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SMALLHOLDER FARMERS ADAPTATION STRATEGIES TO THE CONSEQUENCE OF CLIMATE CHANGE AND VULNERABILITY IN GELANA WOREDA OROMIA REGION, ETHIOPIA

Belay Daba Gutema

Department of Geography and Environmental Studies,
College of Social Science and Humanities,
Bule Hora University

ABSTRACT

This study was aimed at Smallholder farmers' adaptation strategies to the effect of climate change and vulnerability in Gelana Woreda, Oromia region, Ethiopia. A total of 156 households were sampled using random sampling methods. A household questionnaire survey, focus group discussions, key informant interviews, and field observation was undertaken to collect primary data. Furthermore, 96.8% of the respondents perceived occurring of climate variability in the study area. The decline in crop and animal yield as well as productivity (30.8%), reduced water availability (21.8%), early and late rainfall (26.2%), the decline in soil fertility (12.2%), and human and animal disease (9%) were the major indicators of climate change and variability used by farmers. Crop disease (31%), livestock feed scarcity (24%), health problems and/or human disease (13%), soil erosion (8%), and loss of water point (8%) were the major climate-related effects in the study kebele. Seasonal migration, mixed farming, improved crop variety, feed management, soil terrace, tree planting, medication/vaccination, and rainwater harvesting is coping and adapting strategies of rural farmers to cope with climate variability. Nevertheless, putting those options into practice is constrained by lack of access to climate information (33%), lack of access to credit (25.6%), lack of water for irrigation (21.7%), and lack of enough farming land (11.4%. Therefore, the governments need to improve farmers' access to credit services and climate information to minimize climate-related problems. Furthermore, strengthening the farmers' adaptive capacity to climate change through awareness creation on climate change and variability is important.

Keywords: Climate variability, Vulnerability, Adaptation, Constraints

1. INTRODUCTION

1.1 Background of the Study

Climate change is the most critical concern as it is affecting all nations and regions of the world differently depending on their context. The concern is due to the huge impact the on environmental environment, economic and social aspects of the world communities (IPCC, 2014b; Hirpha et al., 2020). The earth's climate is still changing, posing a serious challenge to the environment and agriculture (Musyimi, 2020). Though the threat to rain-fed cultivation is considered the most prevalent as future impacts are again projected to worsen following changes in temperature and precipitation (Gedefaw et al., 2018). In this case, the developing countries and the poor are the most vulnerable due to low adaptive capacity (Kahsay et al., 2019; Marie et al., 2020).

In Africa, climate change and variability have a significant impact on the livelihood of rural farmers who depend upon rain-fed cultivation (Dereje and Nega, 2019). Adding to this, the impact on agricultural output will also directly affect rural communities,

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through reducing household income, knock-on effects for rural economies as a whole; and the food security nexus (Ngcamu and Chari, 2020).

In the context of Ethiopia, the effect of climate variability is not a recent situation (Weldearegay and Tedla, 2018). The numerous and frequent occurrences of extreme climatic events such as droughts over the years, 1889–1892, 1972–1974, 1984–1985, 2002–2003, and 2015–16, and floods have disastrous effects on rural households by destructing their assets (Birhanu et al., 2016; Teshome and Zhang, 2019). The frequent occurrence of drought and flooding can deplete the natural resource base that rural households depend upon causing soil erosion and forest degradation (Araro et al., 2019). In addition, **in**consistent rainfall makes farmers uncertain in growing seasons and led to low crop yield and livestock production (Amare et al., 2018; Ruo et al., 2018).

Moderating the problems associated with climate change and vulnerability requires farmers' perceptions to decide relevant adaptation measures (Elum et al., 2017). In connection to this, farmers' climate perceptions are responsible for shaping their adaptive responses and are thus essential to consider for the design of strategies to reduce vulnerability and increase resilience (Darabant et al., 2020). According to a report of Hirpha et al. (2020), farmers have long records of managing the impacts of climate-related events and they have already begun practicing adaptation strategies, but efforts are still at a relatively early stage due to the presence of constraints to climate change adaptation.

According to Fagariba et al. (2018), constraints to adaptation are the obstacles that can be overcome with concerted effort. In addition, Marie et al. (2020) reveal that lack of knowledge about adaptation, adequate irrigation facility, enough farming land, and credit services were the major constraints to climate change and vulnerability adaptation. This study was revealed constraints of adaptation strategies to climate change and vulnerability in the study area.

Climate change impact assessment research such as Alemayehu (2019); Tesfaye (2020) have been conducted in some areas of the Guji zone. Nevertheless, none of them have focused on the Gelana district to assess the explicate-specific effect of climate change and vulnerability and farmers' responses. Therefore, these studies were inconclusive because of the difference in time and place. And most of it focuses on policy responses to climate change leaving out the effort made to adapt to farmers and community levels. The overall objective of the study is to investigate the adaptation strategies to the effect of climate change and vulnerability in Gelana district, Oromia Region, Ethiopia.

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2. METHODS AND MATERIALS

2.1. Description of the Study Area

Gelana is a **woreda** in the **Oromia Region**, **Ethiopia**. Gelana was bordered on the south by **Bule** Hora, and on the west, north and east by the **Southern Nations, Nationalities, and Peoples Region** (SNNPR). **Lake Abaya**, on the western border, is divided between this woreda and the SNNPR. However, the **Guji Oromo** who live in **Nechisar National Park** are claimed to be administratively part of this woreda, in a kebele called "Irgansaa"

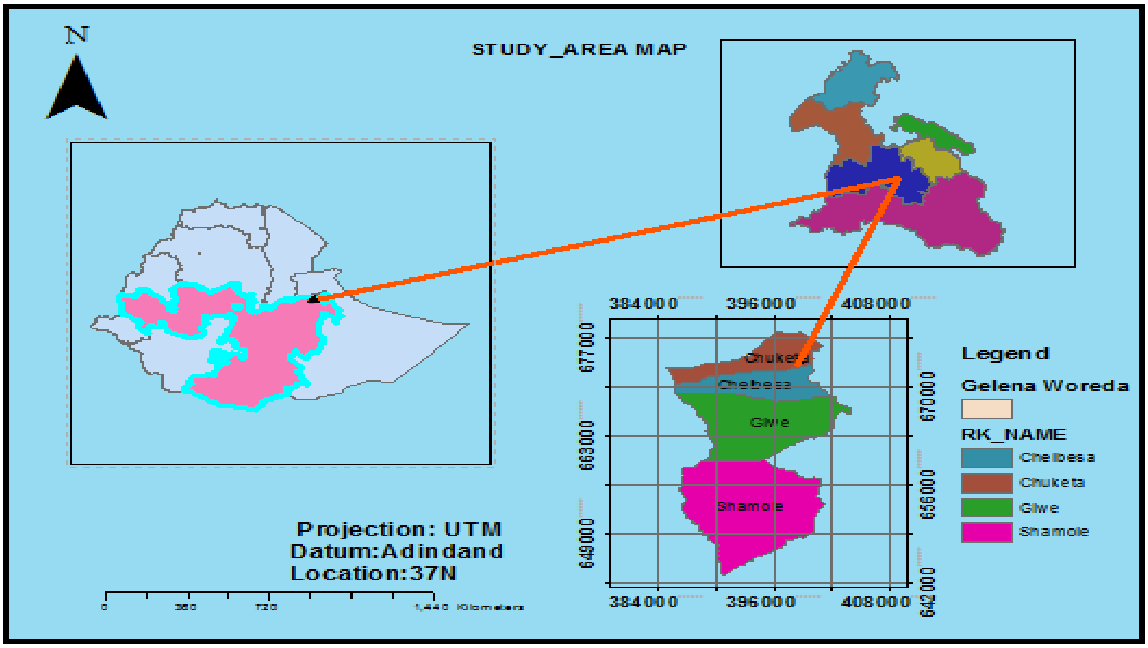

Figure 2.1. Study area, GIS-lab of Bule Hora University

2.2. Research Design and Approach

A cross-sectional survey was carried out in the study area because the method is the least costly. In this case, the data are collected at one point in time from a sample selected to represent a study population-. The study employed a combination of quantitative and qualitative approaches.

2.3. Target Population

The Gelana district consists of a total population of 103,348. Out of kebeles, the present study will be focused on four Kebeles of the Gelana district which which were purposively selected 5914 total population from four kebeles (1947 male and 1745 female) with 971 households. Therefore, the target population of this study would be Gelana district farmers who are married and above 18 years old.

2.4. Sampling Techniques and Sample Size Determination

Multi-stage sampling techniques were undertaken to obtain representative study sites and respondents. Firstly, the study site is selected purposively due to the adverse effects of climate change on rural farmers. Secondly, out of rural kebeles, 4 kebeles' (lowest administrative unit) vulnerable to climate change were effectively identified.

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The criteria for the identification are environmental attributes like the severity of the impact of climate change and the associated challenges that farmers faced through their farming time. Thirdly, the Gelana district is taken using purposive sampling methods.

After purposive selection of the study kebeles, the total number of households was obtained from the Gelana district administration office where a list of households is available. Then, the required sample from the kebeles was also randomly selected from the list of households. This is also based on pre-determined 156 sample households using simplified formula provided by Yamane (1967) at 92% confidence level and 8% level of precision. The formula is given as:

$$n = \frac{N}{1+N(E)^2}, \quad n = \frac{971}{1+971(0.08)^2} = 156$$

Where, "n" is the sample size, "N" is the population size, and "E" is the level of precision.

2.5. Data Source and Methods of Data Collection

The study employed both primary and secondary sources of data. The primary data was gathered from **a** household questionnaire survey, key informant interview, field observation, and focused group discussion (FGD). Also, secondary sources such as books, journals published and unpublished materials, internet sources, and reports were employed.

2.6. Methods of Data Collection

The household **survey** which was composed of both closed and open-ended questions were prepared in English, then it was translated into Afan Oromo-is local language.

Focus Group Discussion (FGD) was conducted with four men and women. Local leaders and elders were participate to capture local knowledge on climate change and vulnerability, adaptation strategies, and factors affecting their adaptation strategies.

Field Observation was carried out to assess the loss and failure of crops due to changes in climate and the employed adaptation strategies like traditional irrigation and tree planting in the representative kebele.

Key Informant Interview (KII) was undertaken. The open-ended questions were discussed about the farmer's vulnerability of climate change effect and various responding strategies that practiced and the constraints of adaptation in the study area.

2.7. Data Analysis

The collected data were processed and analyzed, based on both qualitative and quantitative methods. Qualitative data obtained from key informant interviews, field observation, focused group discussion was narrated and described following quantitative analysis triangulating diverse ideas of on similar issue. In addition, descriptive statistics such as tables, bar graphs, and pi-chart were applied to show the quantitative data set. As the data analysis tools Microsoft Excel version 2019, SPSS Version 20 was used.

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3. RESULTS AND DISCUSSIONS

3.1. Characteristics of the Respondents

Socio-Demographic Attributes

Table 4.1. Demographic characteristics of the Respondents

R.No.	Variables		Frequency	Percent
1	Sex	Male	120	76.9
		Female	36	23.1
2	Age	<30	2	1.3
		31-51	48	30.8
		51-60	101	64.7
		>60	5	3.2
3	Marital status	Married	154	98.7
		Single	2	1.3
4	Family size	1-5	64	41.0
		5-10	88	56.4
		Greater than 10	4	2.6
5	Education level	unable to read and write	52	33.3
		Grade 1-4	84	53.8
		Grade 5-8	16	10.3
		Grade 9-12	4	2.6
		Certificate and diploma	-	-
		First degree and above	-	-

Source: Authors' field survey, 2021

According to the survey of the households, the majority of the respondents are men (76.9%) while 23.1% of them are headed by women. Concerning the marital status of the respondents, 98.7% are married and 1.3% of them was were married.

The result of the study also revealed that the majority of the respondents (64.7%) were between 51-60 years of age, while the respondents whose age group was 31-51 constituted about 30.3%. In the same way, 1.3% of the respondents were less than 30 years old and 3.2% are above 60 years. This entails that most of the sampled households can be well aware of their area and prevailing climate change and variability-related problems to adapt to climate change effects. Lemma (2016) revealed that the age of the household head was used to capture the farming experience and its influence on adaptation to climate change.

On the other hand, some of the respondents (53.8%) have not gone beyond grade 1-4 level of education, whereas 33.3% of the respondents are those who cannot read and write. Those respondents who completed grades 5-8 constituted about 10.3% and the remaining 2.6% of them are those who have better education levels (above grade 9). This has a significant impact on the practices of climate change adaptation strategies because a minimum threshold qualification is necessary for the activities related to climate change adaptation. In connection to this, Hirpha et al. (2020) state that for agricultural productivity in face of changing climate enhanced farmer'' educational status play a significant role in applying adaptation strategies.

In addition, as indicated in Table 4.1, the majority (56.4%) of the respondents have got a family size of 5-10 members, while those with family member's between1-5

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constitute 41% and 2.6% of them got greater than 10 family members. This indicates the study district is relatively characterized by households with larger family sizes indicating the potential increment in population in the study area.

Socio-economic Attributes

According to the result of the study, almost all (100%) of the respondents have their plots of land but, small and different sizes. About the size of the land, about 27.6% of the respondents owned between 0.5-2ha plots of land. On the other hand, the majority (56.4%) of the farmers own 2-3ha plots. The remaining 16% of them have greater than 3ha of land. This indicates farmland possession is relatively small to influence crop diversification strategies to adapt to climate change and variability in the study site. The result is similar to the study of Lemessa et al. (2019) who found small landholding of farm households, little effect on influencing crop diversification in changing climate in Eastern Ethiopia.

Table 4.2. Socio-economic characteristics of the respondents

R.No.	Variables		Frequency	Percent
1	Own land	Yes	156	100
		No	-	-
2	Fam size (ha)	0.5-2	43	27.6
		2.3	88	56.4
		Greater than 3	25	16
3	Agricultural activities	Crop production	-	-
		Livestock production	-	-
		Both crop and livestock	156	100
4	Main agricultural practice	Rain-fed agriculture Irrigation agriculture	156 -	100 -
		Both spots of rain-feed and irrigation	-	-
5	On-farm	On farm	120	76.9
		Off-farm	10	6.4
		Both on-farm and off-farm	26	16.7

Source: Authors' field survey, 2021

Likewise, rain-fed agriculture predominates in the study areas, which entirely depend on annual rainfall. This implies that agricultural activities practiced are climate-sensitive. A similar study was obtained by Berhe et al. (2017) who suggest that farmers in the countries like Ethiopia are at risk of climate change effect due to their over-dependency on rain-fed cultivation. Moreover, the source of income for the majority (76.9%) of the farmers is on-farm activities (crop and livestock production) while 6.4% and 16.6% of them got income from off-farm and both on-farm and off-farm activities, respectively.

3.2. Farmers Perception of Climate Variability in Gelana District

In this study, farmers were asked how they perceive long-term climate changes. Accordingly, the following table 4.3 depicts the farmers' perception of climate variability in the study area.

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Table 4.3 Farmers perception on the general trend of climate in the study area

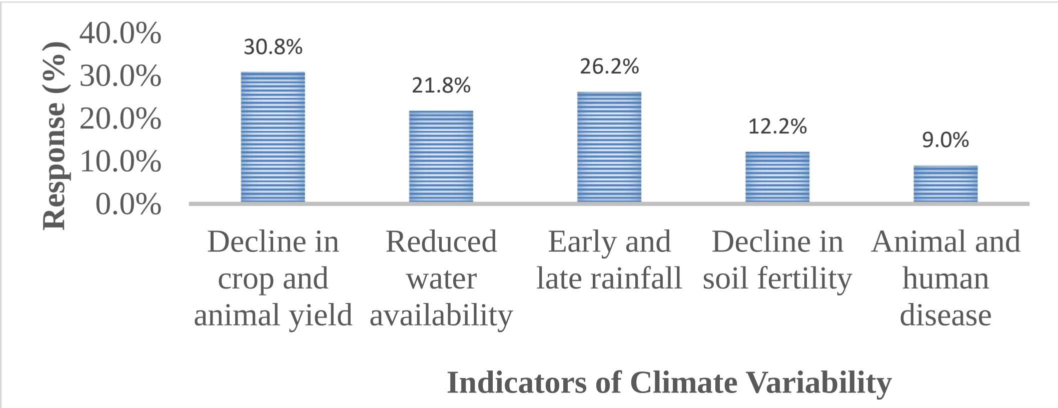
What do you say about the climate in your area?		
Perception	Frequency	Percent
Changed	151	96.8
Not changed	2	1.3
I don't know	3	1.9
Total	360	100

Source: Authors' field survey, 2021

The highest proportions of farmers (96.8%) were recognizing the variability in climate in their area while 1.39% of them did not observe any change in climate situation in the study area. Moreover, 1.9% of the respondents did not know about climate conditions.

3.3. Indicators of Climate Variability Used by Farmers

The farmers used different indicators to perceive whether the climate is varied or not in the study area as illustrated in following figures 4.1.



Source: Authors' field survey, 2021

Figure 4.1 depicts about 30.8% of the respondent's use decline in crop and animal yield to realize variability in climate followed by early and late rainfall (26.2%) in the study area. In addition, reduction in water availability constitutes 21.8% of farmers' perception as an indicator of climate variability. Also, 12.2% of the surveyed farmers reported that a decline in soil fertility was a crucial indicator of long-term variability in the local climate. Finally, 9% of farmers reported the prevalence of human and animal disease as an indicator of climate variability in the study area.

3.4. Farmers Vulnerability to Effect of Climate Variability

In this study, farmers were asked to understand the vulnerability of their livelihood to the adverse impact of the climate variability in the study site. Accordingly, 31% of the respondents reported crop disease which was attributed to variable climate (Figure 4.2). The study is supported by Amphune et al. (2019) who reported 70.72% of farmers' perception on increased crop pests which was associated with erratic rainfall in Southern Ethiopia.

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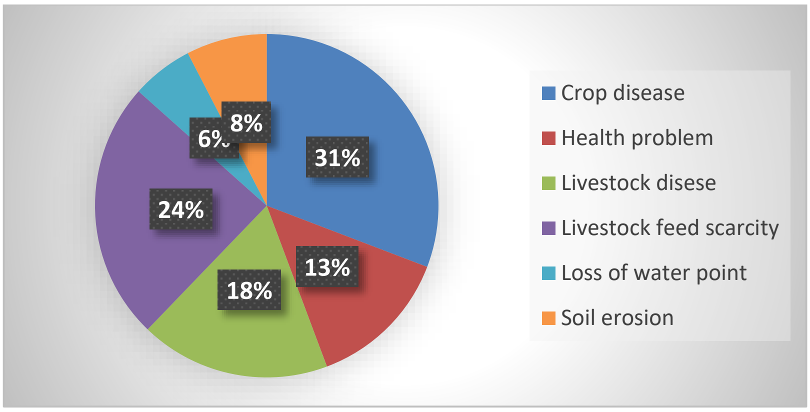

Source: Authors' field survey, 2021

On the other hand, Livestock feed scarcity (24%) was one of the major shocks that farmers were vulnerable to its impacts in the study area. In addition, 18% of the respondents recognized outbreaks of livestock disease during periods of extremes temperature. According to key informants, the incidence of livestock disease is high during extreme temperatures and low during heavy rainfall. This result coincides with the study made by Nhara et al. (2020) who stated animal disease due to body temperature exceeds the upper critical zone.

About 13% of farmers reflect that health problem in the study kebele. According to focus group discussion (FGD), communicable disease such as typhoid and common cold was the common climate-related health impacts in the area. In adding to this, respondents described that contamination and deterioration of drinking water mostly ponds by floods caused typhoid, which is affecting many people's health in the study area. This is similar to the report of WHO (2018) that indicated climate variability causes vector-borne disease and is estimated to be responsible for approximately 2.7% of worldwide diarrhea, and 8% of malaria in some middle-income countries by 2000.

Moreover, the presence of soil erosion was a climate-related problem as it was perceived by 8% of the respondents in the study area. Local elder key informants reported that soil erosion caused by flooding and wind affects soil fertility and water pollution. This is supported by Borrellia et al. (2020) who studied farmers' vulnerability to climate-related hazards such as flooding and wind-caused soil erosion in the United States of America.

Finally, 6% of respondents indicated losses of water points were the existing problem over the past three decades due to seasonal variation and reduction of rainfall. Further, the study indicated that due to reduction in water availability and drying up of water points more than 50% of people traveled about 3km in search of water for their family and livestock. Therefore, water scarcity was a serious problem for Gelana district peoples due to the reduction of water points. Marie et al. (2020) reported that 9.1% of farmers' perception on drying of streams and rivers by climate change in North-western Ethiopia. Similarly, a study by Fenta (2017) showed dried up of water point due to recurrent drought and people traveled long distances, more than 20km, to access water in Afar Region.

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3.5. Adaptation Strategies Employed by Farmers

The study revealed that, despite the difficulties of climate variability effects, the farmers tried to sustain and improve their livelihood through a range of climate variability adaptation strategies. Accordingly, about 33.3% and 42.3% of the farmers use mixed farming practices and improved crop variety respectively to reduce the effect of crop pests in the study area. The remaining 24.4% of the respondents did not adopt any adaptation strategies to changing climate.

Table 4.4. Adaptation strategies used by farmers in the study area

R. No	Adverse Effects	Adaptation strategies	Frequency	Percent
1	Crop disease/pests	Mixed farming	52	33.3
		Improved crop variety	66	42.3
		No adaptation	38	24.4
2	Soil erosion	Tree planting	39	25
		Soil terracing	41	26.3
		No adaptation	76	48.7
3	Livestock disease	Mixed farming	75	48
		No adaptation	81	52
4	Health problem/human disease	Medication	94	60.3
		No adaptation	62	39.7
5	Loss of water Point	Seasonal migration	96	61.5
		Rainwater harvesting	60	38.5
6	Livestock feed scarcity	Feed management	114	73.1
		No adaptation	42	26.9

Source: Authors' field survey, 2020

The respondents in the Focus group discussion (FGD) replied that mixed farming help to compensate for the damage of crops by livestock and vice versa. On the other hand, improved crop variety is less vulnerable and more tolerant to the effect of harsh climatic conditions. This study is in agreement with Shishay **et al. (2018) who study** owning livestock may buffer the farmers against the effects of crop failure.

Soil terracing is used by 26.3% of farmers to prevent soil erosion caused by excessive floods while 25% of them practice tree planting. About 48.7% of the farmers did not employ any adaptation strategies to soil erosion.

In addition, out of the total respondents, 48% of them were used mixed farming strategies to adapt to livestock disease caused by variability in climate while the remaining 52% of them had not carried out any adaptation activities due to several reasons (see Figure 4.3). Moreover, key informants (KI) illustrated those farmers use vaccination and veterinarian support to cop up animal disease. Furthermore, 60.3% of the farmers use medication for a health problem and/or human disease associated with climate variability while 39.7% of them did not employ adaptation strategies for the problem.

The study found out that 61.5% of the farmers do seasonal migration to adapt to the loss of water points while 38.5% of the harvested rainwater. On the other hand, 73.1% of farmers used feed management (feeding fist cut-silage) as a climate change

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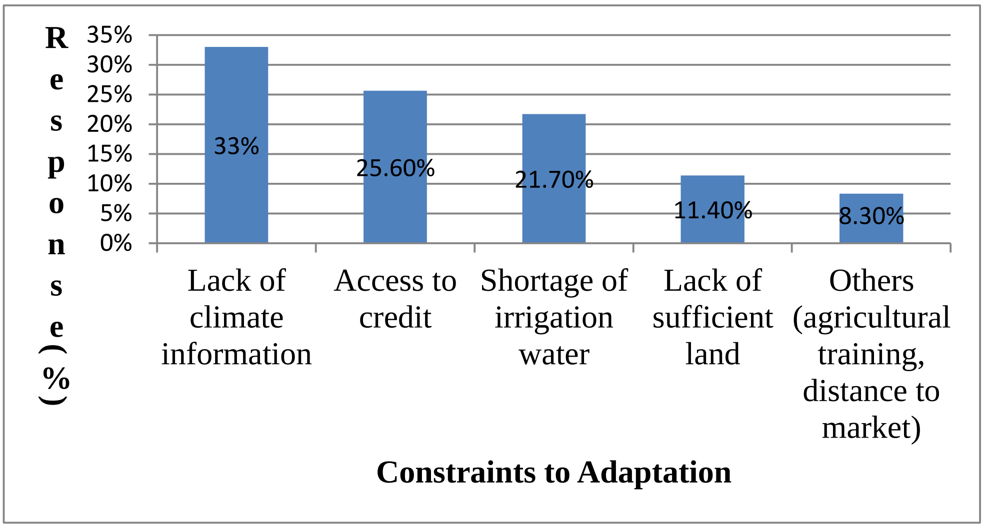
adaptation strategy for livestock feed scarcity. However, 26.9% of the respondents did not adapt to feed scarcity in the study area. In line with this discussion, key informants noted that feeding livestock through a cut system is commonly practiced to cop up livestock feed scarcity.

3.6. Constraints to Adaptation

(Figure 4.3). **Constraints to Adaptation**



Source: Authors' field survey, 2021

The majority (33%) of the farmers reported lack of climate information was a major constraint to responding to climate variability. This is related to the study of Amare et al. (2018) who argue that rainfall variability and the delayed onset of the rainy season, along with rising temperatures lead farmers to uncertain planting dates and harvest failure.

Having access to credit allows the farmers to buy inputs such as fertilizer, improved crop varieties that are more tolerant to drought and other climatic events, and irrigation equipment. However, about 25.6 % of the farmers reported a lack of credit serves as a key constraint to adapt to the adverse effect of climate variability. This is in line with a study made by Abid et al. (2014) who found out limited access to farm credit reduces farmers' adaptive capacity as they are unable to buy farm-level equipment and farm inputs.

About 21.7% of respondents reported the shortage of irrigation water which constrained implementing adaptation strategies in the study area. The combined result of key informants and field observation indicated that the less application of irrigation strategies due to lack of access to water. This result is similar to Tesema et al. (2013) who found that the farmers were constrained to adapt to climate variability due to limited access to water for irrigation in Eastern Hararghe Zone, Ethiopia.

Lack of sufficient land (11.4%) was identified by responding farmers as another key constraint for climate change adaptation. Lack of sufficient farmland is another constraint to grow different crop varieties to cope with the adverse effect of climate variability. This is in line with Asfaw et al. (2018) who reveal that the financial

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constraints, shortage of land, and scarcity of water were constraints inhibiting smallholder farmers from taking adaptation measures in north-central Ethiopia. Furthermore, other constraints such as lack of agricultural training and distance to market to buy agricultural inputs were reported by 8.3% of the respondents.

CONCLUSION

Farmers in the study area well recognized that climate change and variability are real and occurring. Moreover, the decline in crop and livestock yield, decrease in water availability, late and early rainfall, the decline in soil fertility, and animal and human disease were the best indicators of rainfall variability employed by farmers.

Crop disease, health problems and/or human disease, livestock disease, livestock feed scarcity, loss of water points, and soil erosion, are the impacts in the study site attributed to climate change and variability and which farmers are vulnerable.

Famers have used different adaptation strategies such as seasonal migration, soil, and water conservation practices like soil traces, mixed farming, improved crop variety, livestock feed management, medication, tree planting, and rain water harvesting to overcome the effect of climate change and variability. However, efforts to adapt to climate change and variability are very low due to the presence of constraints of adaptation. In connection to this, lack of climate information, access to credit services, shortage of irrigation water, lack of sufficient land, and others such as agricultural training and distance to market are among the constraints of adaptation in the study kebeles.

Recommendations

Based on the findings of this study, the following recommendations were forwarded to help the rural farmers in the Gelana district.

- ✓ As most of the farmers recognize climate change, it is worthwhile encouraging them to give training in climate change and variability to enhance farmers' awareness and enable them to use environmentally friendly adaptation measures to climate change and variability.
- ✓ Disseminating timely weather information to enable farmers to help them revise their climate change adaptation decisions for agricultural activity is very essential.
- ✓ In addition, improving access to improved crop variety and credit facilities are crucial for enhancing farmers' adaptation decisions and planning.
- ✓ Developing springs, digging water wells, and motorized pumps to recharge underground water should be accomplished. This will also help the farmers to use small-scale irrigation schemes for their farming activity. Furthermore, income diversification and off-farm activities should be encouraged to reduce the adverse effect of climate change and variability on rain-fed cultivation.

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Conflict of Interest

The authors declared no conflict of interest.

Disclosure Statement

No potential conflict of interest was reported by the authors.

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