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# Impact of Improved Dairy Technology Adoption on Rural Household Food Security: A propensity Score Matching Estimation in North, Ethiopia

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***Abstract***

In Ethiopia, usually, small scale farmers are not adopted to use all kinds of improved dairy technologies. However, the improved dairy technology adoption has direct impact on the milk production and rural household food security. The objective of this study is to examinethe adoption of dairy technology and its impact on rural household food security. The study is conducted in Basona Worena *woreda*, Amhara regional state Ethiopia. The farm household primary data were collected from 283 farmers consisting of 155 non technology user and 128 dairy technology users. This paper employed Propensity Score Matching (PSM) procedure used to determine the adoption of dairy technology and its association with household food security. Result of the finding shows that households' using improved dairy technology adoption has increased thehousehold food consumption score by 23.19% and household dietary diversity by 13.7%. This implies thatAdoption of dairy technology has a positive and significant impacts on household food consumption and dietary diversity intake of technology users than non-users. Based on the findings of the study, introducing and disseminating appropriate dairy technologies to smallholders reduces the milk demand-supplygap in rural households and improves household food consumption and dietary diversity.A rural level milk collection center is also one of the rural institutes that provide dairy input to rural households. Such a center provides services such as market linkage for their milk product, advice, training, and information. Strengthened the centers create the environment for increased milk production in order to meet the consumption of smallholder farmers whose livelihood is dependent on it.Moreover, improve the smallholder's purchasing power of nutritious and diversified food. Furthermore, the strong linkage among research institutes, extension, and agriculture bureaus enhance the attitude of farmers towards the technology adoption.

**Keywords***:* Basonaworena, technology adoption, food security, PSM

**NOTE:** This manuscript is extracted from my thesis work part which entitled with this title “Dairy technology adoption and its impact on household food security: the case of BasonaBarenaworeda, Amhara region, Ethiopia”.

## Introduction

For most of the developing countries including Africa, agriculture is the one of the leading sources of employment, income and even it is a means of living for the rural households. Particularly in Sub-Saharan African (SSA) country agriculture is an important motor for realizing economic development. According to World Bank (2008), increasing the productivity in rural household’s agriculture through adoption of new technologies is considered as an important in the sub-sector to reduce the prevalence of rural poverty and large productivity gap in developing countries.

In Ethiopia, dairy production is mainly of subsistent type and largely dominated by indigenous breed of cattle. The production generated from this system is low to support the demands of the continuously increasing human population (Kassahun et al, 2012). Hence to increase production and productivity of the sector; introducing improved method of forage production for dairy cattle, introducing cross breed heifer, providing bull service for farmers, delivering pure-bred Friesian and Jersey breeding bullsto villages and increasing adoption level of farmers for improved breed are of the main practices employed. In addition to this, they also improve the food and nutritional status of the rural households (Dehinenet, 2014).

Since then different dairy technologies have been transferred through governmental, NGOs and private sectors. Even though large efforts have been made to disseminate dairy technologies through the support of governmental and non-governmental organizations in different parts of the country, the rate of adoption of dairy technologies by farm households varies widely across different agro-ecologies and within the same agro-ecology based on various technical and non-technical factors. Accordingly, the contribution and benefits of dairy technologies differ among farm households.For instance, the long-term research program initiated between the International Livestock Research Institute (ILRI) and the Ethiopian Institute of Agricultural Research (EAIR) was aimed at increasing milk and meat production, household income, use of dairy cows for traction and nutritional status of household members. The results of the program were relevant for nutrition and food security policies in the East African region in general and Ethiopia in particular.

On the other hand, the policy design andeffectivemanagement of extension programs,information on the impact of dairy technology on thelivelihoods of smallholder farmers is veryimportant andwould help to comeup with workablerecommendations in order to improve the performanceof the sector. Recognizing this, improved dairy technologies are widely considered as the key means ofaddressingmost of the problems of low livestock productivity throughout the regions of the country.

Poverty and food insecurity are quite pervasive in the Amhara regional state where more than 27% of the national population lives. The level of poverty in the region was 36.1% in 2011. The figure was as high as 41.1% in the rural areas. Even though food poverty declined in all regions of Ethiopia, exceptionally, it has been increasing from 32.5% in 1999/00 to 38.8% in 2004/5 and to 42.6% in 2010/11, consecutively, in the Amhara regional state. In addition to this, the region has the highest rate of stunting, which is nearly 42%, in the country (CSA, 2014). The same pattern of realities holds true in Basona Worena in Northern Showa zone of the Amhara regional state.



The consumption pattern of dwellers in central highlands area, where Basona Worena is located, largely confined to cereals crop and their products. However, the diets form those crops are recognized as monotonous and lacking essential micronutrients and contributing to malnutrition and micronutrient deficiencies, especially in children, who need energy and nutrient-dense food to grow and develop both physically and mentally (Megersa, *et al.*,2011). In terms of energy source, dairy products contribute very high in Ethiopia. This is evidenced by the fact that dairy accounts only 7% of the total energy requirements of households **(**Zewdu & Peacock, 2012)**.** This is accounted to low level of diary productivity emanating from low level of technology adoption (Kebebe, 2015).

In order to ameliorate the productivity of diary in a bid to combating food insecurity, new technologies mainly the provisions of improved breed dairy cattle have been introduced in Basona Worena *Woreda* where there is immense potential of livestock production.

There are a number of questions that require rigorous assessment which adhere to what extent the provision and adoption of improved dairy technology reduced food security?Does the adoption of such improved dairy technology enhance the food security status of the household?

The few research studies have been carried out on improved dairy cattle production and their associated effects on households (Amanuel, *et al*, 2018; Melesse and Jemal,2012,Muuz 2018, (Mekonnen, *et al*, 2010; and Samuel, *et al.*, 2016). These researches have been mainly describing the effect of improved dairy farming on poverty and the challenges of adopting improved dairy farming. The impact of improved dairy farming on food security and its associated impact are at rarity.

This research is therefore, an attempt to bridge such knowledge gap by examining the impact of adoption of improved dairy technology on household food security and extent of adopting dairy technologies among the adopter's group. The study also identifies the determinants of dairy technology adoption in the study area.

## Methodology

### Description of the study area

The study is based on primary data collected from dairy farm households in two kebele (districts) of Basona Worena *woreda*. The *woreda*is one of the 10 *woredas* of the North Shewa Zone in Amhara National Regional State. The *woreda* is located in the north at a distance of 130 km from Addis Ababa on the main road to Dessie. According to CSA (2017), the total population of the *woreda* is 140,386. The total number of agricultural households is 138,264 of the total rural households, 71,439 are male and 68,947 are female headed. The majority of the rural people generate their livelihood from agriculture and agriculture related activities.Basona Worena *woreda* is one of the 10 *woredas* of North Shewa Zone of Amhara National Regional State. According to the data obtained from the *woreda* administration office, there are 30 rural *kebeles* and one urban center in the *woreda*.

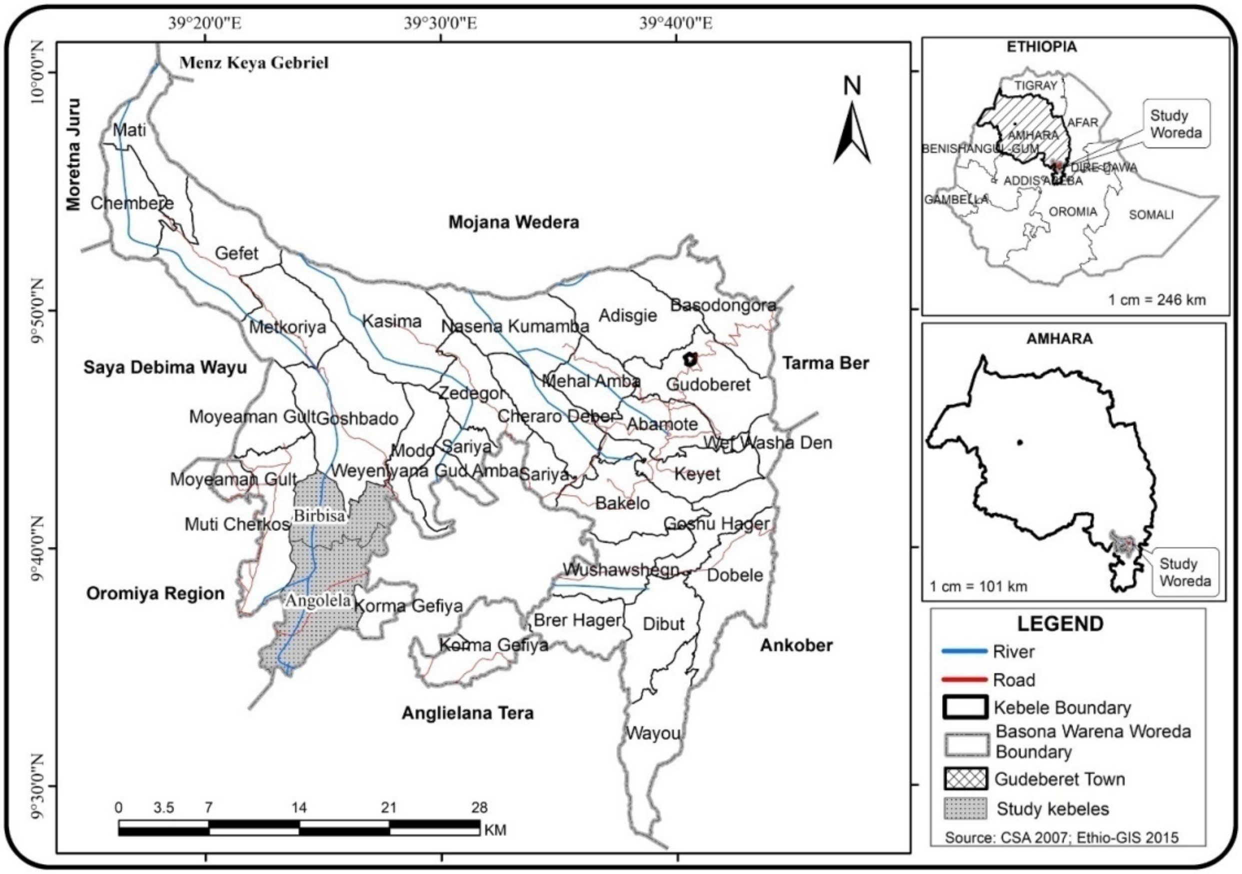



Figure 1: Map of the study area
(Source: CSA 2007, Ethio-GIS 2015)

**Sampling technique and sampling size**

Multi-stage sampling procedure was employed used to select the respondent. In the first stage, the study areawas selected from North Shewa region purposively based on its dairy technology adoption and milk production (milk shad) area. At the second stage, the *woreda* (Basonaworena) selected based on the dairy production potential of the area. During the third stage, two *kebeles* were randomly selected. In the last stage of sampling, the farm households were stratified in to two groups: dairy technology adopters and non-adopters and systematic random sampling were applied to select the sample household. The sample of the respondent households was selected representative way of selection with ±5% precision level and 95% confidence interval. The farm households selected using listing method with the *woreda* agriculture office.

N = P (100% - P)/ (SE) 2; SE = MRE/1.96

**Where;**

N= Sample size; P= Proportion of dairy technology adopter smallholder farmers; SE= Standard error; MRE= Margin for random error (5%) and 1.96 is tabular value for 95% confidence interval

Table 1: Distribution of sample respondent probability proportional to size by KA's

| Kebele's name | Total households in each KA's | Adopter Households | | Non-adopter households | | Total Sample size |
|---|---|---|---|---|---|---|
| | | Total | Sample | Total | Sample | |
| Angolela | 772 | 300 | 92 | 472 | 112 | 204 |
| Birbisa | 300 | 111 | 36 | 189 | 43 | 79 |
| Total | 1,072 | 411 | 128 | 661 | 155 | 283 |

Source: Computed based on data obtained from Basona Worena *woreda* administration.

$$n = \frac{Z^2\, pq}{d^2} \text{------------------------------------------------} (1)$$

Where,

n = the desire sample size;Z= standard normal variable at the required level of confidence; *p* = the proportion in the target population estimated to have characteristic being measured; d= the level of tactical significance set; and q=1-p

**Method of data collection**

All relevant primary and secondary data source were employed in the study. Where, primary data were collected using two type household survey (formal and informal), direct observation, key informant interview, and focusing group discussion. In the formal survey: the data were collected using a structured questionnaire through face-to-face interview with household heads.While secondary data were collected from published and unpublished work on dairy technologies adoption and food security related materials. The questionnaire was used to collect the information related to socio-economics, and institutional characteristics of the household. At the end well trained enumerators and good experience in the survey were employed to gather the data for this specific study.

### Method of data analysis

To analyze the data both descriptive and inferential statistics were employed to characterize and analyze dairy technology adoption and food security of the households. Food consumption score and household dietary diversity scores were employed to examine the food security status of the sample households. The statistical models namely, binary logistic regression,and propensity score matching were used to determine factors affecting the decision of farm households who participate (adopt) dairy technologies, and impact of technology adoption on household food security respectively. The explanatory variables identified from different literatures that wrote in different time and theory of innovation diffusion theory.

### Statistical analysis

### Propensity score matching

It employed Propensity Score Matching (PSM) approaches that select, match, and compare dairy producing households and without improved dairy technologies with similar characteristics. This is used to measure the impact of dairy technology adoption on household food security.

Match treated (adopters) and untreated (non-adopters) observations on the estimated probability of being treated (propensity score). Enables matching not just at the mean but balances the distribution of observed characteristics across treatment and control. It is used to match each adopter with an identical non-adopter and then measure the average difference in the outcome variable between the adopter and the non-adopter.

### Estimation of propensity score

The first one is concerning the model used for the estimation of variable, and the second is about the variable to be included in the model. In this case application of logit model was appropriate in estimating the logit model. Since this study had binary treatments adopter and non-adopter of improved dairy technologies. The dependent variable was dummy variable (dairy technology adopter in this case). Adopters took a value of one if the households adopt improved dairy technologies and zero otherwise (caliendo and kopeinig, 2008).

$$Pi = \frac{e^{zi}}{1 + e^{zi}} ------------------------------------(2)$$

**Where**,

Pi is the probability of adoptionof improved dairy technology

$$Zi = \beta_0 + \sum \beta i X_i + ui - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - (3)$$

Where, $\beta_0$ = intercept, $\beta_0$= Regression coefficient to be estimated, Xi= Variable, Ui= Disturbanceterm

The probability that a household belongs to the non- adopter's group is:

$$1 - Pi = \frac{1}{1+e^{zi}} - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - (4)$$

The odds ratio can be written as

$$\frac{pi}{1-pi} - \frac{1+e^{zi}}{1+e^{-zi}} = e^{zi} - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - (5)$$

Therefore, to estimate average impact of dairy technology adoption on household food security

$$E\{Y1 - Y0|Di = 1\} = E[Y1|D = 1] - E[Y0|D = 1] \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (6)$$

Where, $Y_1$ is expected average consumption score of adopter households

$Y_0$ is expected average consumption score of non-adopter households

Three matching methods were employed under this study. Namely, kernel matching which matches each participant using weighted average over multiple persons in the comparison group. The second one is nearest neighbor matching which match for each treated group find a non-treated group that is closest in terms of propensity score. The last one is radius matching method which matches to all controls with a certain radius (Cochran & Rubin, 1973, Smith & Todd, 2005).

**Model specification for matching algorithm**

**Kernel Matching**

The model is applied to pooled data from both treated and untreated subjects an estimated probability of participation for each subject.

$$Eyi^{1-}yi^0 = /p(xi)\,Ti = 1) = \frac{1}{n^1}, \sum_{t=1(T1=1)}^{n^1}[yi^1(xi) - wj\big(p(xi)\big)yj^0] \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Associate to the outcome *yi* of treated unit *i*. the matched outcome given by kernel- weighted average of the outcome of all non-treated units.

Where the weight given to non-treated unit *j* is in proportional to the closeness between *i* and *j*.

**Nearest Neighbor model specification**

C is the set of control (non-adopters) unit, denoted by C($i$) the set of control units matched to treated unit *i* with an estimated value of the propensity score *pi*. Nearest Neighbor matching set

$C(i) = \min j \left|\left|pi - pj\right|\right|$------------------------------------------------------------------------------(8)

**Radius matching**

If the control units with estimated propensity scores falling within a radius *r* from *pi* are matched to the treated unit *i*.

$C(i) = \{pj\left|\left|pi - pj\right|\right| < r\}$-------------------------------------------------------------------------(9)

Each treated unit is matched only with the control unit whose propensity score falls into a predefined neighborhood of the propensity score of the treated unit.

Table 2: Explanatory variable description and its expected sign

| **Explanatory variables** | **Unit of Measurements** | **Expected sign** |
|---|---|---|
| | **Dependent variable** | |
| Adoption of improved dairy technologies | 1=if the household use the improved technologies , 0= otherwise | |
| | **Outcome variables** | |
| Food security | Dietary diversity and consumption score | |
| | **Independent variables** | |
| Age of the household head | Years | -/+ve |
| Sex of the household head | 1 for male and 0 for female | -ve |
| Educational level of the household head | Year of education | +ve |
| Farm size/land holding/ | Hectare | +ve |
| Labor availability/ family size/ | Number | +ve |
| Income from off-farm activities | Yes or No | +ve |
| Farming experience | Years | +ve |
| Market distance | Kilometers | -ve |
| Membership of milk collection center | Yes or No | +ve |
| Input access | Yes or No | +ve |

| | | |
|---|---|---|
| Access to credit | Amount in Birr | +ve |
| Extension contact | Number | +ve |
| TLU | TLU | +ve |

## Result and discussion

### Descriptive statistics results

In this particular study, a total thirteen (13) explanatory variables were identified and out of this variables, nine of them shows that a significant association with dairy technologies adoption and intensity to use at different level of significant.Variables such as age of the household, education level, family size, TLU, market distance, extension contact, off-farm activity, access to input and membership of milk collection centers were statistically significant relation with adoption decision. Whereas, dairy farming experience, credit and sex of the household had not statistically significant relation to adoption decision of the households.

### Demographic and socioeconomic characteristics of the household



As indicated in table **3**, as the t-test result reveals, there is significant difference between adopters and non-adopters in age, education, and farm size, number of family, TLU, market distance, and extension contact. The mean age of adopters is 43.74, while it is 46.12 years of non-adopters.The mean age of the adopters is less than the mean age of the non-adopters in technology adoption. Thus, the mean variation was found to be statistically significant with p-0.0592 value, this suggest that there is significant difference on the mean age of the household head in the two groups at 1% level of significant. These results suggest that young people tend to be more adopters of new technologies than the old aged people.

The other most important factor that determines the adoption decision is education. The results revealed that the year of education of the adopters is 1.22 while the figure is 0.79 for the non-adopter households, respectively. In addition, the mean difference was found to be statistically significant with P=0.0000. The calculated probability implies that there is significant mean difference in education status of the adopter and non-adopter households at 1% significant level.

Family member who engaged in diary activity result indicated that, there is a significant mean difference between two groups. The mean value for adopters and non-adopter found to be 3.71

and 3.29 respectively. Besides, the difference is statistically significant with p=0.0404 level of significant. This implies that the mean difference was found to be statistically significant at 5%. This result asserts that as the number of family members engaged in diary activity increases the tendency of using dairy technology increases.

The effect of livestock ownership (TLU) was found have a significant effect on adoption of improved dairy technology. The average livestock ownership for adopters and non-adopters was found to be 7.51 and 6.71, respectively. The p-value implies that there is a significant mean difference between two groups at P=0.0176. The probability shows 5% significant level. Accordingly, the adopter household has more livestock owners than non-adopters. This can be the large household with large number of livestock's holding tends to adopt dairy technologies. This finding is conformity with the work of Birhanu, (2002).

On the other hand, The mean treated time market distance of adopter are 112.96 and 125.58 non-adopters were walking distance in minutes, respectively. The calculated probability implies that there is significant mean difference between the market distance of adopter and non-adopter households at 1% level of significant. This result indicated that the household with the nearest distance was more likely to access dairy technologies input than the long-distance households.



Similarly, the average mean of extensions contact of the adopters was 2.60 while the difference for non-adopter respondent was 1.44, and there is a significant difference between two at 1% of significance level. The result is in harmony with (Quddus, 2012) finding, extension contact develop the household knowledge and perception with regard to dairy production technologies and improve their practice and also the household who has contact more with kebele extension agent know more about the use of the service those who cannot access (Berihun, *et al*., (2014).

Table 3:demographic and socioeconomic characteristics forcontinuous variables (*t*-test)

| Name of the variables | Adopters (N=128) Mean value | Non-adopters (N=155) Mean value | Total Mean | T-value | P-value |
|---|---|---|---|---|---|
| Age (year) | 43.74 | 46.12 | 45.04 | 1.8944 | 0.0592* |
| Education (grade) | 1.22 | 0.79 | 0.98 | -4.7197 | 0.0000*** |
| Farm size (hectare) | 1.98 | 2.02 | 2.00 | 0.3350 | 0.7379 |
| Number of family | 3.71 | 3.29 | 3.48 | -2.0595 | 0.0404 ** |
| TLU (number) | 7.51 | 6.71 | 7.06 | -2.3898 | 0.0176 ** |
| Market distance | 112.96 | 125.58 | 119.87 | 2.8304 | 0.0050 *** |

| | | | | | |
|---|---|---|---|---|---|
| Extension contact | 2.60 | 1.44 | 1.96 | -4.9987 | 0.000*** |
| Dairy experience | 17.25 | 18.21 | 17.78 | 0.9367 | 0.3497 |
| Credit (Birr) | 1122.65 | 860.64 | 979.15 | -0.6957 | 0.48 |

*Note: ***, **, *, show significance at $p<0.01$, $p<0.05$, and $p<0.1$ respectively*

*( ): means standard deviation*

***Source: Computed own survey result (2019)*** Among the dummy variables, sex of the household head has no mean difference between adopters and non-adopters. The sex distribution of sample households, from the total sample household, 87.99% of them were male and 12.01% of them were female headed. With regard to the sample respondents improved dairy technology adoption status 85.16% of improved dairy technology practitioners were male household head while the rest 14.84 % was female. From the non-adopter's household side, around 90.32% and 9.68% of the total respondents were male and female respectively.

Table 4: Demographic and socioeconomic characteristics for dummy variables ($X^2$-test)

| Name of the variables | Category | Adopters (N=128) | | Non-adopters (N=155) | | Total Value | | $Chi^2$ -value (probability) |
|---|---|---|---|---|---|---|---|---|
| | | Count | % | Count | % | Count | % | |
| Sex | Male | 109 | 85.16 | 140 | 90.32 | 249 | 87.99 | |
| | Female | 19 | 14.84 | 15 | 9.68 | 34 | 12.01 | 0.183 |
| Income from off-farm activities | Yes | 120 | 93.75 | 152 | 98.06 | 272 | 96.11 | |
| | No | 8 | 6.25 | 3 | 1.94 | 11 | 3.89 | 0.062* |
| Access to input | Yes | 124 | 96.88 | 21 | 13.55 | 145 | 51.24 | |
| | No | 4 | 3.13 | 134 | 86.45 | 138 | 48.76 | 0.000*** |
| Membership of milk collection center | Yes | 102 | 79.69 | 28 | 18.06 | 130 | 45.94 | |
| | No | 26 | 20.31 | 127 | 81.94 | 153 | 54.06 | 0.000*** |

*Note: ***, *, show significance at $p<0.01$, and $p<0.1$ respectively*

*Source: Computed own survey result (2019)*

Similarly, adopter's participation is on off-farm activities was found to be 93.75% and 6.25% of the households not engaged in off-farm activities. While from non-adopters 98.06% are engaged in the off-farm activities and 1.94% are not part of it. The chi-square result indicated that there is a variation between adopters and no-adopters at ($p<0.1$) significant level with ($x^2$=0.062). This result might be the household engaged in other off-farm activates increase the household decision of dairy technologies.

Regarding to input access of the respondent households, 51.24% of adopter's households responded availability of input supply for their dairy production while the rest 48.76% didn't. It means that, around 3.13% of adopters group and 86.45% of non-adopters respond that there was no access to technology input supply. In the revers, 96.88% of adopters and 13.55% non-adopter group was access to dairy input supply. Based on this, the chi-square test result revealedthat there is statistically significant association between adopters and non-adopters in input availability and adoption of dairy technologies at ($p<0.01$) level of significant. This could be the availability of dairy input nearby market is crucial to facilitate the adoption of new or existing technologies.

Similarly, participation of farmers in milk collection center could possibly increase the adoption of dairy technologies. Regarding to this, 79.69% of adopter's households were members of milk collection centers while 20.31% did not part of it. Likewise, about 18.06% of the non-adopters found to be participate in milk collection center and 81.94% was not. Based on this, the chi2 test shows that, there was statistical significance difference between dairy technology adopters and non-adopter households on the participation of milk collection center at ($p<0.01$) level of significant. Milk collection centers provide dairy technologies like breed and AI, such benefits might to be increases the probability of farmers for adoption. This finding is conformity with focus group discussion.

**Econometric model estimation result**

**Impact of improved dairy technology adoption**

This section describes econometric analysis which was followed to identify the impact of improved dairy production technologies adoption on rural household food security. The section was analyzed that the estimation of propensity scores, choosing matching algorithm and calculate Average Treatment Effect (ATT) on treated and sensitivity analysis.

Propensity Score Matching (PSM) is used to match adopter and non-adopter in order to create reasonable counterfactual (Rosenbaum and Rubin, 1983). Propensity score construct a statistical comparison between treated individual with control individual based on similarities in all observable characteristics except the treatments in order to compute the difference in the outcome variable. Which means that the average treatment effect of the technology adoption is calculated as the mean difference in outcomes across the two group (Rosenbaum and Rubin, 1983). According to khandker*et al.*, (2010) the PSM effect validity depends on conditional independence and sizable common support across the adopter and non-adopter sample household.

In the first step, logit model is used to estimate the propensity scores for matching purpose Baker (2000). Accordingly, in this study thirteen explanatory variable were identified and used to fulfill the criteria of the balancing propensity. The next step after balancing the predicted probability values, from the binary estimation, matching was done by using matching algorithm. A matching algorithm is selected based on the data at hand in order to select the control group who are matched with the treated group based on the covariant which need to be controlled.

In general, this section presents the result of logistic regression, in the first step in the propensity score matching to estimate for matching dairy technology adopter household with non-adopters. The logistic regression results in the Table-5showed that, there are different variable that determine household decision in improved dairy technologies practice at different statistically significant levels.

In this study, thirteen selected explanatory variables were hypothesized that determine household's participation in dairy technologies adoption. Among those variables, five of them were found to be significant variable that determine the adoption of households in the decision of adopting improved dairy technologies practice and use of improved dairy technologies either positively or negatively while the rest of eight variables were not significant in explaining the variation in the dependent variable.

Among the explained variables by logistic regression model that influence the probability of household in the adoption could be age of the household, frequency of extension contact, participation in milk collection center, input access, livestock holding (TLU) were the variables identified by logistic regression model that influence household probability of adoption in improved dairy technologies in the study area.

The output of logistic regression Table 5, indicated that the household frequency of extension contacts, participation households in milk collection center, input access livestock holding (TLU) were affect the household's probability of adoption and use of improved dairy technologies positively and statistically significant at p<0.01, p<0.01, p<0.01, and p<0.0 5 significant level respectively. While age of the household affects it negatively at p<0.05 significant level.

In this study the number of extension contact of the household increase by one unit, also an increase the probability of participation in adoption process and use dairy technologies by 92.5% units. The possible reason for this may be, farmers which have strong communication with extension agents were expected to more adopt dairy technologies than less contact. The implication of the result that obtained could be household with more contact has access to know about the new technology and intensity to use.

With regard to farmer participation in milk collection center, the main benefit of these were to provide agricultural input like Artificial insemination (AI) service and veterinary service, market and information to increase the production and productivity to their member. Table 5indicated, the membership of households in milk center have a positive influence on adoption and intensity of use improved dairy technologies significantly at (p<0.01) significant level. The possible explanation could be the involvements of farmer in such institute motivate households to engaged in dairy technologies. This implies that strengthen the center enhance the adoption of improved dairy technologies adoption for rural households.

Similarly, access to dairy input supply result indicated that, the unit increases the household increase the probability of household adoption and level of adoption for dairy technologies increased. Not only the availability of input in the area. Access of input by the households and cost of the technologies also matter the adoption of the households. In this study, the implication could be households who have more income are able to adopt improved dairy technologies in better manner. Table5reveals that, access to input have a positive influence on adoption and intensity of use improved dairy technologies significantly at (p<0.01) significant level.

In addition to this, tropical livestock unit affect the household's probability of adoption and practice of improved dairy technologies positively and significantly at (p<0.05) of significant level. The logistic regression results show, tropical livestock unit increase by one unit the probability of adopting dairy technologies is increased by 21.25%. The potential reason for this result could be households who owned large livestock have the capacity to afford to adopt improved dairy technologies as well as the imitation to purchase new increases.

As described in the Table 5, the Pseudo- $R^2$ value is large and the value is (0.7758) indicated that the adoption of the household is fairly random. According to (Caliendo and copeinig, 2008), after matching there should be systematic difference in the distribution of covariates between adopters and non-adopter groups.

Table 5: Logit estimation model for estimating propensity scores

| Variables | Coef. | Std. Err. | Z | P-value |
|---|---|---|---|---|
| AGEHH | -.098142 | .0402782 | -2.44 | 0.015** |
| SEX | .5900471 | .9590324 | 0.62 | 0.538 |
| EDU | -.2141835 | .4343176 | -0.49 | 0.622 |
| DARIYACT | .1180851 | .1983707 | 0.60 | 0.552 |
| FRMSIZE | -.2240464 | .2861133 | -0.78 | 0.434 |
| MARKDIS | -.0054058 | .00761 | -0.71 | 0.477 |
| EXTFRQ | .9255643 | .244037 | 3.79 | 0.000*** |
| OFFFARM | 2.820787 | 1.947668 | 1.45 | 0.148 |
| CREDIT | -.0000281 | .0000761 | -0.37 | 0.712 |
| MILCCOLL | 4.30878 | .8509251 | 5.06 | 0.000*** |
| INPUTACCES | 5.761459 | .9756375 | 5.91 | 0.000*** |
| TLU | .212503 | .120482 | 1.76 | 0.078** |
| EXPDAIRY | .0651064 | .0508883 | 1.28 | 0.201 |
| _cons \| | -5.988286 | 2.308024 | -2.59 | 0.009 |

*Sample size (N) =283 Pseudo R2=0.7758 LR chi2 (13) =302.37Prob > chi2=0.0000 Log likelihood = -43.687911*

*Note**:** ***, **, *, show significance at p<0.01, p<0.05, and p<0.1 respectively*

*Source**:** Computed own survey result (2019)*

**Propensity score histogram**

The propensity score matching (PSM) is to match each participant based on an identical common characteristic with non-participants. Thus, the distribution helps to identify the impact of dairy technology adoption on household food security based on food consumption score and dietary diversity. In line with this the density distribution of propensity scores for adopters and non-adopters is shown in (Figure 2) below. The bottom half of each graph shows the propensity score distribution of non-treated (non-adopters) while the upper-half refers to treated individuals. The y-axis indicated the frequency of the propensity score distributionRegion of common support between Treated and untreated.

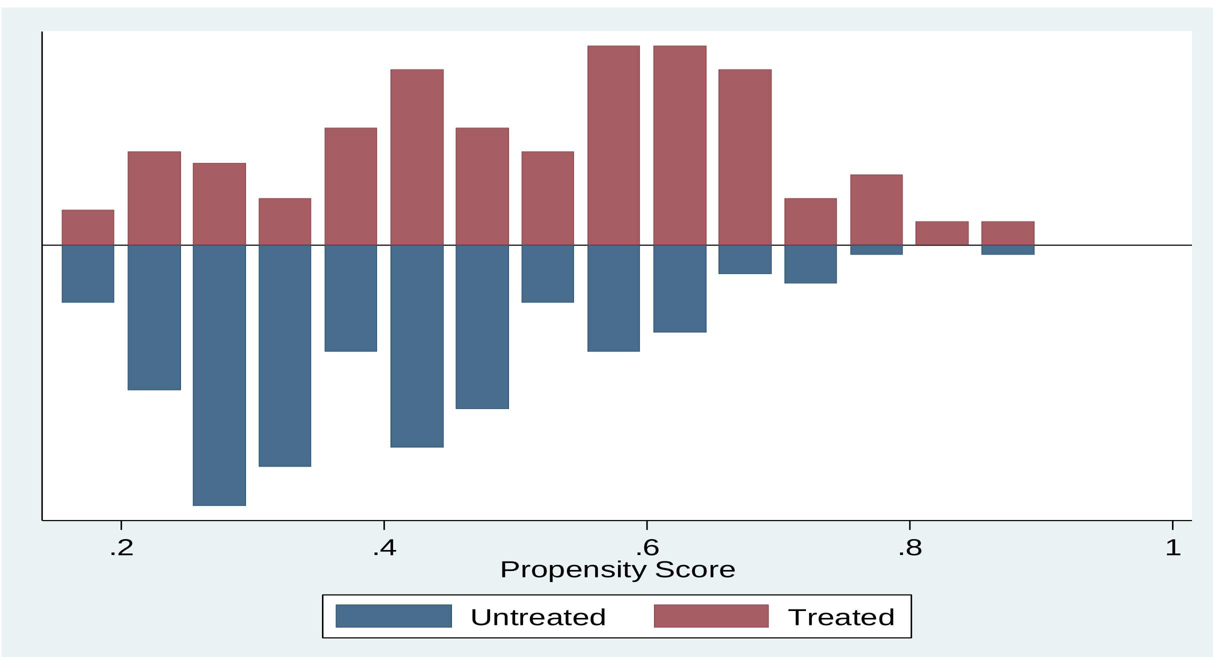



Figure 2. Propensity score distribution and common support region between the treated and untreated

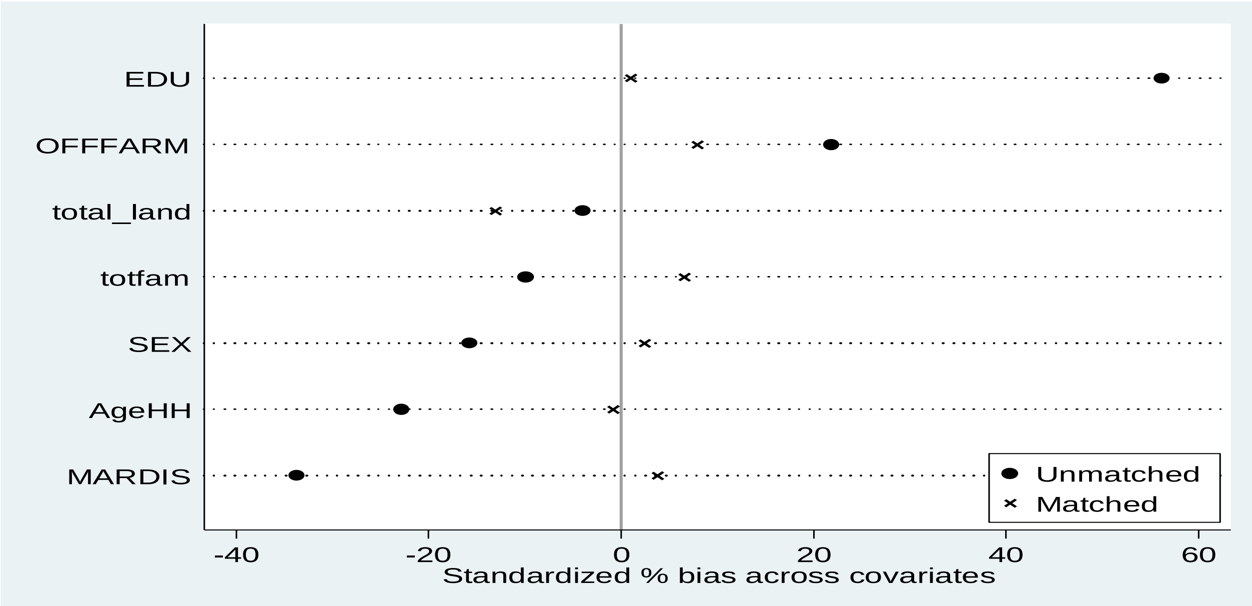
Table 6: Testing of covariance balance using propensity score (evaluation of quality of match)

| **Covariates (variables)** | **Samples** | **Mean** | | **%of bias** | **%reduction bias** | **P-value** |
|---|---|---|---|---|---|---|
| | | **Treated** | **Control** | | | |
| Age HH | Unmatched | 43.742 | 46.123 | -22.8 | | **0.059*** |
| | Matched | 43.742 | 42.617 | 10.8 | 96.4 | 0.438 |
| SEX | Unmatched | 0.85156 | 0.90323 | -15.7 | | 0.185 |
| | Matched | 0.85156 | 0.84375 | 2.4 | 98.2 | 0.863 |
| EDU | Unmatched | 1.2266 | 0.79355 | 56.2 | | **0.000***** |
| | Matched | 1.2266 | 1.2891 | -8.1 | 85.6 | 0.476 |
| Total land | Unmatched | 1.9884 | 2.0258 | -4.0 | | 0.738 |
| | Matched | 1.9884 | 2.0293 | 13.1 | -228.4 | 0.265 |
| MARDIS | Unmatched | 112.97 | 125.59 | -33.7 | | **0.005***** |
| | Matched | 112.97 | 111.88 | 3.8 | 88.9 | 0.779 |
| Family size | Unmatched | 5.0547 | 5.2323 | -9.9 | | 0.408 |
| | Matched | 5.0547 | 4.9375 | 6.5 | 34.0 | 0.603 |
| OFF-FARM | Unmatched | 0.0625 | 0.01935 | 21.8 | | **0.062**** |
| | Matched | 0.0625 | .04688 | 7.9 | 63.8 | 0.584 |
| (Figures in bold shows significant covariates) | | | | | | |

*Note: ***, **, *, show significance at p<0.01, p<0.05, and p<0.1 respectively*

*Source: Computed from own survey (2019).*

The above Table and figure results revealed that the mean standardized bias difference in before matching is in range of 4% - 56.29% in absolute value and P-value in same table shows 73% of




chosen variables exhibited statistically significant difference at before matching. Whereas, after matching the standardize bias/standard error difference of explanatory variables lied between 3.8%-10.8%. if the value of this statistics exceeds 20 the covariate is considered to be unbalanced (Rosenbaum & Rubin, 1985). Accordingly, in all cases, it was evident that sample differences in the unmatched data significantly exceeded those in the samples of matched cases. Hence, the process of matching created a high degree of covariate balance between the treatment and control samples that were ready to be used in the estimation procedure.

*Figure 3.Unmatched and Matched standardized % bias across covariates*

Source: Computed own survey result 2019)

Similarly, the value of Pseudo R2 was very low it was minimized to 0.006 and the low value of Pseudo R2 indicated that the dairy technology adopter and non-adopter households had same distribution in the covariates after matching. The mean bias is also minimized from 23.5 to 5.1. Beta is also minimized to 18.3 which is less than 25 so, this all indicates the matching was good. Hence, this is used to assess the impact of dairy technology adoption among group of households having similar observed characteristics. The below figure indicated that the standardized % bias across covariates (unmatched with matched covariates).

As indicated in Table 7, the value of Pseudo R2 was very low it was minimized to 0.006 and the low value of Pseudo R2 indicated that the dairy technology adopter and non-adopter households had same distribution in the covariates after matching. The mean bias is also minimized from

23.5 to 5.1. Beta is also minimized to 18.3 which is less than 25.So, this all indicates the matching was good. Hence, this is used to assess the impact of dairy technology adoption among group of households having similar observed characteristics.

Table 7: Post estimation of PSM

| **Sample** | **Ps R2** | **LR chi2** | **p>chi2** | **Mean Bias** | **B** |
|---|---|---|---|---|---|
| Unmatched | 0.085 | 33.08 | 0.000 | 23.5 | 70.9 |
| Matched | 0.006 | 2.16 | 0.950 | 5.1 | 18.3 |

***Source****: Computed own survey result (2019)*

## The treatment effect (Impact)

The impact of dairy technologies adoption on household food security computed using the three matching algorithms namely, kernel-based matching (KBM), nearest neighbor matching (NNM) and radius matching (RM) are show below in Table 8the outcome variable was the household food consumption score and intake of diversified food in the household. The impact of the adoption is shown by the difference in ATT.

Table 8: Performance criteria of matching algorithms

| Outcome variable | Match algorithms (kind of matching) | Matched samples | | ATT (Impact) | Std. Err. | *t*-test |
|---|---|---|---|---|---|---|
| | | Adopters | Non-adopters | | | |
| FCS | Kernel-based matching (KBM) | 128 | 155 | 6.490 | 1.359 | 4.777*** |
| | Nearest neighbor matching (NNM) | 128 | 155 | 6.490 | 1.238 | 5.243*** |
| | Radiusmatching (RM) | 128 | 155 | 6.521 | 1.238 | 5.267*** |
| HDDS | Kernel-based matching (KBM) | 128 | 155 | 1.038 | 0.248 | 4.192*** |
| | Nearest neighbor matching (NNM) | 128 | 155 | 1.038 | 0.244 | 4.253*** |
| | Radius matching (RM) | 128 | 155 | 1.055 | 0.244 | 4.318*** |

*Note: *** statistically significant at p<0.01*

*Source: Computed from own survey (2019)*

Table 8 presents the estimated effect of dairy technology adoption on household food security status based on food consumption score and household dietary diversity by kernel-based matching (KBM), nearest neighbor (NNM), and radius or caliper (RM) methods. The post matching result from KBM reveals that dairy technology adoption tend to positively and significantly affect household food consumption score and dietary diversity of the households. The difference is statistically significant at ($p<0.01$) level. The estimates of NNM shows that adoption of dairy technologies improves household food security by 6.490 and 1.038 frequency of consumption of households per week and dietary diversity of the household respectively. The difference is significant at ($p<0.01$) level.

Similarly, the RM result reveals that adopting of dairy technologies also guarantees favorable effect on food security. This means that when we compared to matched households that did not adopt any of the dairy technologies, households that did not adopt experienced a 6.521 and 1.055 frequency of consumption score and dietary diversity respectively. Based on radius, the difference between two groups was still significant at ($p<0.01$) level.

Based on the study result, all of the above result suggested that the matching algorithm chosen relatively for this study. Therefore, it can possible to proceed to estimate the average treatment effect on the treated (ATT) for the sample households.

## The impact of adoption of dairy technology on Food Consumption Score (FCS)

The final step in PSM process is to estimate treatment effects on the outcome variable in the matched sample trhough a t-stat result. It has been found that, on avarage, dairy technology adopter households have increased the food consumption score 7.88 in terms of frequency of eating diversified food per a week. This means that dairy technology adoption has increased the household food consumption score by 23.19%.

Table 9: ATT Estimation results of household Food Consumption Score (FCS)

| Variable Sample | Treated | Controls | Difference | S.E. | *t*-stat |
|---|---|---|---|---|---|
| FCS Unmatched | 34.0546875 | 27.5645161 | 6.49017137 | 1.2209734 | 5.32 |
| ATT | 34.0546875 | 26.15625 | 7.8984375 | 1.74639659 | 4.52 |

### The impact of dairy technology adoption on household food security (HDDS)

The average household dietary diversity score result of the sample households indicated those dairy technology adopter households have decreased the intake of diversified food 1 in terms of access and utilization of diversified food in 24 hour recall. This means that dairy technology adoption has increase the household daitery daiversity by 13.7%. This result shows positive effect is estimated for the adopter households who are more taking diversified food than the non-adopter households. Accordingly to the preferred estimates, the dairy technology adoption has significantly and positive impact on daitry diversity of the adopter households.

Table 10: ATT Estimation results of Household Dietary Diversity Score (HDDS)

| Variable Sample | Treated | Controls | Difference | S.E. | T-stat |
|---|---|---|---|---|---|
| HDDS Unmatched | 7.2578125 | 6.21935484 | 1.03845766 | .246914672 | 4.21 |
| ATT | 7.2578125 | 6.2578125 | 1 | .356177762 | 2.81 |

## Conclusion and Implication

The data was mainly collected from 283 farm households living in two randomly selected kebeles. The samples were 128 dairy technology adopters and 155 non-adopter households. A structured questionnaire, focus group discussion and key informant interview were key data collection tools. The study employed the PSM estimation methods through collecting data specifically for impact evaluation. From the total sampled households 12.01 % (34) were female and 87.99 % (249) male respondents.

Generally, food security implies that access, availability, utilization and stability of food by a household in sufficient and safe manner where dietary diversity and food consumption score are proxy indicator of household food security. The key finding of study showed that, improved dairy technology adoption has increased the smallholder’s food consumption by 23.19% and dietary diversity of the household by 13.7%. The result of this specific study reaveld that adopters are more food secure than non-adopter. Introducing and disseminating of dairy technologies to smallholders farmers could improve dairy production and productivity of the household. In spit of this, different governmental research center, NGO's, universities and extension service should participate in the interventionand dissimination process of improved technologies to smallholder dairy farmers in the district and to the region at large scale. Thus,smallholder dairy farmers would increase access and utilization of diversified food and improve hosehold food security.

**Abbreviations**

ATE: Average treatment effect

ATET: Estimated average treatment effect on treated

CCT: Contingency coefficient test

CSA: Central statistical agency

EARI: Ethiopian Institute of Agricultural Research

FGD: Focus group discussion

GDP: Gross domestic product

KBM: Kernel-based matching

KI: Key informant

RM: Radius matching

SSA: Sub-Saharan African

ILRI: International livestock research institute

NNM: Nearest neighbor matching

NN: Nearest neighbor

NGOs: Non-Governmental Organizations

PSM: Propensity score matching

VIF: Variance inflation factor.



**Data Availability**

The data analyzed for this study are available from the author on reasonable request.

**Consent**

During the survey, official letters were written for the district and eachrespondent provided informed verbal agreement, and their identity was not identified during interview also not use any of the respondent's photo and other confidential identities in the time of data analysis and report

### Disclosure

This manuscript is extracted from the author's thesis work part which entitled "Dairy technology adoption and its impact on household food security: the *case of Basonawarenaworeda, Amhara region*, Ethiopia." "*Wereda*" is an administration unit equivalent to district whilst "Kebele" is the lowest administration unit in Ethiopia

### Conflicts of Interest

The authors declare that they have no conflicts of interest.

### Authors' Contributions

The author designed the study, analyzed the data, and wrote the paper.

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