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Farmers Perception and Adaptation to Climate Variability and Change: The Case of Godere Woreda of Gambella Regional State, Ethiopia

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Abstract

Climate change is a global environmental threat and development concern. Increasing fossil fuel burning and land use changes have emitted and are continue to emit, increasing quantities of greenhouse gases into the earth's atmosphere. This increase in heat has led to the greenhouse influence, resulting in global climate change and variability. The main characteristics of global climate change are increases in average global temperature (global warming); changes in cloud cover and precipitation mainly over land; melting of ice caps and glaciers and reduced snow cover and increases in ocean temperatures and ocean acidity because sea water gripping heat and CO_2 from the atmosphere.

Keywords: Climate change; Global environmental; Variability; Global warming; Green house

Introduction

According to Halkano, et al., scientific proof more suggests that climate is changing into more variable with important impacts on rural households notably in geographic areas [1]. The impacts of global climate change phenomena or associated degree and more rising as a new world challenge to development normally and financial condition reduction above all particularly among numerous rural individuals living in marginal regions with stripped down support choices [2-4]. Various studies have shown that as variability in climatically condition will increases, the vulnerability of rural livelihoods and also the ability of farmer manage need to touch upon its shocks and stresses will increases. Usually this can be notably thus among rural households United Nation agency often suffer massive social and economic effects because of climatic condition.

IPCC conducted study in adaptation will greatly diminish vulnerability to global climate change by creating rural communities higher able to fit climate change and variability, regulating potential damages and serving to them address adverse consequences [5]. The aim of this study is to determine or establish adaptation methods used by rural small scale farmers to attain manage food security with in the enterer of the results of global climate change [6].

However, such local level coping and adaptation responses as well as the farmers' perception in shaping smallholders decision are not well documented. In this regard, no empirical study has been conducted to examine the perception of farmers to climate change, identify adaptation choices and their determinants (such as adjusting plant date, soil and water conservation, rain water harvesting, change in cropping pattern, income diversification, growing short maturing crop) that groups possess and the ways in which institutions and networks connect these resources to affected groups to encourage the choice and implementation of successful adaptive strategies in Gambella region Godere Woreda. Consequently, the primary motive to embark on this research is to investigate and fill the existing gap of knowledge on farmer's perception and adaptation strategies in response to the changing climate [7-9].

Statement of the problem

According to the Jiri, et al., climate change and variability is one of the biggest global problems to agricultural production for the current and future generations. There is some evidence that climate change has greatly modified the hydrological cycles, rainfall and temperature patterns in many parts of the world [10]. The effects of climate change and variability vary across regions, farming systems, households and individuals. The combined effects of all these occurrences put a strain on the livelihoods of smallholder farmers, especially in developing countries.

Like in the other Sub-Saharan countries, agriculture is the major driver of economic growth especially in Ethiopia where its population depends on agriculture sector. Gebre Egziabher, et al., have found out that rising the agricultural production at the national level leads to improve overall economic growth and development [11]. However, currently climate variability has become a serious threat to sustainable economic growth. Yesuf, et al. stated that farmer's perception is an essential strategy to enable farmers to adapt the adverse effect of climate change and variability which in turn increase the agricultural production of the poor farm households.

In recognition of these challenges, governments, donors and development partners in many parts of Ethiopia including this study area have devoted substantial resources to develop and promote adaptive mechanisms and technologies for sustainable intensification of coping strategies [12]. Despite the intensive efforts of many institutions at the national and international levels, perceived changes may not always reflect reality and climatic events or trends may be misinterpreted or wrongly remembered for different reasons.

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Similar to other parts of Ethiopia, in the study area, farmers' perception and adaptation to climate variability and change is still very low. Furthermore, there are discrepancies of knowledge in addressing the adaptation strategies of smallholder farmers [13]. These adaptations are often varies with the behaviors of smallholders, socioeconomic, agro-ecological and cultural set up of the farmers.

Therefore, this study evaluates the farmers' perception and coping strategies to climate variability from the context of vulnerability in Gambella region Godere Woreda. In line with this, the research attempt to fill the gaps by investigating the challenges and opportunities of the farmers' perception and adaptation to climate variability in the study area.

Objectives of the study

General objective of the study: The general objective of the study is designed to assess farmers' perceptions and coping to climate variability in Godere Woreda.

Specific objective of the study: The specific objectives intended to:

- To identify the trends of rainfall and temperature of the study area for the last three decades.
- To examine farmers coping strategies on climate variability.
- To evaluate factors affecting farmers perception on climate variability.

Research questions

Given the above objectives of the research, the study will attempt to raise the following three basic research questions.

- What are the trends of rainfall and temperature of the study area for the last three decades?
- What factors affect farmer's perception to climate variability?
- What are the determinants of coping mechanisms?

Significance of the study

Purposely this research was intended to study farmers' perception and coping to climate variability in Godere Woreda. This study was conducted at micro level so that it is very interesting to use as guideline document for further research in the area and could be upscale to areas with the same climatic, socioeconomic and geographical features. In addition, it might provide significant contribution to local and national government, NGO and other bilateral donors in an effort to minimize the impact of climate change and also will provide information to design appropriate policy frameworks at local level [14-16].

Materials and Methods

Description of the study area

This study will be conducted in Godere Woreda of Majang zone in Gambella regional state. Gambella is one of the nine regional states that among the federal democratic republic of Ethiopia. It is boarder in the western tip of the country and has common borders with Sudan in the West and North; the regional state of the SNNP in the South, with the regional state of Oromia in the North and East, Baro and Akobo rivers is lying in Gambella. The total area of 25,802.01 square km, in 2007, the region has a total population of 306,916. The capital city of Gambella region is Gambella town.

Godere is one of the districts in Majang zone in the Gambella people's national regional state located in South-Western part of Ethiopia. The district is bordered on the South and East by the southern nations, nationalities and peoples region, in the West by Mengesh Woreda and North by Oromia. The capital city of Godere Woreda is Meti town.

According to Ethiopian 2007 population projection by (CSA) Godere Woreda has total population of 38,781. Number of male is 19,928 (51.4%) and female 18,853 (48.6%) (Table 1). Godere encompasses the headwaters of the Gilo river, thus its terrain is predominantly hilly and unlike the rest of Gambella over 40% of the area is covered with forest. The economy of Godere is predominately agricultural (Figure 1).

Male		Female		Total	
Number	Percent (%)	Number	Percent (%)	Number	Percent (%)
19,928	51.4	18,853	48.6	38,781	100
Note: CSA population projection, 2007.					

Table 1: Total population of Godere Woreda.

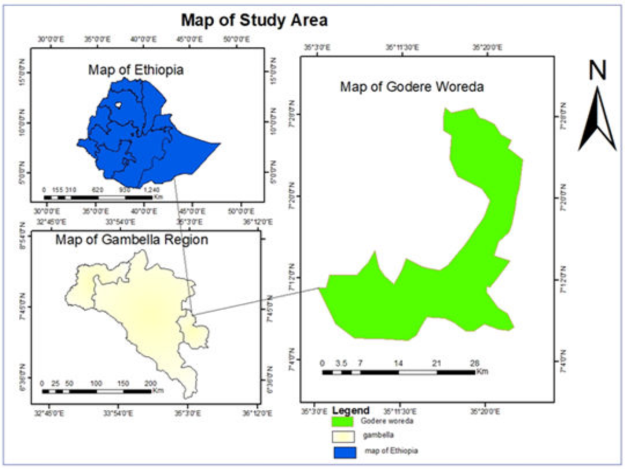

Figure 1: Map of the study area.

The main livelihood activities of the district community are pastoralism and agro-pastoralism. Almost all the animals reared by smallholder farmers in extensive system. The livestock populations owned by the farmers are large in number. Opportunities for petty trading, such as selling grains, stationaries and foods, have also expanded with the shift to settlement, which the influx of highlanders has also helped. The main crops that are grown in Godere are corn, maize, sweet potato, sesame and peanuts, which are produced in two farming seasons; using rain fed and flood receding farming schemes. About 90 percent of the land is flat and suitable for farming [17].

Research design

The study was utilized cross sectional survey research design or non-experimental research design. Cross sectional surveys help to gather information of a particular population at a distinct time. Therefore in this study, it helps to obtain information concerning farmer's perception to climate variability and change and its adaptation measure at one shot.

Data type and source

The data which was used for this study obtained from both primary and secondary sources. The primary data was collected through household survey, focus group discussion and field observation and key informant interview. Secondary sources were included from published and unpublished information about farmer's perceptions on the climate variability and adaptation mechanisms. A 30 years rainfall and temperature data of Tinishu Meti station was collected from metrological agency [18].

Sampling procedure and sample size determination

The study was implemented multi stage sampling procedures to get relevant data from the respondents. In the first stage, Godere Woreda was selected randomly out Woredas in the region. In the second stage representative of four kebeles (lowest administration) from respective Woreda was selected randomly through lottery method. Finally, in the third stage sample households were selected using systematic random sampling based on probability proportional to size method. Household list of each selected kebeles was collected from a list of households obtained from the administrative records of each kebele [19].

Determination of sample size is an indispensable issue in scientific researches. For a household survey, a number of approaches use different formulas to determine the sample size of the population. Therefore, for this study, from several approaches, the sample size (n) was determined using the formula proposed by Yamane.

$$n = \left(\frac{2559}{1 + 2559\,(0.07)^2}\right) = 189$$

Where;

N=Sample size,

N=Population size (total household in sampled kebeles) and

E=Level of precision (margin of error).

The respective numbers of households will be allocated for each sampled kebele based on PPS ($Ni/N^{*}n$) of each kebeles as indicated in the below Table 2.

No.	Name of kebele	Total number of HHs	Number of sampled HHs	Sample size
1	Gengeboz	465	$465^{*}189/2559$	43
2	Gonchi	246	$246^{*}189/2559$	18
3	Gumare	975	$975^{*}189/2559$	72
4	Semuy	762	$762^{*}189/2559$	56
Total		2559		189
Note: Woreda demographic and socioeconomic information center.				

Table 2: Distribution of sampled farmers in each kebeles.

Data collection methods

Structured questionnaires and focus group discussions were used as research tools to collect data. Questionnaires were made simple by use of closed ended questions. Local concepts are going to be used to avoid ambiguity. Questionnaires were arranged in blocks of topics in a logical flow of questions [20]. They was cover generalities about climate change perceptions of farmers on climate change, adaptation measures used and factors that influenced decisions of the farmers to adapt or not to adapt to climate change. Prior to implementation of the survey, a structured questionnaire was developed and pre-tested randomly selected households from non-sampled kebeles. Data collection was carried out by applying face to face interview with farmers.

Secondary data of monthly rainfall and temperature records (1984-2020) were obtained from the National Meteorological Agency (NMA) of Ethiopia. In addition, secondary data was collected from pertinent offices of the district and other sources to augment the survey data.

The field study combined household surveys, key informant interviews, focus group discussions and filed observations. These methods generated relevant information for the study.

Household survey: The household survey was conducted with sample respondents. Detailed and a well-designed structured questionnaire was developed in a way that enables to gather full information about the study objectives. The questionnaire was pre-tested among ten randomly selected households from sampled kebeles to detect misunderstandings, ambiguities or other difficulties of participants. Prior to the final administration of the interview schedule, first enumerators were selected and given training on the concept and objectives of the study and the contents of the interview schedule to be acquainted with the basic techniques of data collection. The data was collected through direct interview of the sample HHs using the questionnaires. The researcher was also directly involved in collecting the data using the same questionnaire and closely assists enumerators for quality assurance.

Others were perception of farmers on the climate change impacts using indicators such as diversity of livelihood strategies, changes in crop management practices and access to and knowledge of climate related helpful information for their farm level decision that was used in use past thirty years, farm household characteristics was used to related questions.

Key Informant Interview (KII): Key informant interviews were conducted with different individuals at different levels. At kebeles level, individual interviews was conducted with elderly people aged thinking that they have sufficient knowledge about the area and be able to memorize well its historical climate trends. The interview was carried out with a total of 18 key informant interviewees) which have included 4 DAs (one from each kebele), 2 Woreda experts and 12 elder informants (three from each kebele) were selected based on seeking information about background of farmers. The key informants were selected purposively on the basis of their understanding and knowledge of their local climate.

Focus Group Discussion (FGD): Discussions focused on the research issues was carried out among groups classified by sex and age. Separate discussion was held with young, old and female groups so as to avoid specific group's idea dominancy and capture gender and age disaggregated data. There Woreda total of three FGDs in each kebele and each group involved 7 individuals who were not involved in household survey. To guide the discussion, semi-structured checklists were designed specific to the research issues. The general direction pursed in those discussions was triggering by the researcher and promote active group participation. The purpose of the discussions session was checking the validity of the general over view of the survey questionnaire and research objective. Focus group discussion was conducted in all four kebeles were selected farmers in the study area.

Field observation and informal interview: Field observation was started while writing the proposal and continued on to the whole process of data collection to make sure the validity of acquired information. It was aimed at understanding the local condition of local community in terms of their culture, farm practices and traditional way of resources utilization and application of conservation measures, etc. During field surveys, transect walks was conducted in the four kebeles with the guidance of the kebeles chairman leading the team, including voluntary farmers, development workers and the researcher. In the meanwhile, the researcher was tried to triangulate farmers' responses with actual physical observations and took pictures of important observations which are actually put as exhibits to support findings. An appropriate record sheet was developed and used by the researcher for recording observation.

Methods of data analysis

The data obtained from both primary and secondary data sources were analyzed by using both qualitative and quantitative method of data analysis. The qualitative data's collected through KIIs, FGDs and observational notes were transcribed, categorized and interpreted qualitatively.

Both descriptive as well as inferential analysis was employed in the analysis. Descriptive statistics includes: Mean, percentages and standard deviation was used to describe various aspects of sample respondents. Inferential statistics includes: One way ANOVA (F-test), *chi-square* were used to characterize farmer perceptions on long term temperature and rainfall changes as well as various adaptation measures being used by farmers and barriers they face to adapt. Logistic regression logit model was used to identify the major factors determining adoption of adaptation options to climate change and variability. Long term trends of rainfall and temperature was analyzed by undertaking linear trend analysis and coefficient of variation. Intra seasonal rainfall variability was analyzed using the Coefficient of Variation (CV). According to Hare, CV (%) values are classified as follows: <20% as less variable, 20%-30% as moderately variable and >30% as highly variable (Supplementary Tables 1 and 2).

$$CV=\frac{SD}{\bar{X}} \times 100$$

Where;

CV=Coefficient of Variation,

SD=Standard Deviation and

$\bar{X}$=Mean.

On the other hand, standardized anomalies of rainfall have been calculated to examine the nature of the trends, enable the determination of the dry and wet years in the record and used to assess frequency and severity of droughts. It is calculated as:

$$SRA = \frac{Pt - Pm}{\sigma}$$

Where;

SRA=Standardized Rainfall Anomaly,

Pt=Annual rainfall of a particular year,

Pm=Long term mean annual rainfall over a period of observation and

'σ'=Standard deviation of annual rainfall over the period of observation.

Mann- Kendall (MK) test

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sgn(xj - xi)$$

Where;

n=Length of the data set,

xi and xj=Two elements of the considered time series at the time step I and j respectively and the application of trend test is done to a time series Xi that is ranked from i=1, 2…n-1 and Xj, which is ranked from j=i+1,2….n. Each of the data point Xi is taken as a reference point which is compared with the rest of the data point's Xj so that:

$$sgn(xj - xi) = \begin{cases} +1\ if (xj - xi) > 0 \\ 0 if (xj - xi) = 0 \\ -1 if (xj - xi) < 0 \end{cases}$$

Where xi and xj are the annual values in the years i and j (j>i) respectively. It has been documented that when the number of observations is more than 10 (n ≥10), the statistic 'S' is approximately normally distributed with the mean and E(S) becomes 0. In this case, the variance statistic is given as:

$$var(s) = \frac{n(n-1)(2n+5) - \sum_{t=1}^{m} t1(t1-1)(2t1+5)}{18}$$

Where;

n=Length of data set and

m=Number of tied groups (a tied group is a set of sample data having the same value) in the time series and

ti=Number of data points in the i^{th} group. The test statistics Zc is as follows:

$$Z = \begin{cases} \frac{s-1}{\sigma} ifs > 1 \\ 0\ ifs = 0 \\ \frac{s+1}{\sigma} ifs < 1 \end{cases}$$

Where;

Zc follows a normal distribution, a positive Zc and a negative Zc depict an upward and down wards trend for the period respectively. A significant is also utilized for testing either an upward or down ward monotone trend. The trend is significant at the 90% confidence level if |Z|>1.65, at the 95% confidence level if |Z|>1.96 and at the 99% confidence level if |Z|>2.85. The positive and negative Z values indicate increasing and decreasing trend, respectively.

Sen's slope estimator

This study used Sen's slope estimator to calculate the actual slope of time series data trends. If a linear trend exists, the magnitude of the monotonic trend in hydrologic time series can be quantified by using the nonparametric Sen's estimator of slope using the following equation.

$$\beta = \text{median}\ (Ti = \frac{xj - xi}{j - i})$$

Where;

β represents the median value of the slope values between data measurements xi and xj at the time steps i and j (i<j), respectively. Positive value of β indicates an increasing trend whereas negative value of β indicates a decreasing trend. The sign of β reflects data trend direction, whereas its value indicates the steepness of the trend. The advantage of this method is that it limits the influence of missing values or the outliers on the slope in comparison with linear regression.

The median of these N values of Ti is represented as Sen's estimator of slope which is computed as Qmed=T(N+1)/2 if N appears odd and it is considered as Qmed= (TN/2+T(N+2/2)/2) if N appears even. A positive value of Qi indicates an upward (increasing trend) and a negative value of Qi gives a downward or decreasing trend in the time series.

Definition of variables and working hypothesis

The dependent variable (adapt): The study used binary dependent variable taking the value 1 if the farmer adapted to climate change and 0 otherwise. This is done to distinguish between farmers who adapted and those who did not in the study area. A farmer is considered to have adapted to climate change if he/she has employed at least one of the adaptation strategies such as planting trees, soil and water conservation, using improved crop variety and changing planting date. The potential explanatory variables which are hypothesized to influence farmer's adaptation strategies in the study area are summarized and presented in Table 1.

The explanatory/independent variables: The choice of independent variables used in the study is influenced by literature reviewed on factors that influence farmers' decisions to adapt to climate change, previous research findings and the knowledge about adaptation to climate change in the agro ecology of the study area.

Sex of the Household Head (SEXHH): It is dummy variable taking value 1, if the household head is male and 0, otherwise. Tenge and Hella revealed that having a female head of household may have negative effects on the adoption of soil and water conservation measures as adaptation strategy, because women may have limited access to information, land and other resources due to traditional social barriers. Ajibefun and fatuase stated that male headed households were likely to perceive changes in climate than the female counterpart, suggesting that the reason might be the large involvement of the male in farming activities. Therefore, it was hypothesized that male headed households are more likely take climate change adaptation. On the other hand recent study in South Africa by Nhemachena and Hassan, argued that female headed households are more likely to take up climate change adaptation methods.

Age of Household Head (AGEHH): It is continuous variable and expressed in years. Age of the head of household can be used to capture farming experience and its influence on adaptation to climate change. For example Obayelu, et al., reported that age has an influence on farmer's efforts to adapt to climate change. Similar views were also expressed on effect of age on adoption of improved agricultural technologies.

Educational level of the Household Head (EDUHH): Educational level of head household is discrete variable taking value of years of schooling. Education equips individuals with the necessary knowledge of how to make living. Ajibefun and Fatuase study reveals that highly educated persons were likely to perceive that climate is changing than uneducated ones. Consistent with this, stated that educated farmers and those with strong social network are more likely to adapt climate variability and change. Therefore, this study will be hypothesized that, farmers with higher level of education are more likely to implementing adaptation measure to climate change.

Family Size (FSIZE): Family sizes member of households living together. This consider as continues explanatory variable to positively influence the household's adaptation strategies by contributing labor. In the other words, as a family size increases food consumption of the household increase and inversely decrease the adaptation strategies due to food scarcity.

Livestock ownership size in TLU (LISTOW): It is a continuous variable. This refers to the size or numbers of livestock owned by households measured in terms of the Tropical Livestock Unit (TLU). As reported by Temesgen, Aemro and Belaineh, et al., ownership of livestock has positive and significant impact on the probability of using improved crop variety, soil and water conservation techniques, planting trees and changing planting dates as an adaptation strategies. It is, therefore, hypothesized that farmers with livestock are expected to use improved crop varieties, adjusting planting date and soil and water conservation practices as an adaptation strategies to climate variability and change positively.

Land Holding Size (LAHSIZ): It is refers to the size of land owned by the household and continuous variable measured in hector. Land is the basic asset of the majority of rural household. Studies on adoption of agricultural technologies indicate that farm size has both negative and positive effects on adoption, showing that the effect of farm size on technology adoption is inconclusive. In contrary Aymone indicated that farm size increases the perception and adaptation to climate change strategies as farmers with large land can avoid making some capital intensive adaptation like irrigation. Farm size is always associated with greater wealth, more capital and resources. Thus, it were hypothesized that the larger the farmer's landholding size, the more likely increase the probability of adapting to climatic change.

Frequency of Extension contact (FREX): It is the number of extension contact with the farmers on yearly basis for consultation on the different agricultural activities. Agricultural extension contact enhances the efficiency of making adoption decisions and in the specific case of climate change adaptation. Aymone indicated that access to extension service increases probability of perceiving the climate change and increases the likelihood of uptake of adaptation techniques. Thus, this study also hypothesizes that access to frequency of extension contact increases enhance of adapting to climate change. Most authors have documented positive correlation between extension contact and adoption decision of farmers.

Access to Climate Change Information (ACINF): It is a dummy variable that takes 1, if households have an access to climate change information and 0, otherwise. Farmers' have an access to climate change increases the probability adjusting planting date and harvesting time, decision on choice of variety and time of fertilizer application, practicing soil and water conservation and planting more trees at plot level. Moreover, Kadir indicated that access to climate change information increases the perception level of farmers and hence increase the probability of farmers to take adaptation measure Therefore, this study will be hypothesized that access to climate change information positively affect the decision of farmers to take up climate adaptation measures.

Distance of Market from home stead (MARKD): It is continues variable measured in kilometers from homes. Accessibility to the nearest market is another important factor affecting adoption of agricultural technologies. Proximity to market is an important determinant of adaptation, presumably because the market serves as a means of exchanging information with other farmers. Therefore, it is expected that households nearer to the market take more climate adaptation measures and otherwise negatively related.

On-Farm Income (OnFARIN): It is a continuous variable measured in Birr. The farm income of the households has a positive and significant impact on the adoption of improved crop varieties, soil and water conservation techniques and crop diversification. When the main source of income in farming increased, farmers tend to invest in productivity smoothing options such as improved seed varieties, soil and water conservation and crop diversification options. Deressa reported that farm income has a statistically significant impact on climate adaptation strategies. And on-farm income is expected to influence positively the probability of using adaptation option/ strategies.

Non/Off-Farm Income (ln OF FAR): Both off-farm and non-farm will be considered. It is a continuous variable. This refers to access to off-farm activities like laborer and non-farm activities like petty trading, handcraft, selling of firewood, gifts, and remittance. Aemro, et al., found that off/non-farm income positively affected farmers' use of SWC practices, adjusting planting date and improved variety.

Additionally, Temesgen, et al., confirmed that off-farm income increases the likelihood of farmers planting trees and adjusting planting dates. In contrary to this, Belaineh, et al., revealed that an increase in off-farm income decreases the likelihood of crop diversification and the use of SWC practices as an adaptation strategy. Farmers are assumed to get additional income sources and may or may not give time to take adaptation measures and pay less attention to agriculture. Therefore, it was expected to negatively affect farmer's adaptation decisions (Table 3).

Independent variables	Nature	Measurement	Hypothesis
Sex of household	Dummy	1 for male 0 for female	+
Age of household	Continuous	No. of year	-
Family size	Continuous	No. of person	+/-
Educational status	Continuous	Level of grade completed	+/-
Livestock ownership size in TLU	Continuous	TLU	+
Land holding size	Continuous	In hectare	+
Frequency of extension contact	Continuous	No. of day	+
Distance of market from home	Continuous	Km	-
Access to climate information	Dummy	1 for yes, 0 for no	+
On-farm income	Continuous	In birr	+
Non/off-farm income	Continuous	In birr	-

Table 3: Summary of independent variable description.

Results and Discussion

This chapter presents the results and discussion of the study obtained from quantitative and qualitative data secured from a household survey and desk review. Section one presents sample households' characteristics and their climate change adaptation strategies. Section two presents climate related hazards, the most affected social groups and major constrains affecting adaptation strategies. Section three presents result of the maximum likelihood estimates for factors affecting the choice of adaptation strategies to climate change in the study area.

Characteristics of sampled households

Demographic characteristics of the households: For this study, essential information was collected from a total of 189 sampled households. Different studies have revealed that sex of the household head plays an important role on smallholder farmers' perception to climate change and response strategy. Out of the total sample households surveyed, 75.7% of the respondents were male headed while 24.3% accounts female headed households.

It was put in the literature, age is considered as a proxy to the farming experience of the household, which is likely to have a significant influence on choice of adaptation strategies to climate change. The youngest household head that was interviewed was aged 25 years whilst the oldest was aged 65 years with average of proximate age of 32 years.

The survey data indicated that the family size of the sampled households varies from 2 to 23 members with an average household size of 7.8 and a standard deviation of 4.12, which is higher than the national average family size of 5.32.

Moreover, educational level of sampled household heads was believed to be an important feature that determines the readiness of the household head to accept new ideas and innovations regarding climate change adaptation strategies and efficient use of resources. The empirical result shows that the educational status of the smallholder farmers ranges from 0 grade to 12 grade of schooling with average level of education was proximate grade two (Table 4).

Variables	Percentage		
Sex of household	Female	24.3	
	Male	75.7	
	Minimum	**Maximum**	**Mean± SD**
Age of household (years)	25	65	30.7 ± 14.7
Family size (number)	2	23	7.8 ± 4.12
Education level of household	0	12	2.02 ± 2.28

Table 4: Demographic characteristics of sampled households.

The survey results also show that 46% of the household heads were literate and 54% were illiterate. From this, it can be inferred that there is high level of illiteracy in the study area (Table 5). It concluded that there is low literacy rate among respondent household in the study area. It is believed that, lower education level discourages the household's perception to climate change and response it effect. According to Daniel, the number of education years of household head is the source of key decision making in the family, the better he or she learns the better he or she will be likely to be aware of information and technology adoption.

Variables	Number of households	Percent
Illiterate	102	54
Grade 1-4	38	20.1
Grade 5-8	34	18
Grade 9-10	10	5.3
Grade 11-12	5	2.6

Table 5: Educational status of sample households.

Socioeconomic characteristics of the households: Farmers in the study area are engaged in mixed farming activities, including staple food crops production such as corn, maize, root and tuber (kechi, baka, sweet potato and enset), which are produced in two farming seasons, using rain fed and surface irrigation they produce vegetables like onion, tomato, cabbage, kosta, carrot and beet root and rearing domestic animals such as cows, oxen, goats and sheep.

Asset of the household heads: Land is the ever known to exist resource as the most limiting factor for agricultural production in Ethiopia, in general and the study area in particular. The result revealed that per capita land size is small and landholding of the interviewed farmer's falls between 0.5 and 5 hectares and the average landholding was 0.7 hectare per household with a standard deviation of 0.56 (Table 6). The dominant animals reared in the study area include cattle, sheep, goats, horse and chicken. Sampled farmers maintain animals for various uses, including milk, meat, eggs and for means of transportation. On average, the livestock holding of the sampled household was proximate 15 tlu.

Variables	Minimum	Maximum	Mean ± SD
Landholding (hectare)	0.5	5	0.7 ± 0.56
Livestock size (TLU)	0.58	51.39	7.8 ± 4.12

Table 6: Socioeconomic characteristics of the household.

Institutional factors: Farmers' access to agricultural service, credit service, climate information and markets were depicted in Table 7. The result showed that most of the surveyed households had access to agricultural extension services. Agricultural extension systems in the study area offer a multitude of activities such as training, organizing demonstration trials. These activities might have a direct effect on creating awareness of the households on new agricultural technologies and environmental developments, which later affect perception and decision making of the farmers. The availability of credit for resource poor farmers is quite important to finance agricultural technologies and management options that enable them to increase farm investment. Among the surveyed respondents 32.3% had access to credit service; whereas 67.7% have not access.

Reliable information about seasonal forecast of the weather condition and climate variability is necessary to understand the climatic condition and to take some measures to adverse effects. This implied the importance of climate information as a driving force to enhance the tendency of farmers' perception. In the study area, there were no formal sources that deliver weather information. Most farmers obtained climate related information from local meetings, radio and development agents. The result indicated that, regardless of the source, majority of the sampled households have access to climate information.

Variables	Alternative	Frequency	Percentage
Access to extension services	No	68	36
	Yes	121	64
Access to credit services	No	128	67.7
	Yes	61	32.3
Access to climate information	No	66	34.9
	Yes	123	65.1

Table 7: Sampled households access to institutional information.

State of local climate

Climate station data analysis in study area: It is shown in Table 8 and Figure 2.

Time series	MK statistics (Z value)	Sen's slope (Q value)	Significance level
Spring (MAM)	1.96*	0.656	
Summer (JJA)	0.86	2.94*	
Autumn (SON)	0.46	3.45**	
Winter (DJF)	0.00	0.09	Ns
Annual RF	1.18	3.356**	
Note: ZS: Mann-Kendall test; Qmed: Sen's slope estimator; *Significant trend at (Zs)>1.96 (0.05); **significant at (0.01) and NS (Non-Significant).			

Table 8: Results of rainfall trend analysis using Mk test and Sen's slope estimator.

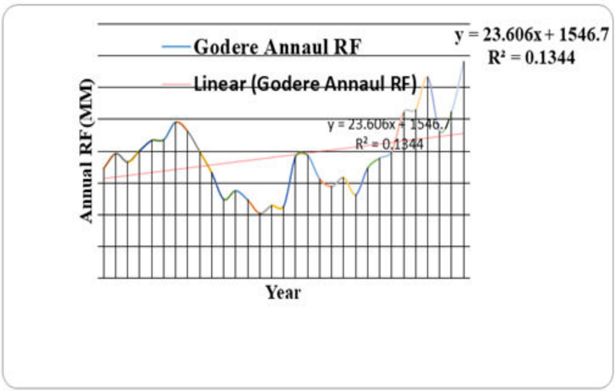

Figure 2: Annual RF of Godere Woreda.

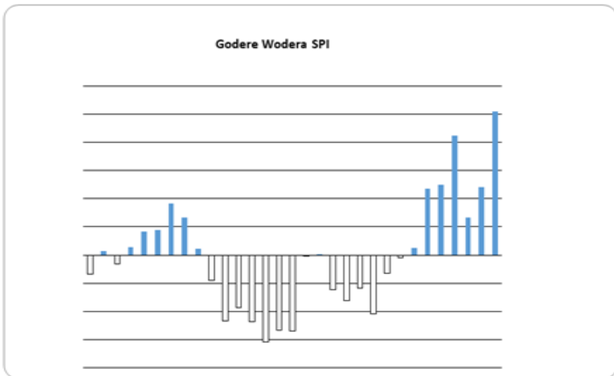

Figure 3: Yearly standardized precipitation index of Godere Woreda.

The results shown in Table 8 indicated a rising trend in all annual, summer, spring, autumn and winter seasons. Annual rainfall and autumn shows rising trend with significant at 0.01, significance level and summer and spring shows rising trend with significant at 0.05 significance level. But, winter season shows rising trend with non-significant at 0.05 significance level. The seasonal and annual rainfall trends of Godere experienced both positive trends over the period of analysis. This is in a good agreement with farmers' perception. The monotonic trend of rainfall time series was measured using the Mann-Kendall trend test. Mann-Kendall (MK) test was used in order to analyze the true trend value. The trend tests for seasonal rainfall were show statistically non-significant results in winter seasons whereas summer, spring, autumn and annual rainfall were statistically significant at 0.05 and 0.01 during the period of analysis (1990-2020). In the study area, annual rainfall has been increasing by about 23.60 mm per annual although there was an absolute decrease in mean annual rainfall amount. This implies no circumstances of agricultural drought and enhanced crop production and livelihoods (Figure 3).

Variability analysis of rainfall: Monthly values of rainfall were aggregated to obtain seasonal rainfall for the Woreda. Seasons were defined using the standard meteorological definition: Winter (December, January and February), spring (March, April and May), summer (June, July and August) and autumn (September, October and November).

The long term mean annual rainfall was about 1924.3 mm in Godere during the study period. Summer season is the main rainy season and spring is the short rainy season. Summer rainfall dominates the seasonal pattern and spring considerably contributes to the annual rainfall in Godere Woreda. The long term mean annual and seasonal rainfall was unevenly distributed in the Woreda. High mean annual rainfall variability (CV) ranged from 30.4% in Godere. A rainfall amount with CV above 30% is an indication that the variability of rainfall is high.

The SPI calculation for any location is based on the long term precipitation record for a desired period. This long term record is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero. Positive SPI values indicate greater than median precipitation and negative values indicate less than median precipitation. Because the SPI is normalized, wetter and drier climates can be represented in the same way; thus, wet periods can also be monitored using the SPI. McKee, et al., used the classification system shown in the SPI value table below to define drought intensities resulting from the SPI. They also defined the criteria for a drought event for any of the timescales. A drought event occurs any time when SPI is continuously negative and reaches an intensity of -1.0 or less (Table 9). The event ends when the SPI becomes positive. Each drought event, therefore, has a duration defined by its beginning and end and intensity for each month that the event continues. The positive sum of the SPI for all the months within a drought event can be termed the drought's "magnitude".

2.0+	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
-0.99 to 0.99	Near normal
-1.0 to -1.49	Moderately dry
-1.5 to -1.99	Severely dry

Table 9: SPI values.

The results of SPI for Godere Woreda were evaluated and found that the results of SPI and actual climatic condition have quite similar results as per their respective categories. For example (-1 to -1.99) categories indicates (moderately dry to severely dry) drought years include 2000, 2002, 2003, 2004, 2005 and 2011. The second category (+1 to +1.99) indicates (moderately wet to very wet) wet years include 2015, 2016 and 2019. The third category (-0.99 to +0.99) indicate normal condition years include remaining years for Godere Woreda (Table 10).

Years	SPI value	Class description	Years	SPI value	Class description
1990	-0.3	Near normal	2006	0.0	Normal
1991	0.1	Near normal	2007	0.0	Normal
1992	-0.2	Near normal	2008	-0.6	Near normal
1993	0.1	Near normal	2009	-0.8	Near normal
1994	0.4	Near normal	2010	-0.6	Near normal
1995	0.4	Near normal	2011	-1.0	Moderately dry
1996	0.9	Near normal	2012	-0.3	Near normal
1997	0.7	Near normal	2013	-0.1	Near normal
1998	0.1	Near normal	2014	0.1	Near normal
1999	-0.5	Near normal	2015	1.2	Moderately wet
2000	-1.2	Moderately dry	2016	1.2	Moderately wet
2001	-0.9	Near normal	2017	2.1	Extremely wet
2002	-1.2	Moderately dry	2018	0.7	Near normal
2003	-1.5	Severely dry	2019	1.2	Moderately wet
2004	-1.3	Moderately dry	2020	2.5	Extremely wet
2005	-1.3	Moderately dry			

Table 10: Standardized precipitation index of Godere Woreda.

The mean annual SRA analysis showed that there were 1 severely dry, 5 moderately dry, 18 near normal, 2 normal, 3 moderately wet and 2 extremely wet years in Godere Woreda, over the period of analysis. 12 month accumulated precipitation. SRA is calculated to determine seasonal and intermediate term drought indexes. Drought occurs when the SRA initially drops below zero and ends with the first positive value. Rainfall has been increasing in Godere since 2014.

Citation: Taye S, Abebe D (2023) Farmers Perception and Adaptation to Climate Variability and Change: The Case of Godere Woreda of Gambella Regional State, Ethiopia. J Earth Sci Clim Change 14:684.

Trend analysis of temperature

Maximum temperature: The preliminary data analysis was carried out to find the statistical parameters (mean, standard deviation and coefficient of variation) of annual maximum temperature series for the period 1990-2020. Maximum temperature in Godere varies between 25.1°C (1982) to 37.9°C (2003) where mean annual maximum temperature is 30.9°C with standard deviation 1.2°C and CV of 3.9%. All the statistical parameters for annual and seasonal basis are shown in Table 11.

Time series	Mean	Min (year)	Max (year)	SD	CV (%)
Spring (MAM)	29.4	27.5 (1995)	32.7 (2003)	1.4	4.8
Summer (JJA)	27.2	25.8 (1996)	29.9 (2004)	1.1	4.1
Autumn (SON)	34	30.6 (1996)	37.9 (2003)	1.6	4.6
Winter (DJF)	33.2	25.1 (1982)	36.6 (2005)	1.4	4.1
Max annual T	30.9	28.6 (1996)	33.7(2003)	1.2	3.9

Note: SD: Standard Deviation; CV: Coefficient of Variation.

Table 11: Statistical parameters of annual and seasonal maximum temperature pattern.

The results of MK test and Sen's slope estimator for maximum temperature of Godere Woreda are presented in Table 12. The results indicated a rising trends but not significant in all seasons and annual. The annual average maximum temperature in the study area for the period of analysis showed an increasing trend (Z value +0.48).

Time series	MK statistics (Z value)	Sen's slope (Q value)	Significance level
Spring (MAM)	2.9	0.008	NS
Summer (JJA)	0.14	0.011	NS
Autumn (SON)	0.04	0.026	NS
Winter (DJF)	0.39	0.004	NS
Max. annual temp	0.48	0.008	NS

Note: ZS: Mann-Kendall test; Qmed: Sen's slope estimator. *Significant trend at (Zs) >1.96 (0.05) and NS (Non-Significant).

Table 12: Results of maximum temperature trend analysis using Mk test and Sen's slope estimator.

The results shown in this Table 10 indicated rising trend in seasons of summer, springs, autumn and winter with non-significant at 0.05 level of significance. Figure 4 depicts the maximum temperature variability during the period 1990-2020.

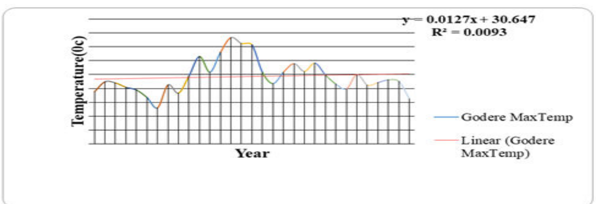

Figure 4: Yearly Godere maximum temperatures.

Minimum temperature: The preliminary data analysis was carried out to find the statistical parameters (mean, standard deviation and coefficient of variation) of annual minimum temperature series for the period 1990-2020. Minimum temperature in Godere varies between 16.6°C (1993) to 17.6°C (2003) where mean annual minimum temperature is 17.1°C with standard deviation 0.3°C and CV of 1.7%. All the statistical parameters for annual and seasonal basis are shown in Table 13.

Time series	Mean	Min (year)	Max (year)	SD	CV (%)
Spring (MAM)	16.4	15.6 (1991)	17.8 (1997)	0.5	3.3
Summer (JJA)	16.7	16.2 (2008)	17.2 (2010)	0.3	1.6
Autumn (SON)	18.4	17.5 (2018)	19.2 (2004, 2016)	0.5	2.5
Winter (DJF)	16.7	15.6 (2017)	17.9 (2006)	0.5	3.1
Min. annual T	17.1	16.6 (1993)	17.6 (2003)	0.3	1.7
Note: SD: Standard Deviation; CV: Coefficient of Variation.					

Table 13: Statistical parameters of annual and seasonal minimum temperature pattern.

The results of MK test and Sen's slope estimator for annual and seasonal minimum temperature are illustrated in the following Table 14.

Time series	MK statistics (Z value)	Sen's slope (Q value)	Significance level
Spring (MAM)	1.08	0.075	NS
Summer (JJA)	1.31	0.02	NS
Autumn (SON)	0.72	0.025	NS
Winter (DJF)	0.2	0.056	NS
Min. annual temp.	0.33	0.041	NS
Note: ZS: Mann-Kendall test; Qmed: Sen's slope estimator. NS (Non-Significant) trend at (Zs) >1.96 (0.05).			

Table 14: Results of minimum temperature trend analysis using Mk test and Sen's slope estimator.

The results shown in this Table 14 indicated a rising trend in all seasons of the Woreda with non-significant at 0.05 level of significance. The annual mean minimum temperature in the study area showed an increasing trend (Z value +.33). An increasing minimum temperature will support the global warming causing climate change. This suggests that temperature trend shows rising and due to this rising temperature, other climatic variables may experience affected in the hydrologic processes and surrounding the environment. The minimum temperature variability during the period 1990-2020 is presented in Figure 5. It also indicated the linear trend line overlaid on the time series for annual. Generally, the study revealed that annual minimum temperature is increased by (0.006) trend whereas the annual maximum temperature is increased by (0.012) in the study area.

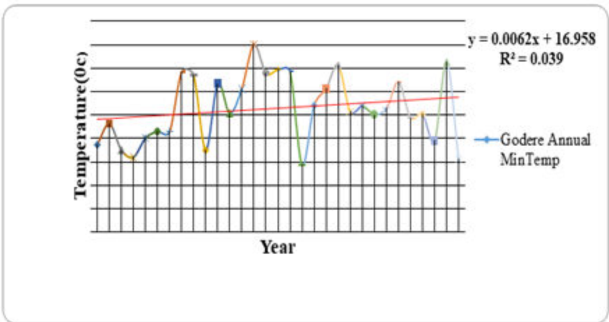

Figure 5: Yearly Godere minimum temperatures.

Variability of temperature: The mean annual temperatures were computed as an average of the maximum and minimum temperatures. Mean and standard deviation values of temperature during the study period of analysis are presented in Tables 11 and 13. The mean maximum (Tmax) and minimum (Tmin), were 30.9°C and 17.1°C respectively for Godere during the study period. Generally, Godere had been recording higher mean temperatures. In Godere, the highest and the lowest mean annual temperature was 33.7°C and 15.6°C in 2003 and 1991 respectively.

Trends of temperature: Warming trends of maximum, minimum seasonal and mean annual temperatures were observed in Godere Woreda. The warming trends of maximum, minimum seasonal and mean annual temperatures were discussed in Tables 9 and 11 in Godere over the period of analysis. Maximum temperature in Godere varies between 25.1°C (1982) to 37.9°C (2003) where mean annual maximum temperature is 30.9°C with standard deviation 1.4°C and coefficient of variation 4.1% and minimum temperature of the area lies between 15.6°C (1991) to 19.2°C (2004, 2016) where mean annual minimum temperature is 17.1°C with standard deviation 0.5°C and coefficient of variation is 3.3%. Generally, the annual minimum temperature is increased by (0.006) trend whereas the annual maximum temperature is increased by (0.012) in the Woreda during the study period.

Perception of farmers on climate change and variability in study area: This section attempts to identify how local households in the study area perceive and explain their local climate conditions such as annual rainfall amount, Belg rainfall amount, Kiremt rainfall amount, onset date, cessation date and length of growing period its distribution is presented in Table 8. The results showed that more than

92% of the farmers had perceived a decreasing trend of annual, Kiremt and Belg rainfall.

The farmers in the study area perceived that rainfall characteristic such as start of rainy season, end rainy season and length of growing period had changed. It has been indicated that about 96.3% and 98.4% of the farmers had perceived increasing late start of rainy season and early end rainy season, respectively and consequently, 97.4% believed decreased in length of growing season. In this regard, perception of farmers' on increase in frequency of late onset of kiremt rainfall and subsequent reduction in LGP was agreed with previous finding by Kemausuor and Nyanga, et al., reported that farmers in Ghana and Zambia, respectively, perceived rainfall timing had changed, resulting in increased frequency of drought (Table 15).

Rainfall characteristics	Farmers' perception on rainfall variability (%)		
	Increased	Decreased	No change
Annual rainfall amount	3.7	95.2	1.1
Kiremt rainfall amount	2.1	92.6	5.3
Belg rainfall amount	2.6	93.1	4.2
Late onset of rainfall	96.3	-	3.7
Early cessation of rainfall	98.4	-	1.6
Length of growing period	-	97.4	2.6

Table 15: Farmers' perception on the trends of rainfall in the Lare Woreda.

As mentioned earlier, majority of the respondents perceived a shift in start of rainy season and end rainy season. The respondents who noted changes in start of rainy season and end rainy season reported that as it cause subsequent reduction in length of growing period. Too early or too late stopping of rainfall is not good for agriculture. Early stop leads to fewer crop yields and late stop damages the harvest as well as threaten fodder and pasture availability and quality. This unfavorable rainfall conditions have aggravated food insecurity problem leaving significant proportion of sampled farm households vulnerable to risks pertaining to weather variability and climatic change. This collaboration with the finding of Belaineh, et al., which shows awareness of farmers increased temperature, changes timing of rains and frequent drought than it was before in central Tigray and Western Hararghe of Ethiopia.

Further the farmers seriously reported that the annual and seasonal temperature was increasing progressively every year as depicted in Table 16. The results revealed that, regardless of agro ecological settings, majority farmers had perceived an increasing trend of mean belg, kiremt seasons and annual temperatures. According, about 90.5%, 93.1% and 97.9% of respondents had perceived increased level of belg, kiremt and annual temperatures respectively. In line with this, Deressa, Mengistu, Taddesse and Tessema et al., revealed that most of the farmers in Ethiopia are aware of the fact that temperature is increasing.

Parameter	Farmers' perception on temperature variability (%)		
	Increased	Decreased	No change
Belg	90.5	1.6	7.9
Kiremt	93.1	1.1	5.8
Annual	97.9	0	2.1

Table 16: Farmers' perception of annual and seasonal temperature trends in the study area.

There is a significant relation between climate and agricultural production in terms of the timing, variability and quantity of seasonal and annual rainfall in Ethiopia. As a result, farmers during unexpected break in rainfall in early growing season may be able to recover and resume production despite the loss of some of their crops. Majule, et al., has also reported similar results. Moreover, the results from key informants and focus group discussion were corroborated with the survey.

Farmers' perceived shocks: The surveyed households have encountered many environmental shocks such as drought, flooding, crop failure, food crisis, pests and death of animals as result of drought, flooding (Figure 6). The result revealed that most of the contacted households had recognized flooding as the major environmental hazard that they have encountered in their life.

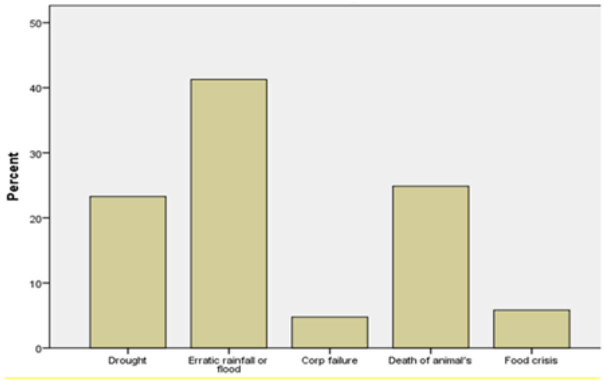

Figure 6: Farmers' perceived climate induced disasters in the study area

The findings from the focus groups and in-depth interviews well recognized the existence of heavy rain resulted in excessive flooding which devastated vegetation, land degradation and had contributed to crop losses. They had mentioned occurrence of severe flood in the 1996, 2006, 2008, 2009, 2010 and 2012 years. They argue, though, the current flooding may be worse than the previous one because crop and animals death are reportedly really severe than before. As a result, they do not have enough crops to feed on and plant in the coming season during that period.

Further, they declared that, drought and the frequency of drought increase from decade to decade, *i.e.* in the beginning there was drought for every ten years, next every five years at the end every two years. In view of that majority of respondents had mentioned occurrence of drought in the years 1971/2, 1984/5; 1999, 2000/01, 2008/09 and 2015/2016 during the last thirty years. Out of these droughts, they singled out three the big and worst droughts were: 1971/72, 1984/5 and 2015/2016. The current drought, according to respondents, is comparable to the 1971/2 and 1984/5 drought in terms of severity of effect. They argue, though, the current drought may be worse than the previous one because crop loss and animals are reportedly dying and feed shortage is really severe than before.

Factors affecting farmer's perception to climate change and variability

It is interesting to know which types of farmers are likely to recognize the climate change an important issue to understand for practicing adaptation strategies. For this study, temperature increase and rainfall decrease are considered as the two measures of perceptions. To identify the correlates of farmers' perception of change in climate, the dependent variable is a binary variable that takes the value 1 if the head of household perceives that temperature is increasing or rainfall is decreasing from last twenty years and the value 0 otherwise.

Farmers should perceive changes in the climate trends to respond effectively through adaptation practices. It is through adaptation that they can minimize adverse effects of climate change in their agricultural production in particular and livelihoods in general. The sustainability of implementation of adaptation strategies also depend upon the right belief, perception, knowledge and commitment of the smallholder farmers' themselves. However, ability of farming households to perceive climate change is affected by diverse socio-economic, demographic and institutional factors. Those factors had significant influence on farmers' perception to climate change in Godere Woreda.

Household characteristics: The effect of household characteristics including age of the household, educational level, family size and number of active age group of the family on perception of climate change is presented in below table. The average age of the household head who perceived change in climate was 41.1 years while those who did not perceive have 51.4 years. Age is considered as a proxy to the farming experience of the household, which is likely to have a significant influence on perception of climate change. On the other hand, the independent samples t-test showed non-significant difference in average age between households who perceived change in climate and those who did not. This implies that age might not be a determinant factor that affects the perception of farmers' to climate change. In contrast, Deressa and Tesso, et al., reported that age has a positive and significant influence on farmers' climate change perceptions.

Mean family size in the study area was 7.7 persons per household. The average household size was higher for the households who perceived climate change (7.8 individuals per household) than their counterpart (6.8 persons per household). The difference in mean family size between households who perceived change in climate and those who did not was not statistically significant. Unlike to this, finding conducted by Taddesse showed that having large family size had positive and significant effect on climate change perception. Increase in economically active family member might contribute to increased income of the family, resulted from on/off-farm engagements, which in turn improved financial capacity. Farmers with strong financial capacity had increased perception of climate change and respond to adapt its impact.

The result also indicated that most of the interviewed farmers were illiterate as only a third of them had formal educations ranging from 0 years to 12 years of schooling. The average level of education was 1.71 years and 1.39 years, respectively, for farmers who perceived change in climate and for those who did not (Table 17). The independent sample t-test also revealed that the average difference between the two groups with respect to the level of education was statistically significant at 5% significant level. The result corresponds with that of Deressa, et al., that noted significant difference between farmers' who perceived climate change and those who did not and contradicts with that of Taddesse and Tesso, et al., who reported non-significant effect of farmers' educational level on their perception to climate change.

HH characteristics	Climate change and variability		
	Perceived	Not perceived	t-value
Age	41.11	51.39	5.56^{ns}

Family size	7.8	6.8	8.11^{ns}
Education	1.71	1.39	1.29**
Note: **Indicates significance at less than 5% level, ns is non-significant difference.			

Table 17: Farmers' perception of climate change and variability as affected by demographic and socioeconomic characteristics of the sample households.

Different studies have revealed that gender of the household head plays an important role on farmers' perception and response to climate change. To this end, it is important to investigate on the relationship between sex of household heads and perception on climate change. In this study, from 189 respondents 46 (24.3%) were female-headed while 143 (75.7%) were male headed households (Table 18). With regard to climate change perception, 78.9% and 21.1% of the respondents, respectively, in the male headed and female headed household had perceived the presence of climate change and variability. The *chi-square* test also showed that the average difference between the two gender groups was statistically significant ($p<0.05$). This result supported the idea that male headed households are often considered to be more likely to get information about climate change. Moreover, Tesso, et al., reported that gender of the household head has a significant effect on climate change perception; as male headed households' perceive climate change more than their female headed counter parts.

Variables	Perceived change and variability		Not perceived change and variability		χ^2 value
Sex of the HHH	Freq.	Percent	Freq.	Percent	
Female	135	78.9	8	44.4	10.53**
Male	36	21.1	10	55.6	
Note: **Indicates significance at less than 5% probability level.					

Table 18: Farmers' perception of climate change and variability as affected by sex of the sample households.

Asset of the household: Land is the ever known to exist resource as the most limiting factor for agricultural production in Ethiopia, in general and the study area in particular. The result revealed that per capita land size is medium and the average landholding of the interviewed farmers falls between 0.5 hectares-5 hectares. Overall, there was no difference in cultivated land between those who perceived and those who did not perceived climate change.

Like in many other African countries, livestock in the study area is an important component of the farming system. The majority of the sampled households own small ruminants and chickens are sold to serve as a source of cash income at a time of cash shortage. The have domestic animals reared in the study area include cattle, sheep, goat, donkey and chicken. Sampled farmers rear animals for various uses, including milk, meat, eggs and for means of transportation. On average, the livestock holding of the sampled household was 15.8 TLU. Sampled households who perceived change in climate have relatively lower livestock holdings (15.48 TLU) than those who did not perceived (16.14 TLU). However, the independent samples t-test showed non-significant mean difference in the livestock holding between the two groups.

The average farm income of the households for the year 2020 was 8560 ETB and 6671 ETB, respectively, for those who perceived change in climate and the one who did not perceive. The result further revealed that the difference in mean income between the two groups was statistically significant. This implied that farm income of a household is likely to affect the farmers' perception of climate change. Likewise, Deressa and Taddesse, et al., reported positive and significant effect of farm income on the farmers' perception of climate change.

In addition, the sampled households who did not perceive change in climate earned relatively higher income (1567 ETB) from non-farm activities, compare to those who perceive change in climate that earns about 3846 ETB for the year 2020 (Table 19). However, the average difference in non-farm income between the farmers who perceived change in climate and those who did not was statistically at par. In line with this, non-farm income had positive but non-significant influence on the farmers' perception of climate change. On the other hand, non-farm income has a negative and non-significant effect on the farmers' perception of climate change.

HH characteristics	Climate change and variability		
	Perceived	Not perceived	t-value
Farm size (ha)	0.55	0.53	0.381^{ns}
Livestock owned (TLU)	15.48	16.14	0.221^{ns}

Farm income (birr)	8560	6671	0.82^{***}
Nonfarm income (birr)	3846	1567	0.44^{ns}
Note: ***Indicates significant at <10% probability level; ns is non-significant difference.			

Table 19: Farmers' perception of climate change and variability as affected by asset holding of the sample households.

The survey result revealed that farming (crop production and livestock rearing) is the main source of income for most farmers. Moreover, in addition to farming, farmers were also engaged in extra income sources, which include daily labor, safety net program, salary, remittance and petty trade (Table 20). The result further showed that farmers who did not perceive climate change participate in a larger proportion on the non/off farm activities as compared to those farmers who perceived change in mood.

Source of income	Perceived change and variability		Not perceived change and variability		Total	
	N=171	Percent	N=18	Percent	N=189	Percent
Farm and firewood sales	116	67.8	13	72.2	129	68.3
Farm and remittance	16	9.4	2	11.1	18	9.5
Farm and petty trade	35	20.5	3	16.7	38	20.1
Monthly salary	4	2.3	0	0	4	2.1

Table 20: Major income sources of the surveyed households in study area.

Institutional factors

Use of credit service: The availability of credit for resource poor farmers is quite important to finance agricultural technologies and management options that enable them to increase farm investment. Moreover, credit access is also important to explore different farming opportunities, which are used for climate change adaptations. Currently, the government and a private company known as micro finance institution are the major source of credit in the study area.

As can be seen from Table 21, among the surveyed respondents 32.3% used credit offered mainly for package program. Moreover, regardless of farmers' perception of climate change, about 50.9% of the household heads had access to credit service. *Chi-square* test was conducted to compare the percentage scores of households who perceived change in climate and who did not perceive with regard to use of credit. The test statistics showed that, there was no statistically significant difference between the two groups of the sampled household heads. In contrast, Taddesse reported significant differences between families who perceive climate change and those who did not on use credit. Moreover, Tesso et al., noted that credit service was one of the most important determinants that affect the perception of farmers to climate change.

Access to credit service	Climate change and variability (%)		
	Perceived	Not perceived	χ^2 value
	N (171)	N (18)	
Yes	50.9	50	8.86^{ns}
No	49.1	50	

Table 21: Farmers' perception of climate change and variability as affected by access to credit service of the sample households.

Access to climate information: Reliable information about seasonal forecast of the weather condition and climate variability is necessary to understand the climatic condition and to take some measures to adverse effects. In the study area, there were no formal sources that deliver weather information. Most farmers obtained climate related information from local meetings, pamphlets, development agents and radio (Table 22). The result revealed that development agent is the most important approaches to convey information about climate, followed by radio; while pamphlet played the lowest role. This might be related to the illiteracy of most interviewed household heads.

Source of information	Climate change and variability					
	Perceived		Not perceived		Total	
	N=171	%	N=18	%	N=189	%
Meeting	9	5.3	1	5.6	10	5.3
Television	15	8.8	1	5.6	16	8.5
Development agents	117	68.4	11	61.1	128	67.7
Radio	30	17.5	5	27.8	35	18.5

Table 22: Farmers' sources of climate information.

Table 23 shows sampled households access to climate information. The result indicated that, regardless of the source, majority of the sampled households have access to climate information. About 80.7% of the farmers who have access to climate information perceive change in climate while about 88.9% of the farmers who did not perceive change in climate had no access to climate information. On the other hand, about 19.3% of the households who have not access to climate information perceived change in climate while about 11.1% of the households who did not perceive change in climate have no access to climate information. This implied the importance of climate information as a driving force to enhance the tendency of farmers' perception. The percentage scores of households those who perceived change in climate and those who did not perceive with respect to access to climate information showed significant difference between the two groups ($p<0.05$). The present result was in line with the finding of Deressa and Tesso, et al., where they pointed out that access to climate information was among the most important variables that positively and significantly influence the perception of farmers about the change in climate conditions.

Access to climate information	Climate change and variability				
	Perceived		Not perceived		χ^2 value
	N (171)	%	N (18)	%	
Yes	138	80.7	16	88.9	3.33**
No	33	19.3	2	11.1	
Note: **Indicates significant difference at <5% probability level.					

Table 23: Farmers' perception of climate change and variability as affected by access to climate information of the sample households.

Use of agricultural extension service: Farmers' access to agricultural service and its relation with perception on climate change is depicted in Table 24. The result showed that majority of the surveyed households had access to agricultural extension services. Moreover, the perception of farmers' has related to the use of agricultural extension service, as most of the farmers who perceive climate change has obtained extension service while those who did not perceive had not use agricultural extension service. Agricultural extension systems in the study area offer a multitude of activities such as training, arranging field days, organizing demonstration trials. These activities might have a direct impact on creating awareness of the households on new agricultural technologies and environmental developments, which later affect perception and decision making of the farmers. The *chi-square* test also revealed that the difference in percentage scores between the households who perceive change in climate and those who did not perceive the change was statistically significant ($p<0.05$). The result also agreed with the finding of Tesso et al., where they noted that farmers who have frequent contact with extension agent have been significantly perceived change in climate than those who have not. On the other hand, Taddesse reported that extension service had no effect on the farmers' perception of climate change.

Agricultural service	Climate change and variability				
	Perceived		Not perceived		χ^2 value
	N (171)	Percentage	N (18)	Percentage	
Yes	163	95.3	17	94.4	0.76**
No	8	4.7	1	5.6	
Note: **Indicates significant difference at <5% probability level.					

Table 24: Farmers' perception of climate change and variability as affected by access to agricultural extension services of the surveyed households.

Citation: Taye S, Abebe D (2023) Farmers Perception and Adaptation to Climate Variability and Change: The Case of Godere Woreda of Gambella Regional State, Ethiopia. J Earth Sci Clim Change 14:684.

The frequency of household head contacts with a development agent in the study area is depicted in Table 25. The result indicated that out of the total sampled respondents most of the farmers had once/ production season 55.6%, while 3.7% had no extension contact at all.

Frequency of contact	Climate change and variability					
	Perceived		Not perceived		Total	
	N= 171	%	N= 18	%	N=189	%
Not at all	6	3.5	1	5.6	7	3.7
Once in two week	20	11.7	2	11.1	22	11.6
Once a month	49	28.7	6	33.3	55	29.1
Once/production season	96	56.1	9	50	105	55.6

Table 25: Households' frequency of contact with the development agents.

Adaptation strategies employed by farmers

Sample households are also asked whether they adopted or not adaptation strategies in response to climate change and variability. Accordingly, changing planting dates is preferred climate change adaptation strategy in crop production as it is indicated by (47.6%) of respondents followed provide supplement feeds and water; herd splitting and migration (14.29%) respectively. On the other hands, crop diversification; root and tuber, hunting, herd composition diversification are the third stage commonly used adaptation strategies as reported by (12.69%) of respondents. Further, farmers were used improved crop varieties and diversify income as adaptation strategies in responses to climate change impact (Figure 7).

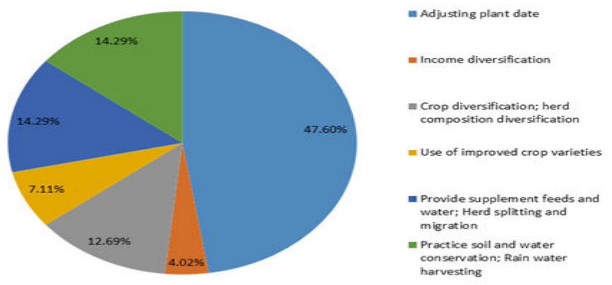

Figure 7: Adaptation strategies employed by farmers.

Determinants of adaptation strategies

It is shown in Table 26.

Factors	APD	ID	CD; HCD	UICV	PSFW; HSM	SWC; RWH
Gender of HH	-2.8538	-0.41193	-0.44835	1.1371	16.4512	-0.5561
Age of HH	-0.18805	3.106548	-0.13599	1.3267	1.62973	.2941**
Education level of HH	7.2046	0.38926	0.034862	0.4005*	-0.82831	.1091**
Family size	-0.18806	.05054**	1.53214	0.11646	-0.83347	-0.0232
Farm land size	1.38233	-0.19732	1.563**	0.6424	-0.48671	0.00974
Livestock ownership	1.4178	-0.05111	.0664***	1.251	0.23123	0.00984
Access to extension service	-1.1195	1.00073	0.1355	1.1371	16.4***	-0.5561
Access to credit service	-2.8538	17.91**	-0.0286	0.0561	0.30476	-0.0294
Access to climate information	7.2046*	0.1355	-0.0023	-.1 0.47	-0.0378	0.01099

Off-farm and non-farming	-0.18805	.0435*	0.0435	-0.75427	-0.0292	-0.0232
On-farm	0.0091	0.0927	0.1355	-.10.47	0.00403	0.00974
Note: *,**,***: significant at 1%, 5% and 10% probability level, respectively; APD: Adjusting Plant Date; ID: Income Diversification; CD: Crop Diversification; HCD: Herd Composition Diversification; UICV: Use of Improved Crop Varieties; PSFW: Provide Supplement Feeds and Water; HSM: Herd Splitting and Migration; SWC: Practice Soil and Water Conservation; RWH: Rain Water Harvesting						

Table 26: Logistic regression result for perception of climate change adaptation in study area.

Conclusion

The survey result showed that most farmers in the study area perceived an increasing and decreasing trends of temperature and rainfall mounts respectively. Their perception is in line with the results obtained from the analysis of observed meteorological data indicating a significant increasing trend of temperature throughout the year and increase trend of annual and seasonal total rainfall. As a result, low agricultural productivity, due to low rainfall, high rainfall variability and increased temperature, farmers of the Woreda has been practicing different adaptation methods households in the area rely on rain fed agriculture taking into consideration risky of climatic condition. Farmers of the study area are highly affected by climate change; however, they have attempted different adaptation strategies to overcome climate change impacts.

The study also revealed that the majority of the households were able to take one or more kinds of adaptation strategies, specifically use of planting trees and soil and water conservation, using improved crop variety and changing planting date. The sample households listed a number of interrelated barriers associated with adaptation strategies that can make their lives very difficult in the presence of unreliable rainfall and other climate related hazards. These have serious implications for climate adaptation and agricultural development more broadly in the study area. The most common barriers reported by the respondents were financial constraints, shortage of labor, shortage and high cost of farm inputs, lack of credit and saving services, shortage of land and lack of irrigation and access of water.

Finally, a logit (binary) model, an econometric investigation was used to identify determinants of adaptations. The result revealed that sex, age, martial statues, land size and access of extension service were found to be major determinants of adaptation. Based on this result the following recommendations are suggested.

Recommendations

According to the nature of the data and based on the findings and results of the study the following recommendations are suggested to minimize the impacts of climate variability and change on rural livelihood communities of Godere Woreda.

- Government policies should ensure that in terms of credit service to enhance farmers' will increase their ability and flexibility to change crop and soil management strategies in response to climate change.
- Furthermore, given the inadequate extension services in the area, improving the knowledge and skills of extension service personnel about climate change adaptation strategies, increasing extension farmer ratio and making the extension services more accessible tofarmers appear to be the key components of a successful adaptation program.
- The provision of access to education, credit, extension service on crop and livestock production, and information on climate and adaptation measures are necessary to better cope with climate change in the study area. Therefore, Government should interventions that encourage informal social networks *i.e.* farm to farm extension services can promote group discussions.
- This is very necessary for farmers to share experience, information and knowledge among them. Therefore, government should improve policy program which is intended at reducing the climate related problems should also focus on accessing improved inputs such as better seeds, improved livestock and fertilizer to farmers with fair price. In addition, provision of crop and livestock insurance has very crucial role in supporting the smallholder farmers to recover from risks against climate related problems.
- National, regional governments and NGOs are needed to tackle the obstacle of the current increasing climate change and variability would require integration and involvement of government to enable farmers livelihood survive in the changing climate and its adverse impact.

Limitations

This study was only limited to one Woreda called Godere Woreda located in the Gambella region. Which the result may not reflect the regional context. As primary data sources, the study were only depend on the farmers' perception and adaptation to climate change and variability in the study site. Due to financial and time limitation, the study was deploying non-experimental survey type of approach to collect the necessary representative data from the selected kebeles.

Ethical Considerations

Ethical thought are going to be taken into consideration seriously. I will be open and honest regarding united nation agency I am doing our research in very good manner. Individuals can build and aware alternative things regarding whether or not they participate with in the analysis. Once individuals have in agreement to require half with in the analysis, code of ethics are going to be provided to them. I attempt to respect native culture and it cannot use a jargon language in our study areas. These codes are going to be confidentiality, right to comment, the ultimate report and data protection. Finally, I will additionally keep the respondents aware regarding the progress of the study.

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Conflicts of Interest

The authors declare no conflict of interest.

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