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Factors Influencing the Adoption of Improved Forage Varieties in Gursum District, Somali Regional State, Ethiopia

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ABSTRACT

In sub-Saharan Africa, scarce feed and nutrition significantly constrain livestock production. While various improved forage species have been developed to address feed shortages, the adoption of these technologies varies due to socio-economic, institutional, demographic, and biophysical factors. This study focuses on identifying the factors influencing the adoption of improved forage technologies at the household level in Gursum District, where forage is available. Out of 25 kebeles, 15 were selected based on higher forage production, and 6 were chosen randomly for the study. A total of 151 farmers participated, using key informative interviews and focus group discussions to complement quantitative data analyses, including chi-square tests and binary logistic regression. Results show that 63 farmers adopted improved forage, while 88 did not. The regression analysis indicated that education, farm size, access to credit, extension services, number of livestock, and water availability positively influenced adoption, whereas market distance had a negative effect. The study highlights the agricultural extension service as a key barrier to adoption and suggests the need for better stakeholder linkages to promote the diffusion of improved forage technologies tailored to smallholder farmers' needs. Ensuring sustained adoption involves addressing the identified influencing factors.

Key Words: Improved forage, species, Technology, Adoption rate, factors Gursum district.

1. Introduction

1.1. Background of the Study

Agriculture is the main economic sector in Ethiopia, accounting for about 40.2% of GDP, 80% of employment, and 70% of export earnings in 2013/14 (CSA, 2013). Livestock products are vital, contributing 15-17% of total GDP and 35-49% of agricultural GDP. This contribution is low given the growing population and rising demand for meat, milk, and draught power. The country's livestock population consists of 59.5 million cattle, 54.5 million sheep, 30.2 million goats, 8.44 million donkeys, 0.41 million mules, 1.21 million camels, and 56.53 million poultry (CSA, 2015).

However, productivity per animal is low, and the livestock sector's economic contribution is declining due to insufficient quality and quantity of feed (Howley et al., 2012). Natural pastures and crop residues, which are the primary feed sources, lack the necessary quality and quantity for sustainable livestock production (Bashe et al., 2018). The Ethiopian government has promoted agricultural technology to enhance livestock productivity by introducing improved forage species tailored to the country's agroecological zones (Beshir, 2013). Key forages include oats, Rhodes grass, pigeon peas, elephant grass, Sudan grass, and alfalfa (Assefa et al., 2012; Tekalign, 2014). Sudan grass, Rhodes grass, and alfalfa have been particularly successful in lowland areas, providing quality forage for both smallholder and intensive livestock production systems (Melese et al., 2018). Although technology adoption is vital for agricultural advancement, various factors influence its acceptance . The forage sector is crucial for transforming the livelihoods of poor farmers, with the government focusing on strategies to enhance agricultural productivity (Assefa et al., 2012). This includes agricultural intensification through increased use of improved forage seeds (Mengistu et al., 2016). Key strategies to address feed availability and quality involve improving forage production, expanding improved pastures, and enhancing crop residues.

In the past, natural pasture was the primary forage source for livestock. However, improved forage species have become widely adopted in agro-pastoral areas, aiming to address feed challenges for cattle and small ruminants (Ehui and Bank, 2015). High livestock production and positive responses to improved technology increase the demand for forages, greatly influencing pastoral and agro-pastoral systems. In the Somali region, agriculture, particularly livestock

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production, faces significant challenges due to prolonged droughts and feed shortages. To address these issues, the Somali Region Pastoral and Agro-pastoral Research Institute (SoRPARI) has tested various forage species, including grasses and legumes, sourced from similar agro-ecological regions. These species have been trialed at research sites in West Gode, Kalafo, Dolo Ado, Jareti, Fafen (Gursum), and Jijiga. The Regional Agricultural Bureau, in collaboration with SoRPARI and the Ethiopian Seed Enterprise, has started the introduction and dissemination of these forages to farmers. Enhancing agricultural productivity through improved technologies is vital for reducing poverty and improving food security in the agro-pastoral areas of the region. In agro-pastoral farming, the introduced technologies were not widely accepted by farmers (Mengistu, 2018), indicating various factors influence the adoption of technologies aimed at enhancing smallholder productivity.

The Gursum district is primarily characterized by smallholder farming systems. Ten years ago, improved forage technology was introduced through livestock fattening cooperatives. However, feed shortages continue to be a significant challenge, and further investigation is needed to understand the factors affecting the adoption of improved forage species. Analyzing these factors is essential for effective resource allocation in resource-limited areas like the Somali region. While the Gursum area is mainly known for cereal production, there has been limited focus on studying the adoption of improved forage species. This research aims to address that gap and highlights the importance of continuously assessing the impact of agricultural technology over time. Ultimately, the study will provide insights into the adoption of improved forage species, facilitating their promotion in Gursum and beyond. The specific objectives of the study are to assess the extent of adoption of improved forage species in the area and to identify and investigate the factors influencing this adoption at the household level.

1.2. Significance of the Study

The adoption of improved forage species in the country has been limited despite ongoing forage innovation since the 1970s. This study aims to identify the gaps in the adoption process and provide essential information for researchers, policymakers, and agricultural offices. Additionally, it will analyze the factors influencing the adoption of these technologies to support policy promotion by relevant institutions, including NGOs and government agencies.

1.3. Conceptual Framework of the Study

Farmers' adoption behavior, particularly in low-income countries, is influenced by a complex set of socio-economic, demographic, institutional, and biophysical factors (Feder et al., 1985). The table below conceptualizes the variables expected to measure the adoption of improved forage species. Based on the literature review, independent variables such as age, gender, education, livestock ownership, access to credit, land cultivation, access to training, access to extension services, distance from markets, distance from development agent offices, free grazing availability, and

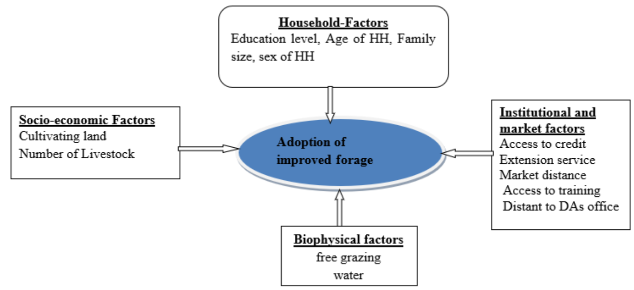

Figure 1: Framework of the Study

access to water are hypothesized to be important factors influencing technology adoption in this study. Therefore, the following conceptual framework illustrates the key variables anticipated to affect the adoption of improved forage species technology in the context of this research.

2. Materials and Methods

2.1. Description of the Study Area

The Gursum district, located in the Fafan Zone of the Somali Regional State, covers an area of 937 square kilometers. It borders Ajersagora to the north, Jijiga and K/bayah to the east and southeast, Babile to the south, and the Oromia Region to the northwest, west, and southwest. The district capital is Bambas town, situated 48 kilometers west of Jijiga, the regional capital. Geographically, the district spans coordinate from 1,008,000 to 1,058,250 UTM north and from 215,000 to 245,000 UTM east, with an altitude ranging from 1,200 to 2,950 meters above sea level. The climate features temperatures between 15°C and 35°C, and the district receives an average annual rainfall of 450 to 600 mm, primarily falling in a single rainy season from June to August. According to the last figures published by the Central Statistical Agency, the district has an estimated total population of 27,400, comprising 14,753 males and 12,647 females. There are approximately eight wireless telephone stations serving eight of the 18 villages in the district, along with two telephone stations in urban centers. Most villages are covered by wireless mobile service, except for Tomah village. Water sources in the district include hand-dug wells, hand-dug wells with hand pumps, shallow wells, and motorized boreholes that are currently under construction. An asphalt road connects Addis Ababa to Jijiga, which runs through Gursum. However, most of the existing urban and rural road network is seasonal, leading to restricted movement and transportation during the rainy season, thereby hampering development efforts. Improving education and health services is believed to be crucial for enhancing productivity, increasing household income, reducing poverty, and ensuring food security in the district.

2.2. Farming system

The farming system in the district is characterized by both agro-pastoral and pastoral approaches. The agro-climatic conditions in the area are favorable for growing a variety of crops and raising different species of animals. Land preparation for crop husbandry is typically carried out using oxen or tractors, while hand-digging tools or hoes are employed for perennial and garden crops. Farmers in Gursum district commonly practice mixed agriculture, utilizing both intensive and extensive systems. Key agricultural staples in the district include sorghum, maize, barley, wheat, beans, and tomatoes. Farmers typically own cattle, ruminants, camels, scavenging poultry, and donkeys. Male small ruminants, such as billys and rams, are often sold to meet immediate cash needs. Milk from does and ewes is consumed by both children and adults, frequently served with tea, while any surplus is either sold or converted into butter. Bulls are primarily used for draft power or are sold.

Camels and donkeys also serve as draft animals, assisting in transporting farm produce to the market and fetching water from nearby sources. Farmers sell chickens and eggs while keeping a few chickens for breeding purposes. The income generated from the sale of these produce items is used to purchase essentials such as rice, sugar, salt, cooking oil, tea, soap, kerosene, household utensils, clothing, and to contribute to social events. Agricultural production in the district relies heavily on rain-fed agriculture, with irrigation mainly occurring during the rainy seasons, which happen twice a year. The size of farmland varies from one kebele to another, influenced by the availability of land resources and population density among households. Additionally, the region experiences bimodal rainfall patterns.

2.3. Study Design

The study employs a mixed-methods research design, integrating both qualitative and quantitative approaches to comprehensively examine factors influencing the adoption of improved forage varieties in the Gursum District. A cross-sectional survey will be conducted among smallholder farmers, utilizing structured questionnaires for quantitative data and key informant interviews for qualitative insights.

2.4. Sources and Methods of Data Collection

2.4.1. Sources of data

This study utilized both primary and secondary data. Primary data were collected from Gursum farmers who practice improved forage cultivation. Secondary data were gathered from various sources in the study area to support the findings from the primary data. The institutions providing secondary data included the Fafan Agricultural Research Center and the Gursum district agricultural office. Additionally, regular statistical reports from sources like the Ministry of Agriculture and the Central Statistical Agency (CSA) were reviewed.

2.4.2. Sampling Design

This study employed a multistage sampling method to select the sample respondents. Firstly, the Gursum District was purposively chosen due to its improved forage availability and its long history as a major site for agricultural research interventions and technology promotion. Secondly, out of the 25 kebeles in the district, 15 were selected based on their higher forage production and practices. From these 15 kebeles, 6 were randomly selected. Finally, a total of 151 farmers were chosen using probability proportional to size sampling to adequately represent the forage adoption status in the district. The total sample size is determined by the help of Yemane formula as follows.

Table 1: Distribution of sample households in selected forage practicing kebeles

Kebele	Household size	Sample size n= $\frac{n}{N} * Ni$
Kubijaro	575	19
Dhufays	740	25
Gola-hajo	830	28
Dhagahle	930	31
Kubijaro	535	18
Goblet	908	30
Total	4518	151

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

Where, N=total number of households in the selected kebeles (4518), n=sample size and e=error of tolerance at 8%. According to this; the sample size was 151.

$$n = \frac{4518}{1 + 4518(0.08)^2} = 151 \quad (2)$$

Adopters were defined as farmers who practice improved forage species for two consecutive seasons and non-adopters were defined as farmers who practice non-improved forages.

2.5. Instruments of Data Collection

Primary data were collected using both quantitative and qualitative approaches through a household survey that utilized a set of pre-tested questionnaires. The quantitative method involved a structured questionnaire distributed to a sample of farmers. Meanwhile, the qualitative method included observations and focus group discussions to gather farmers' reactions regarding their experiences in forage knowledge sharing. Additionally, key informant interviews were conducted with experts from the Gursum District and the Rural Development Office.

2.6. Method of Data Analysis

The data were analyzed using software SPSS version 16.0. Appropriate techniques and procedures were used in the analysis to identify the influence of demographics, socioeconomic, institutional and biophysical factors on farmers' improved forage species adoption decision. Descriptive statistics such as mean, standard deviation (std.), frequencies, percentages and cross tabulations were used to have a clear picture of the characteristics of sample units. Chi-square and an independent sample t-test were used based on categorical and continues variable respectively. Finally, Binary Logit model were used to estimate the associate among the variables and identify the factors affecting adoption of improved forage species by smallholder farmers in the study area.

2.7. Model specification

Various models have been utilized to study the adoption behavior of farmers. Among these, logit and probit models have been commonly employed in different adoption studies (Shita et al., 2018). Although the cumulative probability functions of the probit and logit models are quite similar, the logit model has the advantage of allowing for easier calculation of predicted probabilities compared to the probit model. These models not only help assess the various factors influencing the adoption of specific technologies but also provide insights into the predicted probabilities of adoption.

For example, they can illustrate how the likelihood of a farmer adopting a particular technology changes based on their level of education while keeping all other factors constant. Analyzing the relationships between the promotion of a practice and its determining factors involves a combination of qualitative and quantitative data. In this case, the logit model was applied to estimate the probability of adopting improved forage species, which can either be classified as "adopt" or "not adopt" (Gujarati and D., 2009). The logistic distribution function for the decision to use can be expressed as follows(Table 2)

$$Pi = 11 + e - z(i) \tag{3}$$

Where: $p(i)$: is a probability of a household being not adopted improved forage species household e: represents the base of natural logarithms (2.718) and $Z(i)$: is a function of m explanatory variables (Xi) and is expressed

$$Z(i) = \beta 0 + \beta i \bullet 1 + \beta 2 * 2 + ... * m \tag{4}$$

Where $\beta 0$ is the intercept and βi is the slopes parameter in the model which is estimated using maximum likelihood method. The slope tells how the log-odds in favor of not adopted technology change as independent variables change by a unit. The odds to be defined as the ratio of the probability that a household being not improved forages pi to the probability that household adopted improved forages $(1 - Pi)$. But, the odds to be defined as the ratio of the probability that a household being not adopted the improved forages pi to the probability that household adopted technology $(1 - Pi)$.

$$(1Pi) = 11 + ez(i) \tag{5}$$

Therefore;

$$\left(\frac{Pi}{1 - Pi}\right) = \frac{1 + e^{z(i)}}{1 + e^{-z(i)}} = e^{z(i)} \tag{6}$$

$$\left(\frac{P(i)}{1 - P(i)}\right) = \frac{1 + e^{z(i)}}{1 + e^{-z(i)}} = e^{\beta_0 + \sum_{i=1}^{m} \beta_i Y_i} \tag{7}$$

Taking the natural logarithms of the odds ratio of equation (7) will result in what is known as the logit model as indicated below.

$$\left(\frac{P(i)}{1 - P(i)}\right) = \ln\lfloor e^{\beta_0 + \sum_{i=1}^{m} \beta_i Y_i} \rfloor = Z_i \tag{8}$$

Before incorporating the selected variables into the binary logit model, we verified whether there was a multicollinearity problem among the continuous and dummy variables. Multicollinearity occurs when it becomes challenging to discern the individual effects of independent variables on the dependent variable due to strong relationships between them. In other words, multicollinearity arises when explanatory variables are highly correlated, which can lead to prediction issues in the logit model. To test for the existence of multicollinearity, we used Variance Inflation Factors (VIF) and the Contingency Coefficient (Gujarati et al., 2009).

2.7.1. Variables hypothesized and relationships

3. Results and Discussion

This chapter is the core of the paper, providing a detailed explanation of the overall findings of the study. It is organized into several sections, including descriptive statistics and econometric analysis related to the study's objectives. The results highlighting significant differences between adopters and non-adopters are presented. Finally, this chapter includes a discussion of binary logistic regression and various key findings.

3.1. Descriptive and Statistic Analysis

3.1.1. Demographic characteristics of farm household

This subsection covers the demographic characteristics of respondent households relevant to their adoption status. It summarizes data on age, sex, family size, and educational level for both adopters and non-adopters, using continuous and categorical variables.

Sex of Household Heads: The sampled households included both male and female heads. Among the 151 sampled households, 55 (36.4%) of the adopter households were headed by males, while 8 (5.3%) were headed by females. In contrast, for the non-adopters, there were 82 (54.3%) male heads and 6 (4%) female heads of household.(Table 3). These results indicate that there are more male-headed households among both adopters and non-adopters. This disparity may be attributed to various factors, including the economic challenges faced by female-headed households, such as labor shortages and limited resources. A chi-square analysis comparing the sex distribution between adopters and non-adopters revealed no statistical significance (X^2=1.509, P-value=0.261).

3.1.2. Education

Education is an important variable for farmers in understanding the adoption of improved forage species. Among the adopters, the majority of respondents were literate, with 26 (17.2%) being able to read and write, 20 (13.2%) having

Table 2: Summary of expected independent variables

No	Independent Variables	Description of variables	Nature of variable	Expectation effect
1	Age	Age of household head	Continuous	Negative
2	Sex	Sex of household head	Categorical	Positive
3	Educational level	Education of HH	Categorical	positive
4	Livestock ownership	Total livestock unit of HH	Continuous	Positive
5	Distance from market	Traveling from home KM	Continuous	Negative
6	Cultivating land size	Are in hectare use farmer	Continuous	Positive
7	Access to extension service	Extension service provides to farmers	Categorical	Positive
8	Access of credit	Access of accredit	Categorical	Positive
9	Distance to DAs office	The distance from farmers to DA office	Continuous	Negative
10	Family size	Technology accessibility to farmers	Continuous	Positive
11	Training access	Access of training to farmers to forages	Categorical	Positive
12	Free grazing	Open grazing of livestock affects the adoption of improved forage	Categorical	Negative
13	Water	Water availability, whether shortage or not	Categorical	Positive

Table 3: Demographic factors of categorical variables sample households (n=151)

		Adopters		Non-Adopters		X^2	P-value
Variables	Categories	N	%	N	%		
Sex of HH	Male	55	36.4	82	54.3	1.509	0.261
	Female	8	5.3	6	4		
Education of HH	Illiterate	17	11.3	66	43.7	34.477	0.000***
	Read and write	26	17.2	14	9.3		
	Elementary1-6	20	13.2	8	5.3		
	Secondary	0	0	0	0		

Significance level. ***1%

completed elementary education, and 17 (11.3%) being illiterate. In contrast, among the non-adopters, 66 (43.7%) were illiterate, 14 (9.3%) could read and write, and only 8 (5.3%) had completed elementary school.(Table 3) In this study, the chi-square test indicated a highly significant relationship (X^2=34.477,

p-value=0.000***) between the adoption behaviors of adopters and non-adopters, as presented in (Table 3). This suggests a strong positive correlation between education levels and the adoption of improved forage species. These findings align with the research conducted by (Shiferaw et al., 2011), which found that the educational level of household heads enhances awareness and decision-making, likely increasing the probability of adopting new technologies.

3.1.3. Age

The average age of farmers who adopted improved forage species was 38.65 years, with a standard deviation of 10.36, whereas the average age of non-adopters was 42.36 years, with a standard deviation 11.63544. A t-test revealed that the age of respondents was statistically significant (t-test = -2.023, p = 0.002) when comparing adopters and non-adopters of forage.(Table 4), the study's assumption was that as age increases, farmers' interest in new technology decreases. Thus, it was hypothesized that age would negatively correlate with the adoption of improved forage species. Younger farmers are generally more likely to adopt new technologies than older farmers, possibly due to their greater access to information. This finding aligns with the study conducted by (Melese et al., 2018), which indicated a negative relationship between age and the adoption of new agricultural technologies.

3.1.4. Family size

The average family size of adopters was 6.76, with a standard deviation of 2.33289, while the average family size of non-adopters was 42.36, with a standard deviation of 11.63544. There is a significant difference in household family size between adopters and non-adopters (p = 0.003). A similar finding was reported by (Shiferaw et al., 2011).(Table 4)

3.2. Socio-Economic Factors

This subsection examines the socioeconomic characteristics of respondents, comparing adopters and nonadopters based on variables such as number of livestock and cultivated land.

3.2.1. Number of Livestock

The average livestock size for adopters of improved forage species was 16.4603 Tropical Livestock Units (TLU), while non-adopters averaged 12.0271 TLU. The t-test results showed a significant difference (t-test = 9.859, p-value = 0.000***), indicating that farmers with more livestock are more likely to adopt improved forage technology. (Table 5).This trend may be due to the additional income livestock provide, which enables the purchase of improved forage and other farm inputs. Focus group discussions supported these findings, showing that most farmers cultivate improved forage for their livestock.

Table 4: Demographic factors of continues variables sample households (n=151)

Variables	Adopters		Non-adopter		t-test	P-value
	Mean	Std.	Mean	Std.		
Age of Respondents	38.6508	10.36147	42.3636	11.63544	-2.023	0.002***
Family size	6.7619	2.33289	5.5795	2.16939	3.200	0.003***

Significance level at ***1% ** 5%.

Table 5: Continuous socio-economic variables of sample respondent (n=151)

Vari-able	Adopters		Non-Adopters		t-test	P Value
	Mean	Std.	Mean	Std.		
Number of livestock	16.4603	2.80029	12.0271	2.66951	9.859	0.000***
Farm size	2.6667	1.15703	1.0909	.90511	3.429	0.001***

significant level at***1% ** 5%,

3.2.2. Farm size

According to (Table 5), farm size was identified as one of the factors influencing the adoption of improved forage species. The average farm size for farmers who adopted improved forage species was 2.67 hectares, with a standard deviation of 1.16. In contrast, non-adopters had an average farm size of 1.09 hectares and a standard deviation of 0.905. The ttest results indicated that farm size is statistically significant at the 1% level (ttest = 3.429, p-value = 0.001***). This finding suggests that larger farm sizes are associated with higher rates of adoption of improved forage technology, which aligns with previous studies on technology adoption among agropastoral farmers in Ethiopia (Melese et al., 2018; Beshir, 2013).

3.3. Institutional and Market Factors

This subsection explores how institutional and market factors influence technology adoption among farmers. Key institutional factors include distance to development agencies, market proximity, access to credit, extension services, and training.

3.3.1. Distance to DAs office

In the study area, the average distance between the development agent's office and the farmers' households shows no significant difference between adopters and non-adopters. The average distance for adopters is 18.48 kilometers, with a standard deviation of 10.040, while for non-adopters, it is 18.24 kilometers, with a standard deviation of 9.036. A t-test analysis revealed that there is no statistically significant difference between the two groups in terms of distance to the development agent's office (t-test = 0.152, p-value = 0.466).(Table 6) This suggests that the distance to the development agency's office does not impact farmers' adoption decisions.

3.3.2. Distance to market

On the other hand, the average distance from farmers to the main marketplace was 17.0317 kilometers, with a standard deviation of 6.48315. In comparison, the average distance for non-adopters was 15.3068 kilometers, with a standard deviation of 51770. This difference was statistically significant (t-test = 1.760, p-value = 0.006) at the 1% level. This implies that farmers who are closer to markets are more likely to adopt improved forage technology. The results of this study align with findings from other researchers who have conducted technology adoption studies in Ethiopia (Bashe et al., 2018; Feyisa, 2020).(Table 6)

3.3.3. Problem Traveling to Market

The findings in (Table 7) shows that 17 (11.2%) of adopters reported problems traveling to the market, while 46 (30.46%) had no issues. In contrast, most non-adopters indicated they faced difficulties, with 46 (30.46%) saying they had problems and 42 (27.8%) reporting no challenges. The chi-square test revealed no statistically significant difference (X^2=2.657, p-value=0.068) between adopters and non-adopters. Focus group discussions (FGD) and key informant interviews (KI) also indicated that both groups have no significant issues accessing markets within a 10-20 km radius, such as Dehagle, Fafan, Mombas, Adaade, and Tikdam. Overall, market distance is not viewed as a challenge by the farmers.

3.3.4. Access to Credit Services

Access to credit is a significant factor distinguishing adopters from non-adopters of forage species. Descriptive statistics reveal that both groups face credit shortages. Among adopters, 38 (25.2%) have no access to credit, while 25 (16.5%) do. For non-adopters, 76 (50.3%) lack credit access, and only 12 (7.9%) have received it. Statistical analysis shows a significant relationship between the two groups at the 1% level (X^2=13.464, p=0.000), (Table 7)indicating little difference in credit access. Focus group discussions and key informant interviews support these findings, noting a lack of credit services in the area and that many residents are Muslims, whose beliefs restrict engagement with interest-based financial services. They reported receiving no direct credit or support.

3.3.5. Access of extension

The accessibility of extension service is also crucial variable for the adoption of improved forage technology. However, only 20 (13.2%) of adopters and 10 (6.6%) of non-adopters had accessed the extension service. Although, the number of farmers who had accessed the extension service was low, there was a significant difference between adopters and nonadopters as chi-square test indicated (X^2 =

Table 6: Continuous of institutional variables sample respondent(n=151)

Variable	Adopters		Non-adopters		t-value	p-value
	Mean	SD	Mean	SD		
Distance to DAS Office	18.48	10.040	18.24	9.036	0.152	0.466
Distance to market	17.0317	6.48315	15.3068	5.51770	1.760	0.006***

significant level at***1% ** 5%,

Table 7: Categorical of institutional variables sample respondent(n=151)

Variables	Categories	Adopters		Non-Adopters		X^2	P value
		N	%	N	%		
Problem traveling to market	Yes	17	11.2	46	30.46	2.657	0.068
	No	46	30.46	42	27.8		
Access of Credit	Yes	25	16.5	12	7.9		
	No	38	25.2	76	50.3	13.464	0.000***
Access of extension	Yes	20	13.2	10	6.6		
	No	43	28.5	78	51.6	9.581	0.002***
Access of Training	Yes	26	17.5	17	11.3		
	No	37	24.5	71	47	8.686	0.003***

Significance level at ***1% **5% respectively.

9.581, p=0.002***). Access of extension service has been reported to have influence on the adoption decision of farmer (Leake Gebresilassie and Adam Bekele, 2015).(Table 7)

3.3.6. *Access of training*

In the study, it was found that 26 smallholder farmers (17.2%) had access to training, while only 17 farmers (11.3%) actually received training. A chi-square test indicated a significant difference (X^2 = 8.686, p-value = 0.003***), suggesting that the majority of smallholder farmers did not receive any training.(Table 7) Consequently, the availability of training for improved forage species in the area is notably low. Similar findings were reported by (Mengistu et al., 2016), who discovered that only 37.5% of the surveyed households had access to training on improved forage development and utilization

3.4. Bio-physical Factors

Biophysical factors significantly impact the adoption of improved forage species, particularly water availability. Both adopters and non-adopters face challenges due to water shortages, with 25% of adopters and 23.8% of non-adopters reporting insufficient water access. A chi-square analysis indicated a significant difference (X^2 = 5.534, p-value = 0.0014) regarding water scarcity between the two groups.(Tale 8) Focus group discussions and key informant interviews revealed that water shortages, especially during certain seasons and within irrigation schemes, hinder forage innovation adoption. Farmers noted that while some have access to irrigation, many struggle with water scarcity, which particularly affects the cultivation of species like alfalfa and Rhode's grass. These qualitative insights align with the statistical findings.

3.4.1. *Free grazing*

free grazing poses a significant challenge for farmers in adopting improved forage species. About 30.4% of adopters and 49.66% of non-adopters identified free grazing as a barrier to growing forages, indicating that adopters perceive it as a more serious issue.(Table 8) Statistical analysis supports a significant difference (X^2=12.337, p-value=.000) between the two groups regarding this problem. Research shows that free grazing hinders the survival of forage plants, particularly legumes, which struggle under continuous grazing and poorly drained soils (Kebede et al., 2017). Farmers in focus group discussions expressed that while they could potentially allocate land, use water harvesting, hire labor, and sell products, avoiding uncontrolled grazing remains a significant challenge.

3.5. Adoption Status of Improved Forage Technologies

(Table 9) shows that improved forage species are recommended in package form for farmers, but many only adopt certain components. This section examines the adoption status among sample households, categorizing them as adopters or non-adopters based on their decision to grow or reject the recommended forage species. From a total of 151 sampled households, 63 adopters and 88 non-adopters were identified. Of the adopters, 56 had heard of improved forages, with 52 engaging in their cultivation. Currently, 59 adopters use these forages, while 86 non-adopters do not. Previous studies indicate that low adoption rates are influenced by various factors including demographics and socioeconomic status (Beshir, 2013; Bashe et al., 2018).

3.6. Econometric Results of the Binary Logistic Regression Model Testing

The model estimated the statistical significance of variables affecting the adoption of improved forage species using data from 151 respondents analyzed with a binary logistics model. Both continuous and categorical variables were checked for multicollinearity, which occurs when an independent variable is a linear combination of others. After addressing multicollinearity, the Logistic Model Estimates were used to evaluate the likelihood of households adopting forage species based on farmers' and technological characteristics.

Table 8: Categorical of Bio-physical variables in sample respondent (n=151)

Variables	Categories	Adopters		Non-Adopters		Chi-square	
		N	%	N	%	X^2	P value
Is there shortage of water in the locality?	Yes	38	25	36	23.8		
	No	25	165	52	34.4	5.534	0.0014***
Do you face water shortage to grow forage?	Yes	12	7.94	18	11.9		
	No	51	33.7	70	46	.046	0.500
Do you think free grazing is problem to grow forages?	Yes	46	30.4	75	49.66		
	No	17	11.2	13	8.60	12.337a	.000***

Significance level at ***1% **5% respectively.

Table 9: Distribution of respondents by status of forage adoption (n=151)

Description		Adopters (N=63)	Non-adopters (N=88)	Total sample (n=151)
have you ever heard improved forage?	Yes	56	72	
	No	7	16	
Have you ever disseminated improved forage species	Yes	52	62	
	No	11	26	
Do you use improved forage currently	Yes	59	2	
	No	4	86	

Source: computed survey, 2021

Table 10: Variable inflation factor for continues variables

Variables	R^2	Tolerance	VIF
Age	0.123	.877	1.140
Family size	0.15	.850	1.176
Cultivating land	0.085	.915	1.093
Number of live-stock	0.246	.754	1.326
Distance market	0.316	.684	1.461
Distance From DA Office	0.275	.725	1.380

3.6.1. Multi-collinearity diagnoses.

Two measures commonly used to test for multicollinearity are Variance Inflation Factors (VIF) for continuous variables and Contingency Coefficient for categorical variables (Gujarati and D., 2009). VIF is specifically employed to detect multicollinearity among continuous variables.

$$VIF(xi) = \frac{1}{(1 - Ri^2)} \quad (9)$$

Ri^2 represents the square of the multiple correlation coefficients when one explanatory variable (xi) is regressed against all others. A higher $VIF(xi)$ indicates greater multicollinearity, with a value exceeding 10 signaling a problem. As shown in (Table 10), all continuous variables had VIF values below 10, indicating no multicollinearity issues. Therefore, the six continuous variables were retained for binary logistic regression analysis.

To check for the existence of multicollinearity among the discrete explanatory variables, the contingency coefficient was analyzed and computed.

$$CC = \sqrt{x}\frac{X^2}{(N + X^2)} \quad (10)$$

Where CC= contingency coefficient, X^2 = Chi-square random variable, and N = total sample size. The decision rule for the contingency coefficient states that as its values approach 1, there is a significant association between the discrete variables.(Table 11)

3.6.2. Logistic Model Estimates

In this regression model estimation, two groups of farmers were identified; technology (a)adopters and (b) non-adopter while adopters were represented by 0 and non-adopters were 1. Moreover, these models relate household and technological characteristics to the probability that a household will adopt improved forage technology or not. The logit model has resulted in the estimates of the 13 variables as presented the(Table 12.)

The maximum likelihood estimation methods were employed to analyze the binary logistic regression model and identify significant factors influencing farmers' adoption of improved forage technology. As shown in (Table 12), the model indicates that education, farm size, access to credit, extension services, number of Livestock, and water positively and significantly influence adoption. In contrast, market distance has a negative and significant effect. Variables such as age, sex, family size, access to training, and distance to DAs office do not show statistical significance. The significance of the identified variables reflects their positive or negative associations with the adoption of improved forage species. **Education:** (Table 12) shows the text discusses the reading and writing abilities of farmers in relation to their adoption of improved forage technologies. It suggests that education has a positive and significant impact on the

Table 11: Contingency coefficient of categorical variables

Variables	Sex	Education	Access extension	Access of Credit	Access of Training	free grazing	Access of Water
Sex	1.00						
Education	.026	1.000					
Access extension	-.128	-.040	1.00				
Access of Credit	.130	.055	.023	1.00			
Access of Training	.157	.093	.157	.093	1.00		
Free grazing	-.070	-.106	.032	.050	-.054	1.00	
Access of Water	-.090	-.014	.072	.011	-.170	-.175	1.00

Source: survey result 2021.

Table 12: Binary logit model output (n=151)

Variables	B	S.E.	Wald	Odds	P-value
Age	0.042	.031	1.827	1.043	0.177
Sex	-.840	.960	.766	0.432	0.382
Education	2.230	.528	17.845	0.107	0.000***
Family size	-.074	.151	.238	0.929	0.626
Farm size	.824	.328	6.311	0.439	0.04***
Access credit	0.999	.888	5.066	0.379	0.024***
Distance market	-.086	.074	1.342	0.918	0.03****
Access extension	1.334	.994	1.800	3.795	0.02***
Distance DAs office	-.001	.046	.001	0.999	0.981
Access Training	-.896	.952	.886	0.408	0.347
Free Grazing	-.649	.825	.618	0.523	0.432
Water	1.675	.745	5. 049	5.339	0.025***
Number of livestock	.670	.151	19.608	0.511	0.000***
Constant	10.303	3.925	6.892	2.9834	0.008***
Omnibus Chi-square -2	133.197				
-2 Log likelihood ratio	69.796[a]				
Cox & Snell R Square	591				
Nagelkerke R Square	794				

Note: ** = significant at $p < 0.05$; *** = significant at $p < 0.01$

adoption of these technologies. The model indicates that education is positively associated with technology adoption at a 1% level of significance. This implies that as farmers receive more education, the number of farmers adopting improved forage species increases. Additionally, the odds ratio is 0.107, which suggests that for each additional unit of education, the likelihood of adopting improved forage species increases by a factor of 0.107. Various empirical studies conducted in different parts of Ethiopia also support the finding that education is positively associated with technology adoption (Bashe et al., 2018; Egge et al., 2012; Gebreselassie, 2019).

Farm size: it refers to the net amount of land devoted to crop cultivation. The model estimate under this study does confirm expectation. The odd ration of 0.439 indicates other things being constant the odd ratio favor for adopting of new technology as the farm size increased by one-hectare adoption of forage technology was increased by the rate of 0.439. (Tale 12). Therefore, the result of this study implies if the farmers have large farm size they have the confidence to take risk of the new technology and that is the main reason farm size have positive and significant association at 1% significant level. This result was similar by various empirical studies conducted by (Wudu, 2017; Worku, 2019; Hassen, 2019), who found that the farm size has positive association to the most agricultural technology in Ethiopia.

Access credit: This variable was expected to positively influence farmers' decisions to adopt improved forage. The model results indicate a significant effect of credit availability on the adoption of improved forage species at the 1% level. This suggests that farmers face a severe shortage of credit. Additionally, the odds ratio demonstrates that the likelihood of adopting improved forage technology increases by a factor of 0.379 for each unit increase in access to credit. This finding is consistent with the research by (Wudu, 2017), which revealed that as farmers receive more credit, their adoption of new technologies also increases.(Table 12)

Distance to Market: This refers to the distance from a farmer's home to the nearest market. It is a crucial factor influencing the adoption of improved forage species, as farmers travel to the market to purchase agricultural inputs, including improved seeds, and to sell their agricultural products. Consequently, it is hypothesized that the distance to the market is inversely related to the adoption of improved forage species. The model results indicate that the distance from the town market negatively affects the adoption of forage technology species, with a significance level of 1%. (Table 12)The odds ratio shows that adoption increases by a factor of 3.795 for each kilometer increase in distance from the town market.

Access of extension: Extension services provided by both governmental and non-governmental organizations are crucial for farmers. Improved extension services lead to better adoption of forage species. Regression analysis shows that participation in these services, such as on-farm demonstrations and training, significantly influences the adoption of improved forage, with a noteworthy increase in the odds of adoption (by a factor of 3.795) for each unit increase in extension services.(Table 12) This aligns with (Worku, 2019) findings of a positive relationship between contact with extension agents and the adoption of improved technologies.

Water: Since forage cultivation relies on irrigation, the availability of water was hypothesized to positively influence the adoption of improved forage species in the area. The model estimate revealed that water accessibility significantly affects the adoption of these forage species at a 1% significance level. Specifically, the odds of adopting improved forage species increase by a factor of 5.339 for each unit increase in water availability for farmers(Table 12).

Number of Livestock: As expected, the number of Livestock, measured in tropical livestock units (TLU), affects the adoption levels among farmers. Regression analysis indicates that having a greater number of ;ivestock is positively and statistically significant at the 1% level. The odds ratio shows that the likelihood of adopting improved forage species increases by a factor of 0.511 with more livestock ownership.(Table 12) This suggests that having more livestock enhances the adoption of improved forage species. This finding aligns with the study conducted by (Solomon et al., 2014), which indicates that livestock ownership based on TLU positively and significantly influences the adoption of agricultural technology.

4. Conclusion and Recommendations

This study examined the factors influencing the adoption of improved forage species in Gursum District, Somali Regional State. The findings reveal significant differences between adopters and non-adopters in terms of socioeconomic, demographic, institutional, and biophysical factors. Key determinants such as education level, farm size, access to credit, extension services, number of livestock, and water availability were found to positively and significantly influence adoption. In contrast, market distance was a major constraint, negatively affecting adoption decisions. Other factors, such as age, sex, family size, training access, and distance to development agents' offices, were found to be statistically insignificant. The study also identified critical institutional and market-related challenges. The majority of non-adopters had lower literacy levels, limited access to extension services, and poor financial resources, which hindered their ability to adopt improved forage species. Limited access to credit was a significant barrier, with a larger proportion of non-adopters reporting difficulties in obtaining financial support. Free grazing practices and water shortages were also found to be major obstacles, as they restricted farmers from effectively integrating improved forage varieties into their livestock production systems. Furthermore, while extension services were recognized as an important driver of adoption, the overall coverage and follow-up mechanisms were found to be weak. The lack of targeted training programs further limited farmers' knowledge and capacity to adopt and manage improved forage species effectively. Addressing these challenges requires a holistic approach, including strengthening extension services, improving access to credit, promoting sustainable water harvesting techniques, and supporting research on adaptable forage species. Enhancing farmer awareness through regular training and providing market linkages for forage production will be crucial in increasing adoption rates and ensuring sustainable livestock productivity in the study area.

Conflict of Interest

Authors declare that there is no conflict of interest involve in publishing this paper.

References

Assefa, G., Dejene, M., Hanson, J., Anemut, G., Mengistu, S., and Mengistu, A. (2012). Forage seed research and development in ethiopia. *Ethiopian Institute of Agricultural Research. Addis Ababa, Ethiopia*.

Bashe, A., Bassa, Z., and 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. (2013). Factors affecting the adoption and intensity of use of improved forages in north east highlands of ethiopia. *American Journal of Experimental Agriculture*, 4(1):12–27.

CSA (2013). The federal democratic republic of ethiopia central statistical agency agricultural sample survery. *Vol(2)*, 22.

CSA (2015). (central statistical authority). *2015. Agriculture Sample Survey. Report on Livestock and Livestock characteristics (private peasant holding). Addis Ababa, Ethiopia*.

Egge, M., Tongdeelert, P., Rangsipaht, S., and Tudsri, S. (2012). Factors affecting the adoption of improved sorghum varieties in awbare district of somali regional state, ethiopia. *Kasetsart Journal of social sciences*, 33(1):152–160.

Ehui, S. K. and Bank, W. (2015). Determinants of adoption of improved forage technologies in crop-livestock mixed systems: Evidence from the highlands of ethiopia. *Tropical grasslands*.

Feder, G., Just, R. E., and Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: A survey. *Economic development and cultural change*, 33(2):255–298.

Feyisa, B. W. (2020). Determinants of agricultural technology adoption in ethiopia: A meta-analysis. *Cogent food & agriculture*, 6(1):1855817.

Gebreselassie, L. (2019). Review on determinants for adoption of improved forages in ethiopia. *J Sci Innov Res*, 8(4):112–115.

Gujarati, D. and D., P. C. (2009). *Basic Econometrics*. McGraw- Hill education, New York itio, 5 edition.

Hassen, N. A. (2019). Determinants of adoption of improved sorghum package in agro-pastoral households of somali region of ethiopia: A gender perspective. *Journal of Agricultural Extension and Rural Development*, 11(11):192–199.

Howley, P., Donoghue, C. O., and Heanue, K. (2012). Factors affecting farmers' adoption of agricultural innovations: A panel data analysis of the use of artificial insemination among dairy farmers in ireland. *Journal of Agricultural Science*, 4(6):171.

Kebede, G., Ababa, A., Feyissa, F., and Assefa, G. (2017). *I nternational J ournal of Agriculture and Biosciences*. December.

Leake Gebresilassie, L. G. and Adam Bekele, A. B. (2015). Factors determining allocation of land for improved wheat variety by smallholder farmers of northern ethiopia. *Journal of Development and Agricultural Economics*.

Melese, W., Assefa, A., and Dehninet, K. (2018). Improved forage production practice and challenges in libokemkem district, ethiopia.

Agricultural Science Digest-A Research Journal, 38(4):280–284.

Mengistu, A., Assefa, G., Kebede, G., and Feyissa, F. (2016). Review on the evolution of forage seed production in ethiopia: Experiences, constraints and options. *Academic Research Journal of Agricultural Science and Research*, 4(6):231–240.

Mengistu, S. (2018). *Assessment of forage production, feed resource utilization and substitution effect of oat-vetch forage for concentrate mix on performance of sheep fed desho grass as a basal diet in Damote Gale District of Wolaita Zone, SNNPR*. PhD thesis, Hawassa University.

Shiferaw, A., Puskur, R., Tegegne, A., and Hoekstra, D. (2011). Innovation in forage development: empirical evidence from alaba special district, southern ethiopia. *Development in Practice*, 21(8):1138–1152.

Solomon, T., Tessema, A., and Bekele, A. (2014). Adoption of improved wheat varieties in robe and digelutijo districts of arsi zone in oromia region, ethiopia: a double-hurdle approach. *African Journal of Agricultural Research*, 9(51):3692–3703.

Tekalign, E. (2014). Forage seed systems in ethiopia: A scoping study. *ILRI project report*.

Worku, A. A. (2019). Factors affecting diffusion and adoption of agricultural innovations among farmers in ethiopia case study of ormia regional state westsern sewa. *International Journal of Agricultural Extension*, 7(2):137–147.

Wudu, B. (2017). *Determinants of adoption of improved wheat technology: in case of Gozzamen district, East Gojjam in Amhara Regional State, Ethiopia*. PhD thesis, St. Mary's University.