt AI (Table 1).

Definition of variables and working hypothesis

Definition of dependent variable

It is treated as dummy variable which takes the value 1 if the farmer

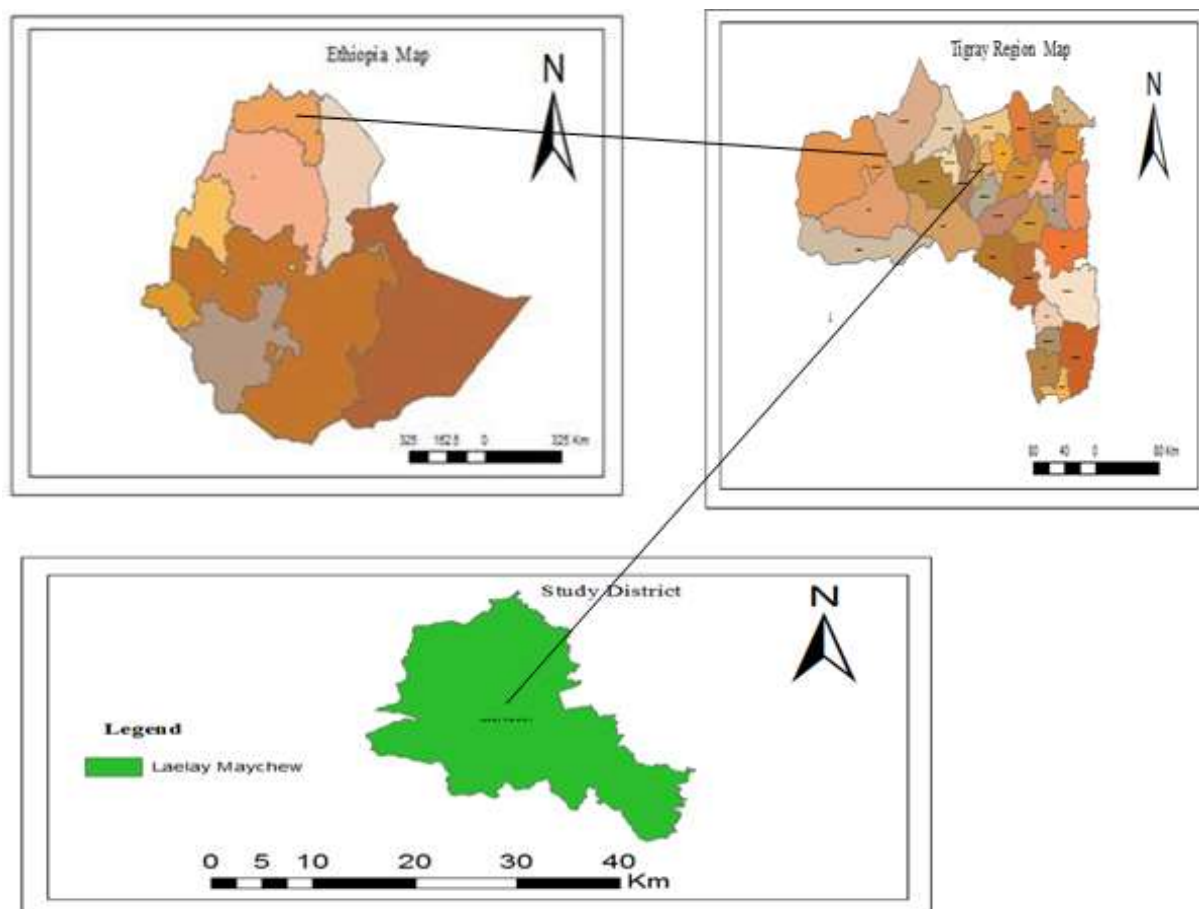


Figure 1. Map of the study area.

Table 1. Working hypothesis of dependent and independent variables.

No.	Variable	Types	Measurement	Hypothesis
Dependent				
	Farmers' adoption AI	Dummy	1 if a farmer has adopted AI, 0 otherwise	
Independent				
1	AGEHH	Continuous	Age of household heads in year	+/-
2	SEXHH	Dummy	Sex of household head 1= if male headed 0=otherwise	+/-
3	EDULEVEL	Dummy	1= if household head literate 0=otherwise	+
4	LHHH	Continuous	Total cultivable land of household heads in hectare	+/-
5	LIVHOLD	Continuous	Total livestock holding measured in TLU unit	+/-
6	OFFINM	Dummy	1=if participate on off-farm activity 0=Otherwise	-/+
7	ANFICM	Continuous	Total annual farm income of the household	+
8	ACMPN	Dummy	1=if household head own mobile 0=Otherwise	+
9	FREXTNCNT	Categorical	Frequency of HHs contact with extension agent	+
10	CREDACCS	Dummy	1=if the household heads get credit 0= Otherwise	+
11	DISAICR	Continuous	One way walking trip in km from home to AI service delivery center	-
12	SOCLPAN	Dummy	1=if the household head participate in social organizations 0= Otherwise	+
13	PAITRG	Dummy	1= if the household head attended in formal training 0= Otherwise	+
14	KNGEAI	Dummy	The household head knowledge towards AI	+
15	PPAIS	Categorical	The household head perception on profit of AI	+

Table 2. Descriptive analysis of continuous explanatory variables (mean±SE).

No.	Variable	Adopter	Non-adopter	t-value	p-value
		Mean ± SE	Mean ± SE		
1	AGEHH	50.932 ± 1.376	52.564 ± 2.238	0.878	0.381 ^{NS}
2	LHHH	1.087 ± 0.096	0.824 ± 0.071	2.292	0.004*
3	LIVHOLD	5.202 ± 0.280	4.536 ± 0.173	2.114	0.036**
4	ANFICM	6681.043 ± 831.923	3466.024 ± 377.575	2.372	0.019**
5	DISAICR	6.235 ± 0.501	7.665 ± 0.423	3.830	0.000*

Exchange 1\$ = 22.4103 Eth birr (End of 2016). * and** represent significant at 1 and 5%, respectively. NS=Non-significant, SD=standard deviation.

Source: Computed from Own Survey (2017).

adopts AI breeding service (used AI for crossbreeding purpose of their indigenous dairy cows) and 0, otherwise.

Definition of independent variables and hypothesized relations

The relation of dependent variables are summarized in Table 1.

RESULTS AND DISCUSSION

Descriptive analysis of continuous variables

The result of the analysis shows that the average age of household heads of adopters were 50.90 years whereas the non-adopters were 52.60 years. The t-test shows no significance between the ages of adoption category. On other hand, landholding and livestock holding (in TLU) of the households of adopters were 1.087 ha 5.20 TLU and 0.82 ha 4.53 TLU of non-adopters, respectively. In other words, the average annual farm income of adopters, an Ethiopian birr of 6681.04 as well as non-adopters was 3466.02, which shows adopters earn an additional income Ethiopian birr of 3215.019 compared to the non-adopters from sale of agricultural products excluding off-farm income. The distance of the household's heads home of adopters to the extension service center was found to be 6.24 km whereas the non-adopters is 7.67 km (Table 2).

Descriptive analysis of dummy and category variables

The descriptive analysis of the dummy and categorical variables is shown in Table 3. The sex of adopter household heads was found 91% male and 9% female whereas the non-adopters are 85 and 15%. About 58% adopters and 31% non-adopters of household heads have access to off-farm activities as source of income. Household heads about 75 and 72% adopters and 33 and 26% non-adopters participated in social institutions and training accessibilities, respectively. In other hands, households 73 and 54.5% adopters and non-adopters, respectively have got credit accessibility from credit

institution. 91 and 60% of the household heads own mobile phone adopters and non-adopters, respectively. The frequency contact of extension workers with the households shows about 15, 17 and 68.6% as well as 9, 10 and 80.7% of household heads adopters and non-adopters, respectively got an extension service from the district experts and development agents. In other words, the household heads were found to have a knowledge of 88 and 45.5% about the AI breeding practice adopters and non-adopters, respectively. About 95.5% adopters and 86.37% non-adopters respondents agreed on the profitability that they perceived AI is important on upgrade of indigenous dairy cows. In other words, 2.98 disagreed on the importance of AI service.

Determinants of adoption of AI

The result of the econometric model shows that out of the fifteen explanatory variables, eight variables significantly determine the probability of smallholder farmers adopting improved breeding method of AI at various level of statistical significance. These potential explanatory significant variables were participation on off-farm activities, social participation, attending formal training, access to credit and access to mobile phone, frequency of extension contact, knowledge about the AI breeding and perception to the profit breeding (Table 4).

Off-farm activity participation (OFFINM)

The result analysis is consistent with the expected hypothesis. Off-farm income activity participation had significant and negative relationship with adoption of improved breeding method of AI at 10% significance level. The result shows that access to off-farm activities decreased the probability of adopting the improved breeding method by 21.6%.

The reason could be that farmers obtained attractive income from the off-farm activities compared to the dairy production not likely to adopt AI breeding method. Raring crossbred dairy cows need intensive management to

Table 3. Descriptive analysis of dummy and categorical variables.

Variable	Description	Adopter		Non-adopter		Total		χ^2	p-value
		N	%	N	%	N	%		
SEXHH	Male	61	91	71	81	132	85	3.2	0.070***
	Female	6	9	17	19	23	15		
OFFINM	Yes	39	58	27	31	66	43	11.78	0.001*
	No	28	42	61	69	89	57		
SOCLPAN	Yes	50	75	29	33	79	51	26.43	0.000*
	No	17	25	59	67	76	49		
PAITRG	Yes	48	72	23	26	71	46	31.73	0.000*
	No	19	28	65	74	84	54		
CREDACCS	Yes	49	73	48	54.5	97	62.5	5.61	0.018**
	No	18	27	40	45.5	58	37.5		
ACMPN	Yes	61	91	53	60	114	73.5	18.6	0.000*
	No	6	9	35	40	41	26.5		
EDULEVEL	Illiterate	15	22.4	36	41	51	33	4.05	0.257NS
	Literate	52	77.6	52	59	104	67		
FREXTNCNT	Weekly	10	15	8	9	18	11.6	5.91	0.015**
	Monthly	11	17	9	10	20	12.9		
	Some times	46	68.6	71	80.7	117	75.5		
KNGEAI	Yes	59	88	40	45.5	96	63.8	20.3	0.000*
	No	8	12	48	54.5	59	36.2		
PPAIS	St. agree	17	25.4	8	9.1	25	16.1	15.82	0.001*
	Agree	47	70.1	68	77.3	115	74.2		
	No opinion	1	1.49	12	13.8	13	8.38		
	Dis-agree	2	2.98	0	0	2	1.29		
	St. disagree	0	0	0	0	0	0		

*, ** and*** represent significant at 1, 5 and 10%, respectively. NS= Non-significant.
Source: Computed from Own Survey (2017).

make farmers ignore the technology; they obtain less profit compare to the off-farm income. Because they focused on off-farm activities income as their main business deciding not to adopt the AI breeding method; instead they used natural breeding method (local bull). The result of this research agrees with the findings of Howley et al. (2012) and Dehinenet et al. (2014) where off-farm activities participation was found to negatively affect adoption of AI breeding method and husbandry adoption. They reported that a household who participated in off-farm activities had time constraint and used AI as labor intensive than using a bull to breed cows that needs to observe detection coming to heat and find

AI technicians. Conflicting result was reported by Sime et al. (2014) that off-farm income was found to positively affect household head adopting AI that off-farm income helps AI breeding method for more dairy cows crossbreeding which is used to keep more crossbred calves which they need to obtain additional source of income.

Social participation (SOCLPAN)

As the analysis result implies, participating in local and public institutions and organizations had significant and

Table 4. Binary logit model output of adoption of AI in Laelay-Maichew district.

No.	Variable	Coefficient	Standard error	Marginal effect	Z	P-value
1	SEXHH	0.785	0.722	0.151	1.09	0.277
2	AGEHH	0.001	0.023	0.002	0.04	0.967
3	LHHH	0.103	0.373	0.041	0.28	0.783
4	LIVHH	0.106	0.128	0.031	0.82	0.410
5	OFFINM	0.949	-0.495	-0.216	1.92	0.055***
6	ANFICM	0.001	0.0006	0.002	1.53	0.164
7	SOCLPAN	1.358	0.479	0.243	2.84	0.005*
8	PAITRG	0.958	0.452	0.178	2.12	0.034**
9	CREDACCS	1.417	0.467	0.277	3.04	0.002*
10	DISAICR	0.021	0.060	0.005	0.34	0.733
11	ACMPN	1.429	0.505	0.277	2.83	0.005*
12	EDULEVEL	0.249	0.592	0.059	-0.42	0.674
13	KNGEAI	0.751	0.302	0.059	2.49	0.013**
14	FREXTNCNT					
	Once a week	0.056	1.615	0.015	-0.03	0.972
	Once a month	0.747	0.373	0.146	1.99	0.015**
15	PPAIS-					
	Strongly agree	0.017	1.144	0.015	0.01	0.988
	Agree	3.230	1.477	0.262	2.19	0.029**
	No opinion	1.052	0.654	0.134	1.61	0.142
16	Con	-4.888	2.011		2.243	0.015
Hosmer and Lemeshow goodness of fit test ($\chi^2=124.24$, $P=0.63$)						
	Observation				155	
	-2Log-likelihood				72.20	
	Pseudo R ²				0.48	

*, ** and *** significant at 1, 5 and 10%, respectively.

positive relationship with the adoption of improved reproductive method of AI. This was found significant at 1% significance level and positively affected the likelihood of adopting the AI technology. Household heads involved in Iquib/edir and public organizations of cooperatives, farmers' development group/army show that the probability of adopting AI had increased by 24.3%. Households' heads participated in public organization of cooperatives, farmers' development group and farmers association help to get new information and other best experiences influence the use of improved breeding method. This result is similar with research findings of Asmelash (2014) that participation in extension organizations was found to be positively affect households to have credit access, access to extension and market.

Participating in training (PAITRG)

Participation in formal (technical) training session about

livestock technologies helps to acquire new knowledge about improved livestock production techniques aware of the improved breeding method and required agricultural production. As the logit model indicates prior to expectation, attending formal training was found to be significant and positive relationship with adoption of improved breeding method of AI at 5% significance level. Household heads' attending formal training had the probability of adopting AI increased by 17.8%. Therefore, understanding from the model result analysis, households who participated in formal training have the probability to adopt the improved breeding method of AI technology would increase. The reason that obtained formal training helped respondents to know the pre-and post-adoption of AI crossbreeding practices and packages. The finding of this research is confirms with findings of Saka and Lawal (2009) in Nepal, Hagos (2015) and Gebiso (2015) in Ethiopia, who noted that participated households on organic vegetable, improved rice, teff and modern beehive related training were found to be positively affected by adoption of these improved technologies.

These findings justified those households' heads who had participated in the training and are helped to acquire skill and knowledge about the practical application of the production package.

Farmers' access to credit (CREDACS)

As it was expected, accessibility to credit facility was found to be significant and positively related to the adoption of improved reproductive breeding technique of AI at 1% significance level. The logit model indicated that attained credit facility makes the households' increased the likelihood to adopt the AI technology by 27.7%. Credit accessibilities help to provide enough resource and nutritional feed equally required as the AI service for conception and to reduce AI service repetition. The reason that credit facility service fills the farmers' gap, the financial provision expense for purchase Begait local dairy cows (for crossbreeding purpose) which are provided by the district in kind and cash and for other improved inputs of recommended feed and wise management. Therefore, credit access helps farmers to relax financial constraints to invest in dairy technology since the ongoing of adopting AI technology need high capital. The result of this survey agrees with the research findings of Umeta and Temesgen (2013) and Tsibuk (2015) who reported that credit accessibility helped farmers to purchase agricultural input for fattening cattle and improved seed and fertilizer for teff production, respectively.

Access to mobile phone (ACMPN)

Access to mobile phone is other important determinant factor and helps to get AI beneficiaries quick service from the AI to take their cows when coming to heat. As it was expected, ownership of mobile phone was found significant and positively related to the adoption of improved breeding method of AI at 1% significance level. Household heads' access to mobile phone had explained the likelihood of adopting the AI technology increase by 27.7%. In the study area, farmers used the mobile phone call for the AI technicians when they want a service for their cattle comes to heat. This contributes to the farmers to get quick responses from the AI technicians' availability of service to take their dairy cow to AI service delivery center. Therefore, having the accessibility to mobile phone would increase in favor to adopt the improved technology and improve their production efficiency. This agrees with the findings of Tadesse et al. (2014), Ergano (2015) and Yohannes (2014) that households who participated in cooperative and dairy production get timely information and better communication about their cooperative activities and dairy technologies.

Knowledge about AI (KNGEAI)

Knowledge is a key determinant of the farmers' to adopt and use continuously the improved method of AI to improve income of household. The result of logit model reveals that the knowledge of the households towards the reproductive method of AI had significant and positive relationship with adoption of AI at 5% significance level. As the analysis result show, the likelihood of adopting AI by household heads with knowledge about the technology increased by 5.9% significance level. This might be due to reason that knowledge about the specific practices of crossbreeding which needs the ability to select good performance cow fitted for crossbreeding, knowledge of heat detection and the accepted time for insemination, the proper feed supply, comparative advantage and disadvantage of the improved breeding method as compared to the natural breeding method (local bull) contributes to the adoption of AI technology by households. This confirms the research findings of Fita et al. (2012), where knowledge was found to positively related to the adoption of dairy husbandry practices and contributed knowledge acquired from the training of household heads had the probability of adopting dairy husbandry.

Frequency of extension contact (FREXTNCNT)

Frequency of contacts with extension agents is important and helps for making farmers technically skillful and confidential on managing integrated dairy production in a sustainable manner. Therefore, the frequency of contacts with extension agents had positively influenced the adoption of crossbreeding method at 5% significance level. The likelihood of adopting AI by households heads who get extension advice monthly in relation to households obtain advice sometimes within a year increased by 14.6%. The reason is that farmers gained technical advice about the preconditions needed for improved breeding method practice helped to adopt AI technology. Awareness of farmers about the input needed for crossbreeding dairy cows and the benefit given is important to the knowledge of households to the given advice by DAs to adopt the technology might be the most important attained by the households. This finding agrees with findings of Sime et al. (2014), frequency extension contact was found to positively affect adoption of AI. He justified that farmers obtained information about production activities and procedures of cattle breeding using AI.

Perception towards to profit AI service (PPAIS)

As expected from the prior hypothesis, the variable perception towards profit of AI technology was found to

be statistically and positively related with the adoption of improved breeding method of AI at less than 5% significance level. The econometric model result showed the possibility of adopting improved reproductive practice by those household heads who agree that the breeding method is profitable compared to those who dis-agreed about the profit of AI that other things being constant adopting the AI technology increased by 26.2%. Farmers in the study area perceived that crossbred dairy cattle gives good performance to crossbred heifers and high milk yielding compared to the local dairy cows with less productive contribution of households to adopt the breeding method. Households keep productive dairy cattle than the local dairy cattle that consume more but give low milk yield important points to select AI breeding method for upgrade of the indigenous dairy cattle breeds. This result is in line with the research findings of Yohannes (2014) that household respondent's perception towards the importance of AI was found to be positively affected by the use of AI for their dairy cows.

CONCLUSION AND RECOMMENDATION

Respondents (adopters) who obtained credit facility and owning mobile phone, participated in social institutions and public organizations and obtained formal training had the probability of adopting the improved breeding method of AI to improve their indigenous dairy cattle. Households who got the extension advice by development agents having knowledge about the crossbreeding practices (AI) and respondents who perceived that AI is profitable contributed to being involved in crossbreeding program of indigenous dairy cattle through AI service. On the other hand, participation of respondents out of agriculture in off-farm activities as option of income source constrained adopting AI by smallholder farmers in the study area. Improving the effectiveness of extension service by strengthening the training, frequent home visit and making accessible the credit service plays great role in adoption of the technology. Educated and aware farmers regarding the knowledge and importance of AI technology for its effective dissemination is important. Further investigation is needed on the effectiveness of AI service and extension service strategy in the study area.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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