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Research Article

The Role of Improved Coffee Variety Use on the Adoption of Key Agricultural Technologies in the Coffee-Based Farming System of Ethiopia

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Abstract: The purpose of the study was to study the adoption status of agricultural technologies and identify factors affecting the adoption of the technologies in the coffee-based farming system of Ethiopia. The study was conducted in major coffee-growing regions of the country: Oromia and SNNP. A multistage sampling technique was employed to select the population for the study which involved both purposive and random sampling techniques. A total of 953 sample households were selected for the study. Descriptive statistics were used to analyze and summarize the collected data. A multivariate probit model was also engaged to estimate the factors that influenced the adoption of improved agricultural technologies (coffee, maize, and crossbreed cows/heifers). The result indicated that the adoption rate of improved coffee and maize varieties was 60 and 72%, respectively. The result also exhibited that 58% and 53% of coffee and maize land was covered by improved varieties, respectively in both regions. Alongside, on average only 6% of the farmers have adopted crossbreed cows/heifers. A relatively high adoption level of crossbred dairy technology was seen in the SNNP region (11%) compared to Oromia (3%). A multivariate model result indicated that improved coffee variety adoption is positively and significantly correlated with improved maize variety adoption and adoption of crossbreed cattle. The result implies that the adoption of improved coffee technologies enhances the adoption of other agricultural technologies. Land size, TV, and radio ownership have affected the adoption of improved coffee varieties positively and significantly. Distance to the all-weather road has a negative and significant relationship which implies that the adoption of coffee varieties declines as the farmers are located farther away from an all-weather road. Land size and education of the household head has also a positive and significant effect on the adoption of improved maize varieties. However, TLU and distance to the district town have a negative and significant effect. On the other hand, male-headed households are less likely to adopt crossbreed cows compared to female-headed. Land size, family size, education level of the household head, and radio ownership have a positive and significant effect on the adoption of crossbred cows, while the distance to the district town has a negative and significant effect. The study recommends multi-technology popularization, diffusion, and adoption to transform smallholder farmers to the next level. Improving the accessibility of farmers to the market and technology sources through the improvement of communication technologies and transportation services is also crucial.

Keywords: Adoption, communication, crossbreed, descriptive, multivariate and technology.

INTRODUCTION

Agriculture driven Gross Domestic Product (GDP) growth is more effective in reducing poverty than GDP growth driven outside agriculture. Thus, policies that increase agricultural productivity can have a significant impact on poverty reduction as the main objective of the generation of modern agricultural technology is to obtain the highest yields and highest economic profit possible. The adoption of modern agricultural technologies is critical for improving agricultural productivity especially in developing countries where new agricultural technologies remain limited and traditional farming practices pre-dominate farmers' farm and plot [1]. These modern agricultural technologies constitute the introduction and use of hybrids, the greenhouse technology, genetically modified food, chemical fertilizers, insecticides, tractors, and the application of other scientific knowledge [2]. Adoption is defined as the integration of innovation into farmers' normal farming activities over

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an extended period [3]. According to Rogers [4], the decision to adopt a new technology involves awareness, persuasion (gaining sufficient information on the characteristics, benefits, and costs of new technology), decision, implementation, and confirmation. Adoption could be measured as the proportion of farmers using the technology or the actual proportion of fields or crop area under the new technology [5]. These two measures will produce comparable results when farm sizes are similar or the rate of adoption is constant across farm sizes. Empirical studies revealed farmers' characteristics, technology characteristics and institutional factors affect agricultural technology adoption [6].

The coffee-based farming system of Ethiopian is situated in the south, southwestern, and western parts of the country. It is characterized by high rainfall, undulling topography, a huge area of forest, and large trees. Coffee and *enset* dominate the southern part while coffee and maize lead the southwestern and western part of the farming system. Federal and regional research centers have done a lot of works to generate and popularize several improved agricultural technologies and practices for farmers. For instance, Jimma agricultural research centers in collaboration with other research centers have released 35 pure lines and 6 hybrids total of 41 coffee varieties for different coffee belts of the country. These improved coffee varieties offer new opportunities for farmers because of their unique characteristics of high sensory quality, higher yield, and huge tolerance to major coffee diseases. Moreover, several recommendations have been developed on pest and disease management, agronomic, and soil fertility management. The effort by the research in the generation and popularization of cereal, pulse, vegetable, fruit, dairy, and forage technologies is also prominent in the farming system through the supply is not satisfactory in the face of high technology demand. To facilitate the uptake of these technologies, Ethiopia has adopted different forms and approaches to extension interventions. The major ones include pre-extension on-station, on-farm demonstrations, and popularization, hands-on training, workshops and conferences, field days and visits, seed and seedling distribution, etc.

Despite the efforts by the research and extension, there is no adequate information regarding the adoption status and adoption-related constraints for different agricultural technologies which could be used as an input for policy intervention in the farming system. Limited previous studies conducted are not only location specific and unrepresentative, but also the information is obsolete and inadequate to capture the growing technology demand of the farmers. This study is believed to bridge-up the gap by generating up-to-date information which helps to generate appropriate technologies and design workable and applicable research and extension intervention. It will also provide inputs for informed policymaking.

Coffee is the main cash crop for farmers of the farming system. It is assumed that the adoption of improved coffee technologies affects the yield and income positively which in turn enhances the adoption of other capital-intensive technologies such as dairy cows. Unlike other studies conducted before [7-11], this study has investigated the relationship between the adoption of different agricultural technologies such as coffee, maize, and dairy cattle.

The purpose of the study was to identify demographic, socio-economic, and institutional factors affecting the adoption of different agricultural technologies in the coffee-based farming system of Ethiopia. Moreover, the study was intended to explore agricultural technology adoption status, study farmers' access to improved agricultural technologies and technology adoption related constraints in the study areas and investigate factors affecting the adoption of improved agricultural technologies.

DATA AND METHODS

Study area

The study was conducted in the major coffee-growing regions of the country: Oromia and SNNP. Four major coffee producing administrative zones [1] were selected from each of the target regions. Gedeo, Sidama, Kafa, and Sheka from the SNNP region and Ilubabor, Jimma, West Wollega, and Kellem Wollega from the Oromia region were the zones selected for the study. Even though Kafa is administratively under SNNP region, its sample has been included with Oromia for similarity of its agro-ecology with adjacent zones selected from Oromia region.

[1] Zone is the second administrative tier of regional states. In Ethiopia, there are nine regional states. Each regional state is divided into zones, and zones in turn embrace districts. Following districts comes, the grass-root structure of peasant associations.

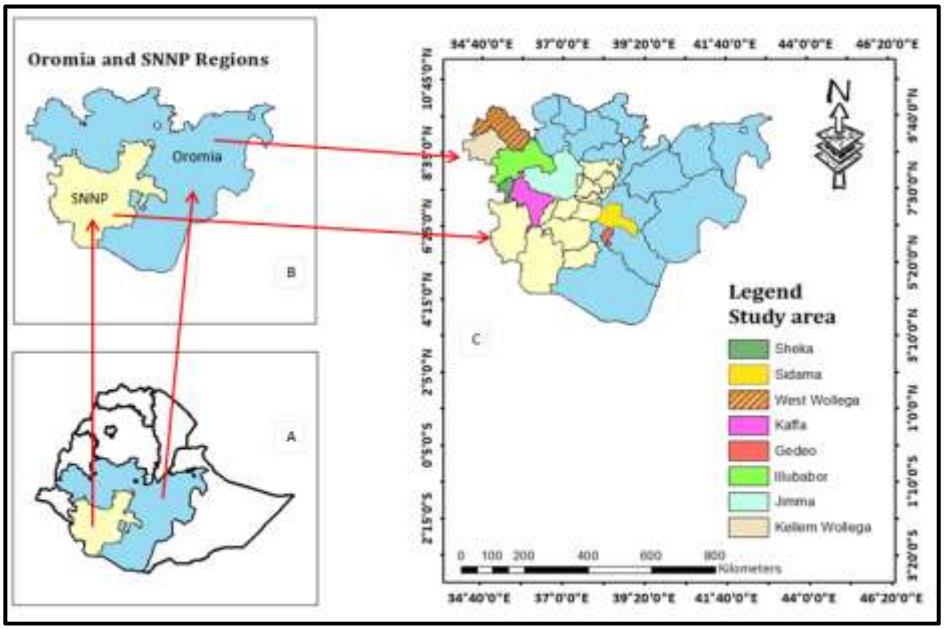

Fig-1: Map of the study areas

Note: A = Map of Ethiopia, B=Map of the study regions, C=Map of the study zones

SAMPLING AND DATA COLLECTION

The multistage sampling technique was employed to select the population for the study which involved both purposive and random sampling techniques. First, regions and zones were purposively selected based on the number of coffee growers, the area allocated for coffee, and the quantity of coffee produced. Accordingly, Oromia and SNNP regions were purposively chosen for the study because these regions alone accounted for 89% of coffee growers, 97% of the coffee area, and 99% of coffee production in the country [39]. Secondly, districts and peasant associations were selected using a random sampling technique. Finally, households were randomly chosen from the sampling frame of the coffee grower population at the peasant association levels. Eventually, a total of 953 sample households were selected for the study (584 from SNNP and 369 from Oromia Regions) (Table 1). Data was collected from the sampled households through a structured questionnaire administered to sampled farmers. Before the actual survey, the questionnaire was pretested in non-sampled villages. Trained enumerators were used to collect the data with close supervision of researchers. The data was collected using CSPro software which largely helped to minimize non-sampling errors and improve data quality. The data was thoroughly cleaned before commencing analysis.

Table-1: Total sample size and sample distribution along study zones

Region	Zone	Total sample size	% of the total
SNNP	Gedeo	199	21
	Sidama	200	21
	Sheka	81	8
	Sub-total	480	50
Oromia	Ilubabor	121	13
	Jimma	107	11
	West Wollega	105	11
	Kellem Wollega	36	4
	Kafa	104	11
	Sub-total	473	50
Grand Total		953	100

Source: Survey result, 2018

Analytical framework: a multivariate probit model

Descriptive statistics and econometric models were used to analyze and describe the collected and cleaned data. Furthermore, a multivariate probit (MVP) model was used to estimate the factors that influenced the adoption of improved agricultural technologies (coffee, maize, and crossbreed cows/heifers). Farmers adopt a mix of technologies to deal with a multitude of agricultural production constraints. This implies that the adoption decision is inherently multivariate, and attempting univariate modeling would exclude useful economic information about interdependent and simultaneous adoption decisions [12]. The Multivariate Probit (MVP) approach simultaneously models the influence of the set of explanatory variables on each of the different agricultural technologies, while allowing for the potential correlation between unobserved disturbances, as well as the relationship between the adoptions of different technologies [10]. One source of correlation may be complementarities (positive correlation) and substitutability (negative correlation) between different agricultural technologies. Failure to capture unobserved factors and interrelationships among adoption decisions regarding different practices will lead to bias and inefficient estimates [14]. The model was also used by recent studies by Kassie *et al*., [15], Koppmair *et al*., [16], and Ali and Burton [17]. The adequacy of the MVP method over other suitable models was formally tested with the likelihood ratio test.

The observed outcome of agricultural technologies adoption can be modeled following random utility formulation. Consider i^{th} farm household (i= 1, 2, 3 …N) which is facing a decision on whether or not to adopt improved coffee, maize, and dairy technologies. Let U_0 represents benefits to the farmer from local technologies (local varieties and breeds) and let U_k represent the benefit of adopting the K^{th} technology (ICV, IMV, CBC) denoting the adoption of Improved Coffee Varieties (ICV), Improved Maize Varieties (IMV) and Crossbreed Cows/heifers.

The farmer decides to adopt the K^{th} technology if $Y^*_{ik}=U^*_k-U_0>0$. The net benefit (Y^*_{ik}) that the farmer derives from K^{th} technology is a latent variable determined by observed household and location characteristics (X_i) and unobserved characteristics (μ_i):

$$Y^*_{ik} = X'_i\beta_k+u_i \qquad (K= \text{ICV, IMV, CBC})$$

Using the indicator function, the unobserved preferences in the equation above translate into the observed binary outcome equation for each choice as follow:

$$Y_k = \begin{cases} 1\ if\ Y^*_{ik} > 0 \\ 0\ otherwise \end{cases} \qquad (K = \text{ICV, IMV, CBC})$$

In the multivariate model, where the adoption of several technologies is possible, the error terms jointly follow a multivariate normal distribution (MVN) with zero conditional mean and variance normalized to unity (for identification of the parameters) where (μ_{ICV}, μ_{IMV}, μ_{CBC}) ~ MVP (0, Ω) and the symmetric covariance matrix Ω is given by:

$$\Omega = \begin{bmatrix} 1 & \rho_{ICVIMV} & \rho_{ICVCBC} \\ \rho_{IMVICV} & 1 & \rho_{IMVCBC} \\ \rho_{CBCICV} & \rho_{CBCIMV} & 1 \end{bmatrix}$$

ρ is the pairwise correlation coefficient of the error terms with regards to any two of the estimated adoption equations in the model. The correlation between the stochastic components of different improved technologies adopted is represented by the off-diagonal elements (e.g. ρ_{ICVIMV} ρ_{ICVCBC}) in the variance-covariance matrix [18]. The correlation is based on the principle that the adoption of a particular improved technology may depend on another (complementarity or positive correlation) or may be influenced by an available set of substitutes (negative correlation). If these correlations in the off-diagonal elements in the covariance matrix become non-zero, it justifies the application of a multivariate probit instead of a univariate probit for each technology. The variables included in the model have been provided in Table 2.

Table-1: Variables included in the model and their descriptive summary

Variable	Description	Observations	Mean	SD	Min	Max
Region	0=Oromia 1=SNNP	953	0.61	0.49	0	1
Sex of the household head	0=Female 1=Male	953	0.90	0.29	0	1
Age of the household head in years	Continuous	953	42.60	12.28	21	90
Mean education of the household head in years	Continuous	953	4.81	3.48	0	13
Family size (number)	Continuous	951	6.33	2.34	1	17
Radio ownership	0=No 1=Yes	953	0.54	0.50	0	1
TV ownership	0=No 1=Yes	953	0.11	0.31	0	1
Extension service on livestock management	0=No 1=Yes	916	0.78	0.39	0	1
Extension service on crop management	0=No 1=Yes	923	0.86	0.28	0	1
Credit service	0=No 1=Yes	953	0.37	0.48	0	1
Distance to district town in km	Continuous	913	9.43	8.07	1	90
Distance to the all-whether road in km	Continuous	910	2.05	4.95	1	78
Head engaged in off-farm income-generating activities	0=No 1=Yes	953	0.25	0.42	0	1
Total land size in hectares	Continuous	928	1.76	1.79	0.01	12
Tropical Livestock Unit/TLU	Continuous	953	4.15	4.43	0	19

RESULTS AND DISCUSSIONS

Farm household characteristics

This study has considered different socio-demographic, economic and institutional variables in the model to explore factors affecting the adoption of major agricultural technologies in the farming system. The descriptive results showed that the mean age of the household heads was nearly 43 years with a minimum of 21 and a maximum of 90 years. The mean completed years of education of the household heads were also 4.8 years with as low as zero (22% of the households) and a maximum of 13 years. The average family size of the household was 6.33 persons, which is higher than the national average of 4.6 and that of many countries. This could largely be attributed to limited access of households for family planning services. More than half of the farmers (54%) owned functional radio while 11% of them owned TV. In coffee based farming systems, farmers are perceived to have better economic status than others dependent on cereals. Therefore, ownership of communication technologies is perceived to be low.

Numerous farmers in Ethiopia continue to cultivate crops and raise livestock in the same ways that have been used in their communities for generations. Most of these farmers are often either unfamiliar with new technologies and practices or have no access to inputs and markets which is primarily related to extension services. The study result showed more than 75% of the farmers have received extension services both on livestock and crop production, which is a witness to the commitment of Offices of Agriculture in helping farmers for better management of agricultural practices. However, the efficiency of extension services and the provision of updated agricultural information are remains to be the fundamental issue.

The investment capacity of the majority of our farmers is low as they are poor and cannot afford to meet the increased demand for the purchase of inputs, such as improved seeds, fertilizer, hiring farm machinery, and others. This indicates the need for credit services for smallholder farmers. However, farmers who received credit services in the study areas were 37%. Limited access to farm credit services could be one of the challenges for transforming agriculture.

The mean distance to the district town and all-whether road was 9.43 and 2.05 kilometers, respectively. Farmers who are located far away from towns might exercise limited market participation and input uses in farming. It may also deter their involvement in supplementary sources of income generating activities. This might be one of the reasons why only 25% of the households had engaged in off-farm income generating activities. Regarding land ownership, on average, a farmer owns 1.76 hectares of land. Land is the scarcest resource especially in coffee based farming systems where farmers have already planted perennials on limited holdings, but did not have other plots to grow annuals, such as maize.

Livestock rearing is also the major means of livelihoods in the coffee-based farming system of the country. The mean Tropical Livestock Unit (TLU) was 4.15.

Patterns of improved technology adoption

Three main agricultural technologies have been selected for the study: two crops and one livestock. It is assumed that the adoption of improved coffee production technologies, which is the major source of income, drives farmers to profitability and enhances the adoption of other technologies especially capital-intensive ones, such as crossbreed dairy cattle. Empirical studies indicated that in many parts of the country, adoption status of crossbred dairy cattle is limited on account of limited availability and unaffordable prices of crossbred cows or heifers. For instance, the study by Agajie *et al*. [19] has reported that adoption rate of crossbred cows in central highlands of the country was 19%. Supply limitation has become the root cause of the unaffordable price of crossbreed dairy heifers that ranged from ETB 30,000-40,000 per cow or heifer. This study has explored how the adoption of improved coffee (major cash crop) varieties boosts the adoption of capital-intensive technologies.

Improved crop varieties adoption

Oromia and SNNP regional states have been introducing and disseminating improved agricultural technologies for decades. The Bureaus of Agriculture had been supporting and enhancing the capacity of farmers to help them increase the adoption of technologies and improve their livelihoods.

According to the findings of this study, 60% of the farmers on average have adopted improved varieties of coffee in both Oromia and SNNP regions (Table 3). This indicates that both regions had similar access to coffee production technologies. The fact that coffee is the major commodity in these two regions and the government's priority focus given to enhance its production and productivity, this level of adoption could still is perceived as low. Apart from this, coffee is the highly demanded commodity in both domestic and world markets. However, the country could not yet meet this ever growing demand mainly due to limited productivity and production of coffee, which is a witness for inadequate adoption level of improved coffee production technologies.

The other major crop highly adopted in both Oromia and SNNP regions was improved maize varieties with an average adoption rate of 72%. The farmers of the SNNP region (77%) were more adopters of improved maize varieties and associated technologies than Oromia counterparts (68%). Oromia is basically a major grower of maize than SNNP despite the expansion of improved technologies still requires further attention and efforts. The other major crop in the study areas is wheat where 45% of the overall farmers on average adopted improved varieties and associated packages. Wheat is not only a major one but also a highly adopted crop in the Oromia (53%) region compared to SNNP (25%).

Since the farmers' allocated more than one plot to a crop, the study has also assessed plot level adoption. For instance, out of the many plots' farmers allocated for coffee, they planted improved varieties on almost half of (48%) them while the other half (52%) were still occupied by local coffee plants. This implies that a substantial proportion of coffee growers are still partial adopters. Strengthening extension services and creating access to quality and adequate supplies of improved coffee seedlings will eventually lead to full adoption where farmers will allocate all of their plots to improved coffee. In such cases, coffee supply both for domestic and world markets will be largely enhanced in quantity and quality.

Table-3: The adoption rates of major crops along the study regions (% of adopter households)

Crop	Oromia n=369		SNNP n=584		Overall n=953		Chi^2	The P-value for HH level adoption
	Plot level	Household-level	Plot level	Household-level	Plot level	Household-level		
Coffee	48	60	48	61	48	60	0.02	0.898
Maize	72	68	76	77	73	72	6.42	0.011**
Enset	5	5	10	11	9	10	2.34	0.126
Teff	16	21	50	63	22	29	31.6	0.000***
Haricot bean	24	24	50	25	32	25	4.37	0.037**
Pulses	11	14	25	25	14	17	8.31	0.04**
Barley	30	27	50	27	33	27	1.33	0.248
Sorghum	5	6	1	1	4	5	1.08	0.298
Wheat	53	53	67	25	55	45	0.38	0.549
****, ** indicates significance level at 1% and 5%, respectively*								

Source: study result, 2018

The intensity of adoption (proportion of land allocated to improved varieties out of total land allocated to the same crop or variety) was also examined for the regions. The result exhibited that a large proportion of coffee land (58%) was covered by improved varieties which is significantly high in the Oromia region (61%) than SNNP (54%) (Table 4). The result could be due to the high emphasis given by the Coffee Improvement Project (CIP) and Jimma Agricultural Research Center (JARC) in the promotion and dissemination of coffee production technologies in Oromia region. On the other hand, farmers in the Oromia region also had large land size which gave them the confidence to uproot the poor performing local variety coffee plants and replace it with an improved one. Alongside, improved maize variety has covered 63% of total maize land which is also significantly higher in Oromia (87%) than the SNNP (74%) region. There was also a statistically significant difference between the two regions in land allocated to improved varieties of sorghum, haricot bean, and *enset*.

Table-4: Adoption intensity of improved varieties along the study regions

Crop	Oromia n=369	SNNP n=584	Total n=953	t	P-value
Coffee	61	54	58	4.46	0.000***
Maize	87	74	63	6.94	0.000***
Teff	47	46	46	0.56	0.581
Sorghum	61	19	52	4.26	0.000***
Haricot bean	60	44	53	2.83	0.031**
Wheat	56	62	57	-1.01	0.345
Barley	42	43	47	0.07	0.943
Enset	27	44	35	-2.92	0.021**
Other pulses	48	33	45	0.01	0.991
****, ** indicate significance level at 1% and 5%, respectively*					

***Source:** study result, 2018*

The source of improved crop variety seeds was also examined in this study. The results provided that most of the improved crop variety seed was supplied to the farmers through government extension services from cooperatives, research centers, and also through farmer-to-farmer seed exchange mechanisms. For instance, 70% and 82% of the farmers sourced improved variety coffee seedlings and maize seeds, respectively, from cooperatives through agricultural extension services (Table 5). The contribution of research centers as sources of improved variety seeds was 13% for coffee and 10% for maize. Extension service facilitates the supply of improved seeds from seed grower enterprises, research centers, and cooperatives. Then, cooperatives distribute the certified and quality seeds to all the needy farmers irrespective of their membership to cooperatives. The improved crop seeds obtained from research centers were harvested from demonstration plots. Farmers also save improved seeds from their own production for use in subsequent growing seasons.

Table-5: Sources of improved crop variety seeds in the study areas (% of households)

Source of improved varieties	Coffee	Maize	Teff	Wheat	Beans	*Enset*
Cooperatives through extension	70	82	59	85	67	40
Research centers	13	10	26	5	17	3
Farmer-to-farmer seed exchange	10	3	7	10	10	45
Farmers' own saved seed from farms	5	3	2	0	4	10
Local traders (markets)	1	1	3	0	2	2
Other sources	1	1	3	0	0	0

Source: *study result, 2018*

Crossbreed dairy cattle technology adoption

Livestock is an integral part of agriculture, accounting for 45% to the total value of Agricultural GDP, 16-19% of National GDP, and supporting the livelihoods of a large share of the population [20, 21]. Moreover, it supports livelihoods through the provision of meat, milk, cash, draft power, hauling services, insurance, and social capital [20]. Table 6 provides that only 6% of the farmers have adopted crossbreed cows/heifers in coffee growing farming systems. A relatively high adoption level was seen in the SNNP region (11%) compared to coffee growing areas of Oromia (3%). The farmers in the SNNP region have a greater number of crossbreed cows than those in Oromia.

Table-6: Crossbreed cattle adoption along the study regions

Livestock types	Oromia n=369			SNNP n=584			Total n=953		
	Adopters (% of HHs*)	Mean	SD	Adopters (% of HHs)	Mean	SD	Adopters (% of HHs)	Mean	SD
Crossbreed oxen	2	1.80	0.84	4	1.20	0.84	3	1.50	0.85
Crossbreed cows	3	0.90	0.32	11	1.74	1.51	6	1.48	1.33
Crossbreed heifers/calves	3	2.01	0.11	11	2.25	0.71	6	1.00	0.63
Crossbreed bulls	1	1.00	0.00	3	1.25	0.50	2	1.14	0.38

**HHs=Households*

Source: *survey result, 2018*

As illustrated in Figure 2, 40% of those adopters sourced crossbred cows through supports of extension services, which often provide on in-kind credit basis. Some farmers (37%) also sourced crossbred cows from other fellow farmers despite their exotic blood levels and, the reproductive and productive status of the cows is little known.

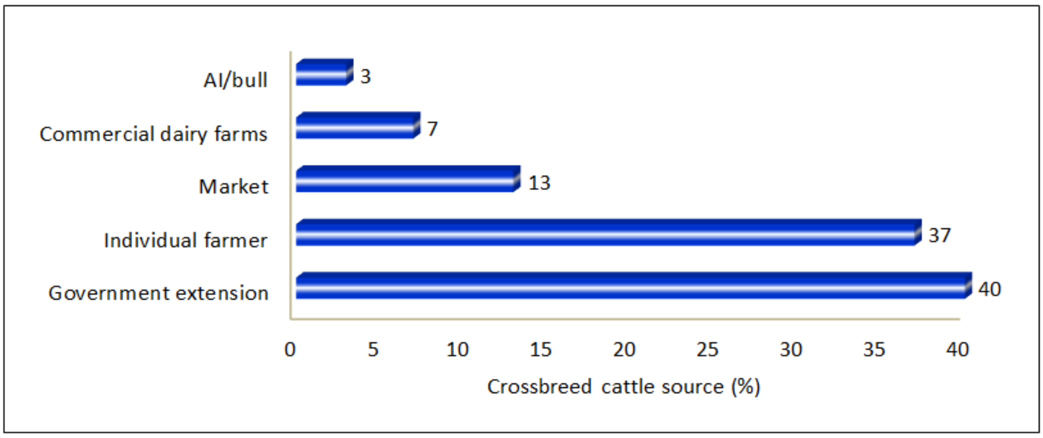

Fig-2: Source of crossbreed cows/heifers in the study regions (%)
Source: survey result, 2018

In Ethiopia, there are neither formal sources nor breeding ranches of crossbred heifers except a few private companies. High demand has been created in the face of scarce supply, which consequently led to unaffordable price of crossbred cows and heifers. As noted by 35% of the farmers, the high price issue has appeared to be the major reason for restricting adoption of crossbred cows (Figure 3). The result is consistent with Agajie *et al.*, [19] who revealed the unaffordability of crossbreed heifers to smallholder farmers and consequent low adoption rate. The second important constraint for the adoption of improved cattle breeds was the feed problem followed by complicated management, lack of awareness, and unavailability of crossbreed cattle breeding centers.

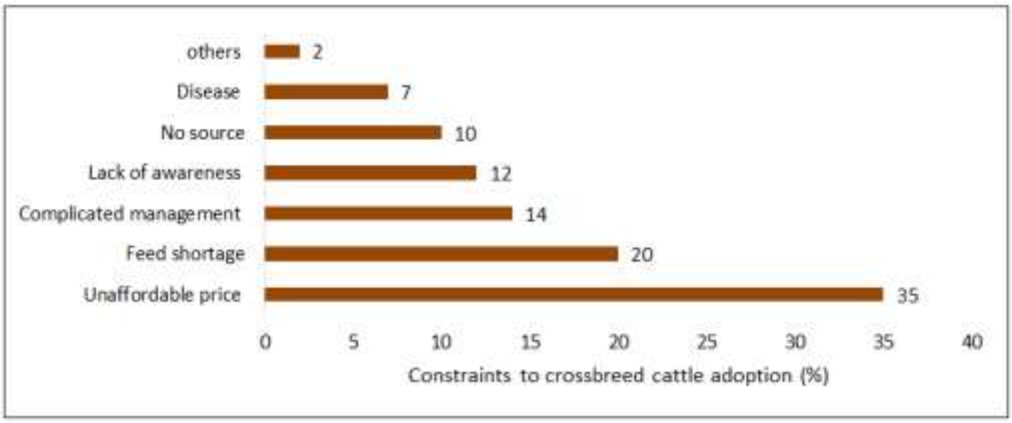

Fig-3: Constraints to crossbred cattle adoption in %
Source: survey result, 2018

Econometric results

With significant Wald Chi-square statistic ($chi^2(39) = 117.20$, $p < 0.001$) and Chi-square statistic for the log-likelihood ratio test ($chi^2(3) = 32.51$, $P < 0.001$), the results of the multivariate probit model for adoption decisions show that the decisions whether or not to adopt a modern technology are dependent on the adoption decision of the other technologies (Table 7). The result, thus, supports the use of a multivariate probit model.

All of the pairwise coefficients are revealed to be positively correlated indicating complementarity among these technologies. The pairwise coefficients of ICV (Improved Coffee Varieties) and IMV (Improved Maize Varieties) and, ICV (Improved Coffee Varieties) and CBC (Crossbreed Cows) are statistically significant. ICV is positively and significantly correlated with IMV and CBC, indicating that farmers who adopted Improved Coffee Varieties (ICV) have also adopted Improved Maize Verities (IMV) and Crossbreed Cattle (CBC). The reason could be that farmers who adopted improved coffee varieties can generate more income from coffee sales which in turn helped to afford the required inputs for the adoption of improved variety packages of maize and crossbreed cows.

Factors affecting Adoption of Improved Coffee Varieties (ICV)

Both TV and radio ownership have affected the adoption of improved coffee varieties positively and significantly. Information is required for farmers to know about technical details, such as type of technology, its benefits, and its management practices to decide on issues of its adoption. One of the sources for such information is mass-media, such as TV and radio. Farmers will only adopt the technology which they are aware of or have adequate information about it. Access to information reduces the uncertainty about the performance of the technology and may change an individual's assessment from purely subjective to objective over time. Thus, radio and TV immensely contributed to the adoption of agricultural technologies. The result is consistent with the findings of Karki [22] and, Diro and Erko [11].

Distance to the all-weather road has a negative and significant relationship to the adoption of improved coffee varieties. This implies that the adoption of coffee varieties declines as the farmers are located farther away from an all-weather road. This could be due to difficulty in transporting coffee seedlings from roadside nursery sites which are usually established near the all-weather road to their farms. Improved coffee varieties are prepared in a polythene bags, which makes difficulty of transporting seedlings. Besides, farmers' proximity to the all-whether road increases their accessibility to markets and the decision to produce for sale rather than consumption. Increased market participation drives the farmers to increase productivity through the use of improved varieties and associated inputs. The result is in conformity with the findings of Abreham and Tewodros [8] and Musba [23].

The size of farm-land owned has also positive and significant relation to the adoption of improved coffee varieties, which is expected and logical as this gives the farmers plenty of options to try different technologies when land size increases. The farmers have to uproot the old coffee plants first and clear the land for the new ones. Households with small farm sizes will lose incomes from coffee and unable to survive in the coming 3-4 years until arrival of the new harvests. To avoid this risk of disruption, the households with small farm sizes tend make a decision not to adopt improved variety coffee plants. If the farmer has a large farm size, it can plant part of the farm with improved coffee plants and leave the other part as it is to help as income source in the coming 3 – 4 years. When the new harvests of improved coffee plants start generating incomes, then the remaining portion with local plants will in turn be replaced with new improved plants. The result is consistent with Abreham and Tewodros [8].

Factors Affecting Adoption of Improved Maize Varieties (IMV)

A significant number of farmers in Oromia Region have adopted improved maize varieties compared to SNNP. Coffee-based farming system zones of Oromia are located near to Bako agricultural research Center which is home to the national maize research. This has made Oromia Region advantageous in better adoption of improved maize varieties.

Education has a positive and significant effect on the adoption of improved maize varieties for it helps to evaluate details of the technologies. Farmers who have been in formal schools were relatively better aware of the means to increase production and productivity. Apart from this, they are better aware of the mechanisms to manage improved technologies. The result corroborates with Alene *et al.*, [24], Nkonya *et al.*, [25], Gideon *et al.*, [26], and Gishu *et al.*, [27]. However, education did not significantly affect the adoption of coffee technologies. The reason could be related to the importance of coffee to farmers' livelihood. Coffee is the major cash-generating commodity in a coffee-based farming system. Thus, education may not be a factor to affect the adoption of coffee as all coffee growers have interest to plant improved coffee varieties in spite of some challenges, such as limited size of farmlands and inadequate access to improved coffee seedlings or seeds.

Distance to the district town has a negative and significant effect on the adoption of improved maize varieties, the same effect as the one on coffee. This implies that the probability of adoption of improved maize varieties has reduced as the distance of farmers' villages increases from the district town. This is because, proximity to towns increases market participation and farmers tend to produce mainly for sale rather than for consumption. This in turn drives the farmers to use improved technologies to produce and supply more marketable surplus for better incomes. The result is consistent with Abadi *et al.*, [28] and Gishu *et al.*, [27].

The total land owned had a positive and significant impact on the adoption of improved maize varieties. The more the farmland, the better the farmers are driven to decide on adopting maize technologies. It helps the farmers to try new maize varieties. Alongside, farmers with large land size have a relatively better income to purchase new crop varieties and related inputs. The result is in line with Nkonya *et al.*, [25] and contrast with Mwakatwila [29].

Factors affecting adoption of Crossbreed Cows and/or Heifers (CBC)

A significant number of farmers have adopted crossbreed cows in the SNNP region than Oromia. The sample zones in Oromia region are far away from central highlands where there is high farmer-to-farmer breed exchange than SNNP. In central highlands of Oromia, dairying is a common practice in both urban and peri-urban settings. On the other hand, access and efficiency of AI increases in urban areas. Thus, the remoteness of zones in Oromia could affect the access and efficiency of AI which affects the ownership of crossbreed dairy cows. From the perspective of gender, male-headed households are less likely to adopt crossbreed cows than female-headed households. The reason could be that female-headed households opt to make dairy as a source of income compared to crop production. On the other hand, dairying is a backyard activity and thus women spend lots of time around homesteads, creating an opportunity for easy management of dairy cattle. Because of this, NGOs also distribute crossbreed cattle for resource-poor farmers, especially women. Education has a positive and significant effect on the adoption of both improved maize varieties and crossbred cows. The reason could be because of the strong link between education and knowledge and the ability to read technical materials. The result is in line with Cicek *et al.,* [30], Quddus, [31], Lemma *et al.,* [32] and Tesfaye *et al.,* [33].

Family size also has a positive and significant relation to the adoption of crossbreed cows (Table 7). This is because, dairying is a labor-intensive business and producing a marketable surplus of dairy products is a function of labor. Accordingly, households with more family members have more labor to help them adopt dairy technology than households with fewer family members. The result is consistent with Howley *et al.,* [34], Dehinenet *et al.,* [35] and Habtamu *et al.,* [36].

Radio ownership also affects the adoption of improved crossbreed cows positively and significantly. This is directly related to the impact of information on the household adoption decision. Distance to the district town has a negative and significant relation to the adoption of crossbreed cows. This implies that the farther the distance from the district town, the lower the probability to adopt crossbreed cows. The logic behind could be that dairy products, such as milk and cheese, are perishable products requiring close distance to towns where there is demand. Total land owned has a positive and significant relationship on the adoption of crossbreed cows. The implication is that larger land holdings are associated with greater wealth and increased availability of capital. Farmers can also produce adequate feeds when they cultivate large size of farm lands. Farmers with larger landholdings are also more likely to invest in technologies that increase agricultural productivity and income. The result corroborates with Staal *et al.,* [37], Jayne *et al.,* [38], Quddus [31], and Tesfaye *et al.,* [33].

Table-7: Factors influencing the adoption of improved agricultural technologies – results of multivariate probit regression

Variables	**Improved Coffee Verities (ICV)**		**Improved Maize Verities (IMV)**		**Crossbreed Cows/heifers (CBC)**	
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**
Region [OROMIA]	0.092	0.1111	0.373***	0.1304	-0.482**	0.1919
Sex [MALE]	-0.019	0.2130	0.173	0.2314	-0.583*	0.3025
Education Level of the Household Head	0.009	0.0152	0.041**	0.0179	0.044*	0.0242
Family Size	0.022	0.0225	0.014	0.0258	0.070**	0.0348
Radio ownership [YES]	0.367***	0.1062	0.079	0.1228	0.340*	0.1751
TV ownership [YES]	0.333*	0.2004	-0.308	0.2064	0.274	0.2402
Extension service [YES]	-0.054	0.1843	0.240	0.2037	-0.131	0.2837
Credit service [YES]	0.068	0.1058	0.204	0.1261	-0.087	0.1698
Distance to district town	-0.005	0.0070	-0.017**	0.0077	-0.053***	0.0160
Distance to all-weather road	-0.025*	0.0150	0.015	0.0181	0.025	0.0196
Head participation on off-farm IGA [YES]	-0.072	0.1235	-0.143	0.1427	-0.102	0.1935
Tropical Livestock Unit (TLU)	-0.002	0.0139	-0.131**	0.0653	-0.012	0.0219
Total land owned	0.148***	0.0389	0.080**	0.0407	0.062*	0.0465
Constant	1.102	0.6342	1.420	0.6949	-2.766	0.9498

Overall estimated model test
Number of observations = 675
Wald $chi^2(39)$ = 117.20; Prob > chi^2 = 0.000
rho Likelihood ratio test
rhoICVIMV= *rhoICVCBC* = *rhoIMVCBC* = 0; $chi^2(3)$ = 32.51; Prob > chi^2 = 0.000
Estimated covariance of the correlation matrix
rhoICVIMV = 0.311 (0.067) ***; *rhoICVCBC* = 0.436(0.103) ***; rhoIMVCBC = 0.047(0.097)

Source: *Survey result, 2018*

Conclusions and policy implications

Ethiopian Institute of Agricultural Research (EIAR), Ministry of Agriculture (MOA) and other development partners have been making ranges of development efforts since decades ago in generating, promoting, and disseminating the production technologies of coffee and other crops. With particular emphasis, Agricultural Research Institutes of the country have generated more than 40 improved coffee varieties along with associated recommended packages. Even though the focus was on coffee, improved varieties of cereals especially maize, pulses, oilseeds, and root crops were also generated and disseminated to the farmers. However, little effort was given to dairy research and development in southern, southwestern and western parts of the country.

It is an encouraging achievement to note that 60% and 72% of the farmers have started using improved coffee and maize varieties, respectively, in both Oromia and SNNP Regions. The strong agricultural extension services, technology promotion, and dissemination efforts made during the two rounds of GTP periods have substantially contributed to more use of the technologies. Despite relentless efforts made by the government and development partners, a quite substantial proportion (40%) of the farmers did not yet have access to improved coffee production technologies. Inadequate availability of coffee production technologies especially improved coffee seedlings and limited promotion and supports of associated management practices were identified to be major reasons reported by non-adopters. On the other hand, only 6% of farmers adopted crossbreed dairy cattle (both cow and heifers).

The major reason for the low adoption of dairy cattle was the unaffordable price of cows/heifers which is primarily caused by the demand-supply mismatch. Policy intervention is required by the government to establish heifer breeding ranches in the regions and meet the growing demands of crossbred heifers. The result of the multivariate probit model also showed that the adoption of one agricultural technology enhances the adoption of other technologies due to the growth of income which is the major driver for the adoption of other technologies. Thus, enhancing multi-technology popularization, diffusion and adoption are decisive to transform smallholder farmers to the next stage. On the other hand, ownership of communication devices and access to market and road boost the adoption of improved agricultural technologies. Thus, improving the accessibility of smallholder farmers to market and technology sources through the improvement of communication technologies and roads is vital.

Conflicts of Interest

The authors declare no conflict of interest.

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