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GUJI PASTORAL HOUSEHOLD VULNERABILITY TO CLIMATE CHANGE IN MALKA SODA DISTRICT, ETHIOPIA

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Abstract

This study is undertaken to assess the Guji pastoral household vulnerability to climate change, including their perception of climate change and impacts in Malka Soda district of Southern Ethiopia. To collect the primary data, key informants interview and focus group discussion and household interview employed. Quantitative data was analyzed using descriptive statistics, Man Kendall trend test, Sen's slope estimator, one way Analysis of Variance, Chi-square tests, Principal Component Analysis and Ordinal Logistic Regression. Qualitative data was textually analyzed and interpreted. The study result shows that the Guji pastoral households had perception of increased temperature and decreased rainfall trends in the study area. Almost all Guji pastoral households were negatively vulnerable to climate change. Relatively rich household was vulnerable by -0.800, as medium and poor households vulnerability was by -1 and -1.001 values, respectively. Out of 42 independent variables, 16 variables were determined the pastoral household vulnerability to climate change at 5% and 10% levels of significance. Finally, the concerned governmental and non-governmental organizations should take interventions to improve pastoralists' access to rural infrastructures, improved technologies and institutional services.

Keywords: Climate Change, Principal Component Analysis, Ordinal Logistic Regression, Vulnerability

1. Introduction

Climate Change impact on developed as well as developing countries are becoming the greatest worries of life and livelihoods (Tesso, Emana, &

Ketema, 2012). Developing countries are considered as more vulnerable to the impacts of climate change than the developed countries (Stern, 2007). Their vulnerability is largely attributed to their low adaptive capacity (Thornton et al., 2006). Of the developing countries, many in Africa are being the most vulnerable to the impacts of climate change; because of their dependency on natural resources for their livelihood (Hahn, Riederer, & Foster, 2009; Agrawal, 2008; Boko et al., 2007; IPCC, 2007). The vulnerability of East Africa linked to factors such as lack of capacity to adapt financially and institutionally, high poverty level, low infrastructure development, hazard exposure, weak technology, and over dependency on rain fed agriculture (Mkonda, 2019; Bahal'okwibale, 2017). Moreover, pastoral livelihoods in dryland environment are highly affected by climate change driven shocks and stress (Asiimwe et al., 2020; United Nation Development Program [UNDP], 2009). In Ethiopia too, 12-15 million pastoral communities' inhabited 62% of dryland and semi-dryland areas of the country dependent on livestock production (Pastoral Forum of Ethiopia, 2009). However, these pastoral communities are vulnerable to climate change even though their level of vulnerability differed (Gezie, 2019; Fenta, Joradaan, & Melka, 2019; Riche, Hachilek, & Cynthia, 2009). The major cause for Ethiopia's pastoral communities' vulnerability to climate change are low livestock productivity, low adaptive capacity, increasing human population, markets inaccessibility, poorly developed infrastructures, and low-level of education, and escalated competition for scarce resources (Fenta et al., 2019; Pantuliano and Wakesa, 2008). Furthermore, climate change manifestation in the form of recurrent drought is increasingly becoming a bigger challenge to development activities in pastoral areas of Ethiopia (Ambelu et al., 2017). Particularly, the Guji pastoral households (HH) inhabited in Malka Soda district of Southern Ethiopia are victim to climate change, because of their higher vulnerability to frequent drought occurrence. However, little is known about levels of Guji pastoralists' vulnerability to climate change by governmental (Zonal and District organizations) and nongovernmental organizations, such as Community Initiative Facilitation Assistant (CIFA), Danish Aid, World Vision, International Organization for Migration funded by United State Aid for International Development (IOM USAID) and PLAN International working in the study area on the community resilience enhancement and vulnerability reduction. Besides, identification of HH vulnerability to climate change can be used as an input for policy makers working on vulnerability reduction and resilience building (Ayodotun, Williams, Gilbert & Joshua, 2018; Addis, Negatu, & Simane, 2017). Therefore, the purpose of this study was to assess the Guji pastoral household (HH) vulnerability to climate change, including their perception of climate change and climate change impacts in Malka Soda district Southern Ethiopia.

2. The Vulnerability Concept

Vulnerability is a term often used to describe the potential threat to rural communities posed (Nelson et al., 2010). Vulnerability is the propensity or predisposition to be adversely affected by hazards (Opiyo, Wasonga, & Nyangito, 2014); whether from natural or anthropogenic. Vulnerability to environmental hazards means the potential for loss. Since losses vary geographically, over time, and among different social groups, vulnerability also varies over time and space (Cutter, Boruff, & Shirley, 2003). Vulnerability in the context of climate change is a function of exposure, sensitivity and adaptive capacity (Ager, 2006). Moreover, Intergovernmental Panel on Climate Change's [IPCC] understood that vulnerability to climate change is "the degree, to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes (IPCC, 2007). According to Fussel (2007), vulnerability to climate change is a function of the character, scale, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity". The people living in the different part of the world may have different levels of vulnerability to climate change. Vulnerability of people to climate change depends on multiple factors (Adger, 2006; Piya, Maharjan, & Joshi, 2012), such as socioeconomic and biophysical factors. But, the socioeconomic factors are the most cited factors in the literature and includes the level of technological development, infrastructure, institutions, and political setups (McCarthy, Canziani, Leary, Dokken, & White, 2001). The environmental attributes mainly include climatic conditions, quality of soil, and availability of water. The variations of these socioeconomic and biophysical factors across different social groups are responsible for the differences in the levels of vulnerability to climate change (O'Brien, Sygna, & Haugen, 2004). Generally, there are different analytical approaches for vulnerability assessment, such as biophysical, socioeconomic, and integrated approaches for vulnerability analysis of climate change (Addis et al., 2017; Tesso et al., 2012; Füssel, 2007). However, in this study, the integrated vulnerability assessment approach combining both the biophysical and socioeconomic attributes (Deressa, Hassan, & Ringler, 2008) employed to assess HH vulnerability to climate change (Smit and Wandel, 2006) based on the indicator method of data collection.

3. Description of the Study Area

3.1. Location

The study conducted in Malka Soda District. Malka Soda district was one among ten districts of West Guji Zone in Oromia Regional State, Southern Ethiopia. It located 532 KM far from Addis Ababa; the capital city of Ethiopia and about 65 km from the Zonal administrative town; Bule Hora town (formerly called Hageremariam town). The district geographically lies between 5.16º- 5.70ºN latitude and 38.30º-38.87ºE longitude (Figure 1).

The total land area of the district is 170,039 kilo meter square (km^2) which comprises a total of 11 kebeles. Relatively, the district bordered in the South with Arero District, in the East with Aaga Wayu and Saba Boru Districts of Guji Zone, in the North with Kercha and Birbisa Kojowa Districts, in the North West with Bule Hora District and in the West with Dugda Dawa district (Malka Soda District Administration Office [MSDAO], 2019). The administrative center of the district is Malka Soda town.

3.2. Climate and Soil

There are two climatic types in the district namely arid (28.58%) and semi-arid (71.42%). The district receives relatively little rainfall with annual averages ranging from 400mm to 800mm. There are two rainy seasons: March-May (*Rooba Gaanna*) and September-October (*Rooba Haggeyya*) (MSDAO, 2019). The soil types of the district are sandy (65%), Vertsols (20%) and silt loam (15%) (MSDAO, 2019).

3.3. Population and Livelihood

The district has 106, 360 number of people, of which 52, 216 are men and 54,144 are women. The population density of the district is 4 persons per square kilometer (km^2). The area was sparsely populated and characterized by moisture deficit, resulting on water and pasture scarcity (MSDAO, 2019).The large part (90%) of the district population’s livelihood activity is mainly based on livestock production characterized by subsistence production system. The major livestock species kept in the area are camel, cattle, sheep and goat. Moreover, the newly evolved livelihood activities are sedentary farming and non-farm activities, such as petty trading and wage labor i.e, artisan gold mining (MSDAO, 2019).

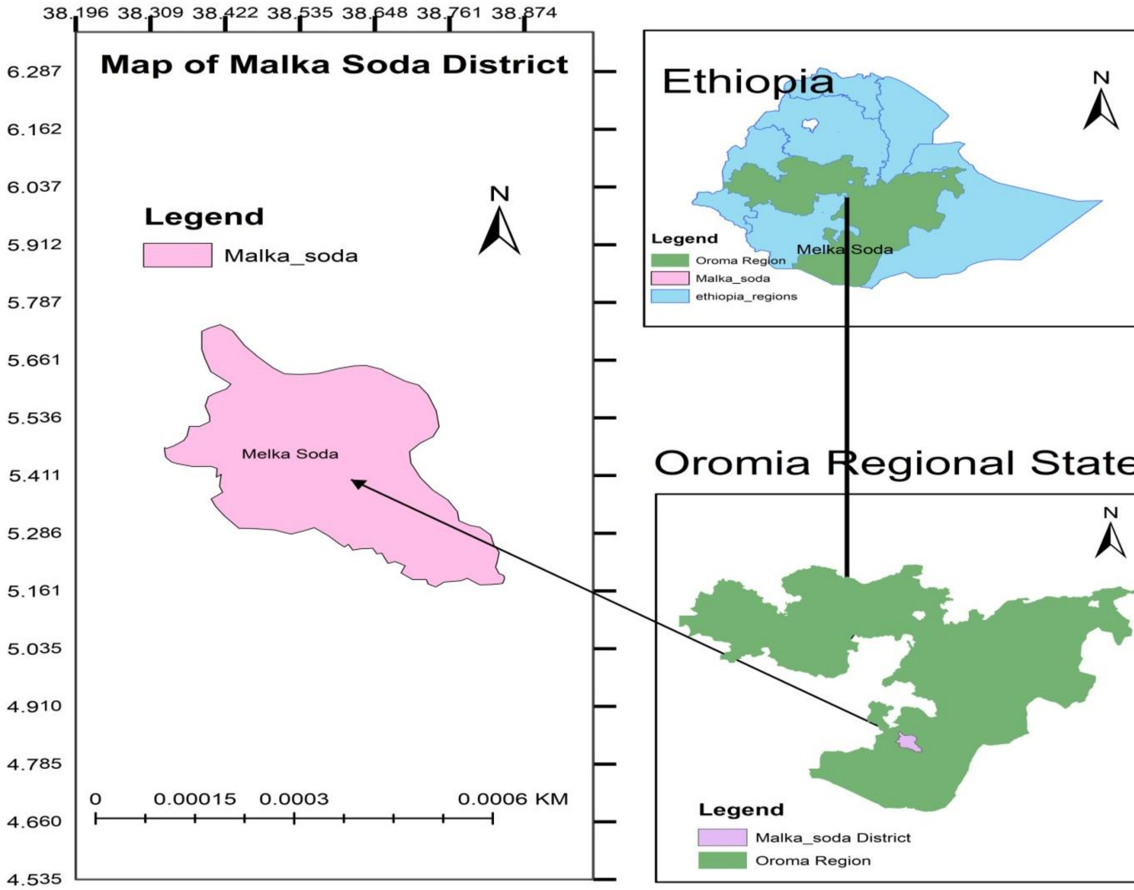

Figure 1: Map of the Study Area

4. Methods and/or Techniques

4.1. Sampling Techniques

4.1.1. Site selection

Malka Soda district was purposely selected, because the aim of the study was on pastoral HHs vulnerability assessment in Malka Soda district; which the outputs of the research taken as a base for those who want to make intervention on vulnerability reduction activities. The district comprised 11 kebeles. Kebele is the smallest administrative unit in Ethiopia. Most of the district kebeles were settled by pastoralists. Only two (2) kebeles were under town administration inhabited by no-pastoralists, their livelihood activities were dependent on petty trading and wage labor. Therefore, these 2 kebeles considered out of the sampling frames of the study. As a result, the attention was given to 9 arid kebeles of the district where pastoralists settled and out of those, 3 sample kebeles picked purposely by considering the representativeness to the realities of pastoralism in the district. The selected three sample Kebeles were Hidi Nagele, Hada Gora and Halo Madeda kebeles.

4.1.2. Key informant (KI) selection

In this study, KI is an elder or knowledgeable people who has been in the area for longer period and have/had a deeper knowledge on local issues like on environmental and livelihood systems. KIs were purposely with the help of the kebele councils. As a result, five KIs were picked from each sample kebele. In general, 15 KIs selected from 3 sample kebeles.

4.1.3. Household (HH) Sample Size Determination and Selection

HH refers to a group of persons living together in the same house or compound and sharing the same housekeeping arrangement. Each HH in the study area have their house head. The HH head sample size was determined using the sample size determination formula developed by Yemane (1967) (Eq1).

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

Where: n is sample size, N is population size and e is the level of precision (5%, 7% and 10%). Five percent (5%) degree of precision used; the target population of the study was heterogeneous population. Therefore, n 1505/ $(1+1505(0.05)^2)$ = 316 HHs were the sample size of the study, which was 21% of the total HH population (1505) of the study area (Table 1). Then, HH stratification into three wealth categories (relatively rich, medium and poor) was undertaken by KIs based on the HH major livestock assets (cattle, camel and goat) holding of the sample kebeles. Therefore, from Hidi Nagele kebele 100 HHs, Hada Gora kebele 92 HHs and Halo Madeda 124 kebeles HHs selected from HHs in 3 wealth categories using lottery method of simple random sampling technique. Generally, 316 HH sampled for this study formal interview.

Table 1. Sample HHs from Sample Kebeles

Wealth category	Total HH population of Sample Kebeles				Sample HH of Sample Kebeles			
	Hidi Nagele	Hada Gora	Halo Madeda	Total	Hidi Nagele	Hada Gora	Halo Madeda	Total
Relatively Rich	100	81	152	333	21	17	32	70
Medium	162	191	228	581	34	40	48	122
Poor	214	167	210	591	45	35	44	124
Total	476	439	590	1505	100	92	124	316

4.2. Method of Data Collection and Analysis

4.2.1. Method of Data Collection

The study carried out using mixed research approach, especially concurrent triangulation employed for data collection and analysis. Both quantitative and qualitative research methods used together to overcome weakness of a single method (Addis et al., 2017; Kothari, 2004; Dawson, 2002). Sources of data were primary and secondary data sources. The main primary sources of data were pastoral HH, KIs and FGDs. The primary data gathering tools were semi-structured questionnaire, check lists and discussion points. Key informants (KIs) were individually interviewed on HH perception of climate change and climate change impacts and vulnerability. The interview was undertaken using open-ended questions. FGD employed with KIs who had similar background and experiences of the subject. Therefore, one FGD carried out in each sample kebele with the selected KIs. It carried out gather detailed information on pastoralists' perception of climate change and impacts and vulnerability status. A total of three FGD were held in three sample kebeles. The HH interview was undertaken with the sample HHs. In the process of HH interview, five stages employed: preparation of semi-structured questionnaires, translation of questionnaires to the local language and training of field-assistants, pre-testing the questionnaire and actual data collection was undertaken. Secondary data sources were published and unpublished data sources like books, journal articles, reports and local materials available in the study area. In addition, climate data's was used as secondary source of information. However, the study area (Malka Soda district) assumed as a district recently after separated from the Dugda Dawa district. As a result, it was difficult to get the climate data specifically for the site at the national metrological agency of Ethiopia. Instead, the nearby Arero district metrological station data used for the analysis, because these two districts have 1) similar climate types (arid and semi-arid) and 2) only 30 kilometer far away from each other. Moreover, Royal Netherlands Meteorological Institute (KNMI) grid based climate data sets used to project the long-term trend of mean annual temperature and mean daily precipitation for 2000 to 2019 consecutive years in the study area.

4.2.2. Method of Data Analysis

First, quantitative data summarized, tallied and coded by using Microsoft excel 2007. The data analysis was undertaken using different statistical tools in STATA/SE version 14.1 and XLSTAT 2020 statistical software. The analysis for HH socio economic characteristics and perception on climate change and its impacts were undertaken using descriptive statistics, one way ANOVA and Chi-square tests. For climate change analysis, descriptive statistics, Mann Kendal trend test and Sen's slope estimator used to analyze the trend and slope by which the mean annual temperature and rainfall changed over the latest 34 years in the study area. Mann-Kendall trend test used to analyze whether a time series had a monotonic upward or downward trend of annual rainfall or temperature was increased, decreased or no trend observed in the study area. The null hypothesis for this study was that there was no trend and the alternative hypothesis was that there was a trend in the two-sided test. For the time series (t) x_1.., x_n, the Man-Kendall test uses the following statistic (Eq2):

$$S = \sum_{i=1}^{n-1} \sum_{j=k+1}^{n} \operatorname{sign}(xj - xi) \qquad (2)$$

Where S was a variance of the time series, $x_{1....}x_n$ were the time series of mean annual temperature and mean annual rainfall data of the study area. When S given by (Eq3):

$$S = 1/18[n(n-1)(2n+5-\sum_t ft(ft-1)(2ft+5)] \qquad (3)$$

Note that if S > 0 then later observations in the time series tend to be larger than those that appear earlier in the time series, while the reverse is true if S < 0. Where t varies over the set of tied ranks and ft is the frequency of times that the rank t appears.

Man-Kendall Test (Z) for trend uses the following test statistic (Eq4).

$$Z=\begin{cases} S-1, S>0 \\ 0, \quad S=0 \\ S+1 \; S<0 \end{cases} \qquad (4)$$

Where S = variance of data. The existence of trend of phenomenon identified using the Z value. A positive (negative) value of Z indicate either an up-ward or down-ward) trend. To test either an upward or downward monotone trend (a two-tailed test) at alpha 0.05 level of significance, H_o rejected if the absolute value of Z was greater than Z1-α/2, where Z1-α/2 obtained from the standard normal cumulative distribution tables, by using Mann-Kendall trend significant test with the level of significance 0.05 (Z1α/2 = ± 1.96) (Shonga, 2018).

Sen's slope used to estimate the slope of a regression line that fits a set of (x, y) data elements. It expressed for the set of pairs (i, x_i) where x_i is a time series (Eq5).

$$f(t) = A + B \qquad (5)$$

Where, t is data in time series, A is the slope and B is constant. To get the slope estimate in equation, first the slopes of data value calculated as (Eq6):

$$Ai = \text{Median}\left\{\frac{xj - xi}{j - i} : i < j\right\} \qquad (6)$$

Where, xj and xi are data value at time j and i (i < j) had an increased (up-ward trend) or positive change and the negative value slope when data series had down-ward trend (Hirsich, Slack, & Smith, 1982).

Furthermore, climate parameters time series analysis was undertaken in Royal Netherlands Meteorological Institute (KMNI) climate explorer website (https://climexp.kmni.nl/). The analysis made based on the fifth IPCC climate change assessment report (AR5) climate models inter comparison (CMIP5) using different climate simulation scenarios (i.e., representative concentration pathway 2.6 (RCP 2.6), representative concentration pathways 4.5 (RCP 4.5), representative concentration pathway 6.0 (RCP 6.0) and representative concentration pathway 8.5 (RCP 8.5). Generally, an ensemble of 42 climate models were used for projection of long term (2000-2019) trend of mean annual temperature and mean daily precipitation of the study area.

Analysis of HH vulnerability to climate change was undertaken passing on 3 steps. First, vulnerability indicators selected. These were socio economic and environmental indicators aggregated into three components of vulnerability, such as exposure, sensitivity and adaptive capacity (Gbetibouo, Ringler, & Hassan, 2010). The selection made by consulting the KIs and reviewing the previously undertaken research in pastoral areas of the country (Fenta et al., 2019; Tesso et al., 2012). In this study, adaptive capacity represented by indicators such as HH sex, HH age, marital status, HH size, educational status, number dependents on HH head, livestock ownership, livestock mobility, HH farm experience, access to national early warning information, HH and their members health status, family planning service, social linkages, membership in cooperatives, water access for irrigation, irrigation use, main livelihood activity, market access, distance from very important road place, access to clean water service, mobile possession, HH saving, credit access, employment opportunities, non-farm income, crop verities, livestock breeds, fertilizer use, extension services, education access, health access, radio ownership and distance to veterinary health post. In addition, HH sensitivity indicators were crop productivity loss, livestock productivity decline, water scarcity and conflict. Exposure is the nature and degree to which a system exposed to climate variations (IPCC, 2001) and their indicators were temperature, rainfall, and drought and bush encroachment in rangeland of the study area.

Next, data normalized by mean and standard deviation to make the indicator value within a similar range (Fenta et al., 2019; Nelson et al., 2010; Vincent, 2004) (Eq7):

$$N = \frac{(x-\pi)}{s} \quad (7)$$

Where: N = data normalization; x = observed value, π = the mean of observed data value; s = standard deviation of data value.

After that weights assignment for indicators of adaptive capacity, sensitivity and exposure to estimate HH vulnerability to climate change. Indicators weight assignment made by PCA approach (Cutter et al., 2003; Filmer and Pritchett, 2001). PCA is a multivariate technique used for extraction of weighted values for a set of variables those have orthogonal linear combinations of variables that successfully capture the common information (Addis et al., 2017; Fenta et al., 2019; Opiyo et al., 2014). In PCA, weight assignment for the indicators was a function of multiplication between data normalization value with principal component (PC) factor score with highest egen value. Most probably, the first PC factor score would be always with highest egen value. Generally, indicator weight assignment mathematically designated as (Eq8):

$$Wvi = fn \quad (8)$$

Where: Wvi = weighted value of indicator of HH adaptive capacity, sensitivity and exposure; f = first factor score; value of indicator of HH adaptive capacity, sensitivity and exposure; n = data normalization by mean and standard deviation for indicators of HH adaptive capacity, sensitivity and exposure.

Next, HH vulnerability index developed separately for relatively rich, medium and poor pastoral HH using the following equation (IPCC, 2012) (Eq9):

$$Vi = Ac - (E + S) \quad (9)$$

Where: Vi = vulnerability index of pastoral HH; Ac = adaptive capacity indicators of HH; E = exposure indicators of HH; S = sensitivity indicators of HH.

Therefore, the HH vulnerability to climate change index value interpreted as "the higher the index value, the higher would be the HH vulnerability to climate change and the lesser the value, the lower the HH vulnerability to climate change" (Addis et al., 2017; Ayodotun et al., 2018; Deressa et al., 2008; Fenta et al., 2019; Tesso et al., 2012).

Finally, the determinants of HH vulnerability to climate change identified using ordinal logistic regression (OLR) model. Basically, the model used when the dependent variables presented in ordinal scales (Ayodotun et al., 2018). Therefore, in this study, vulnerability index values obtained from PCA were presented in ordinal scales and then OLR model analysis was made. For instance, the relatively rich HHs coded as -0.8, since the Medium and Poor HHs represented by -1 and -1.001 respectively; which they used as dependent variables. The OLR model equation is presented as follow (Eq10).

$$Yj = XijC + eij \quad (10)$$

Where Yj = level of vulnerability involves ordered vulnerability categories; X_{ij} were the independent variables determining vulnerability level; C was an estimated parameter; e_{ij} was the error term (Ayodotun et al., 2018).

5. Results and Discussion

5.1. HH Socio-Economic Characteristics

The result shows that 85.1% of HH respondents were male HH, where 14.9% were female headed HH. In relation to HH educational status, 38% of HH educated while 62% of HHs not educated (Chi Square, $P<0.05$). The major livelihood activity of the HH respondents were livestock production (64.2%) and 35.8% of HH respondents were dependent on other livelihood activities, such as on crop cultivation, petty trading, and wage labor. Furthermore, the overall mean HH age was 58 years. Therefore, pastoral HHs was found in working age category. The mean HH size was 7. Besides, one HH in mean had 34.84 livestock in TLU. But, the ownership dominated by relatively rich HH (92.93 in TLU) in the study area (Table 6).

5.2. Climate Change Evidences

The minimum and maximum annual temperature of the study area over the last 34 years (1985 - 2019) was 13.6 ^{0}C and 24.5 ^{0}C, respectively. The minimum and maximum annual rainfall of the study area was 350.6mm and 813.5 mm respectively. Thus, the mean annual temperature and mean annual rainfall of 34 years was 20.9 ^{0}C and was 608.8 mm, respectively. During 22 different years (1988,1990, 1994, 1995, 1996, 1997, 1998, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2011, 2012, 2013, 2015, 2016, 2017, 2018 and 2019), their annual temperature rose up above the mean annual temperature (20.9 ^{0}C) of the study area (Figure 2).

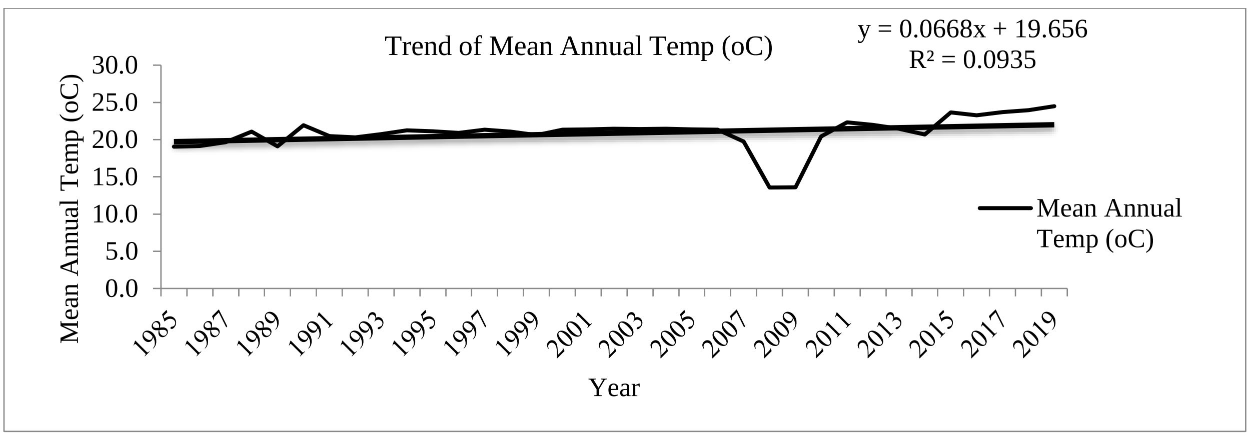

Figure 2. Trend of Mean Annual Temperature (^{o}C) of the study area (1985 to 2019)

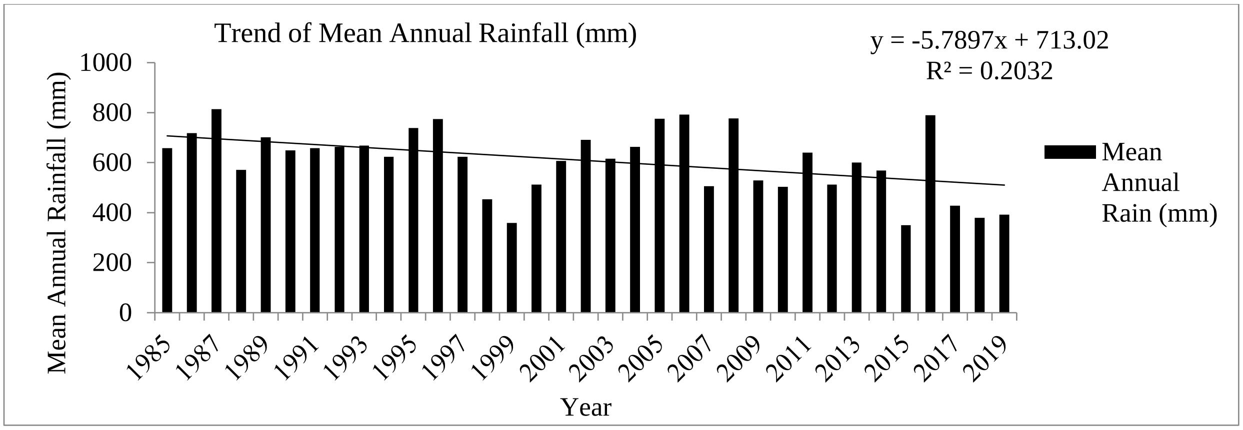

Figure 3. Trend of Mean Annual Rainfall (mm) of the Study Area (1985 -2019)

Agreement with the finding, Man-Kendall trend test result shows that the mean annual rainfall of the area significantly decreased by Kendall's tau -0.297mm (Table 8). Consistent to the finding, Sen's slope result has shows that the slope by which the trend of mean annual temperature was increases; which was 0.091^{0}C (Table 7). However, the slope by which the trend of mean annual rainfall decreases was -6.288mm (Table 8) over the last 34 years in the study area.

Consequently, the results from an ensemble climate models across four climate scenarios such as RCP2.6, RCP 4.5, RCP 6.0 and RCP 8.5 confirmed that the long-term (2000-2019) changed trends of temperature and rainfall in the study area. The simulation result show that the long-term trend of mean annual temperature was varies between 19.5^{0}C and 25.5^{0}C (2000-2019) (Figure 4). On the other hand, three climate scenarios (RCP 4.5, RCP 6.0 and RCP 8.5) confirmed that the long-term (2000-2019) mean daily precipitation was varies between 1mm and 3.5 mm (Figure 5). Therefore, variability of mean annual temperature and mean daily precipitation was the cause for drought frequencies observed in the study area.

Table 2. Man-Kendall Trend and Sen's Slope Results for Trend of Mean Annual Temperature (1985-2019)

Mann-Kendall trend test / Two-tailed test (Mean Annual Temp (^{0}C)):		Sen's slope:			
Kendall's tau	0.486		Value	Lower bound (95%)	Upper bound (95%)

S	289.000	Slope	0.091	0.046	0.127
Var(S)	4958.333	Intercept	19.800	19.170	20.446
p-value (Two-tailed)	< 0.0001				
alpha	0.05				

Table 3. Man-Kendall Trend test and Sen's Slope Results for Trend of Mean Annual Rainfall (1985-2019)

Mann-Kendall trend test / Two-tailed test (Mean Annual Rain (mm)):		Sen's slope:			
Kendall's tau	-0.297		Value	Lower bound (95%)	Upper bound (95%)
S	177.000	Slope	-6.288	-9.725	-1.433
Var(S)	4958.333	Intercept	713.803	642.633	755.950
p-value (Two-tailed)	0.012				
alpha	0.05				

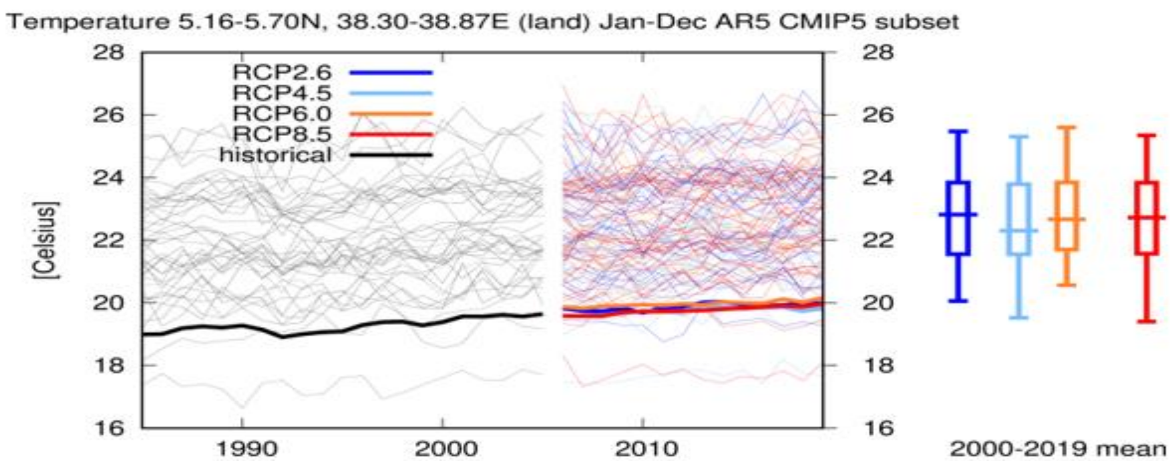

Figure 4. IPCC AR5 CMIP5 RCPs based Mean of Annual Temperature (2000-2019) Simulation

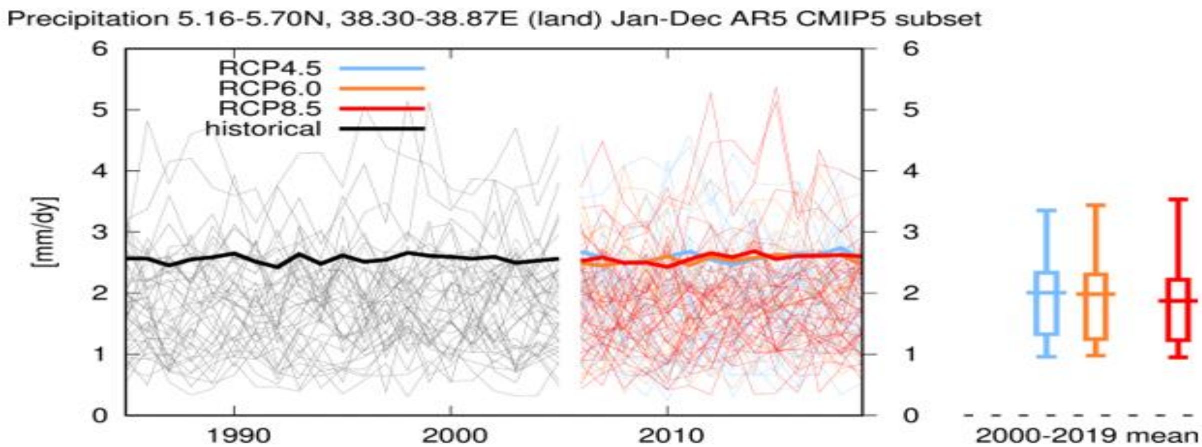

Figure 5. IPCC AR5 CMIP5 RCPs based Mean of Annual Precipitation (2000-2019) Simulation

5.2.1. Pastoralists' Perception of Climate Change

The study result shows that pastoralists had perceived the trend of climate change (trend of temperature and rainfall) in the study area. According to, most of HH respondents (81% of relatively rich, 61% of medium and 59% of poor) climate change ("*jijjiirama qiilleenssa"*) was the reality and its negative impacts observed on their livelihood; livestock production. Consistently, KIs reported that the increased temperature and decreased rainfall trend evidently seen during the latest reigns of five Abba Gadas leadership periods of Guji people namely, Adola Aaga (1987 –1995) Godana Kata (1995 - 2002), Aaga Xenxeno (2002 - 2009), Wako Dube (2009 –2016) and Jilo Mando (2016 - present) in the study area. According to FGD report, "*Abba Gadas are the leaders of Gada system replaced each other regularly once in 8 years round. Gada system is an indigenous system of self-rule that governs the social, economic, political and environmental life of Guji community*" (Jalata, 2012; Sirna, 2012; Udessa and Gololcha, 2011; Legesse, 2006). Thus, according to KIs temperature increased during latest five Abba Gadas of the system whiles the rainfall amount decreased in the study area; especially they reported that the already known bimodal rainfall pattern changed and variability increased. Consistent to the finding, HH interview result has indicated that relatively rich (74%), medium (79%) and poor (81%) respondents observed the changed rainfall pattern from the normal trends in the study area. Moreover, the study confirmed that the pattern of drought cycle in the study area has tightened since 1985 and most HH respondents in wealth categories agreed with the changed drought pattern (frequency). Furthermore, 87% relatively rich, 84% medium and 69% poor respondents (Chi square $p<0.05$) confirmed the increased drought frequencies. In line with the finding, KIs reported that early in 1985 the drought cycle had larger gap (10 years) than the occurrence happened recently (1997 and 2003) in 7 years. The frequency was totally reduced since 2007 and the severity has increased. Moreover, during the latest (2010 and 2015) drought events, large amount of livestock death and crop failures observed in the study area.

5.3. Major Impacts of Climate Change in the study area

5.3.1. Climate Change Impacts on Rangeland Resources

Majority of HH respondents from relatively rich (80%), medium (74%) and poor (78%) revealed that the extreme climate condition (recurrent drought) was driving force for the most of the dried water springs that were regularly used by humans and livestock. Moreover, KIs discovered that the people in district used for long 14 water springs in different pastoral kebeles of the localities, but unfortunately only four of them are left for services of the community and livestock. Above all, the discharging water from these springs has been continuously decreasing compared to the past and the spring water now bears unwanted coloring unlike in the past when it was crystal clear.

5.3.2. Climate Change Contribution for Desertification and Bush Encroachment

According to HH respondents, long years ago desertification was a phenomenon in the study area. As mentioned by most of relatively rich (91%), medium (85%) and poor (86%) HH respondents in wealth category desertification were increasing since the last 34 years. Moreover, HH reports also showed that the cause of desertification was land degradation in the form of soil erosion. Most HH respondents from the relatively rich (87%), medium (93%) and poor (75%) (Chi square, $p<0.05$) reported the grave expansion of bush encroachment in the rangeland since the last 34 years. In line with the finding, KIs revealed that *Dodonea viscosa (Itaacha), Acacia mellifera (Saphaansa diimma)* and *Acacia senegal (Saphaansa guurracha)* was the major bush species progressively encroached in the rangelands. Hence, to find the driving forces for deterioration of the range resources, 91% of HH respondents agreed that climate change in the form of recurrent drought was a cause of bush encroachment in the rangelands of the study area. Nine percent (9%) of HHs reported bun of fire in the forestry policy of the country as a cause for the bush encroachment.

5.4. Weight Assignment for Indicators of Pastoral HH Vulnerability to Climate Change

5.4.1. Adaptive Capacity Indicators Weight Assignment

The PCA result shows that out of 33 indicators, 13 indicators (HH sex, age, marital status, family size, educational status, dependency on HH, livestock ownership, livestock mobility, HH farming experience, HH early warning information, HH health status and HH family planning service) represented 77.45% cumulative variations in the data sets used for relatively rich HH adaptive capacity weight assignment; because they have egen values greater than 1. In addition, for medium pastoral HH adaptive capacity, 10 indicators (HH sex, age, marital status, family size, educational status, dependency on HH, livestock ownership, livestock mobility, HH farming experience, HH early warning information); which represented 71.46 % cumulative variations in the data sets and with egen value greater than 1 used for weight assignment. Finally, the poor pastoral HH adaptive capacity weight assignment made by employing 12 indicators (HH sex, age, marital status, family size, educational status, dependency on HH, livestock ownership, livestock mobility, HH farming experience, HH early warning information, health status and family planning service) with egen value greater 1 and represented 67% of cumulative variations in the data sets. Consistent to the results, FGD participants mentioned that livestock ownership, access to water, market access, money saving in the bank and non farm incomes was the major factors contributed for HH adaptive capacity in the study area. In line to the results, Fenta et al. (2019) disclosed that HH sex, HH age, HH size, educational status, dependents on HH head, livestock ownership, livestock mobility, HH farm experience, access to national early warning information, HH and their members health status, family planning service, social linkages, membership in cooperatives, irrigation farming, main livelihood activity, market access, distance from very important road place, access to clean water service, mobile possession, saving , credit access and employment opportunities were the determinants of adaptive capacity of Afar pastoralists in Ethiopia.

5.4.2. Sensitivity Indicators Weight Assignment

PCA result shows that for relatively rich HHs, out of five indicators of sensitivity, only two indicators (crop productivity loss and livestock productivity decline) with egen value greater than 1 represented 69.21% variations in the data sets used for weight assignment. Similarly, for medium and poor pastoral HH, the first two indicators (crop productivity loss and livestock productivity decline) with egen values greater than 1 represented 68.13% and 64.41% cumulative variations in the data sets respectively used for weight assignment.

5.4.3. Exposure Indicators Weight Assignment

PCA result shows the exposure of relatively rich, medium and poor pastoral HHs, the first and the second components (increasing trend of rainfall and temperature) with egen values greater than 1 represented 67.9%, 67.47% and

82.2% of cumulative variations in the data sets respectively used for weight assignment.

5.5. Indices of Pastoral HH Vulnerability to Climate Change

Vulnerability of pastoral HHs to climate change measured. Thus, the computed vulnerability indices of the pastoral relatively rich, medium and poor HHs in wealth categories were -0.800, -1 and -1.001, respectively (Figure 6).

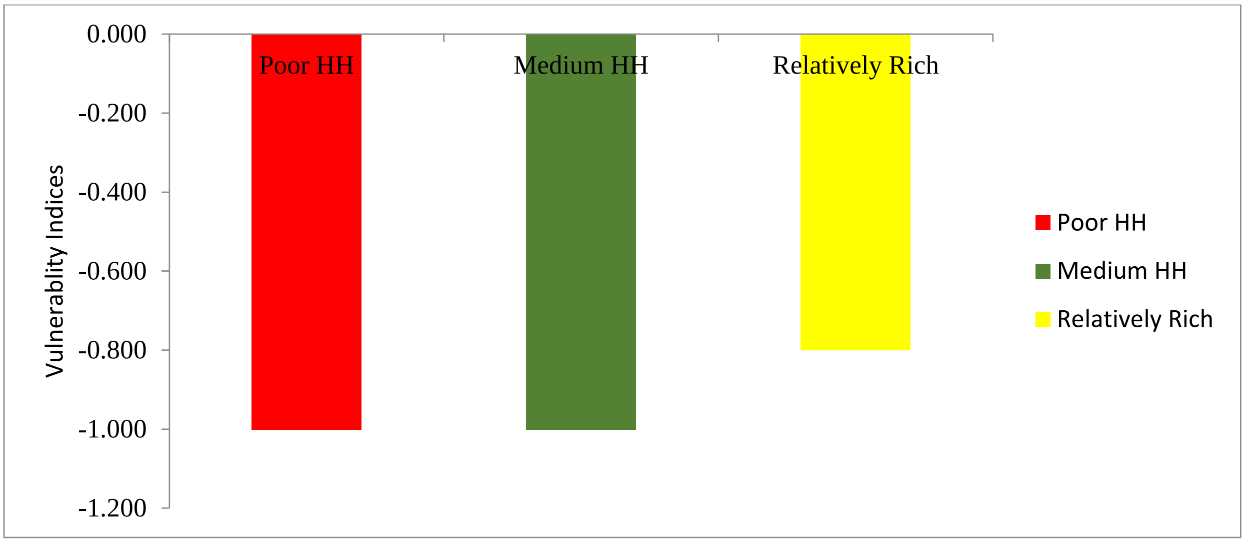

Figure 6. Pastoral HH Vulnerability to Climate Change Indices

Generally, all pastoral HHs in wealth categories was negatively vulnerability to climate change because of their low adaptive capacity, higher sensitivity and exposure status. However, vulnerabilities of poor and medium pastoral HH was higher as compared to relatively rich pastoral HHs; because of the poor and medium had low access to technology, infrastructures development and institutional services. Generally, vulnerability of the relatively rich, medium and poor pastoral HH in wealth categories associated with demographic factors, such as HH sex, marital status, HH age, HH size and dependency on HH heads. Additionally, socioeconomic factors had contribution to their vulnerability to climate change. These factors were low educational status, livestock ownership, livestock mobility, HH farm experience, inaccessibility to national early warning information, HH and their members health status, family planning service, social linkages were among socio-economic factors contributed for low HHs adaptive capacity in the study area. On the other side, HH sensitivity to climate change caused by crop productivity losses and livestock productivity decline. Moreover, HH exposure to climate variations instigated by decreased trend of rainfall amount and increased trend of temperature in the study area. Agree with finding, Opiyo *et al.* (2014) reported the high vulnerability of pastoral HHs in rangelands in Kenya to frequent drought was due to higher dependency ratio, no access to early warning information, no milking herd and own less than two livestock species, and perceived changes in climate. Gebresenbet and Kefale (2012) carried out research on Omo pastoralists and the finding confirmed that the major factors for pastoralists' vulnerability to climate change impacts were poor infrastructure development, economic and political marginalization observed in the area. Furthermore, the study undertaken on Borana pastoralists in Southern Ethiopia concluded that there was shrinkage of grazing lands as a result of widespread encroachment of drought resistant bush species in the rangelands affected livestock production (Desta and Coppock, 2004; Oba and Kotile, 2001) has intensified the communities' vulnerability to the impacts of climate change. Generally, Ali (2012) argued that, poor people were the most vulnerable to climate change because they had little capacity to adapt to shocks. They were also more dependent on ecosystem services and products for their livelihoods. Any impact that climate change had on natural systems therefore threaten the livelihoods and health of poor people. Loss of employment and impacts on assets are likely to reduce opportunities for education in several ways (Sheikh and Aker, 2017). Ellis (2000) stated that the most vulnerable households were those that were both highly prone to adverse external events and lacking in the assets or social support systems that could carry them through periods of adversity.

5.5.1. Determinants of HH Vulnerability to Climate Change

The determinants of HH vulnerability to climate change estimated using OLR model presented in Table 12. The model result has shown that out of 42 explanatory variables, 16 variables had significantly determined HH vulnerability to climate change in the study area at 5% and 10% significance levels (Table 12).

Table 4. OLR Results for Determinants of HHs vulnerability to Climate Change

Determinants HH Vulnerability	Coef.	Std. Err.	z	P>z	Effects
Dependency on HHs**	-.5540436	.1621162	-3.42	0.001	+
Livestock ownership(TLU)**	.1551054	.0271048	5.72	0.000	+/-
Livestock mobility*	-3.205735	1.790964	-1.79	0.073	-
Farming experience**	.5038791	.1455074	3.46	0.001	-
Access to Early warning Information**	2.616114	1.340041	1.95	0.051	-
Access to all weather road**	-.6554163	.2008509	-3.26	0.001	-

Mobile possession**	2.896637	.9467249	3.06	0.002	-
Money saving **	4.708912	1.656044	2.84	0.004	-
Access credit **	2.983074	1.276325	2.34	0.019	-
Employment opportunity**	1.669106	.7616124	2.19	0.028	-
Fertilizer use*	1.428997	.8538494	1.67	0.094	-
Health service*	.1855232	.0985911	1.88	0.060	-
Distance from veterinary post**	.8666815	.2090112	4.15	0.000	+/-
Conflict frequency**	-2.917009	1.039658	-2.81	0.005	+
Trend of temperature**	6.018705	1.975437	3.05	0.002	+
Trend of drought frequency*	-2.873779	1.709662	-1.68	0.093	+

*NB: Ordered Logistic Regression (OLR), Number of observation = 316, z= Z score test Prob > chi2 = 0.0000, Pseudo R2 = 0.8396, LR chi2 (42) = 568.26, Log likelihood = 566.92, ** has statistically significant effect on HH vulnerability at P < 5%, *has statistically significant effect on HH vulnerability at P < 10%*

Explanatory variables, such as dependency on HH, livestock ownership, farming experience, access to early warning information, access to all weather road, mobile phone ownership, HH saving, access to credit service, employment opportunity, health service, distance from veterinary health post, conflict frequency, trend of temperature and trend of drought frequency were significantly determined the probability of HH vulnerability to climate change at 5% significance level. Whereas, HH livestock mobility, HH fertilizer use and HH health service were the determinants of the probability of HH vulnerability to climate change at 10% significance level in the study area.

6. Conclusions and Future Policy Options

6.1. Change in Long term Temperature and Rainfall confirmed Climate Change

Climate is changing manifested in the form of changed temperature and rainfall trends, as well as the already known bimodal pattern of rainfall changed and variability increased. The pattern of drought cycle lessening. As a result, the impacts observed on livestock production in a multiple ways, among others the water and pastures were unavailable; because the already known rangelands used as a natural resource stock degraded due to bush encroachment and desertification. Bush encroachment in the rangeland was due to frequent drought occurrence although the official bun of fire in the forestry policy of Ethiopia has contributed for expansion of bushes in the rangelands. In addition, desertification manifested itself in the form of soil erosion in the rangeland and thereby contributed for rangeland degradation. Therefore, bush clearing and thinning in the rangelands should be undertaken to reduce expansion of bushes in the rangelands, as well as soil and water management technologies, such as Afforestation/or re Afforestation, soil and stone bands construction should be implemented in the study area rangelands.

6.2.Lack of Adaptive Capacity of Poor and Medium Pastoral HHs

The pastoral poor and medium HHs was highly vulnerable to climate change as compared to relatively rich HH. Their vulnerability was mainly due to their low adaptive capacity and sensitivity to climate induced impacts. The poor and medium HHs low adaptive capacity caused from low educational status, dependency ratio, livestock ownership, livestock mobility, HH farm experience, access to national early warning information, HH and their members health status, family planning service, social linkages, membership in cooperatives, access to water for irrigation, irrigation use, livelihood activity, market inaccessibility, distance from important all weather road, mobile ownership and HH saving. Besides, crop productivity decline/loss and livestock productivity decline/death contributed for HHs sensitivity to climate change. Therefore, addressing pastoral poor and medium adaptive capacity, sensitivity and exposure needs a direct policy implication. Thus, all concerned GOVs and non GOVs working in the study area should take actions to make pastoral poor and medium HHs life sustainable under the impacts climate change by improving the communities' access to technologies, social infrastructures and institutional services. Further, to reduce pastoral livelihood sensitivity to climate change impacts, it is better if pastoralists would have access to technologies, like irrigation practices for dry-land crops cultivation. Therefore the applications these technologies can reduce HH sensitivity status and then their resilience to climate change would be improved in the study area.

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