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Research Article

Determinants of Adoption of Improved Dairy Technologies: The Case of Offa Woreda, Wolaita Zone, Southern Ethiopia

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One of the agricultural activities of rural farmers is dairy farming. Furthermore, by providing income, it has the potential to make farm households rich. The objective of this study was to analyze the general factors that influence adoption decisions, as well as the status of adoption of dairy technology in the Offa district, Wolaita zone, southern Ethiopia. The study area has fundamental factors influencing the adoption of dairy technologies which were unknown. This research was started to fill a knowledge gap for responsible bodies. Four kebeles were selected randomly for the study. 150 sample households (63 adopters and 87 nonadopters) were chosen using the SRS (systematic random sampling) method. The interview schedule was used to collect primary data from these households. Secondary data were gathered from a variety of sources, including reports, research findings, documents, and publications. Both quantitative and qualitative data were analyzed by using descriptive and econometric analyzes by SPSS version 21. Focus group discussions and key informant interviews were also used to collect qualitative data. A binary logistic regression model was used to examine the factors that influence the adoption of dairy technologies. The results of the binary logistic regression model revealed that both dairy technology participants and nonparticipant households experienced a combination of personal, demographic, economic, and institutional factors that hindered adoption. Respondent age, access to credit services, size of household landholding, frequency of the extension contact, involvement of outside income, livestock ownership, and distance from the nearest market were all significant negative contributing factors. On the other hand, farm income and dairy farming experience were positively significant variables in the model. Technical assistance to improve farm productivity and income, experience sharing and field visit programs to the fields of early experienced dairy farmers, improvement of farmland usage, improvement of road infrastructure in the study area, provision of appropriate and modernized training and extension services, and so on are among the recommendations.

1. Introduction

1.1. Background of the Study. Dairy farming is one of the agricultural activities for rural farmers that helps them in their daily lives. Farmers who live in rural areas constitute the majority of poor households. As a result, initiatives targeted at tackling rural poor household vulnerability are typically focused on the improvement of agricultural techniques to boost productivity, efficiency, and, ultimately, revenue [1–3].

Agriculture in Ethiopia is a source of growth and a means of alleviating poverty; it can be improved by using new agricultural technologies [4, 5]. Among agricultural components, the dairy sector contributes 15–17% of the GDP, 35–49% of the agricultural GDP, and 37–87% of family wages [6]. The country ranks first on the list of African countries with large livestock populations, with 56.71 million cattle, 29.33 million sheep, 29.11 million goats, 1.16 million camels, and 56.87 million poultry (excluding livestock populations in nonsedentary (nomadic) portions of the Afar and Somali regions) [7].

Ethiopian dairy production is largely reliant on genetic resources from local livestock, particularly cattle, goats, camels, and sheep. Cattle account for 81.2 percent of the total annual milk production in the United States, with goats (7.9%), camels (6.3%), and sheep (4.6%) following closely behind [8].

According to CSA [9], the total cow milk production (excluding suckled milk) for the rural sedentary areas of the country for the reference period is approximately 4.06 billion liters. The average duration of lactation per cow during the reference period was estimated to be around six months at the country level, and the average milk yield per cow per day was about 1.85 liters. According to the most recent CSA report [10], the total population of cow milk is around 3.03 billion liters, resulting in an average daily milk output per cow of 1.35 liters/day. As a result, the per capita milk consumption in the country is only 19.2 kg [11], which is much lower than Africa's per capita averages of 27 kg/year and 100 kg/year [10].

Despite its significance to the farming community and, more specifically, the global economy, the industry has remained neglected and underutilized [7]. The low production in the sector is attributed to the low productivity in livestock due to the conventional production method, inferior breeds, inadequate feeding, bad housing conditions, limited healthcare services, and low capital investment. As a result, several dairy technologies have been shared through the government, nongovernmental organizations (NGOs), and commercial sectors [12, 13]. With the assistance of government and nongovernmental organizations, extensive efforts have also been undertaken to distribute dairy technologies in other parts of the country, including the study areas. The adoption of dairy technologies by farm households varies widely between different agroecologies and within the same agroecology, depending on a variety of technological parameters [14, 15].

As a result, information on the factors influencing smallholder farmers' adoption of the improved dairy technology package is crucial for policy formulation and successful administration of extension programs, and would aid in the creation of feasible recommendations to improve the sector's performance. To improve the intervention, the adoption and intensity of the adoption of improved dairy technology packages such as the use of improved breeds, artificial insemination services (AIS), the improvement of cattle shed, the use of improved feed or forage development, and regular vaccination at the smallholder level in the study area should be evaluated. Figure 1 shows the conceptual framework for the investigation. Based on a literature review, it is hypothesized that personal attributes (age, sex, education, and family), economic factors (farm-land size, farm income, participation in off-farm activities, livestock ownership, and ownership of mobile phone labor), institutional factors (distance to the nearest market, access to dairy production extension service, dairy experience, and access to credit services), and psychological factors (perception) influence technology adoption.

The purpose of this study was to evaluate the overall factors influencing adoption decisions as well as the state of dairy technology adoption in the Offa district, Wolaita zone, southern Ethiopia. Adoption can be impacted by elements that are not entirely economic or entirely noneconomic. Farmers' views toward new technology, as well as its eventual acceptance, are influenced by both economic and noneconomic reasons. The findings of this study could be used as a reference for other similar areas as well as a benchmark for future research. In general, because it is the most recent study in the area, it is expected to generate grassroot information for various stakeholders to promote well-informed research and sustainable development strategies that mitigate the study's drawbacks and other issues. Furthermore, no research has been conducted to identify the key socioeconomic variables in the adoption and economics of the proposed dairy technology. As a result, this study focuses on the adoption of modern improved dairy technology on the old production systems, as well as the factors that influence the choice of improved dairy technology and its associated qualities in the selected area as specified in the background. The final result of the research study could be used by development practitioners, policymakers, and future researchers, among others.

At various times, improved dairy technologies (breed, feed, AIS, housing, and veterinary services) and training were provided to smallholder farmers in the study area; however, the fundamental factors influencing the adoption of these technologies in the study area were unknown. This research was started to fill a knowledge gap for responsible bodies. This study sought to answer the following questions: what is the current state of dairy technology adoption in the study area? what are the major factors influencing rural farmers' adoption of dairy technology in the study area, and what recommendations are needed to address the problem?

1.2. Conceptual Framework. Individual adoption is defined as the extent to which new technologies are used and their potential. They define the diffusion process in the context of aggregate adoption behavior as the spread of new technologies within a region. This means that aggregate adoption is measured by the aggregate level of use of specific new technologies in a given geographic area or population [16–19].

The adoption process, according to Saaksjarvi [20], is the mental process by which an individual progresses from the knowledge of the innovation (first hearing about it) to the final decision to adopt or reject the technology. This suggests that adoption is a process rather than a one-time event. Farmers do not embrace technology right away; they need time to consider their options.

Farmers' adoption decisions are influenced by a variety of factors. Farmers' decisions to adopt agricultural innovations can be influenced by economic, institutional, demographic, and physical factors [21–24]. Previous research has identified some demographic and socioeconomic factors that influence the adoption of various technologies by smallholder farmers in developing countries. Croppenstedt

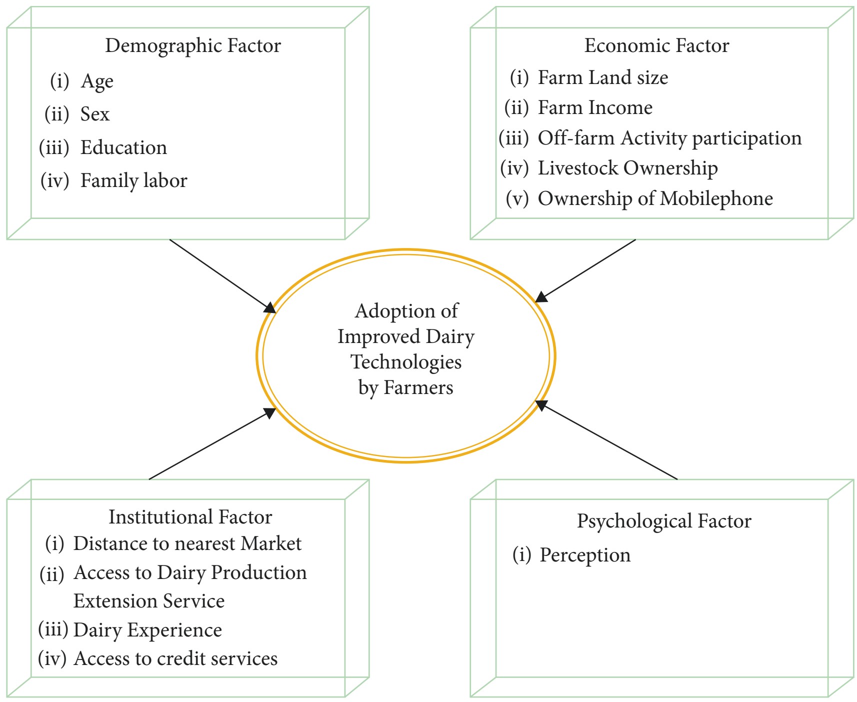

Figure 1: Conceptual framework of the study (source: own conceptual framework of the study, 2019).

& Demeke [25] in Ethiopia and Naseem Akthar et al. [26] in Sub-Saharan Africa identified plot size, previous experience with fertilizer, fertilizer supply, farm size, amount of rainfall, household size, and the ratio of the main crop price to fertilizer cost as factors limiting fertilizer demand among arable crop farmers. According to Feder et al. [27], the main factors influencing technology adoption are credit, farm size, risk, labor availability, human capital, land tenure, and education. The variables identified as having a relationship with adoption are classified as household personnel, economic factors, institutional factors, and intervening (psychological) factors for ease of grouping [28].

The availability of interrelated inputs influences the decision to adopt any single innovation. Ullah et al. [29] reported that input availability had a positive and significant influence on farmers' adoption decisions. According to the findings in [30–32]. Farmer education had a positive and significant influence on adoption. Each additional year of education increases the likelihood of adopting improved seeds. According to the studies in [33–35], market distance has a significant effect on the adoption of crossbred dairy cows in the area.

1.3. Theoretical Framework. The objectives and hypotheses to be tested and verified determined the methodological framework and econometric model to be used. The Heckman two-stage selection model was used to identify determinants of dairy technology adoption decisions and the level of adoption. The decision to adopt and the level of adoption can be seen as a two-stage decision-making process in selectivity models. Smallholder farmers make a discrete decision whether or not to adopt dairy technology in the first stage. Farmers make continuous decisions on the intensity of adoption in the second stage, contingent on their decision to adopt dairy technology. The standard probit model was used in the first stage.

The explanatory variables were checked for multicollinearity before the models were analyzed. When the explanatory variables have little variation and/or a high intercorrelation, this situation occurs [36]. For the exclusion restriction condition, Wooldridge used a heteroskedasticity-robust test [37]. Multicollinearity was measured using the variance inflation factor (VIF) for the association between continuous explanatory variables and contingency coefficients (CC) for dummy explanatory variables. The higher the VIF (Xi) value, the more challenging or collinear the variable Xi is. A multicollinearity problem is present if the VIF of an explanatory variable is greater than 10. Similarly, the decision rule for contingency coefficients states that values less than 0.75 indicate that there is no problem with multicollinearity, whereas values approaching 1 indicate that there is a problem with multicollinearity between the discrete variables [38,39]. Breusch–Pagan/Cook–Weisberg in STATA software should also be used to test heteroscedasticity.

2. Materials and Methods

2.1. Description of the Study Area. This research study was conducted in Offa Woreda, one of the 16 Woredas of the Wolaita zone, located in the Southern Nations, Nationalities, and Peoples' Region (SNNPR), Ethiopia. It is found at about 29 km from the zonal city Wolaita Sodo on the way to the Goffa-Sewula road, 183 km from the regional city Hawassa and 382 km from the capital city Addis Ababa.

Geographically, it is located at 37°.71′E latitude and 6°.83′N longitude [40] (Figure 2). Kindo-KoyshaWoreda bounds it in the north, the Gamo-Goffa zone in the south, Soddo-ZuriyaWoreda in the northeast, Humbo Woreda in the east, and Kindo-DidayeWoreda in the west. The Woreda has a total land area of 38,537 ha, divided into 21 rural kebeles and four municipal administrative districts. Offa Woreda is one of the SNNPR's food-insecure Woredas.

The Woreda has three major agroecological zones, Kolla (lowland), Weynadega (midland), and Wet Dega (highland), covering 31%, 48%, and 21%, respectively, of the total area. The maximum and minimum temperatures range from 34° to 14°c, respectively [40]. The rainfall is biomodal, with the short rainy season (Belg) occurring between mid-February and May, whereas the long rainy season (Kiremt) starts in June and extends to October. The annual rainfall ranges from 850 to 1450 mm, with a medium summer rain period from June to September [41].

2.2. Research Design. To acquire relevant data, the study used a mixed research methodology that combined an explanatory research design and a qualitative approach. Integration of qualitative and quantitative methodologies is believed to provide a greater grasp of the research problem than either method alone.

2.2.1. Sample and Sampling Techniques. The researchers employed the multistage sampling approach. The Woreda was purposefully chosen in the initial stage, since the researcher had prior knowledge in the study area. The kebeles were stratified into three agroecologies in the second stage: Dega, Woynadega, and Kolla. Four kebeles were chosen from the total 21 kebeles in Woreda using a simple random sample based on the proportion of kebeles in each group (Table 1). The households' sampling frames/lists were utilized to pick the sample households from each sample kebele once again. The systematic random sampling approach was used to select sample households from a list/sample frame using the probability proportion to the sample size (PPS).

2.2.2. Sampling Size. The phrase population refers to all members of the study's population, but the term target population refers to the larger group to which one wants to generalize or apply his or her research findings [42]. There are numerous approaches for calculating the sample size, such as mimicking a sample size from a similar study, and using published data and formulas. A simple formula [43] was employed in this investigation to determine the required sample size with a 90% confidence level.

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

where n = total sample respondents, N = 3939, the total number of HHs in the selected kebele, and e = margin of errors at 8%.

According to the abovementioned formula, this study was carried out using 150 sample households selected proportionally across the adopter and nonadopter categories within the four kebeles.

2.2.3. Sampling Procedure. The well-representative sample procedure prepared for this study is represented in Figure 3. A multistage sampling procedure was used to select dairy farm households for this study. In the first stage, Offa Woreda was purposively selected. In the second stage, the Woreda kebeles were stratified into three agroecologies to pick only four kebeles (one kebele from Kolla *(tropical zone),* one kebele from Woinadega (subtropical zone) and two kebeles from Dega *(midlands*). In the third stage, using the sample frame/list of households, sample households were selected by applying the systematic random sampling method. Finally, a total of 150 samples were selected from four sample kebeles using probability proportionate to size (PPS).

2.3. Data Types and Sources. For this study, qualitative and quantitative data were collected from primary and secondary sources.

2.4. Method of Data Collection

2.4.1. Primary Data. The interview schedule was used to collect data on socioeconomic variables between farmers and households, as well as technical, institutional, and environmental issues. Farmers' age, gender, educational status, land size, farming experience, off-farm income, and family size are among the socioeconomic factors. Focus group discussions and key informant interviews were used to acquire qualitative data in the study area. The focus groups were made up of ten people from various backgrounds from each sample kebele. There were also two women and eight men in each focus group. The key informants were five people from each of the sample kebeles who were chosen using the snowball method.

2.4.2. Secondary Data. Secondary data were collected from the Offa Woreda Animal and Fisheries Resources Development Office to know the dairy profile of the Woreda. In addition, the profile of the adopter groups was obtained from each sample of the Kebele Agriculture and Rural Development Office. Finally, qualitative data were triangulated with quantitative data to check the validity of the research.

2.5. Method of Data Analysis. The researchers used descriptive statistics and the econometric analysis method. Percentages, means, and standard deviations were used in the descriptive data analysis method. The chi-squared test was used to investigate the association between the dummy variables in the two groups. When comparing the socioeconomic, demographic, and institutional characteristics of the households in the study area, the *t*-test was used to

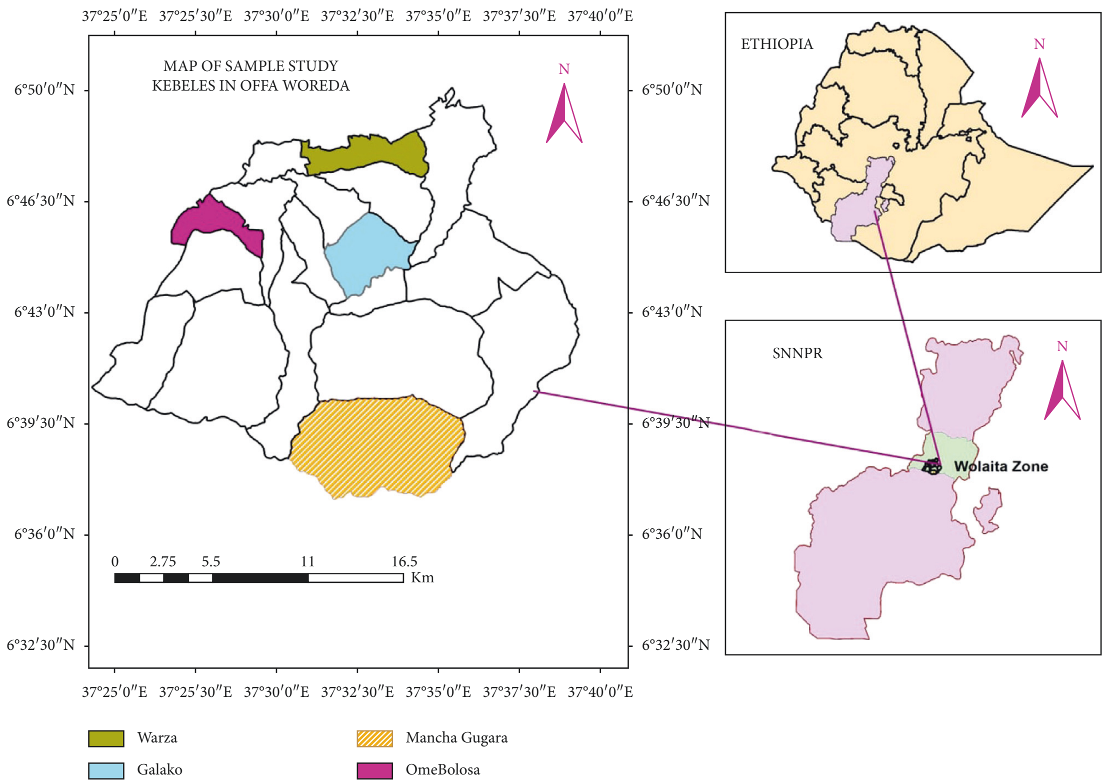

Figure 2: A map of the study area (source: Ethiopia GIS version 10.1 software, 2014).

Table 1: Determination of sample households in the study kebeles.

Selected kebeles	Total number of dairy farm households			Selected samples by using PPS		Total
	Adopters	Nonadopters	Total	Adopters	Nonadopters	
Mancha	197	273	370	6	8	14
Geleko	716	988	1704	27	37	64
Waraza	429	591	1020	18	25	43
Ome bolola	313	432	745	12	17	29
Total	1655	2284	3939	63	87	150

Source: [41].

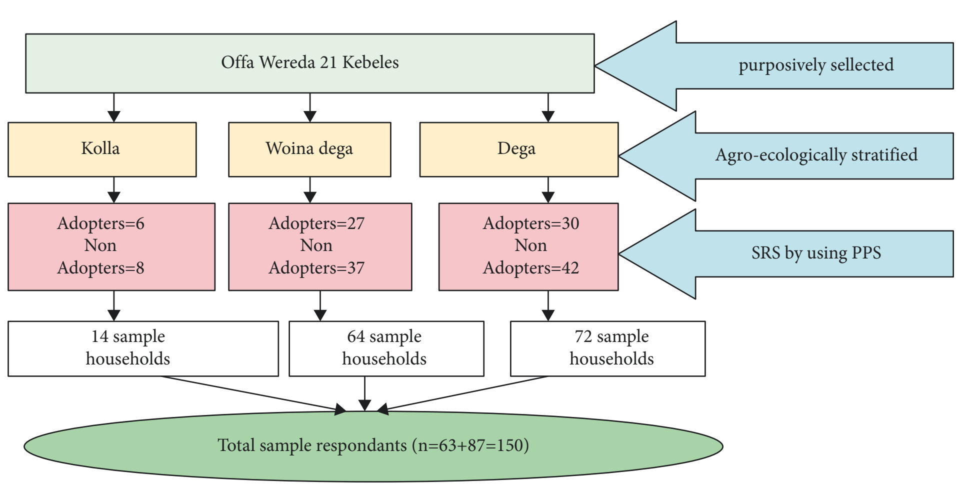

Figure 3: Sampling procedure.

evaluate whether there is a significant mean difference between the two groups for continuous variables. Econometric analysis was employed by using the binary logistic model.

2.6. Variable Definitions

2.6.1. Dependent Variable. The dependent variable for this study was the adoption of improved dairy technologies by farmers. Therefore, the dependent variable is the adoption of dairy technology which is a dummy variable.

2.6.2. Independent (Explanatory) Variables. The independent variables for this study were found by a survey of various literature, and only those which affect the decision of dairy farm households to participate in improved dairy technologies and the outcome evaluated by the study were carefully identified. Based on this, the variables identified as independent variables for this study are the personal and demographic factors of the household, the economic factor, the institutional component, and the psychological factor. The independent variables (as outlined in the conceptual framework) that are most likely to influence the adoption of the improved dairy technology package in the study area are explained in Table 2 and Figure 1.

2.7. The Binary Logit Econometric Model. A qualitative response (dependent) variable of the "yes" or "no" kind is typically seen in a regression analysis. Binary choice models are discrete choice models that deal with such binary responses. The binary logit econometric model was used to examine the factors impacting the adoption and the current state of improved dairy technology packages. When the dependent variables were not modelled using ordinary least squares, the linear regression was limited. Ordinary least squares, on the other hand, work because the dependent variable in the linear model was represented as a linear function. The underlying assumption of the binary choice is that individuals express their preference between two choices, that is, there is a chance of choosing one over the other. As a result, the OLS parameter's estimation will be inconsistent and biased. The linear probability model, logistic model, and probit regression model were presented as the best choices for addressing the limitation in this regard [44]. The error term of the equation in the probit model is normally distributed with a mean of zero and a standard deviation of one. However, in logistic regression, despite the fact that the standard deviation was greater than one, the error term was considered to have a normal distribution. Despite the fact that the logit and probit models were almost identical and that the model choice was arbitrary, the logit model offers some advantages (simplicity and ease of interpretation).

2.8. Specification of the Logit Model. The logistic function is used because it is easy to work with and approximates the cumulative normal distribution well. Furthermore, as Train [45] pointed out, a logistic distribution (logit) has an advantage over others in the analysis of dichotomous outcome variables in which it is mathematically remarkably flexible and simple to use function (model) lends itself to a meaningful interpretation and is relatively cheap to estimate. The logit model was also used with binary choice outcomes (adoption versus nonadoption of technology). Exogenous factors are those that are currently provided by households and hence factored into the model. The model gives empirical estimates of how changes in these exogenous variables affect the likelihood of adoption and assesses the intensity of technology adoption [46].

As a consequence, the coefficients of explanatory variables that are likely to influence farmers' decisions on technology adoption were calculated using a logistic function with odds ratios. The status of technology adoption was the dependent variable in this analysis, while the independent factors were seventeen carefully chosen variables.

Because the dependent variable in this study, adoption of the dairy technology package, is dichotomous, the value 0 was assigned to nonadopters. On the contrary, 1 was assigned to adopters in the econometric model.

Following Gujarati [47], the functional form of the logit model is specified as follows:

$$P_i = E\left(Y = \frac{1}{xi}\right) = \frac{1}{1 + e^{-(\beta 0 + \beta 1 x1)}}. \quad (2)$$

For the case of exposition, we write (2) as

$$P_i = \frac{1}{1 + e^{-zi}}. \quad (3)$$

The probability of the farmer being a nonadopter is expressed by (3), while the likelihood of the adopter is

$$1 - P_i = \frac{1}{1 + e^{zi}}. \quad (4)$$

Therefore, we can write the following:

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{zi}}{1 + e^{-zi}}. \quad (5)$$

Now (Pi/1-Pi) is simply the odds ratio in favour of adoption. The ratio of the probability that a farmer will be an adopter to the li likelihood that he will be a nonadopter.

Finally, taking the natural log of equation (5), we obtain the following:

$$L_i = \mathrm{In}\left(\frac{P_i}{1 - P_i}\right) = Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n, \quad (6)$$

where P_{i} = is a probability of being an adopter, which ranges from 0 to 1; Z_i = is a function of n explanatory variables (x), which are also expressed as follows:

$$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n. \quad (7)$$

β_0 is an intercept, $\beta_1, \beta_2, \ldots, \beta_{\mathrm{n}}$ are slopes of the equation in the model, L_i = is the log of the odds ratio, which is linear in X_i and linear in the parameters, and X_i = is the vector of relevant farmers' characteristics.

Table 2: Variables definition and hypothesis of variables.

Variables	Description of variables	Type	Measurement	Sign
AGE	Age of the household head	Continuous	Measured in years and put into ranges	+
SEX	Sex of the household head	Dummy	1 = Male, 0 = Female	+
EDUCLEV	Education level of the household head	Dummy	Measured in numbers and put into ranges	+
FRMLSZ	Farmland size	Continuous	Measured in Timad and put into ranges	+
OFFAP	Off-farm activity participation	Dummy	1 = participate, 0 = not	+
TLU	Livestock ownership (in TLU)	Continuous	Measured in numbers and put into ranges	−
FLVR	Family labor (in adult equivalent)	Dummy	1 = available, 0 = not	+
OMTPN	Ownership of mobile telephone	Dummy	1 = use, 0 = not	+
DNMKT	Distance to the nearest market (in walking minutes)	Continuous	Measured in km and put into ranges	−
ADPES	Access to dairy production extension service	Dummy	1 = have access, 0 = not	+
ACCS	Access to credit service	Dummy	1 = have access, 0 = not	+
DEXP	Dairy experience	Continuous	Measured in numbers and put into ranges	+
PTECH	Farmers' perception of technology	Dummy	1 = perceive good, 0 = not	−

If the disturbance term (U_i) is introduced, the logit model becomes as follows:

$$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_n X_n + U_i. \quad (8)$$

2.9. Multicollinearity Diagnosis. The factors influencing farmers' adoption of dairy technology, as well as data obtained from 150 dairy farmers, were subjected to logistic regression analysis. SPSS 21 for Windows was the statistical software utilized to analyze the data. Prior to running the logistic regression model, the explanatory variables, both continuous and discrete, were tested for the presence of a multicollinearity problem. When at least one of the independent variables is a linear combination of the others, the problem emerges. Because of the presence of multicollinearity, the computed regression coefficients may have wrong signs and smaller t-ratios, leading to incorrect conclusions. Two measures are frequently proposed to test for the presence of multicollinearity. These are the variance inflation factors (VIFs) for the association among continuous explanatory variables and the contingency coefficients for dummy variables.

The variance inflation factor (VIF) technique was used to detect the problem of multicollinearity among continuous variables. VIF can be defined according to Gujarati [48].

$$\text{VIF}(x) = \frac{1}{1 - R^2}, \quad (9)$$

where R^2 is the square of the multiple correlation coefficients that results when one explanatory variable (X_i) is regressed on all other explanatory variables. The larger the value of VIF (X_i R_i^2) the more "troublesome" or collinear the variable X_i is. As a rule of thumb, if the VIF of a variable exceeds 10, there is a multicollinearity problem. The VIF value displayed below the supplementary material 1 (Table S2) has shown that the continuous explanatory variables have no serious multicollinearity problem.

Similarly, contingency coefficients were computed to check the existence of a multicollinearity problem among the discrete explanatory variables (supplementary Material: 1) (Table S1).

The contingency coefficient is computed as follows:

$$C = \sqrt{\frac{x^2}{n + x^2}}, \quad (10)$$

where C=coefficient of contingency, X_i = chi-squared random variable, and N = total sample size.

The decision rule for contingency coefficients is that when its value approaches 1, there is a problem of association between the discrete variables.

3. Results and Discussion

3.1. Descriptive Analysis

3.1.1. Demographic Variables. Farmers represented 42% of the total sampled households interviewed (participants participated in dairy technology). In 2019, 58% of the sample households were not adopters (households who did not use dairy technology).

3.2. Age of the Respondents. The age of dairy farm households in the sample ranged from 29 to 80 years, with a mean of 40.3 years and a standard deviation of 7.72 years for adopters. The mean and standard deviation for nonadopter respondents are 43.9 and 11.67 years, respectively. The adoption decision of dairy farm households was influenced by the age gap between the two groups. The age of the household head influences whether the household benefits from an older person's experience or bases its decision on a younger farmer's risk-taking attitude. The result is similar to that of Quddus [49], who found that the possibility of cross-breed adoption decreased as the head's age increased. Age is also negatively and significantly associated with adoption, according to Karidjo et al. [50], at a 1% level of significance. In the sampled households, there is a significant difference in the distribution of household head age between adopter and nonadopter household heads (Table 3).

3.3. Sex of the Respondents. The head of the household is generally responsible for coordinating the activities of the household in the study area. As one component of the

Table 3: Demographic variables.

Age category	Adopters	Nonadopters	Total	t-value	P value
Frequency	63	87	100	52.75	0.005***
Mean	40.3	43.9	41.8		
Std	7.72	11.67	9.72		
Maximum	65	80	80		
Minimum	29	29	29		
Sex	Adopters %	Nonadopters %	Total %	x^2	P value
Male	81	80	80.7	0.006	0.207
Female	19	20	19.3		
Total	100	100	100		
Educational level	Adopters %	Nonadopters %	Total %	t-value	P value
Illiterate	8	10.3	9.3	0.293	0.125
Grade 1–4	44.4	41.4	42.6		
Grade 5–8	39.7	31	34.6		
Grade 9–10	7.9	17.3	13.5		
Above 10	0	0	0		
Total	100	100	100		
Mean	4.73	4.75	4.74		
Std.	2.6	3	2.9		
Availability of labor	Adopters %	Nonadopters %	Total %	X^2	P value
Yes	49	61	56	2	0.307
No	51	39	44		
Total	100	100	100		

***Significant at a probability level less than 1% (source: own survey result, 2019).

adoption decision, it is critical to investigate the attribute of the household head's sex. In Table 3, approximately 80.7 percent of the 150 sampled household heads were male, while 19.3 percent were female. Female-headed adopters made up 19% of the total, while female-headed nonadopters made up 20% of the total. It means that the proportion of female-headed nonadopters was the same as the proportion of female-headed adopters. The test ($x^2 = 0.006$) shows no significant difference in the gender of the heads of the households sampled between adopters and nonadopters. As a result, there is no relationship between the adoption decision and the sex of the heads of households. As men gain more information, they make decisions on valuable assets such as land, labor, and capital, all of which are necessary for adoption. This finding is consistent with those of Akudugu et al. [51] and Abbasi & Nawab [52], who discovered significant gender effects on technology adoption in Ghana.

3.4. Educational Level of Household Heads. Many fragments of evidence show that dairy households with higher educational levels may be able to generate a higher income and accumulate wealth. In the study area (Table 3), the majority of respondents have a formal education, with only 9.3% having no formal education. In the household group of participants in enhanced dairy technology, 8% have no formal education, while the remaining 92% have formal education. Similarly, 10.3% of the nontechnology participant respondents had no formal education, while the rest 89.7% had formal education. It shows that the formal education of the participating group (92%) was not statistically different from that of the nonparticipant (89.7%) group. The t-test revealed that there was no statistically significant difference between the two groups in terms of the educational level. In terms of the educational level, there is a statistically significant difference between the two groups. Most of the dairy farm households were in the adopter group, with 28 (44.4%) in grades 1–4 and 25 (39.7%) in grades 5–8. In comparison, nonadopters had 36 (41.4%) and 27 (31%), respectively, indicating that education had no significant effect on dairy activity. According to Cicek et al. [53] and Abbasi & Nawab [52], the educational level influences the adoption of scientific innovation in dairy cattle breeding.

3.5. Availability of Labour. Farmers with labor access are predicted to adopt innovation in dairy technology more than farmers without labor access, because improved dairy technologies require more manpower. In Table 3, the percentage of adopters with sufficient labor force was the same as the percentage of adopters without sufficient labor force. In addition, there is no statistically significant association between labor availability and dairy technology adoption, according to the results of the test.

3.5.1. Economic Variables 3.6. Farmland Size. The lowest and maximum landholding sizes were determined to be 0.124 and 2.5 hectares, respectively. In Table 4, the statistical t-test was used to see if there was a significant mean difference in landholding between the two groups of respondents. There was a considerable mean difference in landholding size between the two groups, according to the findings. The difference was statistically significant at 5% of the statistical significance threshold. Participants in the dairy technology study had smaller land ownership

Table 4: Economic variables.

Land size	Adopters	Nonadopters	Total	t-value	P value
Mean	0.42	0.47	0.44	13.42	0.098*
Std.	0.37	0.41	0.39		
Minimum	0.124	0.125	0.124		
Maximum	1.75	2.5	2.5		
Total farm income	Adopters	Nonadopters	Total	t-value	P value
Mean	9642	6025	7544	18	0.003***
Standard deviation	5209	4480	5107		
Maximum	20000	17000	20000.00		
Minimum	1700	0	0		
Livestock ownership (TLU)	Adopters	Nonadopters	Total	t-value	P value
Mean	2.9	3.5	3.3	30.3	$P = 0.036$**
Standard deviation	1	1.4	1.3		
Maximum	4.8	5.8	5.8		
Minimum	28	.88	.28		

***, **, * denote significance at a probability level less than 1%, 5%, and 10% (source: own survey result, 2019).

than nonadopters in the study area. A plausible explanation for this could be because large landholder farm households are deemed to be less adapters/participants of dairy technologies than their counterparts. The odds ratios demonstrated how the disparity in land distribution among farmers affects the decision to adopt dairy technology in an unequal way. This judgement is consistent with the writing that small farmers are more hesitant to accept new ideas than large farmers [27, 52, 54–56]. According to the studies in [57, 58], a large family size can alleviate labor restrictions and is likely to have a beneficial impact on the decision to use dairy technology.

3.7. Farm Income. Farm income is the annual income of the household. Higher-income households were expected to be more likely to embrace improved dairy technology than lower-income households. In Table 4, the mean difference between adopter and nonadopter households was significant. Furthermore, the t-values of 18 were significant. As a result, farm income was found to be statistically significant at the less than 1% level of significance, which is consistent with [59–62], who found that higher-income households were expected to be more likely than lower-income households to embrace improved dairy technology, with household income being significant to improved agricultural technology (improved dairy technology).

3.8. Off-Farm Activity Participation in Off-Farm Activity (OFFAP). The availability of off-farm employment options promotes the adoption of dairy technology by increasing household income. According to the conclusions of this study, Offa Woreda's off-farm work opportunities included vegetable trading, cattle trading, grain trading, and petty trade. According to Figure 4, approximately 28.6–71.4% percent of adopter households had experience with off-farm employment, respectively, while the remainder had none. Nonadopter households, on the other hand, ranged from 44.8% to 55.2% percent. They had not worked outside the farm to supplement their income or improve their financial status. Furthermore, when its link with the adoption of dairy technology was examined independently, the chi-squared (X^2) test result was significantly less than a level of significance of 1%. The findings are consistent with those of Abbasi and Nawab [52], and Quddus [49], who discovered that the adoption of dairy technology is favorably associated with participation in off-farm activities.

3.9. Tropical Livestock Unit (TLU). For income creation, food, tractor power, social security, organic fertilizer, and asset ownership, rural farm households must keep animals. This study was closely related to identifying restrictions on farm family production and productivity using better dairy technologies. For the sake of simplification, in this research, the number of cattle owned by the respondent families was translated into tropical livestock units [63,64]. Both sample respondents had an average of 3.3 tropical livestock units in the research area. Participants in dairy technology had a mean tropical livestock unit of 2.9, while nonparticipants had a mean tropical livestock unit of 2.9 and 3.5. The statistical t-test (30.3) revealed a statistically significant mean difference in cattle ownership between the two groups (technology participants and nonparticipants) in Table 4. In line with [65,66], we discovered that farmers with a large number of cattle adopted the technology more than those with a small number of cattle.

3.10. Ownership of a Mobile Telephone. The mobile phone is a communication device that allows farmers to get information on the go. It serves as a platform for creative initiatives with the potential to integrate rural agricultural markets and increase competition. Communication with both input sources and purchasers is possible with a mobile phone. Farmers who own a cellphone are expected to be more likely to adopt dairy technology. The percentage of mobile phone owners who are adopters (50.7%) is the same as the percentage of nonadopters, according to Figure 5, (51.7). The x^2-test also shows that there is no link between owning a cell phone and using

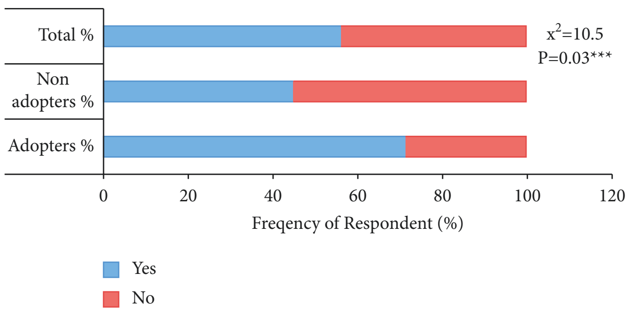

Figure 4: Availability of off-farm activities.

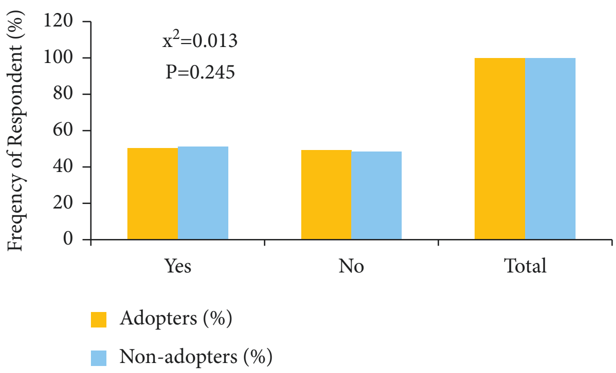

Figure 5: Ownership of a mobile telephone (not significant; (source: own survey result, 2019)).

dairy technology. This finding contradicts Asefa's [67], and Abbasi and Nawab's [52] findings.

3.10.1. Institutional Variables. Institutional variables are described in the following sections.

3.11. Distance to the Nearest Market. In this study, Table 5 shows that the average physical market distance of the houses studied from the nearest market was 4.6 km. The average distances from the market for participant and nonparticipant households were 3.84 km and 3.84 km, respectively (4.74 km). There was a statistically significant difference between the two groups. The *t*-value (15.7) also suggests that the difference in means between the two groups was significant. In Table 5, the likelihood of farmers embracing dairy technology was adversely and significantly ($P < 0.05$) linked with the distance to the market. This means that each unit increase in the market distance reduces the likelihood of adoption. This finding is consistent with the findings of Dehinenet [68], and Abbasi & Nawab [52], who found that increasing market distance lowered (discouraged) adoption.

3.12. Dairy Experience (DEXP). In this study, Table 5 shows the average dairy experience of the households sampled, which began with farming and lasted 24.2 years. The average dairy experience of the participants and nonparticipant households were 27.2 years and 22 years, respectively. There was a statistically significant mean difference between the two groups. The *t*-value (31.9) indicates that the mean difference between the two groups was statistically significant. The findings are consistent with those of Quddus [49], and Abbasi & Nawab [52], who discovered that the adoption of dairy technology is favorably associated with agricultural experience.

3.13. Access to Extension Service. Furthermore, Table 5 shows that of the total sampled households, 52 percent of respondents had weekly interaction with development agents. Similarly, 74.6 percent of the dairy technology participant households and 35.6 percent of nonparticipant households had weekly contact with DAs. Dairy technology participants contacted DAs monthly at a rate of 3.2%, while nonparticipants contacted DAs at a rate of 36.6%. The chi-squared test ($X^2 = 29.3$) was used to assess whether or not there was a significant mean difference in the number of contacts made with DAs between the two groups. There was a statistically significant difference in the number of contacts made by technology participants and nonparticipant households with extension providers at 1% of the statistical significance level. Access to extension services is vital for promoting the adoption of current agricultural technology, since it can balance the negative consequences of the lack of years of formal education with the overall decision to embrace specific technologies [69]. As a result, access to extension services creates a platform for acquiring relevant information that supports technology adoption. As a result, extension services were found to be positively and significantly ($P < 0.05$) connected to the likelihood that households adopt dairy technology. According to Abbasi and Nawab, [52]and Azumah et al. [70], the adoption rate was projected to be higher, positively impacting farmers' access to extension information.

3.14. Access to Credit Service (ACS). Table 5 shows that 60% of the total households studied have access to credit services, whereas 34% do not. Similarly, 81% of dairy technology-accredited households have access to credit services, while only 19% do not have access. To determine whether there was a significant mean difference in the use of credit services between the two groups, the chi-squared test ($X^2 = 10.8$) was used. There was a statistically significant difference in credit availability between technology participants and nonparticipant households at 1% of the statistical significance level. This finding is consistent with Abdulai [71], who discovered a significant and favorable effect of finance availability on the adoption of innovations. Access to credit is an important motivator for technology adoption.

3.15. Farmers' Perception of Technology (PTECH). About 61.3% of the total sampled households have a good impression of dairy technology. Similarly, 62% of the dairy technology participant households and 60.9 percent of nonparticipant households responded positively despite not participating in dairy technology. Only 24% of the dairy technology participants responded negatively to the adoption of dairy technology, while 39.1% of the nonparticipants responded negatively. The chi-squared test ($X^2 = 0.75$) was

Table 5: Institutional variables.

Distance nearest market	Adopters	Non adopters	Total	t-value	p value
Mean	3.84	4.74	4.6	15.7	0.004***
Standard deviation	3.1	3.5	3.4		
Maximum	17	15	17		
Minimum	1	1	1		
Dairy experience	Adopters	Non adopters	Total	t-value	P value
Mean	27.2	22	24.2	31.9	0.007***
Standard deviation	11	7	9		
Maximum	62	44	62		
Minimum	5	10	5		
Access to extension service	Adopters %	Non adopters %	Total %	X^2	P value
Fortnightly	3.2	36.8	22.7	29.3	$P < 0.01$, ***
Monthly	22.2	27.6	25.3		
Weekly	74.6	35.6	52.0		
Total	100.0	100.0	100.0		
Access to credit service	Adopters %	Non adopters %	Total %	X^2	P value
Yes	81	55.2	66	10.8	0.001***
No	19	44.8	34		
Total	100	100	100		

***Significant at a probability level less than 1% (Source: Own survey, 2019).

used to determine whether there was a significant mean difference regarding the perception of dairy technology between the two groups. There was no statistically significant difference between the two groups in terms of perception toward adoption (Figure 6).

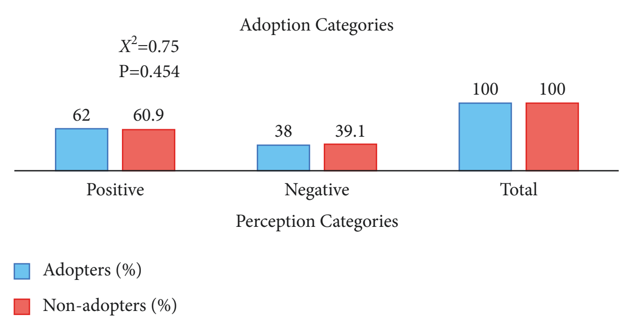

Figure 6: Perception of farmers about dairy technology.

3.16. Summary of Descriptive Statistics. The descriptive analysis summary section of this study connects the findings of the descriptive or quantitative analysis with the qualitative results analysis (FGD, and personal interviews and observations of the researchers). A total of 14 independent variables was expected to affect the dependent variable in the descriptive analysis section (i.e., adoption decision in Offa Woreda). Tables 6 and 7 provide a summary of the models postulated for continuous and discrete variables.

3.17. Factors Affecting the Adoption Decision and the Status of Adoption of Dairy Technologies in Offa District, Wolaita Zone. The binary logit model highlights the factors that influence the adoption of dairy technology. Fourteen characteristics were identified as factors influencing the decision to adopt dairy technology. According to Table 8, the age of the respondents, access to finance, the size of the household's landholding, the frequency of extension contact, participation of off-farm income, ownership of livestock, and the distance to the nearest market were all important variables in the model.

3.18. The Age of Dairy Farming Household Heads. Age was significant at a significance level of 1% with a negative influence on the adoption decision of households; as the age of the household increases, the probability of adopting dairy technology to improve dairy products decreased by 0.837 compared to those in their youth. As a result, at a significance level of less than 1%, age and adoption decisions were inversely related. These findings are in line with those of [49, 68, 72, 73], who discovered that dairy farming adoption is negatively related to the age of the family head, and that the age of the household head negatively affects the decision to adopt in Bangladesh and Ethiopia.

3.19. Landholding Size of the Household. According to the negative association between the size of the cultivated land and the adoption decision, farmers who cultivate the largest land size are not concerned about adoption. As a result, the likelihood that dairy farm households adopt has decreased. As a result, the size of the household's landholding and the adoption decision were inversely associated at a significance level less than 1%. This finding is consistent with Quddus [49], who discovered a negligible relationship between the size of the family land and the adoption decision. The result contradicts the findings of Staal et al. [74], who discovered a positive association between these two qualitative characteristics.

3.20. Livestock Holdings of Farming Households. When all other characteristics are kept constant, it is significantly connected at the 5% probability level, and the odds ratio in favor of being an adopter decreases by a factor of 0.526. The negative relationship means that households with large herd sizes were more likely to be nonadopters because they could make more

Table 6: Statistical summary of sampled adopters and nonadopters on continuous variables.

Variables	Adopters ($n = 63$)		Nonadopters ($n = 87$)		t-value
	Mean	(Std. dev)	Mean	(Std. dev)	
Age	40.3	7.72	43.9	11.67	52.75***
Farm land size	0.42	0.37	0.47	0.41	13.4*
Farm income	9642	5209	6025	4480	18***
Livestock ownership	2.9	1	3.5	1.4	30.3**
Distance to the nearest market	3.84	3.1	4.74	3.5	15.74***
Dairy experience	27.2	11	22	7	31.9***
Education	4.73	2.6	4.75	3	0.293

*, **, and *** denote significance at 10%, 5%, and 1% levels, respectively (source: own survey, 2019).

Table 7: Statistical summary of sampled adopters and nonadopters on dichotomous variables.

Variables	Description	Adopters ($n = 63$)		Nonadopters ($n = 87$)		X^2-value
		No.	%	No.	%	
Off-farm income participation	Yes	45	71.4	39	44.8	0.03**
	No	18	28.6	48	55.2	
Labor availability	Yes	31	49	53	61	0.307
	No	32	51	34	39	
Ownership of mobile telephone	Yes	32	50.7	45	51.7	0.245
	No	31	49.3	48	48.3	
Access to credit services	Yes	51	81	48	55.2	0.001***
	No	12	19	39	44.8	
Access to extension service	Fortnightly	2	3.2	32	36.8	$P \leq 0.01$, ***
	Monthly	14	22.2	24	27.6	
	Weekly	47	74.6	31	35.6	
Perception	Positive	39	62	53	60.9	0.454
	Negative	24	38	34	39.1	
Sex of the household head	Male	51	81	70	80	0.207
	Female	12	19	17	20	

*, **, and *** denote significance at 10%, 5%, and 1% levels, respectively (source: own survey,2019).

Table 8: Parameters estimation of binary logistic regression on the adoption status of dairy households in [41].

Dependent variables $Y = 0$, $Y = 1$	Explanatory variables	B	Std. error	Wald	Odds ratio (exp(B))	Sign
AGE		−0.178	0.064	7.729	0.837	0.005***
SEX		1.754	1.389	1.595	5.781	0.207
EDUCLEV		0.228	0.148	2.352	1.256	0.125
FRMLSZ		−1.913	1.156	2.739	0.148	0.098*
FARMINC		0.000	0.000	8.879	1.000	0.003***
OFFAP		−2.385	1.097	4.725	0.092	0.030**
TLU		−0.642	.307	4.377	0.526	0.036**
FLVR		1.001	0.981	1.042	2.722	0.307
OMTPN		1.102	0.947	1.354	3.010	0.245
DNMKT		−0.524	0.184	8.108	0.592	0.004***
ADPES		−9.988	2.494	16.040	0.000	0.000***
ACCS		−5.671	1.700	11.132	0.003	0.001***
DEXP		0.231	0.086	7.202	1.260	.007***
PTECH		−0.693	0.926	0.560	0.500	0.454

*** denotes significance at a probability level less than 1% probability level, ** denotes significance at a less than 5% probability level, and* denotes significance at a less than 10% probability level, observation: $N = 150$; -2Log likelihood 49.74; chi-squared model: 154.35; sensitivity/correct prediction of adopter: 90.5; specificity/correct prediction of nonadopter: 95.4; overall cases correctly predicted: 93.3.

money from livestock production and pursue other survival options [75, 76].

3.21. Distance to the Nearest Market. The distance was significant at a significance level of 1% and had a negative impact on the adoption decision of dairy households. Compared to individuals in close proximity, the likelihood of adopting dairy technology was reduced by 0.592. As a consequence, at less than a significance level of 1%, the distance to the nearest market and the adoption decision were negatively linked. This finding is in line with the findings of [77, 78], who found that the distance to the nearest market has a negative and significant impact on the decision to use a specific agricultural technology.

3.22. Dairy Farming Experience. The dairy experience was significant at a 1% level, positively influencing the adoption decision of dairy households. Compared to nonadopters, the likelihood of adopting dairy technology increased by 1.26. As a result, at a significance level of less than 1%, the dairy experience and the adoption decision were positively related. The results of the FGD and KII also support the quantitative data findings. Farmers who have been involved in dairy farming for a long time are more knowledgeable about the utilization of advanced dairy technologies. Compared to native species, enhanced types of cows produce more milk and have a longer milking duration than local varieties. After adopting the technology, the adopter may decide to continue using it or abandon it based on the experience and benefits gained [79, 80]. Due to their endowment of resources and their expertise, older farmers may choose improved diversity over young farmers, even if their age limits their ability to search for knowledge on various agricultural methods. Similar findings have been documented in other studies [79, 81, 82].

3.23. Total Farm Income. It is the annual income of the household. Higher-income households are more likely to embrace advanced dairy technology than lower-income households. As a result, the expected sign for this variable was positive. It implies that increased farm revenue may lead to greater use of dairy technology. One explanation for this finding is that increased revenue allows for more technological purchases such as salt blocks, urea, mineral licks, hay, and small dehorning and castration equipment, as well as the purchase of crossbred heifers. According to the studies in [83, 84], higher-income households are more likely to embrace improved dairy technology than lower-income households, with household income being a significant factor in improved agricultural technology adoption (improved dairy technology).

3.24. Off-Farm Income Participation. Increased access to off-farm participation opportunities can result in increased use of dairy technologies. One explanation for this finding is that money from off-farm activities offers supplemental income to finance technology purchases such as salt blocks, urea, mineral licks, hay, and small tools for dehorning castration, as well as crossbred heifers. On the other hand, off-farm income involvement was significant in this study at a 5% significance level, with a negative effect on dairy households' adoption decisions. As a consequence, the off-farm activity participation and adoption decision were inversely associated at a level of significance less than 5%. The finding contradicts the findings of [85, 86], who confirmed that households that engage in off-farm income-generating activities have a higher likelihood of becoming adopters of new agricultural technology than households that do not \engage in income-generating activities other than farming.

3.25. Access to Credit. The results show that loan access has a 1% significance level, which has a detrimental impact on dairy households' adoption decisions. Compared to nonadopters, the likelihood of adopting dairy technology was reduced by 0.003. As a result, at a significance level of less than 1%, loan availability and adoption decisions were inversely associated. The conclusion contradicts the findings of [79, 82, 87–89], who indicated that access to credit can increase the possibility of families lacking money to purchase and possess innovative agricultural technologies.

3.26. Frequency of Extension Contact. According to the findings of this study, farmer contact with development agents has not improved the adoption and diffusion of dairy technology. The frequency of the extension contact has a 1% significance threshold. Many studies, for example, have found that the frequency of contact with extension agents increases the possibility of adopting new agricultural technologies [87, 90, 91]. As a result, the frequencies of extension contact and adoption decisions by the farm household were adversely associated. Furthermore, FGD and KII data demonstrate that dairy farmers who contact the extension agent on a sporadic basis have no greater likelihood of adopting dairy technology than those who do so on a regular basis. Meryem [92] discovered that access to an extension of market-based information had a positive and significant impact on participation in the milk market. Aside from the increasing likelihood of obtaining up-to-date information on new agricultural technologies, extension agents or agricultural development assistants can mitigate the negative impact of a lack of years of formal education in the overall decision to adopt some technologies in many developing countries [93].

3.27. Summary of Qualitative Data Analysis by Focus Group Discussion (FGD) and Key Informant Interview (KII). In the four sampled kebeles, focus group discussions were employed in addition to the data acquired from the household interview to obtain an overall picture of the study's stated objectives. The focus group consisted of ten people from different backgrounds from each sample kebele. Each focus group included two women and eight men. The key informants were five people chosen at random from each of the sample kebeles using the snowball method. The head of the Animal and Fisheries Resources Development Office, as well as two experts from the same office, were among those in attendance. Due to the low capital of the households' inability to endure shocks, the group discussion revealed that the research area was more or less constrained to the diversification of agricultural and nonagricultural activities of smallholder production. The population density in the research area is high and no income-generating activities are carried out. As a result, dairy technology absorbed technologies from agriculture and other organizations during the study year.

The discussion highlighted that having enough money, income, training and extension contacts, land ownership, and cattle ownership are all essential factors in the adoption of dairy technology. In terms of education, the participants agreed that people who can read and write have greater access to knowledge and a better chance of attending expert training. They also have an impact on farmers' adoption of enhanced dairy technology and participate in income-generating diversification programs.

The information obtained from key informant interviews (kebeles, leaders, and model farmers) also supported this abovementioned positive and significant finding; the econometric model and the adoption of improved dairy technology played a great role in household income, but this value was affected by some factors in the adoption of dairy such as lack of sufficient water, lack of forage, climate change (climate variability), and lack of an extension contact. Unavailability of technology, lack of training, and lack of funds were all highlighted as significant barriers to technology adoption [94]. The most significant barriers to dairy growth were a lack of information [95] and animal feed [96]. "Previous to engaging in the dairy technologies program, most of the respondents of the enhanced dairy technology participants were very poor with no financial progress and modest asset holdings." However, after participating and having access to it, their living conditions have improved, they have better saving habits, their consumption habits have increased, and they have a decent health status. In general, the household status in terms of living and production showed a considerably better increase over time than nonparticipant households in the research area.

(i) Household head farm experience: The inference is that household heads with more years of farm experience are more likely to embrace dairy technology than those with fewer years of farm experience. Farmers with more experience appear to have more complete information and expertise, as well as the ability to evaluate the benefits of technology [28, 80].

(ii) Interaction frequency with extension workers: As expected, the frequency of contact with extension workers positively and considerably increased the possibility of adopting dairy technology. The introduction of more improved dairy technologies was a significant intervention by the Livestock Development Office and other concerned bodies, including the Woreda government and the NGOs in the study area, to improve the production and productivity of the dairy sector. The introduction of improved technologies and the improvement of the sound support systems of institutions, especially credit and savings institutions, are essential [97].

(iii) Knowledge: Ideas, concepts, habits, and skills that people learn over time to support their livelihood are called knowledge. Dairy technology, like other technologies, requires knowledge of its normal operations.

Farm income is the primary source of capital for purchasing farm supplies and others.

(iv) Household inputs: home-farm income was assessed in this study based on dairy product sales [98].

3.28. Other Factors. The presence of a significant number of actors in knowledge institutes and NGOs was acknowledged by focus group discussants and key informants. However, the interaction among relevant actors in the agricultural value chain is constrained due to differing perspectives among actors on goals, assumptions, capacity, or lack of trust, suggesting the presence of a "directionality failure" [99]. One of the challenges in Ethiopia's agricultural research and extension system has recently been identified as the lack of linkage between research, extension, and farmers. According to key informants, cooperatives are primarily involved in milk collection and selling, and the vast majority of them do not provide the additional inputs and services required in dairy farming [100]. According to Jaleta et al. [101]; milk marketing cooperatives could help reduce marketing expenses and attract buyers who require bulk purchases at a lower average unit cost. According to Berhanu and Poulton [102]; the cash allotted for agricultural development may not be spent entirely on extension services because paid extension employees spend a considerable amount of their working hours on nonextension activities. The vast majority of small-holder cattle producers have been excluded from technological and market-driven dairy growth. The Derg administration attempted to promote the dairy industry through cooperatives of producers. Cooperatives, on the other hand, have been transformed into government and political tools rather than socioeconomic development tools.

4. Conclusions and Recommendations

The purpose of this study was to identify the factors that influence the adoption of dairy technology and the current status of the adoption of dairy technology in the Offa district of Wolaita, southern Ethiopia. It was based on primary data from dairy farmers' respondents and secondary data obtained from different offices and documented files. A multistage sampling technique was used, and 150 sampled households were interviewed to gather data. The descriptive analysis revealed that nine explanatory variables, including age, access to credit, distance to the nearest market, dairy experience, frequency of extension contact, farm land size, farm income, and participation in off-farm activities, had a significant impact on dairy technology adoption. Nine of the 14 explanatory variables included in the binary logit regression model, such as age, access to credit, distance to the nearest market, dairy experience, frequency of extension contact, farm land size, farm income, and participation in off-farm activities, significantly influenced dairy technology adoption. This is evident from the study's economic analysis and findings. Additionally, the focus group discussion (FGD) and key informant interview (KII)revels different factors that determine the adoption of improved dairy technology. The key factors they revealed as determinates were as follow: income, training and extension contacts, land ownership, and cattle ownership, household head farm experience, and interaction frequency with extension workers. These findings have important policy implications that must be considered.

(I) The District Office of Agriculture and Rural Development should provide technical support to boost farm productivity and improve households' farm income by incorporating income-additive technologies

(II) The District Office for Animal and Fishery Resource Development, in collaboration with different NGOs, should strengthen modern and better training for dairy household heads that have little dairy experience in the area

(III) The Woreda government and the concerned bodies should pay attention to the use of farmland by forcing farmers to leave some part of the land for the development of forage through different methods of subsidizing the forage species as input for them

(IV) In addition, the Animal and Fisheries Resources Development Office should collaborate with kebeles, Omo microfinance agents, and cooperative promoter experts to focus more on the use of dairy technologies

(V) To transport forages and materials to and from the market, the Woreda government should improve the road infrastructure in the study area

(VI) Special training should be provided for older households. Additionally, the District Office of Animal and Fishery Resource Development should prepare experience sharing and field trips to teach old-age households of nonadopters

(VII) The District Office of Animal and Fisheries Resources Development, in collaboration with the Woreda Youth and Entrepreneurship Office, should provide technical training regarding the adoption of more income-boosting technologies, especially dairy technologies

(VIII) The provision of appropriate and modernized training and extension services is needed to improve the adoption of dairy technology and milk production among small-holder dairy farm households

(IX) Extension initiatives to correct farmer adaptation are critical in this scenario. Furthermore, new investment projects that take into account climate change should be supported in the area and dairy farmer subsidies should be linked to climate change

Abbreviations

AIS: Artificial insemination services
BOA: Bureau of Agriculture
CC: Contingency coefficient
CSA: Central Statistical Agency
Das: Development agents
DTs: Dairy technologies
FAO: Food and Agricultural Organization
FGDs: Focus group discussions
HHs: Household heads
IGAD: Intergovernmental Authority on Development
ILRI: International Livestock Research Institute
KII: Key informant interview
LDCs: Least developed countries
LPM: Limited probability method
MoA: Ministry of Agriculture
NGO: Nongovernmental organizations
OWAFRDO: Offa Woreda Animal and Fishery Resources Development Office
OWARDO: Offa Woreda Agriculture and Rural Development Office
PADETES: Participatory agricultural demonstration and training extension system
SNNPR: Southern Nation, Nationalities and People's Region
SPSS: Statistical Packages for Social Sciences
SSA: Sub-Saharan Africa
T&V: Training and visit
TLU: Tropical livestock unit
VIF: Variance inflation factor
GDP: Gross domestic product.

Data Availability

The data will be provided upon request from the corresponding author.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Mr. Zekarias Zemarku was responsible for conceptualization, data curation, funding acquisition, investigation, methodology, validation, visualization, writing the original draft, and review and editing. M. Senapathy (PhD) was responsible for conceptualization, visualization, and review and editing. Mr. Elias Bojago was responsible for contextualization, revising, rewriting, proof-reading, editing, and submitting the article.

Supplementary Materials

The VIF value (variance inflation factor) and contingency coefficients are included as Supplementary Material: 1 in this manuscript (Table: 9; 10). VIF is a metric that measures the degree of multicollinearity in a set of multivariate regression variables. The VIF for a regression model variable is equal to the ratio of the total model variance to the variance of a model with only that single independent variable. The contingency coefficient is an association coefficient that indicates whether two variables or data sets are independent or dependent on one another. Pearson's coefficient (not to be confused with Pearson's coefficient of skewness) is another name for it. Table S1: contingency coefficient for the dummy variables of binary logit regression. Table S2: variance inflation factor (VIF) for the continuous explanatory variables. (*Supplementary Materials*)

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