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RESEARCH PAPER

Determinants of Adoption of Improved Forage and Its Impacts on Income of Smallholder Farmers in Southwest Showa Zone, Oromia Region, Ethiopia

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Abstract

Improved forage is an important livestock feeding. However, adoption and intensity of improved forage in Ethiopia were low. Also, it causes for low level of income. Using cross-sectional data collected from 351 livestock producers in Southwest showa zone we examined the variables that affect the adoption of improved forage and its impacts on household income. Descriptive statistics and econometric models were employed for this study. The average lands allocated by adopters were 0.016hectares. Nine explanatory variables showed statistically significant differences between adopter and non-adopter of improved forage. The Heckman two-stage model analyses indicate that the adoption is significantly influenced by age, education, farm income, frequency of extension contact, access to training, access to credit, family size and the availability of communal grazing land whereas frequency of extension contact, livestock holding, sex, educational, and access to training were statistically significant factors in affecting the adoption intensity of improved forage. According to the PSM model adopters of the improved forage makes on average 2942.652 Ethiopian Birr/year more incomes than non-adopters. The result of this study indicates that a low adoption rate and several factors that influence adoptions in general. Adoption of improved forage is important since it boosts adopters' income and is a solution for the shortage of feed for livestock which now frequently rises. The findings show that smallholder livestock producers should be encouraged to adopt improved forage at a greater rate in order to raise their profitability.

Keywords: Adoption, Challenges, Forage, Heckman two stages, improved, livestock, Ethiopia

Introduction

Livestock production accounts for roughly 25% of national GDP and 40% of agricultural GDP in Ethiopia, as it is an important aspect of agricultural operations (Stapleton, 2016). Ethiopia has the largest livestock population in Africa, with 65million cattle, 40million sheep, 51million goats, 8million camels and 49million chickens in (CSA, 2020a). Milking cow production, however, falls far short of national demand due to a number of challenges such as a shortage of high-quality feed like improved forage and pasture, and the high cost of concentrate (Land O'lakes, 2010; Malede et al., 2015; Ulfina et al., 2013). Natural pasture and crop remnants are the primary feed sources in a mixed agricultural system (Adugna, 2007). Due to declining grazing pastures, crop residues now cover 10% to 50% of animal feed in mixed farming areas (Abera et al., 2014), but natural pasture role has fallen from 80%-90% in the early 1960s to 30%-40% in the last decade of the 2000s (Getnet et al., 2016).

In Ethiopia at the farmers level, fodder-related limitations include shrinking grazing lands, overstocking, and seasonal variations in forage availability, poor nutritional quality, use of crop residues for other purposes, less availability and high cost of feeds, less adoption of improved forages, silage making, haymaking, and urea treatment (Alemayehu, 2012).

Improved forage was introduced in Ethiopia at various times. Around dairy and fattening operations, there is now very little development of improved pasture and forages (Alemayehu et al., 2017a). However, over the last 50 years, 33 improved forage varieties have been recognized and supplied with complete production and use packages for varied agro-ecologies across Ethiopia (Getnet et al., 2016). However, further empirical research is required to conduct on the determinants of adoption and the intensity of improved forage adoption, particularly on income contribution of it's in the study area.

Low level adoption of improved forage was arising from lack of awareness about improved forage production and husbandry practices, insufficient market infrastructure, a lack of a market-oriented cattle production system, and the prevalence of various diseases were identified as main factors that troubled livestock productivity and production in the country (Bashe et al., 2018). The issues, however, were not restricted to these. Furthermore, the characteristics of the problems differed by area, due to that we are motivated to conduct research on the issues to fill gap.

Even though in the last fifty years researchers tested and introduced on nutritive, low-cost legumes and fodder shrubs to improve cattle's protein intake and increase the productivity of sub-Saharan Africa dairy farms (Ndah et al., 2022, their adoption by farmers has proven to be unsatisfactory. Franzel et al., (2007) and Wambugu et al,. (2011) found that despite the heavy sensitization on more nutritive forage technologies in East Africa, only 10% of the smallholder farmers took them.

In spite of the fact that different studies conducted on the factors that influence improved forage adoption in different parts of the country, most of them uses similar models and they look only adoption and intensity of improved forage (Gebremedihin, 2003, Beshir, 2014, Alemayehu et al., 2017a, Woldu, 2016; Tesfaye and Melaku, 2017; Serekebrhan et al., 2018; Abebe et al., 2018). However, in addition to examining the adoption and intensity of improved forage adoption, it is essential to examine the impact of improved forage adoption on household income by using the right model is important rather than employing a homogenous model. Also, those studies carried out in various regions of the country do have the aforementioned problems. This indicates the existence of a potential research gap and hence this study was done to address this research gap regarding the variables that affect smallholder livestock farmers' adoption of improved forages and how it affects their income in the southwest Shawa zone. In the study area, still now some farmers were not adopted and their adoption level is very low, with no one detecting any impact on household income. Therefore, the purpose of this study was to analyses the factors determine the adoption and intensity of improved forage adoption and to analysis the impact of improved forage adoption on income of smallholder livestock farmers in the area.

Methodology

Description of the study area

The study was conducted in southwest showa zone, Oromia regional state in Ethiopia. The This study were conducted in: *Woliso, Wonchi,* and *Amaya*. The three districts were well known for livestock production from the area. In the *Woliso* district, there were 5544 cows, 1585 heifers, and 133 bulls that belonged to improved breeds. In *Wanci* district there were 214 cows, 245 heifers, and 155 bulls of improved breed. In *Amaya* district there were 450 cows, 565 heifers, and 310 bulls of improved breed. In general, there were 1995840, 110400, and 1620000 livestock found in the *Woliso*, *Wanci*, and *Amaya*, respectively (SWZ Livestock department, 2023).

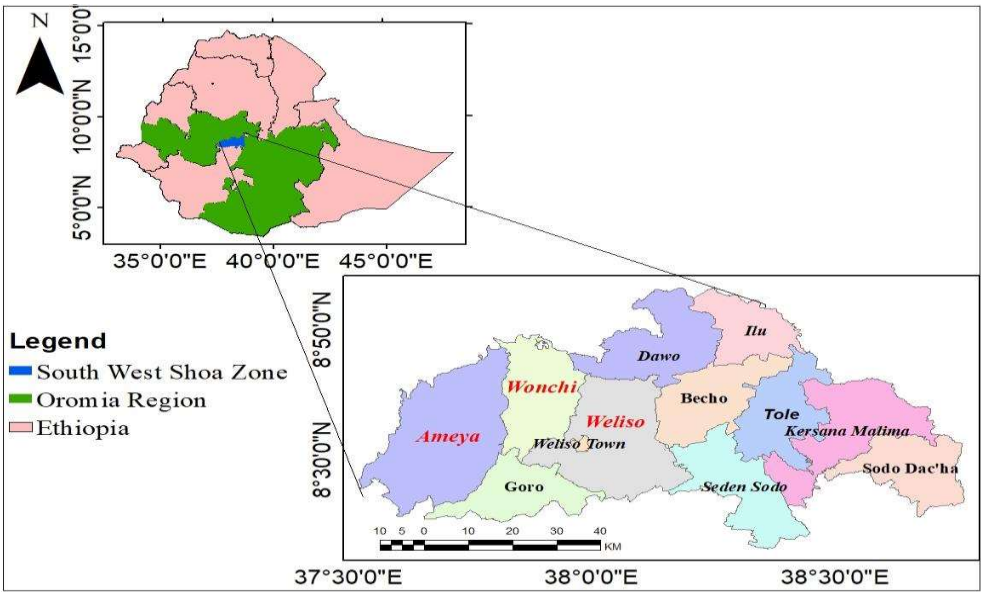

Figure 1. Map of the study area

Sampling methods and procedures

In this study, multistage sampling approaches were used. Initially, the three districts of Southwest Shawa Zone, *Waliso, Wanchi,* and *Amaya* were selected based on their livestock production potential (SWSZ, 2021). Next two *kebeles* from each district were selected by using simple random sampling. At the last stage a list of all smallholder livestock farmers in the six *kebeles* obtained and stratified into two groups: adopters and non-adopters of improved forage. Based on the sample selection proportion, smallholder livestock farmers were then randomly selected from each stratum. Based on statistics from six sampled *kebeles*, the total population size is 4043. In the six *kebeles* under study, 1460 smallholder livestock producers have adopted, while 2583 are non-adopted. Following the Cochran's (1997) formula for calculating sample size for a heterogeneous population: $\frac{pq(Z^2)}{e^2}$ where: n=sample size, z= the value of standard deviation at a given confidence level and to be worked out from table showing area under normal curve is 95% zα/2 =1.96, p= sample proportion = 0.5, q= 1-p = 0.5, e = given precision rate or acceptable error 5%. The calculation of sample size from the formula is 384. However, according to Cochran's formula we use the result as it is when the population greater than 10,000 otherwise we use the next step formula to determine the sample size $n_o = \frac{n}{1+\frac{n-1}{N}}$. Then 351 households (127 adopters and 224 non-adopters of improved forage) were randomly selected from total smallholder livestock farmers of the six sampled *kebeles* in the district.

Data sources, types and methods of collection

For the current study, data was collected in quantitative form. A structured interview schedule was used to collect quantitative data from the household head on improved forage of issues related to demographic, socioeconomic, and institutional characteristics.

Method of data analysis

For this study descriptive statistics and econometric model were employed.

It's probable that being chosen to join in any program isn't always random due to selectivity bias. Because the study's sample was selected from a pool of adopters, there could be selection bias in this case. As a result, to account for selection bias, the Heckman selection model was employed. The Heckman's selection model assumes that technology adopters are not chosen at random, but rather that there is a self-selection bias that must be addressed in order to obtain unbiased adoption intensity analyses. According to Heckman, sample selection bias can occur in practice for two reasons (1979). To begin, a person or data unit under inquiry can opt to self-select. In the same way that self-selection is done, analysts or data processors make a second sample selection decision.

Selective samples may be the result of rules governing data collecting or the actions of a commercial agency. Self-selection is the term used to describe the latter scenario. Non-randomly chosen samples used in statistical analysis could lead to incorrect findings and poor policy recommendations (Heckman, 2008). The two-step statistical method known as Heckman's adjustment can be used to correct non-randomly chosen samples. In the first stage, a model is developed to estimate each person's likelihood of adoption, and in the second stage, bias is removed by removing the portion of the error term related to the explanatory factors. The Heckman's selection model was employed in some Ethiopian and East African adoption studies to assess the likelihood and intensity of adoption (eg. Mideksa et al., 2021). In the first step of Heckman's selection model, an "adoption equation" is used to attempt to capture variables impacting adoption decisions, and an Inverse Mill's Ratio (IMR) is computed. The IMR is one of the independent variable used in the second stage to analyze adoption intensity and correct selection bias. The Maximum Likelihood Probit was used to model the likelihood of adoption before arriving at the inverse Mill's ratio. The features of Heckman's two-step models are as follows:

1. The adoption equation: The Probit model is specified as:

$$Y_i = \beta_i X_i + \varepsilon_i,\ i = 1, 2, n \text{ --------------------- } (1)$$

$$y_i^* = 1, \text{ if } y_i^* > 0 \text{ or } 0, \text{ if } y_i^* < 0$$

Where yi* is the unobserved latent dependent variable and Y_i is a binary variable that assumes 1 if household I adopts improved forage and 0 if it does not. The formula determines the outcome.

β_i is a vector of unknown parameters in adoption equation.

X_i is a vector of explanatory variables in the probit regression model.

ε_i is random error term that are assumed to be independently and normally distributed with zero mean and constant variance.

Lambda (λ_i), which is related to the conditional probability that an individual household was deciding to adopt (given a set of independent variables) is determined by the formula.

$$\lambda_i = \frac{f(x\beta)}{1-F(X\beta)} \text{ --------------------------------- } (2)$$

Where λ_i is Inverse Mill's Ratio (IMR), f (Xβ) is the standard normal probability density function and $1-F$ (Xβ) is the cumulative distribution function for a standard normal random variable. The value of λ_i is not known, but the parameters (β) can be estimated using a probit model based on the observed binary outcome (Y_i). Then it was used in outcome equation to make consistency of the model.

2. Regression (OLS): Outcome model is specified as:

$$Y_i = \alpha_i Z_i + \mu\lambda_i + \eta_i \text{ ---------------------------- } (3)$$

Where, Y_i is the intensity of improved forage adoption, α_i is a vector of unknown parameters to be estimated in the rate of improved forage adoption equation, Z_i is a vector of independent variables determining the rate of improved forage adoption, μ_i is the parameter that helps to test whether there is a self-selection bias in the adoption of improved forage, λ_i is inverse mill ratio and η_i is the error term.

All of the proposed independent variables were examined for the presence of a multi-collinearity issue prior to running the Heckman two-step model. Before running the model, both continuous and dummy variables were examined to get around the issue. The degree of correlation between the dummy variables was evaluated using the contingency coefficient, and the multicollinearity issue for continuous variables was examined using the variance inflation factor (VIF). $\mathrm{VIF} = \frac{1}{1-\mathrm{R}^2}$

The inconvenience increases as the VIF rises. As a general rule, a variable is said to be very collinear if its VIF exceeds 10 (which happens when Ri^2 surpasses 0.95) (Gujarati, 1995). Using the formula below, the contingency coefficients for dummy variables were determined.

$$C.C = \sqrt{\frac{x^2}{n + x^2}}$$

The chi-square value is x^2, the contingency coefficient is C, and the overall sample size is n. When the contingency coefficient for dummy variables exceeds 0.75, the variable is collinear (Mesfin, 2005).

Propensity score matching (PSM) method

The study employs a non-experimental method called propensity score matching, which is popular among non-experimental techniques because it does not require baseline data, the treatment assignment is not random, and it is regarded as the second-best option to experimental design in reducing selection biases. We can extract a set of matching households from the sample of non-involved households using the PSM technique that are similar to the involving household in all relevant ways. In other words, PSM pairs each household that isn't involved with a household that is because they have (nearly) identical features. There are various reasons why PSM is superior to the conventional regression approach. These include, among other things, the fact that PSM exclusively compares households that are located in the common support zone and leaves out other households from the study. It also compares outcomes for observations that share similar observable characteristics. The purpose of this study was to calculate the impact of improved forage adoption on household income. In this study, the terms "treatment" and "effect" refer to the change in income level brought on by the adoption of improved forage. Conversely, "control" refers to households that are not adopting improved forage.

Definitions of Variables and Hypotheses

Dependent variable

In this study, household adoption or not adoption of improved forage is the dependent variable which is dummy. The intensity of improved forage adoption is a continuous variable. It here refers to the cultivation of improved forage per hectare. Farmers who adopt improved forage (Desho, vetiver, saspania and other) are called adopters. Farmers that did not adopt either of these improved forage kinds throughout the survey year (2020/2021) are referred to as non-adopters.

Independent variables

The independent variables are those that are supposed to have an influence on whether a household head is adopted or not improved forage.

Table 1: Summary of description of variables and its value of measurement
Source: Literature review

N/S	Variables	Description	Type	Measurement	Expected Sign
I	**Dependent variables**				
1	Adoption	Household head adoption of improved forage	Dummy	1=participate 0=not participate	
2	Intensity of adoption	Amount of land allocated for improved forage cultivation	Continuous	Hectare	
II	**Independent variables**				
1	AHH	Age	Continuous	Years	+
2	SEHH	Sex	Dummy	1=male 0=female	+
3	EDHH	Education	Continuous	Year of school	+
4	FSHH	Family size of	Continuous	In number	+
5	FCWHH	Frequency of contact with household head	Continuous	Day per month	+
6	LIHH	Livestock holding of household head	continuous	In TLU	+
7	LSHHH	Land size holding of household head	continuous	Hectare	+
8	ATTHH	Access to training of household head	Dummy	1= yes 0= no	+
9	ACGL	Access to communal grazing land	Dummy	1= yes 0= no	**-**
10	DNM	Distance to nearest market/town	Continuous	Km	**-**
11	HOFI	Off-farm income	Continuous	Ethiopia Birr	+
12	ACDS	Access to credit service	Dummy	1=yes 0=no	+
	Outcome variable is Farm income	Income obtain from livestock production			

Result and Discussion

Descriptive results

Table 2 presents the results of descriptive statistics and compares the adopters and no-adopters of improved forage. Accordingly, about 20% of the sample households were female headed. More than 88.97 % and 11.03% of the male and female headed households, respectively, were improved forage adopters. Adopters allocated an average of 0.016ha of land in the study area for improved forage production. In Ethiopia, the allocated land is extremely underdeveloped, and as of yet, no similar study has been carried out in sub-Saharan Africa. Desho grass, oat, sespania, vetch, tree lucerne, and vetiver grass were more frequently adopted in the study area.

Numerous kinds of livestock were raised in the study area for a multiple of purpose, like draught power, milk, meat, eggs, transportation, and money generating through back renting and selling. In the study area, communal grazing, teff straw, legumes, barley and wheat straw, native grass hay and improved forage are the primary sources of feed for livestock. The most common livestock species in the study area were cattle, donkeys, poultry, shoats, horses, and mules, in order of significance (Figure 2).

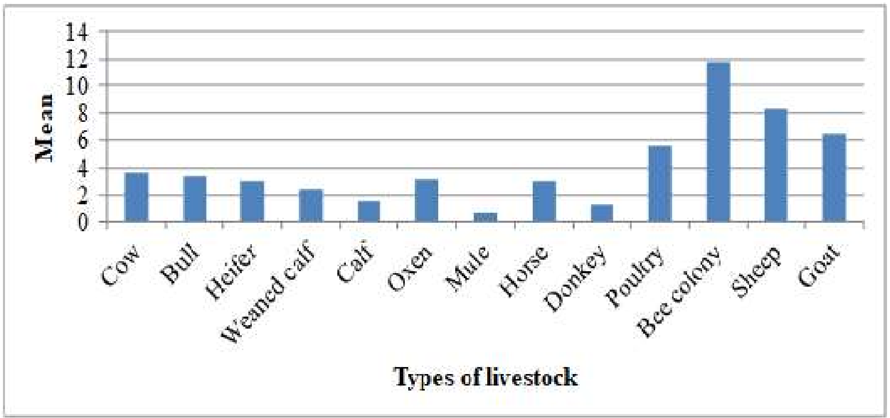

Figure 2. Livestock resource of the study area
Source: Computed from survey data of 2021/2022 production season

The household heads' average ages and levels of education were 44.08 and 3.37 years, respectively. There is no significant difference between the mean age of adopters (44.35 years) and non-adopters (43.93 years), whereas adopters having higher education than non-adopters (i.e, 4.74 and 2.6 years of schooling, respectively). The average family size was 5.74 in adult equivalent. Families of adopters were bigger than those of non-adopters (5.86 and 5.45, respectively) (Table 2). Average annual farm and non-farm household income was 13,186.95ETB and 3,614.95ETB, respectively. In comparison to non-adopters, adopters had a higher average farm income (14,264.66ETB) (11, 286.08ETB). Adopters earned more income than non-adopters in terms of average off-farm income (4,195.0ETB) (3,284.6ETB). Frequency of extension contact with the household head on average was 2.50 day per month. Extension agents contacted adopters more frequently than non-adopters (3.61 day per month) (1.86 days per month). On average the land holding and livestock holding of household head was 2.86haand 9.45TLU respectively. Both adopters and non-adopters had average livestock holdings of 9.63TLU and 9.35TLU, respectively. The average does not show significance between the categories. For non-adopters and adopters, the average land holding was 2.83ha and 2.91ha, respectively.

There is no average significance difference in land holding between groups. The sample respondents' average trip distance was 4.61Km. The sample's adopters and non-adopters travelled an average distance of 4.36Km and 5.05Km, respectively, with a statistically significant mean difference between the two groups (Table 2).

Table 2. Household Characteristics by adoption and intensity of adoption of improved forage

Variable name	Adopters (N=127)		Non-adopters (N=224)		T-value	Total sample household (N=351)	
	Mean	St.D	Mean	St.D		Mean	St.D
Age	44.35	6.63	43.93	7.68	0.54	44.08	7.312
Education level	4.74	2.76	2.60	2.97	6.64***	3.37	3.07
Family size hold	5.45	1.64	5.89	2.17	-2.19**	5.74	2.00
Farm income	14,264.1	21808.1	11286.08	7542.36	1.858*	13186.95	18043.1
Frequency of Extension contact	3.61	2.48	1.86	2.51	6.302***	2.493	2.64
Livestock holding	9.63	5.70	9.35	14.71	0.28	9.45	12.23
Land size holding	2.91	1.48	2.83	2.10	0.38	2.86	1.88
Distance market	4.36	3.54	5.05	2.55	2.130**	4.61	2.96
Off-farm income	4195.0	5612.49	3284.59	7052.44	1.33	3614.01	6574.31

Computed from the data of 2021/2022 production season

According to Table 3, men made up 79.8% of the sampled respondents, while women made up 20.2%. The sizes of male and female adopters were 88.97% and 11.03%, respectively. Non-adopters were made up 74.55% by men and 25.45% by women. The statistics revealed a significant difference between the groups. From the total sampled respondents 36.2% were did not have access to improved forage training, compared to 63.8% of the total sampled respondents who did. Household heads were given access to improved forage training in 74.8% of adopters and 25.2% of non-adopters, respectively. In total, 57.6% of non-adopter household heads received improved forage training, compared to 42.4% who did not. The finding indicates that between the group's statistical significance. The finding indicates that 50.1% of the household heads had access to communal grazing land, compared to 49.9% who claimed they did not. In contrast to 72.4% of adoptive household heads, only 27.6% of household heads had access to communal grazing land. From non-adopters 37.5% was not access to the communal grazing land whereas 62.5% of was access to the communal grazing land. About 35% of the total respondents do not have access to credit services, compared to 65% of the total respondents who do. From adopters 93.7% were access to credit whereas 51.4 % from non-adopters were not access to credit. From adopters 6.3% were not access to credit whereas 48.6% from non-adopter were access to credit. The chi-square(X^2) test shows that statistically significant association between access to credit and adoption of improved forage

Table 3. Households' characteristics by adoption and intensity of adoption of improved forage (for dummy explanatory variables)

Variables name		Adopter		Non-adopter		X^2-value	Total sample	
		N	%	N	%		N	%
Sex	Male	113	88.97	167	74.55	10.45***	280	79.8
	Female	14	11.03	57	25.45		71	20.2
	Total	127	100.0	224	100.0		351	100.0
Access to training	If access	95	74.8	129	57.6	10.40***	224	63.8
	If no access	32	25.2	95	42.4		127	36.2
	Total	127	100.0	224	100.0		351	
Access to communal grazing land	If access	35	27.6	141	63	39.58***	176	50.1
	If no access	92	72.4	83	37		175	49.9
	Total	127	100.0	224	100.0		351	100.0
Access to credit service	If access	119	93.7	109	48.6	72.23***	228	65
	If not access	8	6.3	115	51.4		123	35
	Total	127	100.0	224	100.0		351	100

Source: From the data of 2021/2022 production season

Econometric results

Factors affecting adoption of improved forage

Table 4 presents the factors affecting adoption improved forage. At a 1% level of significance, the age of the household head had a positive and significant influence on the adoption of improved forage. The results indicate that the likelihood that improved forage will be adopted increases by 1% for one year increase of household head age. This might be as a result of older farmers having greater personal experience with the need to improved forage than younger farmers. Older farmers may also take better care of their livestock than younger farmers. The results of this study are consistent with those of (Tesfaye and Melaku, 2017), who declare that older farmers are typically more interested in improved forage development and management practices because they are believed to have a thorough understanding of challenges with livestock feed due to access to information. With a 1% level of significance, the household head's education had a positive and significant impact on their adoption of improved forage. The findings indicate that as the household head's education year increases by one, the likelihood of adopting improved forage for livestock production increases by 2.7%. This might be the case because a well-educated household head is better able to assess and use knowledge obtained from a range of sources. The results of this study supported those of (Zekarias, 2016), which found that giving farmers the opportunity to pursue formal education increases the likelihood of improved forage adoption when compared to farmers who did not pursue formal education.At a 5% level of significance, family size showed a negative and significant impact on the adoption of improved forage. The results show that with each extra household member, the likelihood of adopting improved forage decreases by 3%. This might be the case because the technology only requires a small farm to run. This could also come from shifting family labor from improved forage adoption to other agricultural tasks like agronomic approaches, herd management (on communal grazing land or in distance based grazing like "daraba"), and socioeconomic procedures. This finding was comparable to that of (Beshir, 2014), who found that family size had a negative impact on a family's willingness to adopt improved foraging.

At a 1% level of significance, annual farm income had a positive and significant influence on the decision to adopt an improved forager. The finding indicates that for each additional Ethiopian Birr in annual income, the likelihood of household heads adopting improved forage increased by 0.01%. The study's findings agreed with those of a previous study (Abebe, 2018).

At a 1% level of significance, the frequency of extension contact significantly increased the likelihood that a household head would adopt improved forage. The findings indicate that when extension agents contact with household heads one or more days per month more frequently, there is a 3.3% increase in the likelihood of adoption. This might be because communications with an extension agent a regular basis increase household exposure provide current information on technology, and to more successfully embrace new technology like improved forage among smallholder farmers. The results were in line with those from a previous study (Beshir, 2014).

At a 10% level of significance, the training of the sampled household head was significantly and positively influenced in their decision to adoption improved forage. Training on improved forage increases the likelihood of household head adoption by 7.1%. This may be the case because training fills in knowledge gaps and improves the adopter's exposure, knowledge, competence, and attitude. The results were consistent with those of (Serekebrhan et al., 2018).

At a 1% level of significance, access to a communal grazing land had a negative and significant impact on the likelihood of adoption of improved forage. According to the findings, a sampled respondent's likelihood of adopting improved forage is reduced by 12.7% when they have access to a communal grazing land. This might be so because farmers have free access to and usage of communal grazing lands. The results of this study concurred with those of Zekarias (2016).

At a 1% level of significance, the likelihood of adopting improved forage was positively and significantly influenced by access to credit services. The study's findings indicate that having access to credit services increases the likelihood of adopting improved forge practices by 31% (Table 5). The findings of this analysis were consistent with (Beshir, 2014).

Factors affecting the intensity of improved forage adoption

To understand how adoption affects adopters' livelihoods, it is vital to study adoption's intensity. Table 4 presents the factors affecting the intensity of improved forage adoption. Inverse mill ratio (LAMBDA): The model's findings revealed that the inverse mill ratio for the intensity of improved forage adoption was significant, suggesting that selection bias would have happened if the adoption intensity of improved forage had been analyzed without taking the decision to improve forage into account. The relevance of selection effects is shown by the Inverse mill ratio, which is significant at the 5% (P=0.038) level. So it makes sense to employ Heckman's two-step method. The findings revealed a strong relationship between the adoption rate and the error terms in the adoption equation. This implies that the unobserved factors that influence household adoption of improved forage are likely to be positively related with the intensity of household adoption of improved forage.

At a 10% level of significance, household head sex significantly and positively influenced the adoption of improved forage. The study found that when all other conditions are held constant, having a male head of household increases forage adoption for livestock output by 0.16 ha. This may be because male-headed households are more likely to have access to relevant information and occupy responsibilities in the community. The findings of this research were in agreement with those of (Beshir, 2014), who found that male farmers may have easier access to information, extension, and credit services than female farmers.

At a 5% level of significance, the education of the household head had a positive and significant impact on the adoption rate of improved forage. The result indicates that for every additional year the household head has received formal education, the intensity of improved forage adoption increases by 0.03ha while all other variables remain constant. This may be the case because persons with higher levels of education are more aware of the problem with livestock feed and more eager to find a solution than those with lower levels of education. The finding of this study was in line with the finding of (Legesse et al., 2013).

The frequency of extension contact had a positive and statistically significant impact on the adoption of improved forage at a10% level of significance. The coefficient of the variable showed that, with other factors held constant, increasing the frequency of extension agent contacts with the head of household by one day per month increase the intensity of improved forage adoption by 0.03ha. Extension agents have a critical role to play in educating and training smallholder farmers on the adoption of improved forage. The results of the study were in line with the finding of (Teklay and Teklay, 2015).

At a level of statistical significance of 5%, livestock holding had a positive impact on the degree of improved forage adoption by smallholder farmers. The parameter's coefficient revealed that as smallholder livestock producers' increased in TLU, their intensity of land allocation for improved forage increased by 0.01 ha when all other factors remained constant. The findings of this study were comparable to those of (Beshir, 2014), who found that the availability of finances made having livestock in TLU have the predicted positive and significant impact on the rate of adoption of improved forages.

At a 5% level of significance, the availability of training had a positive effect on the adoption of improved forage by household heads. According to the variable's coefficient, access to training increased the adoption of improved forage by 0.16 ha holding other variable constant. This indicates that training gives households the information, expertise, and capacity to make better use of the forage. The result of the study in line with those made by Gebremedihin, (2003), who found that allowing access to subject matter capacity building increases the intensity of improved forage adoption.

Table 4. The results of Heckman two stage analysis

Determinants of adoption of improved forage in livestock production					**Determinants of intensity of adoption of improved forage**				
Adoption	Coefficient	Std. Err.	Z	Marginal effect	INADHH	Coefficient	Std. Err.	Z	P>|z|
AHH	0.045	0.013	3.53 ***	0 .0104	SEXHH	0.160	0.095	1.72*	0.085
SEXHH	0 .267	0.243	1.10	0.061	EDHH	0.030	0.015	2.10**	0.035
EDHH	0.118	0.033	3.53***	0.027	FSHH	-0.007	0.021	-0.36	0.720
FSHH	-0.134	0.052	-2.55**	-0.030	FIHH	5.42e-06	4.58e-06	1.18	0.238
FIHH	0.000	7.74e-06	3.49***	6.23e-06	FCWHH	0 .031	0.0179	1.76*	0.078
FCWHH	0.144	0.038	3.79 ***	0.033	LIHH	0.014	0.006	2.34**	0.019
LIHH	0.015	0.01	1.57	0.003	LSHHH	0.016	0.022	0.71	0.475
LSHHH	0.002	0.057	0.04	0.0005	ATTHH	0 .160	0.078	2.11**	0.035
ATTHH	0 .31	0.187	1.65*	0.071	ACGL	0 .070	0.080	0.90	0.366
ACGL	-0.553	0.179	3.08***	-0.127	DNM	0.010	0.009	1.38	0.168
DNM	-0.063	0.034	1.45	-0.014	HOFI	8.70e-07	6.23e-06	0.14	0.889
HOFI	0.000	0.000	0.56	2.38e-06	ACDS	0 .222	0.175	1.27	0.202
ACDS	1.351	0.228	5.93***	0.311	cons	-0.578	-0.426	-1.35	0.176
Cons	-4.291	0.722	-5.94		Lambda/mill	0.3650237	0.176	2.08**	0.038
Number of obs=351, Selected=127, Non-selected=224 Wald chi2(12)=22.12 Prob > chi2=0.000					rho 1.00000 sigma 0.36502366				

Propensity score match

For treatment households, the analyzed propensity scores range from 0.0299 to 0.9236, with a mean of 0.6589, while for control households, they range from 0.0018 to 0.9236, with a mean of 0.193. (Table 5). If so, the treatment and control households' minimum and maximum values, respectively, of 0.0299 and 0.9236, would be the minimum and maximum values of the common support area. This makes sure that any characters identified in combination in the treatment group are also present in the control group. In other words, the matching process does take into account households with predicted propensity scores between 0.0299 and 0.9236. This is due to the fact that when there is no overlap between the treatment and non-treatment groups, no matches can be established to estimate the average treatment effects on the ATT parameter (Bryson et al., 2002). 14 households from the adopter were discovered to be out of the common support as a result of the overlap condition, and as a result, they were ignored from the observations used to determine how adopting improved forage affected household income (treatment effect on the treated).

Table 5. Distribution of estimated propensity scores

Variable		Obs	Mean	Std. Dev.	Min	Max.
Propensity	Total households	351	0.3618	0.3289	0.0018	0.9920
Score	Treatment households	127	0.6589	0.2514	0.0299	0.9920
	Control households	224	0.1933	0.2350	0.0018	0.9236

Obs=observation, Std.Dev. =Standard deviation,

Source: Computed from own survey data of 2021/2022 production season

Selecting Matching Algorithm

In order to match the treatment and control households in the common support region, multiple tests were run using several matching estimators, including Nearest Neighbor (NN), Kernel Matching (KM), Caliper Matching (CM), and Radius Matching. The best strategy to use is still up for debate. It is obvious that there is no solitary response to this inquiry. The kind of the available data set affects the choosing of a particular matching estimator (Bryson et al., 2002). In other words, it should be obvious that there isn't always a winner and that the choice of a matching estimator is highly dependent on the particular circumstances at hand (Tolemariam, A. 2010). The decision on which strategy to use is based on the data at hand, particularly the degree of propensity score overlap between the treatment and comparison groups.

Table 6 shows after analysing the data and acting on the indicators, it was revealed that radius matching (0.1) was the most accurate estimate. The radius matching algorithm based on a with band width of is thus directly responsible for the estimation results and discussion that follow (0.1). The estimation findings and comments that follow are thus the direct results of the radius matching technique.

Propensity score match

Table 6. Performance of matching estimator

Matching estimators	Balancing test	Pseudo-R^2 after matching	Matched sample size
Nearest Neighbor(NN)			
Neighbor(1)	11	0.069	336
Neighbor(2)	9	0.043	336
Neighbor(3)	9	0.050	336
Neighbor(4)	9	0.045	336
Neighbor(5)	10	0.042	336
Neighbor(6)	11	0.041	337
Radius matching			
With band width of (0.01)	9	0.062	326
With band width of (0.1)	11	0.027	337
With band width of (0.25)	11	0.033	337
With band width of (0.5)	6	0.107	337
Caliper Matching(CM)			
Caliper (0.01)	9	0.099	326
Caliper (0.05)	8	0.126	337
Caliper (0.1)	8	0.126	337
Caliper (0.5)	9	0.126	337
Kernel Matching (KM)			
With band width of (0.08)	10	0.036	337
With band width of (0.1)	10	0.036	337
With band width of (0.25)	10	0.036	337
With band width of (0.5)	10	0.036	337

Source: Computed from own survey data of 2021/2022 production season

Verifying the Common Support Condition

The estimated propensity scores for adopters and non-adopters of improved forage are histogram med in Figure 3 below. The common support criterion is met, as shown by the large overlap in the distribution of the propensity scores of both the adopter and non-adopter groups, according to graphic analyses of the density distributions of the estimated propensity scores for the two groups. The graph's upper half refer to adopters, while the bottom half depicts the propensity scores distribution for non-adopters. On the y-axis are the score densities.

Figure 3: Propensity score distribution and common support for propensity score estimation.

Note: ''Treated/untreated: on support'' indicates the observations in the adoption group that have a suitable comparison and off support indicates the observations in the adoption group that have no suitable comparison. Source: Computed from own survey data of 2021/2022.

Testing the balance of propensity score and covariates

The basic goal of propensity score estimation is to balance the distributions of important variables in both groups, not to obtain a precise forecast of selection into treatment. Different test methodologies, such as the reduction in mean standardized bias between matched and mismatched households, equality of means using t-test and chi-square test for joint significance for the variables used, are taken into account when determining the balancing capacities of the estimations. In columns five and six of table 7, the mean standardized bias before and after matching are displayed, and column six lists the overall bias reduction achieved by the matching technique. The standard deviation of Z before matching in the current matching models ranges in absolute value from 3.6% to 123.2%. Following matching, the remaining standard deviation of Z for all covariates ranges from 0.5% to 20%, which is below the critical level of 20% recommended by Rosenbaum and Rubin (1985). It is obvious in every instance that sample variations in the unmatched data considerably outweigh those in the matched case samples. Thus, a high degree of covariate balance between the treatment and control samples is produced during the matching step, ready for use in the estimate process.

Table 7. The propensity score and covariate balance

Variables	**Sample**	**Mean**			**% reduct**		**t-test**
		Treated	Control	%bias	bias	t	p>t
AHH	Unmatched	42.094	46.759	-61.0	84.8	-5.44	0.000
	Matched	42.31	41.599	9.3		0.72	0.472
SEXHH	Unmatched	0.85827	.75446	26.4	77.0	2.31	0.021
	Matched	0.84071	.81688	6.1		0.47	0.636
EDHH	Unmatched	5.063	1.7857	123.2	90.3	10.98	0.000
	Matched	4.7788	5.0964	-11.9		-0.78	0.437
FSHH	Unmatched	5.4882	6.6094	-48.7	93.3	-4.14	0.000
	Matched	5.5752	5.5003	3.3		0.33	0.743
FCWHH	Unmatched	3.1339	1.2232	106.7	95.0	10.04	0.000
	Matched	2.7522	2.6562	5.4		0.39	0.696
LIHH	Unmatched	9.5047	6.7272	56.1	97.2	5.25	0.000
	Matched	8.7796	8.8582	-1.6		-0.11	0.910
LSHHH	Unmatched	2.8285	2.4923	22.9	28.0	2.08	0.038
	Matched	2.6767	2.4346	16.5		1.34	0.182
ATTHH	Unmatched	.79528	.55357	53.2	91.6	4.66	0.000
	Matched	.78761	.7674	4.5		0.36	0.716
ACGL	Unmatched	.64567	.5625	17.0	-40.9	1.52	0.128
	Matched	.63717	.75435	-14.0		-1.92	0.056
DNM	Unmatched	4.4555	7.2587	-68.9	94.2	-5.62	0.000

	Matched	4.5527	4.3895	4.0		0.59	0.555
HOFI	Unmatched	3269.6	3482.1	-3.6	85.8	-0.31	0.756
	Matched	2962.3	2992.6	-0.5		-0.05	0.960
UFCRD	Unmatched	.84252	.38393	106.4	81.0	9.23	0.000
	Matched	.82301	.73581	20.0		1.58	0.115

Source: Computed from own survey data of 2021/2022 production season

Treatment effect on the treated (ATT)

The estimation results in Table 8 offer evidence that the adoption of improved forage has a positive impact on farm income that is statistically significant. After accounting for disparities between the socioeconomic characters of adopter and non-adopter of household head, it was discovered that adoption of improved forage has an average effect on farm income of the adopting households' head of 2942.652Ethiopian Birr. However, households that actually adopted would have experienced an increase in farm income of roughly 2942.652Ethiopian Birr over those that did not. Inferring that adoption of improved forage results in an average increase in farm income of 37.3% for adopters households compared to non-adopters households. As seen in table 8, this finding is statistically significant at 1% probability levels.

Table 8. Treatment effect on the treated

Outcome variable	Sample	Treated	Controls	Difference	S.E.	T-stat
Farm income (EB)	Unmatched	8275.47	3180.973	5094.499	613.292	8.31
	ATT	7881.778	4939.126	2942.652	805.235	3.65***

Note: *** = significance level at 1 % and S.E is calculated using bootstrap with 100 repetitions.
Source: Computed from own survey data of 2021/2022 production season

Sensitivity analysis

As evidenced by the findings in Table 9, adopter and non-adopter households were acceptable to differ in their likelihood of receiving treatment up to gamma = 3.45 (100%) in terms of unobserved factors. However, the inference for the impact of the adoption of improved forage is not changing. This means that for the outcome variable estimated, the p-critical values are significant (i.e., there is no hidden bias due to unobserved confounder), further indicating that we have taken into account significant covariates that affected both adoption of improved forage and the outcome variable, farm income. The maximum value for gamma in the analysis was set to 3.45 (100%) with an increment of 0.5. Many social science data sets can be started with these values. We may therefore draw the conclusion that our impact estimates (ATT) are not sensitive to unobserved selection bias and are the sole result of the adoption of improved forage.

The sensitivity analysis of the outcome ATT values of farm income to the covariates was shown in Table 10. It is evident that ATT is resistant to external modification because the significance level is unaffected even when the gamma values are adjusted to any reasonable level (Table 9). As a result, the CIA continues to be important, the results were not susceptible to confounders, and there are no outside cofounders (variables) that alter the ATT calculation's conclusion.

Table 9. Result of sensitivity analysis using Rosenbaum bounds approach

Gamma	sig+	+ sig-	- t-hat+	t-hat-	CI+	CI-
1	0	0	7500	7500	6500	8500
1.5	3.6e-14	0	6500	8475	5600	9500
2	4.6e-11	0	6000	9000	5000	10228
2.5	3.4e-09	0	5500	9500	4600	10900
3	6.1e-08	0	5200	10000	4250	11500

Source: Computed from own survey data of 2021/2022 production season

Conclusion and policy forwarded

Improved forage is an important livestock feeding. This study analyzed determinants of adoption of improved forage and its impacts on income of smallholder farmers using data collected from 351 randomly selected farmers from southwest showa zone.

The finding of this study indicates that average lands allocated by adopters were 0.016hectares, which is very poor. The finding also indicates that age, education, farm income, frequency of extension contact, access to training, access to credit, family size and the availability of communal grazing land were found to be significantly determining adoption of improved forage whereas frequency of extension contact, livestock holding, sex, educational, and access to training were found to be significantly influencing the adoption intensity of improved forage. PSM analysis showed that adopters of the improved forage got on average 2942.652 Ethiopian Birr/year incomes more than non-adopters. It can be conclude that improved forage adoption increases the income of smaller holder livestock farmers in the study area. However, the level of adoption and determinants of adoption hinders the farmers to adopt. Hence, the government should have to design the strategies that build the capacity of smallholders by providing the extension service particularly training to enhance the adoption. Thus, it is important to design a mechanism that eases farmers' access to improved forage varieties in the area.The adoption and intensity of improved forage adoption were very poor in the study area due to different determinants. Hence, it is important to encourage the farmers' adoption and intensity of improved forage adoption to boost the productivity of livestock which implies for the increment of farmers' income. Furthermore, it is important to strength the farmers' training center to build the capacity of farmers and to demonstrate the technology for the farmers. In general, in the future it is better if more study were conducted in the study area.

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Competing interests

There are no conflicting interests, according to the author(s).

References

Abebe, A., Hagos, A., Alebachew, H. and Faji, M., 2018. Determinants of adoption of improved forages in selected districts of Benishangul-Gumuz, Western Ethiopia. Tropical Grasslands-Forrajes Tropicales, 6(2), pp.104-110.

Abera, M., Tolera, A., & Assefa, G. (2014). Feed resource assessment and utilization in Baresa watershed, Ethiopia. International Journal of Science and Research, 3(2), 66-72.

Adugna Tolera (2007). Feed resources for producing export quality meat and livestock in Ethiopia, examples from selected woredas in Oromia and SNNP regional states. Ethiopia Sanitary and Phytosanitary Standards and Livestock and meat Marketing Program (SPS-LMM), USAID, Ethiopia.

Alemayehu Mengistu & Getnet Assefa (2012). The evolution of forage seed production in Ethiopia: Forage Seed Research and Development in Ethiopia, Ethiopian Institute of Agricultural Research, pp: 15-32.

Alemayehu Mengistu, Gezahagn Kebede, Getnet Assefa & Fekede Feyissa (2017a). Overview of improved forage and forage seed production in Ethiopia: Lessons from fourth livestock development project. International Journal of Agriculture and Biosciences, 6 (4): 217-226.

Bashe, A., Bassa, Z., & Tyohannis, S. (2018). The determinants of probability in improved forage technology adoption in Wolaita zone: The case of Sodo Zuria district, Southern Nations and Nationalities Peoples state of Ethiopia. Open Access Journal of Science, 2(4), 228-231.

Beshir, H. (2014).Factors affecting the adoption & intensity of improved forages in North East Highlands of Ethiopia. Journal of Experimental Agriculture International, 12-27.

CSA (2020) Report on Livestock and Livestock Characteristics (Private Peasant Holdings) Addis Ababa. Statistical Bulletin 585.

Cochran, L. (1997). Career counseling: A narrative approach. Sage publications.

Franzel, S., & Wambugu, C. (2007, March). The uptake of fodder shrubs among smallholders in East Africa: key elements that facilitate widespread adoption. In *Forages: a pathway to prosperity for farmers. Proceedings of an International Symposium, Faculty of Agriculture, Ubon Ratchathani University, Thailand* (pp. 203-222).

Getnet Assefa, Solomon Mengistu, Fekede Feyissa & Seyoum Bediye (2016). Animal feed resources research in Ethiopia: Achievements, challenges and future directions. EIAR 50th Year Jubilee Anniversary Special Issue, Ethiopian Institute of Agricultural Research. Addis Ababa, Ethiopia, pp: 141-155.

Gujarati, D. N. (1995). Basic Econometrics, McGraw-Hill, New York. Basic econometrics. 3rd ed. McGraw-Hill, New York.

Heckman, J.J., 1979. Sample selection bias as a specification error *Journal of Econometrica*. Vol. 47(1).

Heckman, J.J., 2008. Role of income and family influence on child outcomes. *Annals of the New York Academy of Sciences*, *1136*(1), pp.307-323.

Land O'Lakes (2010). The next stage in dairy development for Ethiopia: Dairy Value Chains, End Markets And Food Security Cooperative Agreement 663-A-00-05-00431-00, USAID,AddisAbaba,Ethiopia.Retrievedfromwww.usaid.gov/sites/default/files/documents/1860/Dairy%20Industry%20Development%20Assessment_0.pdf

Mesfin, A. (2005). Analysis of Factors Influencing Adoption of Triticale and its Impact. The Case Farta Wereda. MSc. Thesis Presented to School of Graduate Studies of Haramaya University, Ethiopia

Mideksa Dabessa Iticha, Moti Jaleta & Fikadu Mitiku (2021) Determinants and profitability of inorganic fertilizer use in smallholder maize production in Ethiopia, Cogent Food &Agriculture, 7:1, 1911046, DOI: 10.1080/23311932.2021.1911046

Ndah, H.T.; Schuler, J.; Nkwain, V.N.; Nzogela, B.; Mangesho,W.; Mollel, R.; Loina, R.; Zander, P.; Paul, B.K.

Determinants for Smallholder Farmers' Adoption of Improved Forages in Dairy Production Systems: The Case of Tanga Region, Tanzania. Agronomy 2022, 12, 305. https://doi.org/ 10.3390/agronomy12020305

Serekebrhan, T., Animut, G., Mekasha, Y., & Assefa, G. (2018). Assessment of farmers perception towards production and utilization of improved forages for dairy cattle feeding in the central highlands of Ethiopia. East African Journal of Veterinary and Animal Sciences, 2(1), 45-56.

Stapleton, J. (2016). Unlocking the potential of Ethiopia's livestock sector: growth, jobs and environmentalsustainability.Retrievedfro **m**https://news.ilri.org/2016/02/04/unlocking-thepotential-of-the-livestock-sector ethiopia/

Teklay, Y., & Teklay, Z. (2015). Assessment on Farmers' Willingness to Adopt Improved Forage Production in South Tigray, Ethiopia. Assessment, 6(15).

Tesfaye, M., & Melaku, T. (2017). Determinants of adoption of improved highland forage type: evidence from Dendi District, West Shoa Zone, Ethiopia. Journal of Experimental Agriculture International, 1-8.

Tolemariam, A. 2010. Impact assessment of input and output market development interventions by IPMS Project: The case of Gomma Woreda. MSc thesis in Agriculture (Agricultural Economics). 97p. Haramaya (Ethiopia): Haramaya University.

Ulfina Galmessa, Jiregna Dessalegn, Alganesh Tola, Prasad, S. & Late Mulugeta (2013). Dairy production potential and challenges in Western Oromia milk value chain, Oromia, Ethiopia. *Journal of Agricultural Sustainability,* 2 (1): 1-21.

Wambugu, S., Kirimi, L., & Opiyo, J. (2011). *Productivity trends and performance of dairy farming in Kenya* (No. 680-2016-46762).Zekarias, S. M. (2016). The impact of foreign direct investment (FDI) on economic growth in Eastern Africa: Evidence from panel data analysis. Applied Economics and Finance, 3(1), 145-160.