Gender and Climate Change: Perception, Vulnerability, and Agriculture-related Adaptation Preferences among Male and Female Headed Households in Northwest Ethiopia (GCC-PeVAAP)

Final Report

Country:	**Ethiopia**
South Institution:	**University of Gondar**
South Promoters:	**Tewelde Gebremariam/Dereje Amene**
Flanders Institution:	**Institute of Development Policy, University of Antwerp**
Flemish Promoter:	**Dr. Prof. Nathalie Holvoet**

EXECUTIVE SUMMARY

*This research report focuses on the Vlir-UOS south-initiative "**Gender and Climate Change: Perception, Vulnerability, and Agriculture-related Adaptation Preferences among Male and Female Headed Households in Northwest Ethiopia (GCC-PeVAAP)**" jointly implemented by the University of Gondar and the Institute of Development Policy (University of Antwerp) from January 2019 to September 2022. The report provides an overview of the project background, methodology, achievements, challenges, lessons learned and way forward. We thank Vlir-UOS for its financial grant pledged to undertake this research project and look forward to strengthening our partnership in support of development in Ethiopia.*

***Project background:** Recognizing the impacts of climate change, several adaptation initiatives have been implemented in Ethiopia. However, many of the adaptation strategies tend to neglect the existing gendered differences in perceptions, vulnerabilities, and adaptation preferences as well as possible intersections of gender with other variables of influence (i.e. intersectionalities).*

***Purpose of the project:** This research project was conducted in drought prone areas of Northwest Ethiopia, aiming at designing evidence-based gender sensitive agriculture related adaptation strategies.*

***Methodology:** The project had two components: i) Diagnosis and participatory designing of gender sensitive adaptation strategies; and ii) Documentation and dissemination of the project outputs to local communities, development practitioners, policy makers and scientific community so as to promote uptake the findings for future intervention.*

***Project outputs:** Under this research project, five manuscripts and one policy paper are developed; gender and climate change database is created; one M.Sc. Thesis was produced; and results are scheduled to be communicated through different platforms (community meeting, local media, conferences, and workshops); and working papers are also being developed.*

Project duration: 2 Years (due to Covid the project was extended to September 2022).

Project team members (in alphabetical order):

Asmamaw Alemu (dr.), Dereje Amene, Tinsae Birhanu, Tewelde Gebremariam, Tsega Hagos, Nathalie Holvoet (Prof.dr.)

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1. INTRODUCTION

1.1 Project Context

Despite the fact that climate change is a global phenomenon, adaptation of citizens and policy-makers to the changing environment is a local process that requires cross-disciplinary and cross-sectoral long-term solutions (Agrawal, 2010; Adger et al., 2009). According to the 2007 report of the Intergovernmental Panel on Climate Change (IPCC), African countries are amongst the most vulnerable to climate change and climate variability which is further intensified by low adaptive capacity (IPCC, 2007). In Africa, Ethiopia is among the countries most vulnerable to the adverse impacts of climate change (Cochrane & Singh, 2016; Gashaw et al. 2014): 70% of the country is characterized by drylands with a 40% annual probability of moderate to severe drought, particularly in the smallholder farming systems (Singh et al., 2016), where rainfed agriculture is the most common livelihood strategy (Bezu et al., 2012; Gebrehiwot & van der Veen, 2014), characterized by land fragmentation, low productivity, and high sensitivity to climate change (Shumetie & Alemayehu, 2017; UNDP, 2012) affecting the agricultural production, income, consumption, and assets of tens of millions of smallholders (Deressa & Hassan, 2009; Di Falco et al., 2012; Megersa et al., 2014). While these smallholders attempt to adapt (Alemayehu & Bewket, 2017; Berhanu & Beyene, 2015; Conway & Schipper, 2011; Deressa et al., 2011), they are often income and asset poor, food insecure, and subject to multiple stressors, co-creating low ability to adapt to changing conditions and/or recover from shocks (Deressa et al., 2009; Di Falco et al., 2011; Ng'ang'a et al., 2016).

Particularly the negative impact of climate change in the Ethiopian rain-fed agricultural sector is one of the key challenges hampering the country's effort towards poverty reduction and food security. The vulnerability of rural women to climate change is even aggravated owing to the unequal resource access and their disadvantaged socio-demographic conditions. Many rural households and communities display low levels of climate change resilience (Connolly-Boutin & Smit, 2016; WB, 2013) and coping strategies often carry high costs, e.g. when households cut health and education expenditures, resulting in a vicious circle diminishing their buffer capacity and thereby their livelihood resilience over time (Seaman et al., 2014). Building resilience is pivotal towards achieving sustainable development and livelihoods (Berbés-Blázquez, 2017; IPCC, 2014; WB, 2013).

Recognizing the impacts of climate change, several adaptation initiatives have been implemented by the Ethiopian government, bilateral organizations and NGOs, as part of the commitment to build a climate-resilient green economy (CRGE, 2012). However, most of the adaptation strategies are developed using a top-down approach and often in a one size-fit-all manner neglecting the diversity in the perceptions, sensitivities and preferences of different social groups influenced by existing gender relations and intersecting with other variables.

Given the expected variation in their perception and vulnerability to climate change, different social groups are expected to have different adaptation preferences. Disregarding these gender-based differences in policy-making will lead to ineffective policies which might also further reinforce already existing inequalities. Hence adaptation strategies, for their successful implementation and adoption need to be context specific and gender transformative. Against this background, this research project was aimed in studying perceptions, and preferences regarding climate change, vulnerability and adaptation strategies in northwest Ethiopia.

1.2 Project Background

The idea of the project was mainly related to the growing awareness among the staff of the climate change research institute on the one hand and staff of the Gender and Development Studies on the other hand that there exists a mutually influencing relationship among 'gender' and 'climate change'. More specifically, gender influences people's perceptions, vulnerabilities and preferences related to climate change and adaptation, while at the same time climate change might also differently affect differently positioned individuals. From this vantage point, staff of both groups have realised the need for more cooperation among both groups of academics. The VLIR-UOS call for proposals was the trigger to start elaborating a research and outreach project together. The idea was also further boosted after the meeting with Ethiopian alumni at the Belgian Embassy in Ethiopia (March 10th, 2017) where the promoter of the proposal (Tewelde Gebremariam) had an informal discussion with Mr. Jozef Naudts (Deputy Head of Mission of the Belgian embassy to Ethiopia and Djibouti) who also brought the VLIR-UOS call to the attention of the alumni.

After the team identified specific potentially interesting ideas, also benefitting from previous research insights and contacts with local stakeholders, the project initiator contacted Prof. Dr. Nathalie Holvoet, who lectured gender and development issues while studying at IOB. After

frequent communication and clarification on the specific area of joint interest, outcomes, feasibility, and development relevance of the project, all the team members worked jointly with the support of N. Holvoet to develop this proposal. However, when submitted in 2017 the proposal was not successful. After reviewing the committee's comments, the team decided to rework the proposal and to address the issues raised by the committee. More specifically, the objectives have been improved as the committee judged them to be unrealistic (to reach in a two years' time span), beneficiaries have been more clearly identified, the plans that were too ambitious have been revised and the project now more clearly focuses on research & dissemination of findings.

Finally, the project idea was selected for funding by the selection committee of VLIR-UOS in 2019 with a total budget of €69,858.00.

1.3 Project Objectives

Overall project objective: The project aims at generating empirical evidence to contribute to development of evidence based and gender sensitive agriculture related climate change adaptation strategies for resilient rural development.

The project had three specific objectives:

1. Assessing perceptions with respect to climate change and analyze differences between female and male headed households
2. Examining vulnerability to climate change induced impacts and analyze differences between female and male headed households
3. Identifying agriculture-related adaptation preferences for the adoption of risk management practices and analyse the extent to which these are differentiated alongside gender and other variables.

1.4 Developmental Relevance

Major economic sectors in sub-Saharan Africa are highly vulnerable to climate change and climate variability, with huge economic impacts. Agriculture remains the economic mainstay of many countries in sub-Saharan Africa, employing about 60% of the workforce and contributing approximately 30% of gross domestic product (GDP) (Thornton et al., 2011). Ethiopia's economy is highly exposed to climate change and variability. Agriculture forms the

basis of the country's economy contributing about 40% of the GDP and employing 85% of the population (Byerlee et al., 2007). Climate projections for Ethiopia show continued warming, but very mixed rainfall patterns (Conway and Schipper, 2011). Ethiopia is extremely vulnerable to drought, floods, heavy rains, frost and heat waves (NMA, 2007). The greatest loss of life associated with drought in Ethiopia occurred in 1984, 1974 and 1973. In 2002, about 14.2 million people (over 20% of the total population) were affected by drought (World Bank, 2007). Again in 2011, the severe drought in the Horn of Africa affected nearly over 3 million people, mainly in Ethiopia. Whereas the negative impacts of climate change in Ethiopia are imminent and agricultural productivity and food security are already precarious, it is important that gender responsive climate change adaptation measures and policies form the core of all the development processes and be implemented at the local level.

Hence, gender responsive climate adaptation strategies are imperative to sustain the country's economic growth and human development. Ethiopia has taken a bold policy move on Climate Resilient Green Economy (CRGE) to accelerate its development, while minimizing its carbon footprint. The current Growth and Transformation Plan (GTP2) recognizes the importance of developing gender sensitive climate adaptation strategies. In this respect, this research project will support the national development policy (GTP2) of Ethiopia by supporting local communities and local administrators in their design and implementation of adaptation actions which are more gender sensitive, aimed at reducing vulnerability and building resilience. Moreover, the designed gender sensitive climate change adaptation strategies could also support the socio-economic empowerment of the women (52% of the population) in drought prone areas of Northwest Ethiopia. As a socially responsive institution, the University of Gondar has been taking initiatives to study climate change in the drought prone areas of Northwest Ethiopia, however, the existing researches are predominantly on the physical changes and the gendered impact of climate change is not given due emphasis. It is from this vantage point that the IOB research on climate change and gender that was previously done in Tanzania under the supervision of the northern promoter of this south initiative is particularly relevant and an important asset for the feasibility and successfulness of this project.

1.5 Link with the Vlir-UOS Country Strategy and Other Initiatives

Being focused on the major priority areas of the VLIR-UOS country strategy for Ethiopia, i.e.- Agriculture and Environment-with high transversal impact on gender and environment, this project clearly has a direct link with both the Ethiopian and the Belgian stakeholders' interests.

Likewise, the local research team is fully gender-sensitive itself (composed of male and two female senior scholars; the latter are among the few local female scholars) which also supports gender mainstreaming amongst university staff itself. The fact that the Belgian promoter is a female professor might also function as a role model for the Gondar university staff and authorities. Moreover, the VLIR-UOS country/Ethiopia strategy document emphasizes that "high quality teaching and learning is dependent on high quality research whilst the converse is equally true…" As the result, the development of high-quality research and outreach capacity building are priorities for Ethiopia and VLIR-UOS. Therefore, this South Initiative aims at conducting advanced research (knowledge production) with collaboration of a Belgian experienced professor and young researchers in the University of Gondar; and to disseminate the findings among relevant stakeholders for policy consideration and development interventions (outreach).

The VLIR-UOS country strategy also identifies the University of Gondar as a potential partner in capacity building in the areas of agriculture, environment, and gender. Thus, this multidisciplinary research and outreach project is contributing to the research and outreach efforts on poverty reduction and quality academic (education/research/outreach) achievement which are the two major priority areas of Ethiopia.

Directly related to this project, in Ethiopia there are Belgian organizations such as SOS FAiM, Caritas International and recent newcomers like BOS+.

1. This research project has clear complementary to the efforts of SOS FAiM (active in "supporting family farming in order to fight rural poverty and food security) as it is targeting a vulnerable group of the society with the intention of focusing on gender dimensions of climate change. By identifying gender sensitive adaptation strategies, the most vulnerable group of the society will substantially benefit. This can also be important for future collaborative interventions.
2. The presence of BOS+ in Northern Ethiopia is an asset for future collaboration, given its experience in a similar physical geography and the emphasis it puts on synergy, networking and exchange of expertise. Moreover, there is an overlap in the area of interest as BOS+ also focuses on climate change and environment.

2. METHODOLOGY

Climate change is likely to aggravate the problems of food insecurity, especially in developing countries which heavily depend on rain-fed farming systems. This usually disproportionately affects women who are confronted with a double or triple burden (increasing time to be invested in productive, reproductive and community roles) due to unequal resource access (being poor) and their disadvantaged socio-demographic conditions. Thus, this research project aims at generating empirical evidences to contribute to development of evidence based and gender sensitive agriculture related climate change adaptation strategies for resilient rural development. Evidence based adaptation strategies have proven crucial in changing and improving the adaptive capacity of the agricultural system and facilitating specific adaptations. In line with this, this research project is expected to generate empirical evidences to support the decision of development practitioners and policy makers to design and implement a gender sensitive climate change adaptation strategy. Such demand driven and system-based adaptation strategies are supposed to enhance the productivity of the women farmers through their condition-based resource utilization.

Thus, the immediate output of this project is the research findings that can be used for evidence-based gender sensitive adaptation strategies. The intermediate results (evidence-based interventions) will enable the target group to improve their adaptive capacity and enhance their productivity, and then improve their livelihood which is the expected impact of the project. To achieve this intended impact, a participatory research on drought prone districts of Northwest Ethiopia will be conducted. To assure the connection of the research outputs with the intermediate results, the findings will be disseminated through policy brief, workshops, local media, publications, and an international conference. Stakeholders including Belgian Non-Governmental Organizations contacted for possible synergy and complementarity will be involved in the envisaged conference where options for intervention based on the findings of this research will be sought.

The project has two major components: i) diagnosis and participatory designing of gender sensitive adaptation strategies; and ii) documentation and dissemination of the project outputs. The diagnosis phase involved examination of climate change perceptions, vulnerability and adaptation preferences of male and female headed household and analysis of underlying factors of influence.

Perception on climate change: To understand how differently positioned groups (men, women and taking into account intersections) perceive climate change, a set of indicators using 5-point Likert scale (strongly agree = 5, agree = 4, neutral = 3, disagree = 2, and strongly disagree = 1) were developed and used for data collection. As discussed in Olika B. et al (2015), using Likert scales is popular in assessing the perception of different groups within the community on climate change. After checking internal consistency (using reliability tests), average rankings for each respondent were used as a numerical value in multivariate analysis. Data analysis involved descriptive analysis and inferential statistics such as Chi-square test and Multivariate Analysis of Variance (MANOVA). Climate change perception of the respondents were assed based on four sets of indicators: i) perceived changes in climate variables such as sort and long rainy seasons rainfall amount and length, soil moisture, air moisture, and temperature ii) perceived frequency of climate change induced disasters and iii) the perceived frequency of the impacts of climate induced disasters.

The non-parametric Mann-Kendall (M-K) test was used to assess monotonic trend (linear or non-linear). It is the most widely used method since it is less sensitive to outliers, and it is the most robust as well as suitable for detecting trends in rainfall and temperature data (Gilbert, 1987). The M-K test is often combined with the Theil-Sen's method to determine the magnitude of rainfall and temperature trends. In this study, the time series data were pre-whitened prior to applying M-K statistical tests. Mann-Kendall's test checks the hypothesis of no trend versus the alternative hypothesis of the existence of increasing or decreasing trend. This trend test has been commonly used in similar applications (Gavrilov et al., 2016; Hirsch et al., 1982; Khalili et al., 2015; Pohlert, 2018; Tabari et al., 2014) and has been found to be an effective tool for identifying trends in climate and hydrological variables.

Vulnerability assessment: An intrinsic vulnerability index was applied to examine the degree of vulnerability of smallholder farmers to climate change in the three districts of North-western parts of Ethiopia. The indicators involved in this study to construct the intrinsic vulnerability index consist of two major contributing factors based on the new vulnerability assessment paradigm of IPCC 2014 report (i.e. sensitivity and adaptive capacity). The variables for each of the contributing factors in this study were selected from a review of recent published studies conducted in the Ethiopia and other countries with similar contexts (Ahsan & Warner, 2014; Carr et al.,, 2015; Deressa et al., 2008; Esteves et al., 2016; Mekonnen et al., 2019; Senbeta,

2009; Teshome, 2016a). In addition, IPCC's AR5 framework (IPCC, 2014) and reconnaissance survey results on socio-economic and bio-physical characteristics of the study districts were also used to select the indicators. Furthermore, some indicators were selected based on the knowledge and expertise of local community and stakeholders. The final list of indicators was selected through an iterative process (annex 1). For instance, indicators selected from literature were validated through consultation of experts in the districts. The vulnerability index in this study was estimated using CATPCA.

Nonlinear PCA has been suggested as a solution to the possible inappropriateness of applying linear PCA to categorical data when these variables may not fulfil the assumptions of linear relationships between variables and a measurement scale at least on the interval level (Costantini, Linting & Porzio, 2010; Linting, 2007; Linting, Meulman, Groenen & Van der Koojj, 2007; Meulman, Van der Koojj & Heiser, 2004). Hence, CATPCA was used to generated object scores across the principal components and thereby derive an index of vulnerability to climate change for each household in the three districts. In line with this, Dharmaratne and Attygalle (2018) pointed out that conducting a CATPCA is a dynamic process that require the researcher' active role in appraising results at each phase.

Normalization of indicators having decreased/negative functional relationship with climate risks was computed using the formula adopted by Esteves et al. (2016):

$$\text{Normalised value of IVI}_j = \left(\frac{\text{Maximum value of NSIVI}_j - \text{observed value of NSIVI}}{\text{Maximum value of NSIVI} - \text{Minimum value of NSIVI}}\right) \ldots\ldots\ldots\ldots (3.1)$$

Normalization of indicators having increased/positive functional relationship with climate risks was computed using the formula:

$$\text{Normalised value of N}_{ij} = \left(\frac{Observed\ X_{ij} - \text{maximum } X_{ij}}{\text{Maximum } X_{ij} - \text{Minimum } X_{ij}}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.2)$$

where *Nij* is the normalized value of the indicator *i* at the study district *j*, Observed *Xij is* the actual value of the indicator *i*, at the study district *j*, Maximum *Xij* is the maximum value of indicator *i* and minimum *Xij* is the minimum value of indicator *i*.

All indicator values were transformed into a relative score ranging from 0 to 1, where higher values imply high vulnerability (Esteves et al., 2016). This implies that a positive sign indicates high indicator values which increase the vulnerability, while low values decrease the

vulnerability and vice versa. The next procedure was to compute normalised squared component loadings of variables using:

$$\text{Normalised squared component loadings of variable i} = \frac{(\textit{Component loading of variable i})^2}{\text{Variance explained by component j}} \ldots. (3.3)$$

Then, the intermediate composite indicators were aggregated by attaching a weight which is equal to the percentage of explained variance in the dataset. The percentage of explained variance was calculated using equation (3.4) following Dharmaratne and Attygalle (2018).

$$\text{Proportion of variance explained by the } j^{th}\text{component} = \frac{\text{Variance explained by } j^{th} \text{ component}}{\text{Total variance explained by all components}} \ldots (3.4)$$

The final index was then calculated using:

$$\text{Weight of the variable i} = C_j * NL_i \ldots \ldots (3.5)$$

Where,

C_j is the component weight of the j^{th} factor

NL_i is the normalized squared factor loading of variable i.

Therefore, Standardized Vulnerability Index was constructed using the Equation (3.6) following Terence (2013) and Rajesh et al. (2018).

$$SIVI_j = \sum_{i=1}^{n} W_i(C_{ji} - X)/STD \ldots \ldots (3.6)$$

Where,

$SIVI_j$ represents standardized intrinsic vulnerability index for household j, W_i represents the weight of the i^{th} variable, and n is the total number of factors resulting from factor analysis. C_{ji} represents the object score coefficient of household j for factor i whereas X represents the mean indicator value and STD is the standard deviation of the indicator. To quantitatively assess the overall vulnerability index, a CATPCA with 40 indicators was run using SPSS 25. Low values representing higher degree of vulnerability for that indicator whilst high values, implying otherwise (Esteves et al., 2016).

Last but not least, intersectionality of gender with resource endowments and other socio-demographic indicators was analysed using Venn-diagram scoring and participatory ranking approach to determine how these interactions produce complex and unexpected effects on adopting gender sensitive and climate smart agricultural policies.

Adaptation preferences: To identify adaptation strategies that are gender sensitive in light of gendered adaptation preferences, men and women were interviewed separately to capture the order of their preferences from the most preferred to the least preferred. This was done using Rank Ordered Logit model which can best capture gender sensitive adaptation preferences compared to other econometric models. Using STATA 14 statistical package, Odds ratio, 95% C.I, and p-values were used to report the regression results. Besides, prior to running the above specified model different diagnostic tests were done; particularly model fitness via Hosmer and Lemeshow test, multicollinearity, and sample size sufficiency.

Participatory designing of gender sensitive adaptation strategies: in this phase, a stepwise participatory designing approach was used. The local community had central positions and interactions. This interaction involved both using the knowledge and preferences of the local community to design gender responsive strategies. Here, separate meetings and discussions were held with experts and male and female interviewees to design gender responsive adaptations strategies from existing long lists of possible adaptation strategies.

Documentation and dissemination: knowledge and other innovative tools of the project are documented and being shared with different audiences, including the local communities (male and female headed households of targeted drought prone areas in Northwest Ethiopia), development practitioners and policy makers as well as the scientific community.

2.1 Case Selection and Sampling Procedure

In terms of study areas, the aim was to cover all vulnerable districts of Northwest Ethiopia to explore major vulnerable groups. Here the vulnerable districts are those that are food insecure, lack effective coping and gender responsive adaptation strategies to deal with the shocks and stresses of climate change. Additionally, study areas are carefully selected to represent diverse agro-ecology realities and experiences in dealing with the changing climate. Accordingly, 3 drought prone districts were selected purposely for the above reasons. From these districts, a total of 1620 samples were selected using stratified sampling techniques considering gender and different agro-climatic zones. Key Informant Interviews and Focus Group Discussions were also be included to ensure representation of other key stakeholders (i.e. policy makers, extension workers, NGOs, and others) of the drought prone community of Northwest Ethiopia; and to enrich and triangulate the data.

Sample size: The sample size determination formula of a comparative study was used. The sample size was determined with a 95% confidence interval, 80% power, 4:1 ratio, and giving a 10 percentage of exposure to the control group (in this study female respondents). Thus, the sample size calculated was 900 (720 male household heads, and 180 female household heads). To make a comparison between the female household heads and the female in the male headed households, 720 female in the male headed households were included; and a total of 1620 sample was used in the study (Table 1).

Table 1: Sample distribution among the study districts and population groups

District	***Target population***			***Total sample***
	Male head	Female in the male headed hhs	Female head	
East-*Belessa*	356	356	90	802
West-*Belessa*	229	229	57	515
Dabat	134	134	35	303
Total				1620

Sampling procedures: The study employed a multi-stage sampling procedure. The primary sampling units were districts in the zone. Of the 20 districts in the zone, seven districts were identified as drought prone. From these seven districts, three districts (i.e. East-*Belessa,* West-*Belessa* and *Dabat*) were purposively selected based on their climate change vulnerability and agro-ecological representation.

In the secondary sampling unit, from the identified drought prone districts, three *kebeles* were selected randomly depending on the size of the randomly selected *kebeles*. Finally, the required sample size was allocated to these selected *kebeles* proportionate to their sizes; and the respondents were selected via systematic random sampling (see Figure 1). The safety net member residents' household lists of each randomly selected kebeles were used to develop a sampling frame of the households.

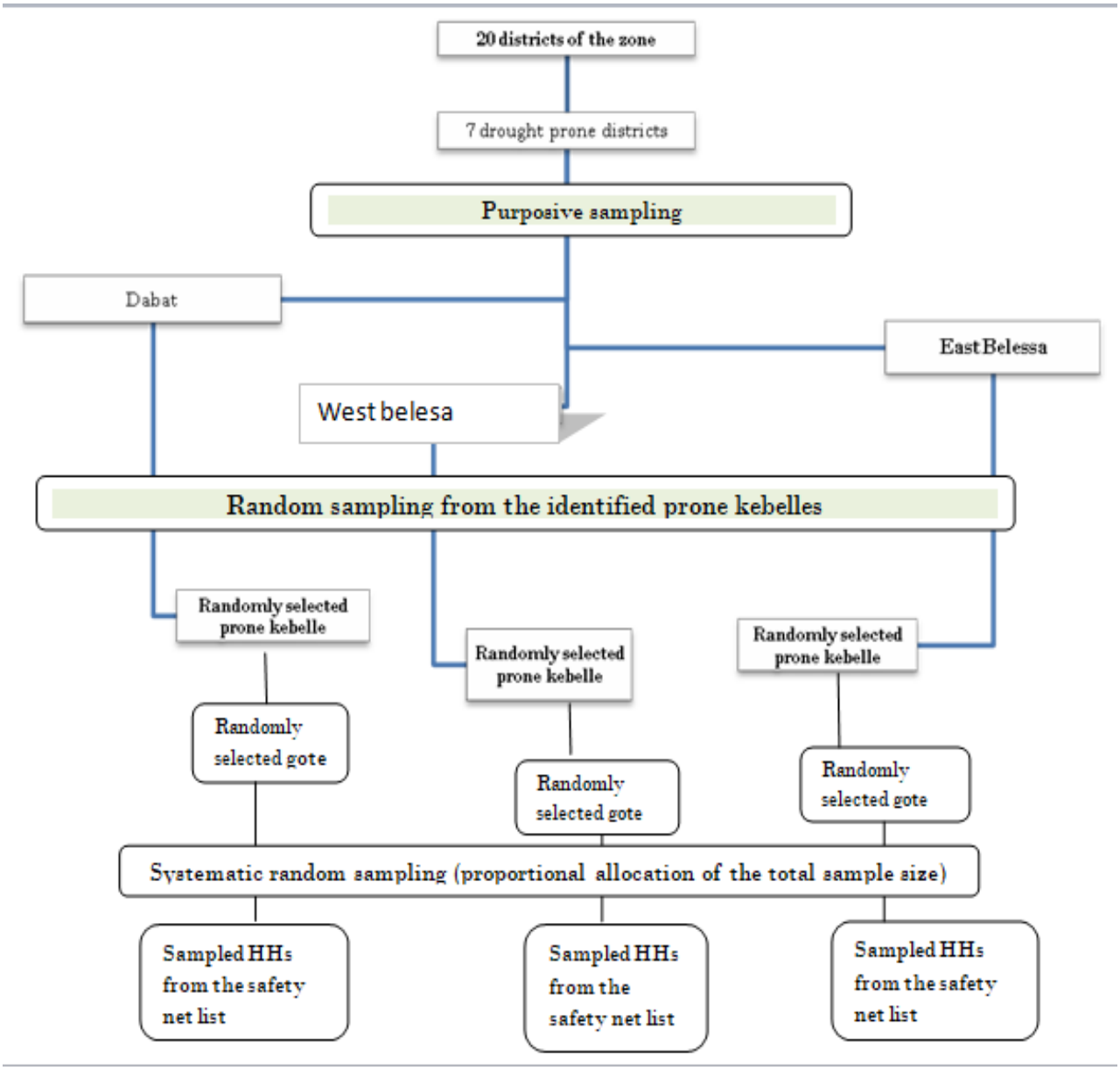

Figure 1: Graphical representation of the quantitative sampling procedure

2.2 Study Area Description

In order to comprehend to what extent gender and marital status intersect in determining the level of vulnerability of smallholder farmers in Northern parts of Ethiopia, *Dabat* district/highland agro-ecology, *Mirab Belessa* district/midland agro-ecology and *Misrak Belessa* district/lowland agro-ecology were chosen. These districts are located in the Northern parts of Ethiopia characterised by three different ago-ecologies (i.e. highland, midland, & lowland agro-ecologies). The geomorphological setup of the three districts is by large rugged and mountainous which is prone to extreme climate shocks. The three districts have a mean annual rainfall ranging between 1110mm to 980mm (92% received during summer season),

and an average annual temperature ranging between 22^0C to 34^0C. According to the information retrieved from the North Gondar Zone Agriculture and Rural Development Bureau (NGZARDB), the topographies of the study areas are characterized by mountains (69 %), valleys (16.8 %) and plain land (14.2 %) (NGZARDB, 2019). The major crops grown in the highland agro-ecology include barely, wheat, finger-millet while the lowland and midland have grown sorghum, teff, maize and sesame.

The study districts for this assessment were selected considering the dominance of rainfed agriculture and for that reason the study areas are among the 48 districts out of 169 in Amhara national regional state that are frequently affected by extreme climate shocks (USAID, 2000).

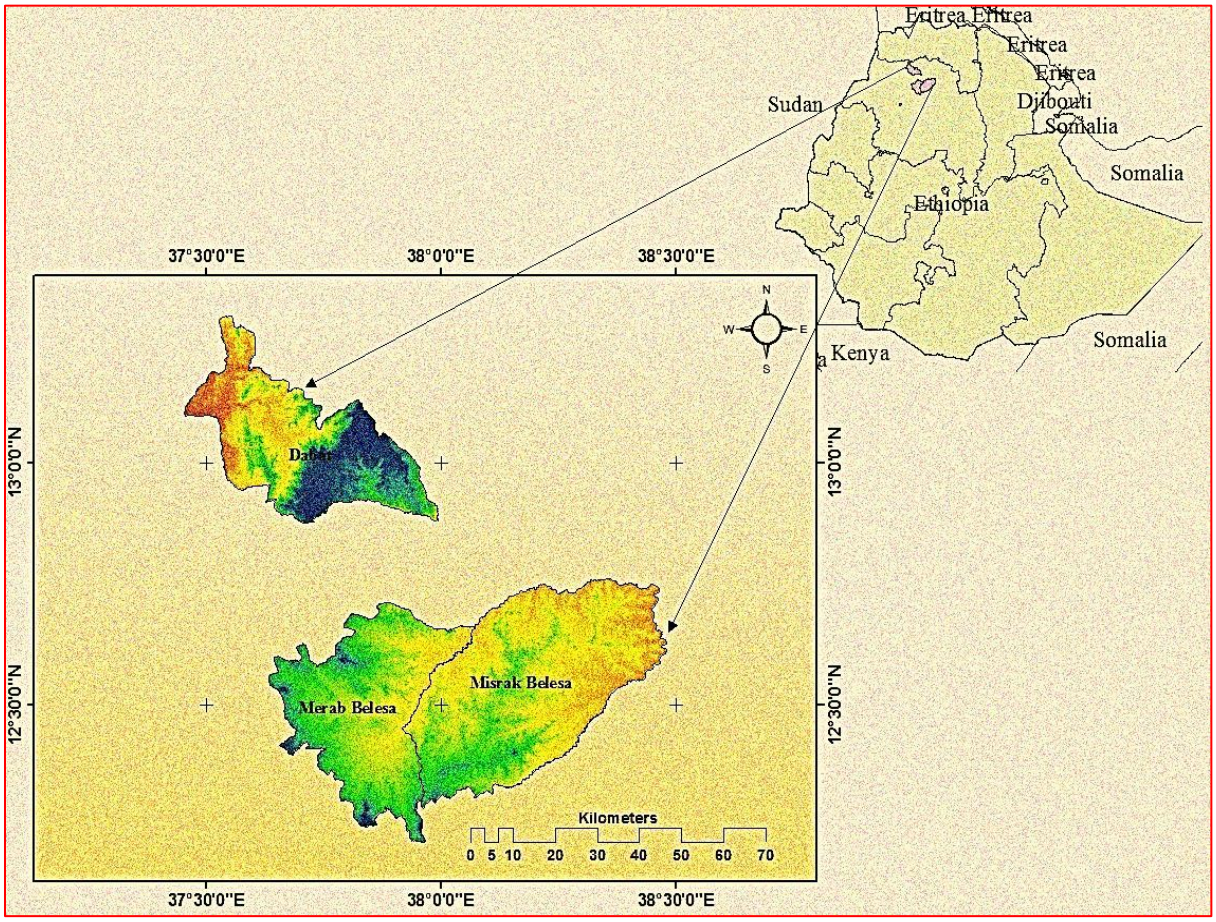

Figure 2: Location map of the study areas in North-western Ethiopia (extracted from Ethio-GIS database)

3. SUMMARY OF KEY ACHIEVEMENTS DURING THE REPORTING PERIOD

In this section, the objectives that the project aims to achieve and the progress made in achieving/contributing to the realization of the outputs and outcomes as specified in the Logical Framework Matrix and the main activities that were implemented during the reporting period are summarised as follows.

3.1 Activities Accomplished

Table 2: List of activities accomplished

No.	List of activities done	Time frame	Progress
1	**Proposal development**: A multidisciplinary team of researchers (Economist, Gender studies expert, Public Policy researcher) was drawn from University of Gondar and University of Antwerp. The team has developed the full pledged proposal as per the ToR of VLIR-UOS program.	June - December 2018	Completed
2	**Action plan development**: After making sure that the proposal was selected for funding, the team has developed working packages and action plan by prioritizing activities of the research project.	March 2019	Completed
3	**Reconnaissance survey**: Trip to *Dabat*, East *Belessa* and West *Belessa* was organised to collect preliminary socio-economic and biophysical profiles of the study districts and the number and location of samples/sample frame, and to recruit field assistants at each district. During the survey, targeted villages and households were identified; Sampled districts were characterised in terms of their agro ecologies. Areas affected by recurrent droughts were visited. The types of physical and biophysical soil and water conservation practices on the farmland were also observed.	April 2019	Completed
4	**Discussion with focal persons at district level:** In-depth discussion were organised on general and specific aspects of the study areas with focal persons at district level. Some of the topics discussed include gender equality in terms of access to and control over resources, level of vulnerability of smallholder farmers to climate change in those districts, type of physical and biological adaptation strategies, stakeholders involved, and others.	April 2019	Completed
5	**Key informant interview:** Interview checklists were prepared and dispatched to 25 key informants at district level to get baseline impression for the development of survey instruments. Some of the topics raised during the interview include perceptions of experts about the socio-economic and ecological responses of climate change, and gender-sensitive adaptation strategies	April 2019	Completed
6	**Secondary data collection:** After **i**dentifying the source organisations for secondary data, we fetched: 1. Climate data (daily rainfall, min and max temperature data) from National Meteorological Agency of Ethiopia, Addis Ababa 2. Other relevant socio-economic data of *Dabat*, East *Belessa* and West *Belessa* were collected from each district's communication offices. 3. Hard copies of socio-economic assessments and other studies of climate change and gender issues were collected at *Bahirdar*.	May 2019	Completed

7	**Research Materials Acquisition:** One Laptop and 4 Tablets were purchased to facilitate and organise research works effectively and efficiently. Project office is supplied by University of Gondar to coordinate and document the research activities.	February to May 2019	
8	**Tool development:** After reviewing the reconnaissance survey, the baseline data, related literatures, and consultation with key informants, the team has developed field survey tools/instruments. The questionnaires are carefully designed and validated by the team of experts through long iterative process and pilot.	May to August 2019	Completed
9	**Sampling procedure is determined**: We determined the sample size and sampling techniques.	August 2019	Completed
10	**Reviewing and revising methodological framework**: The team critically reviewed related literature to revise the methodological framework of the study as discourses and narratives of scientific methodologies are increasingly becoming dynamic and advanced.	May to August 2019	Completed
11	**Survey Data collection:** Data was collected by recruiting 27 staffs from University of Gondar and experts from *Dabat*, East *Belessa* and West *Belessa* districts as enumerators. Kobo Toolbox was installed in each Tablet and other Android Phones to collect data. Enumerators were trained on how to administer and manage the software. We used this tool for three main reasons: • Data does not need to be transcribed from paper to computers before it can be analysed. Some analyses can be applied within minutes of the data being collected. We simply, exported the data into STATA 14. • It is much more accurate**.** Enumeration errors are minimised because of the data validation that can occur in real time as data is collected. Transcription errors are entirely eliminated. • It works offline, is easy to use (requires no technical knowledge to manage and enumerators can be trained within minutes), and can be rolled out rapidly in even the harshest or remotest situations.	September to October 2019	Completed
12	**Establishment of Database:** Database is established which can be used for graduate students and other researchers interested to work on Gender and Climate change related issues with permissions from VLIR-UOS.	November 2019	Completed
13	**Trip to Belgium:** Local team members travelled to Belgium to organise encode and analyse the data which was collected in the study areas. Local team members under the close supervision of Prof. Nathalie were able to produce draft results of the research.	October to November 2019	Completed
14	**Drafting intermediate results and drafting manuscripts:** All the pieces of results from every one of the team members were organised and compiled in a more comprehensive and scientific way at *Bahirdar*, the regional capital, in addition to drafting the manuscripts we already promised to publish as per the Logical Framework Matrix.	August 2021	Completed
15	**Final Project report write up**: In order to write the final report of the project, team members organized retreat time at *Bahirdar* for 20 days and compiled the final document.	September 2021	Completed
16	**One MSc dissertation:** A dissertation titled ***'Intrinsic vulnerability of rural farming households to climate-induced shocks and its intersectionality with marital status: Evidence from smallholder farmers in Northwest Ethiopia'*** was produced by Dereje Amene under supervision of Prof. dr. Nathalie Holvoet	September 2020	Completed
17	**Manuscripts Submissions:** Two manuscripts are finalized and submitted to journals. Proof of submission is annexed in this document. The articles are titled as:	December 2021 to	Completed

	1. Assessing climate change vulnerability of smallholder famers in Northwest Ethiopia: application of an intrinsic vulnerability index (submitted to International Journal of Climate Change Strategies and Management) 2. Unpacking the invisible complex realities: Intersections of gender and marital status in determining the intrinsic vulnerability of smallholder farmers to climate change in north-western Ethiopia (submitted to Climate and Development journal)	February 2022	
18	**Working on two more manuscripts:** Team members are working on two more articles: 1. Complementarities of experiences and measurements: analysis of local farmers' perceptions and observed changes in climate variables in Northwest Ethiopia. 2. Gender differentiation of smallholder farmers' preferences for adaptation strategies.	February 2022	In progress
19	**Dissemination of outputs through a workshop:** Two days' workshop on August 28 to 29/2022 was organized. The workshop participants were representatives of smallholder farmers from Dabat district (i.e. male household heads, female household heads, and women within male headed household), project team members, concerned administrative officials from the district and the province, representatives from University of Gondar, and journalists from the local medias. The main objective was to present main findings of the project, and to have a shared understanding of the key strategic interventions such as possibility of mainstreaming gendered adaptation preferences into programs and projects, economic empowerment of divorced women, and other issues.	August 28 to 29/2022	Completed
20	**Dissemination of outputs through conferences:** We presented two papers in annual research conferences organized by University of Gondar.	May 26/2022	Completed

3.2 Outputs of the project in Logical Framework Matrix

Table 3: Progress Achieved Compared to Indicators in the Logical Framework Matrix of the Project

LOGICAL FRAMEWORK MATRIX									
I. General Objective (GO)		**Objectively Verifiable Indicators (OVI)**	**Source of Information**	**PLANNING**		**MONITORING**			
				Baseline value	**Target value**	**Value year 1**	**Value year 2**		**Final value**
To contribute to evidence based and gender sensitive agriculture related climate adaptation strategies for resilient rural development.		Number of articles published to international peer reviewed journals and policy paper produced	Publishers website, the project coordinating office	0	3	0	3		3
II. Specific Objective(s) (SO)		**Objectively Verifiable Indicators (OVI)**	**Source of Information**	**Baseline value**	**Target value**	**Value year 1**	**Value year 2**		**Final value**
To examine the extent of variation in perception, vulnerability, and agriculture-related adaptation preferences to climate change from a gender and intersectionality perspective		Number of articles submitted to international peer reviewed journals	The project coordinating office, reports, journal websites	0	2		2		2
		Number of articles submitted to national peer reviewed journals	The project coordinating office, reports	0					0
		Number of working/technical papers	The project coordinating office, reports	0	1		1		1
To document and disseminate the research findings to local communities, development practitioners, policy makers and scientific community so as to promote uptake the findings for future intervention.		Number of policy papers developed	The project coordinating office, reports	0	1		1		1
		Number of workshops organised	The project coordinating office, reports	1	1		1		1
		Number of presentations at annual research conferences	The project coordinating office, reports	0	1		2		2
III. Intermediate Results (IR)		Objectively Verifiable Indicators (OVI)	Source of Information	Baseline value	Target value	Value year 1	Value year 2		Final value
IR 1	Empirical evidences for the design of gender (& intersectionality) sensitive climate change	Number of technical reports on gendered & intersectionality related variations in perceptions, vulnerability and	Progress report, Technical reports	0	2		2		2

	adaptation strategies generated	agriculture-related preferences							
		Database on gendered perceptions, vulnerabilities and agriculture-related adaptation preferences.	Data base	0	1		1		1
IR 2	Adaptation strategies designed that take into account differences among gender & intersections	Number of technical reports on design of adaptation strategies	Progress report, technical reports	0	1		1		1
IR 3	Research findings documented and disseminated to community members, policy makers, practitioners, academics, and alumni using meetings, conference, workshops, local media and publications	Number of workshops	The project coordinating office, reports	0	1		1		1
		Number of conference proceedings (full paper)	The project coordinating office, reports	0	1		2		2
		Number of community meetings	The project coordinating office, reports	0	1		1		1
		Number of citations in local media	The project coordinating office, reports	0	1		1		1
		Number of policy briefs	The project coordinating office, reports	0	1		1		1

3.3 Challenges Encountered during project implementation and Actions Taken

During the implementation process, the research team experienced a number of challenges related to issues, including outbreak of Covid-19 pandemic, national instability and to some extent over expectation of target groups from the project. Even though the research team was able to manage most of the routine activities of the project, it was delayed for almost a year as a result of those challenges mentioned above.

With the expectation of some form of payments/subsidies/interventions, the project team members were able to brief and convince target groups. Prior to data collection, the team members were able to persuade them that the project is important for further policy decisions and development efforts.

With regard to outbreak of Covid-19 and instability problems, virtual meetings were arranged frequently to discuss about our paper works and assignments.

4. RESEARCH FINDINGS

4.1 Introduction

This section analyses the perception, vulnerability, and agriculture-related adaptation preferences among male and female headed households in Northwest Ethiopia. The first section analyses changes in climate variables using Mann-Kendall and Sen's slope estimator statistical tests. Section two presents smallholder Farmers' perception on climate change. Section three presents intrinsic vulnerability assessment at household and agro-ecology level while section four presents agriculture-related adaptation preferences among male and female headed households. Section five discusses about the pair-wise matrix ranking of adaptation strategies.

4.2 Analysis of Changes in Climate Variables using Mann-Kendall and Sen's Slope Estimator Statistical Tests in North-western Ethiopia

This section discusses the current rainfall and temperature variability and trends in North-western Ethiopia for the period 1980-2018. In order to detect increasing or decreasing trends and magnitudes of both rainfall and temperature, the non-parametric test was employed and presented as follows.

4.2.1 Annual and Seasonal Rainfall Trend Analysis

Temperature and rainfall are two of the most important variables in the fields of climate sciences (Chattopadhyay & Edwards, 2016). The implications of changes in rainfall and temperature make it crucial for climate policy makers and planners to accurately map whether climate change is in place or not. That is why this study starts the analysis by looking at the trend of the two climate variables in North-western parts of Ethiopia. Trend analysis was conducted using the Mann-Kendall non-parametric statistical test for trend, since it has been successfully used in other similar studies (Addisu, Selassie, Fissha, & Gedif, 2015; Bekele, Mosisa & Terefe, 2017; Longobardi & Villani, 2001; Mulugeta, Fedler & Ayana, 2019) as originally recommended by Kendall (1975) and Mann (1945). Accordingly, the results of the trend analysis of seasonal and annual rainfall over the study areas show no statistically significant trends with respect to time (at 0.1, 0.5 and 0.01 significance level). The trend is clearly first decreasing and then increasing and thus the trend is neither linear nor monotonic (Table 4).

Table 4: Trends of annual and seasonal rainfall total in the three agroecological zones of northwest Ethiopia.

Station name	*Annual*		*Summer*		*Autumn*		*Spring*		*Winter*	
	Z	Slope	Z	Slope	Z	Slope	Z	Slope	Z	Slope
Dabat	-0.70^{ns}	-4.54	0.00^{ns}	-0.39	-0.95^{ns}	-1.51	-2.29*	-3.25	0.03^{ns}	0.00
Mirab Belessa	-1.30^{ns}	-7.51	-2.26*	-3.78	0.07^{ns}	0.29	0.07^{ns}	1.61	-0.83^{ns}	-0.24
Misrak Belessa	0.00^{ns}	-0.23	-0.72^{ns}	-8.76	0.00^{ns}	1.50^{ns}	0.54^{ns}	5.83	-0.54^{ns}	-0.40

Z stands for Mann–Kendall trend test, Slope refers to Sen's slope value; ns denotes non-significant trend while +, * and** represents significant trend at 0.1, 0.05 and 0.01 significance level respectively.

Based on seasonal scale, however, spring rainfall had decreased by 3.25mm in the *Dabat*/highland agro-ecological zone while summer rainfall trend of *Mirab Belessa*/midland agro-ecological zone decreased by 2.26mm (significant at 0.05). The findings further illustrate both statistically non-significant decreasing and increasing trend of summer, autumn, spring and winter rainfall over lowland agro-ecological zone. The findings further exhibit that the magnitude of the rainfall trend was lowest for the winter rainfall benefiting areas over the three districts.

Figure 3, 4, & 5 reveal a more thorough description of the data for the three districts in addition to the computed trend slope with 95% confidence limits. While it must be noted that the homogenization tests admit the possibility of a series with very low variability about a relatively large trend slope failing the tests, this appears not to have happened in this case.

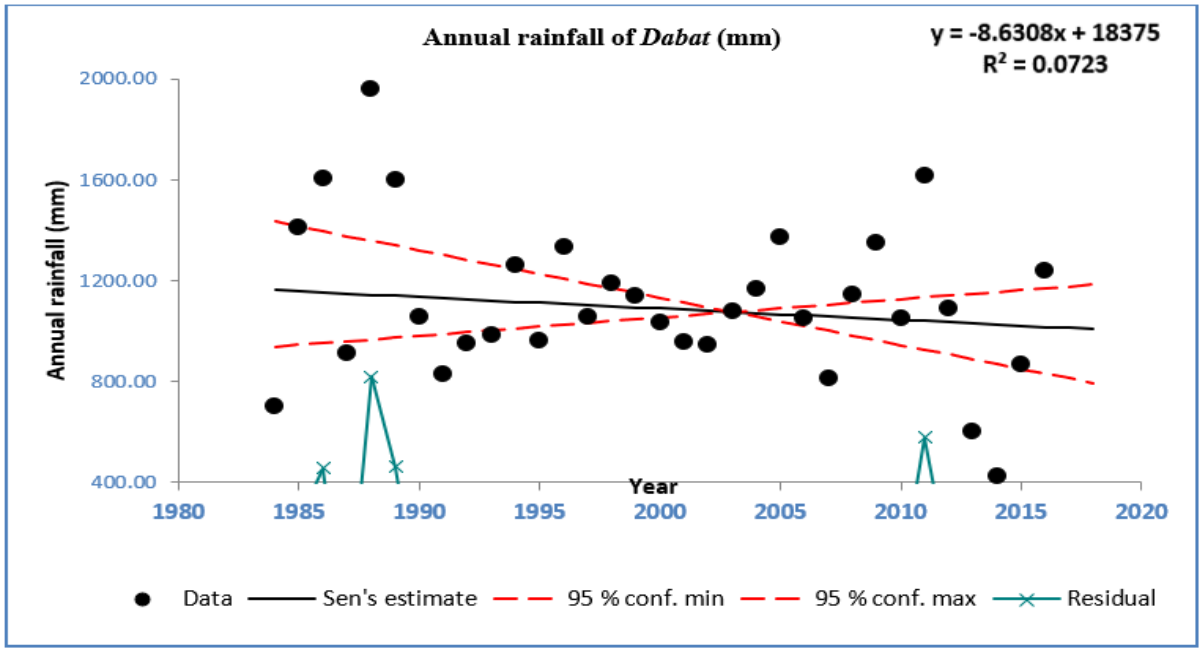

Figure 3: Annual rainfall with Sen Slope estimates for *Dabat*/highland agroecological zone.

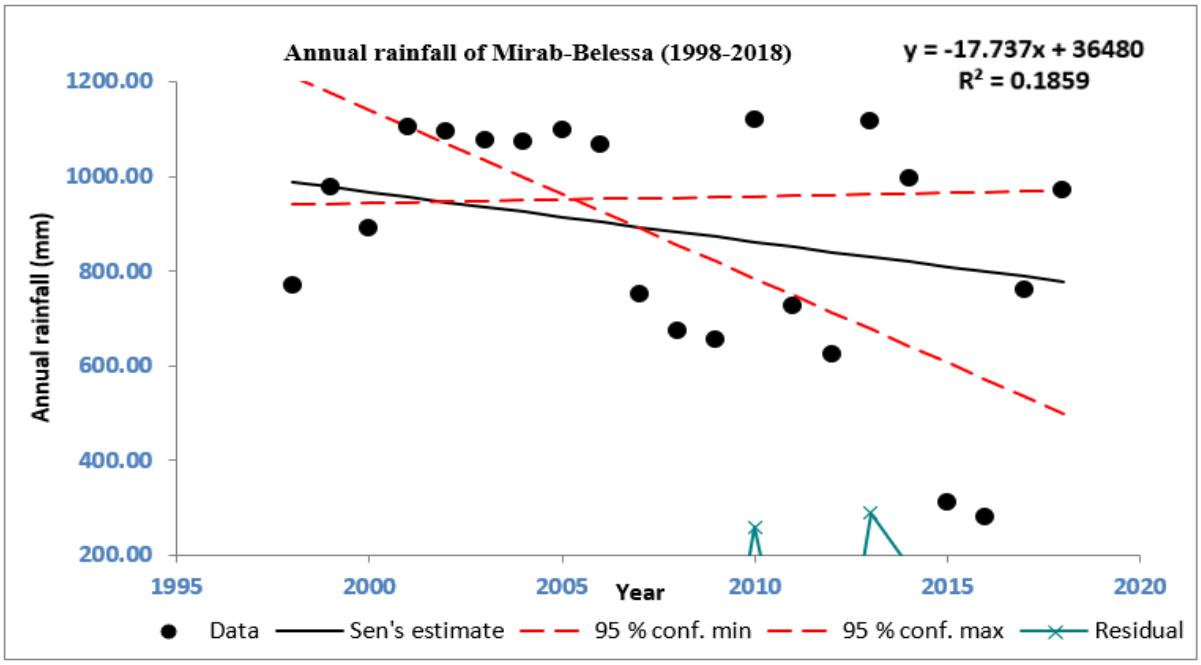

Figure 4: Annual rainfall with Sen slope estimates for *Mirab Belessa*/midland agroecological zone.

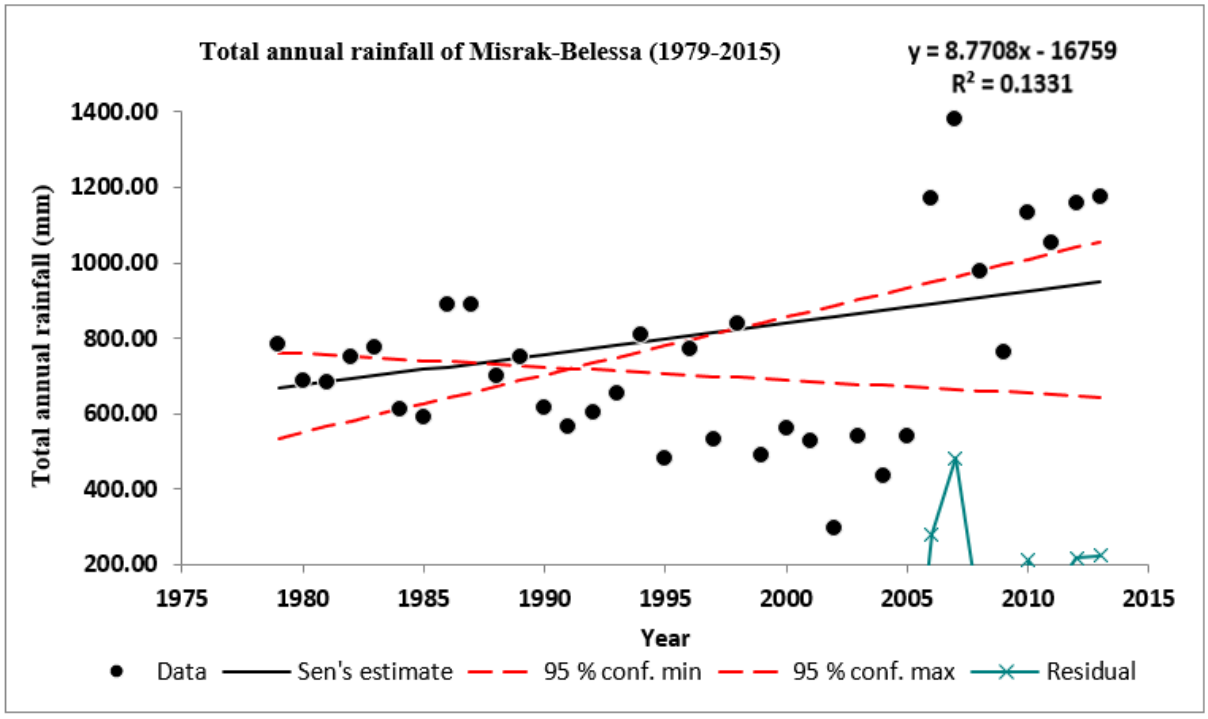

Figure 5: Annual rainfall with Sen Slope estimates for *Misrak Belessa*/lowland agroecological zone.

The computed p-value is greater than the significance level α=0.05 which is indicative of the fact that there is an insignificant decrease and increase of the rainfall trend. However, this does not imply that a climate change shock was not in place; rather, it shows a highly irregular and erratic rainfall over the study areas.

It is difficult to compare the result of this study with previous similar studies due to difference in space, source and time reference of the data, as well as methods of trend analysis and data pre-processing methods. However, the findings of our study seem consistent with Bekele et al. (2017) which report annual and inter-annual rainfall variability and a decreasing rainfall trend over the South-eastern highland parts of Ethiopia. Along the same lines, a study conducted by Mulugeta, et al. (2019) in the Awash river basin of Ethiopia report that the annual rainfall has consistently shown no trend over the basin, indicating that the risk of droughts in the basin may be related to the seasonal distribution of rainfall. On the other hand, a study conducted by Addisu, et al. (2015) over Lake Tana sub-basin of Ethiopia demonstrates that the mean temperature had a general increasing trend which is consistent with the finding of this study (see below) whereas, a contrasting result is reported with respect to rainfall trend showing a general decreasing trend in Lake Tana Sub-basin.

4.2.2 Annual and Seasonal Temperature Trend Analysis

Average annual and seasonal temperature trend was analysed across the three districts using the same technique applied to the rainfall data. Accordingly, the mean annual and seasonal temperature data have been stated in Table 5. The Sen's slope value of both mean annual and seasonal temperature trend exhibits a positive value implying an increasing trend across the three districts. The changes in mean annual temperature are significant in *Mirab Belessa*, *Misrak Belessa* and *Dabat* at 0.05, 0.01, and 0.05 significance level respectively.

Table 5: Trends of average annual and seasonal temperature trends in the three agroecological zones of Northwest Ethiopia.

Station name	***Annual***		***Summer***		***Autumn***		***Spring***		***Winter***	
	Z	Slope	Z	Slope	Z	Slope	Z	Slope	Z	Slope
Dabat	2.19*	0.07	2.16*	0.07	2.28ns	0.077	2.25*	0.06	2.46*	0.09
Mirab Belessa	1.68*	0.09	1.07ns	0.1	1.97*	0.08	1.07ns	0.07	2.18*	0.14
Misrak Belessa	2.21**	0.14	1.65**	0.08	2.03*	0.09ns	1.32ns	0.04	2.38*	0.18

Z stands for Mann–Kendall trend test, Slope refers to Sen's slope value; ns denotes non-significant trend while +, * and** represents significant trend at 0.1, 0.05 and 0.01 significance level respectively.

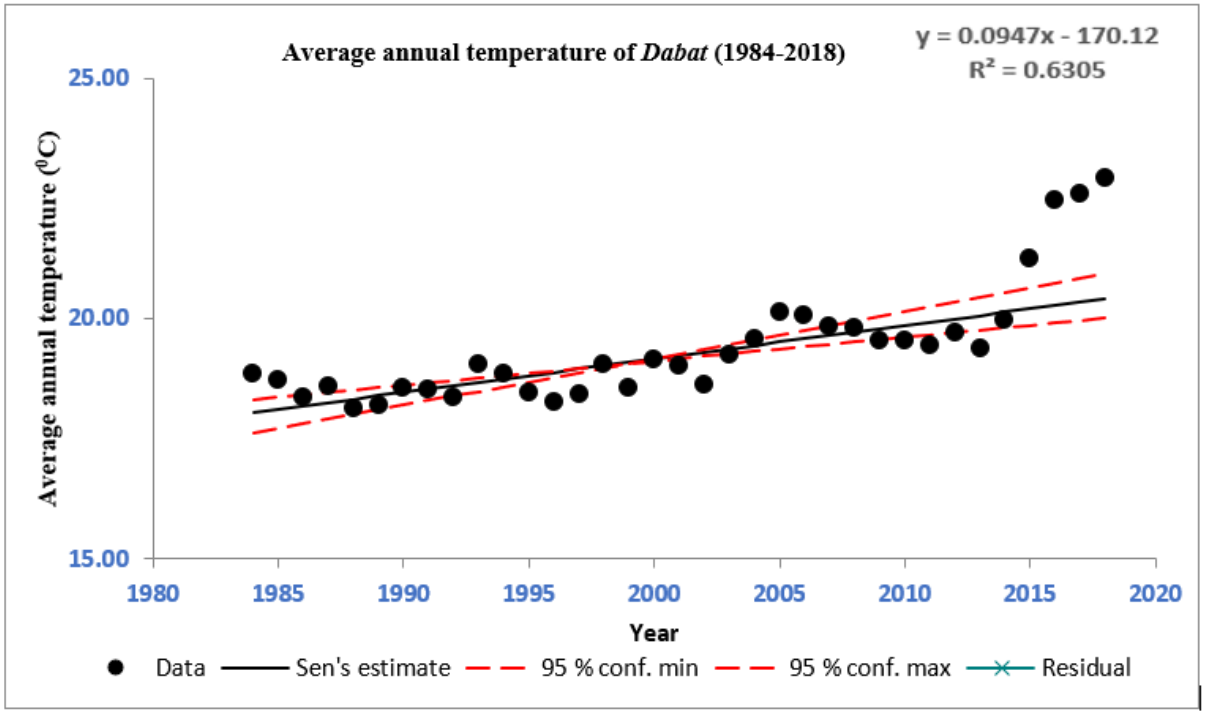

Figure 6: Average Annual temperature trend with Sen*'s Slope* estimates for Dabat/highland agro-ecological zone.

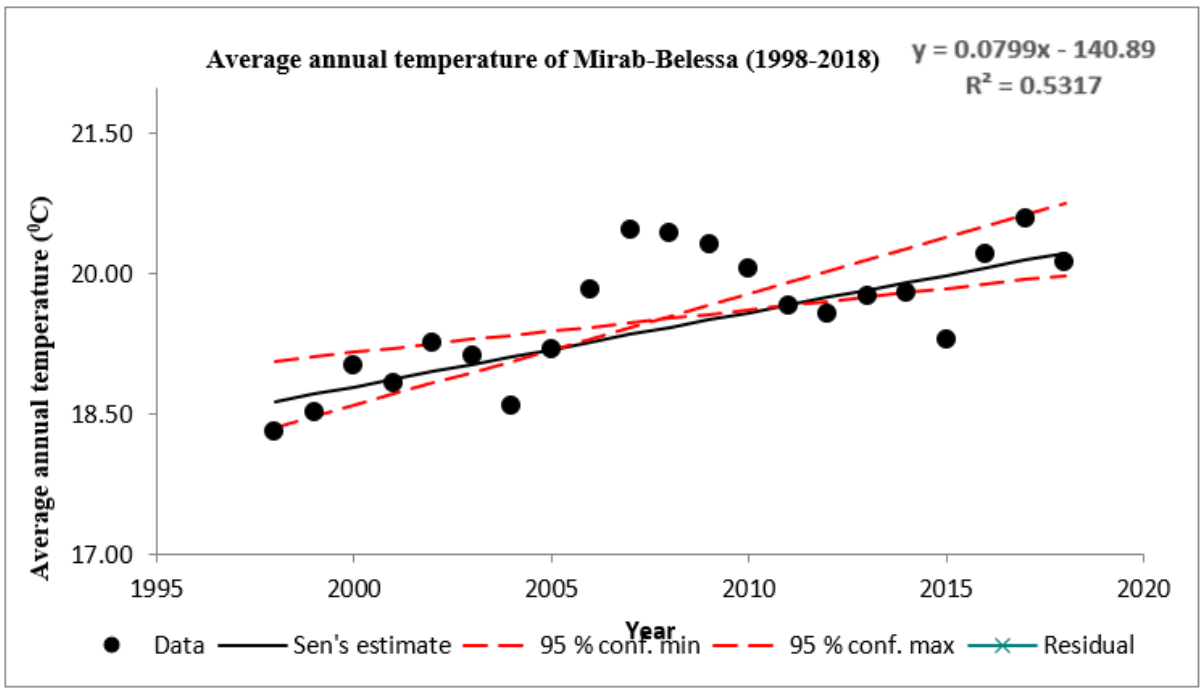

Figure 7: Average Annual temperature trend with Sen's Slope estimates for *Mirab-Belessa*/midland agro-ecological zone.

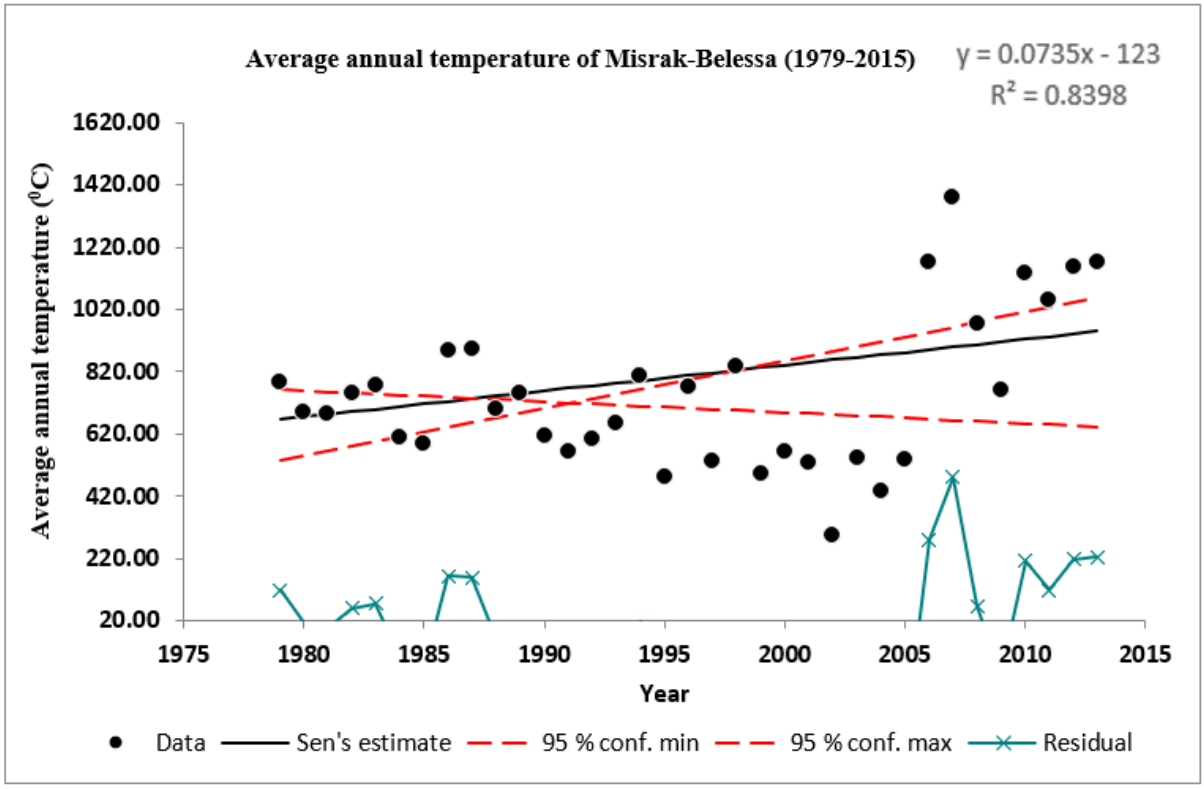

Figure 8: Average Annual temperature trend with Sen's Slope estimates for *Misrak-Belessa*/lowland agro-ecological zone.

As can be seen from the figures above (i.e., Figure 6, 7, & 8), a fitting of Sen's slope lines reveals an increasing trend. The time series, along with the linear trend line were graphically characterized for the average annual temperature in each of the districts.

The results elucidate that average annual temperature in the three districts generally demonstrates statistically significant trends with respect to time. As confirmed by Smadi (2006), the increasing trends in temperature have been related to several factors such as global warming, increased concentrations of anthropogenic greenhouse gases, aerosols which exert cooling effects on the climate, increased cloud cover and urbanization. Consistent with the result of this study, a nation-wide temperature trend analysis by NMSA depicts an increase of 0.37^0C per decade (NMSA, 2007). In addition, a similar conclusion has been confirmed by Addisu et al., (2015), Chattopadhyay and Edwards (2016), Tabari, Somee and Zadeh (2011).

4.3 Smallholder Farmers' perception on Climate change: a Case Study of Drought Affected districts in North-western Ethiopia

Perception of local community on the prevailing climate change and its impacts shape the adaptation behaviour and strategies (Adger et al., 2009; Pauw, 2013). Hence, understanding local perceptions of climate change provides an insight on the local contexts and information relevant to policy making for adaptation to the perceived climate change impacts among the rural community.

This study, therefore, examines the perception of smallholder farmers on climate change and analyzes and explains the perception differences between female and male headed households in the study districts. Specifically, this section specifically addressed the following four research questions: i) How does rural households in the study areas perceive climate change? ii) How does climate change perception vary across gender and agro-ecologies? iii) What determines the inter-household and intra-household variation in climate change perception? and iv) Are the perceptions by the rural community consistent with the observed metrological data? (Do the local perceptions reflect what is measured?).

4.3.1 Information access on climate change

Of the entire sample of respondents, about 37.2 % of the respondents heard about climate change from different sources such as from agricultural experts, extension agents, local leaders, mass media and neighbours. Exposure to climate change information varies greatly with gender as depicted by 52% of the male respondents having information as compared with only 24 % of the female respondents who have heard about climate change (Figure 9). Among the female respondents, female household heads (26%) have relatively better climate change information access than the women within the male headed households (23%).

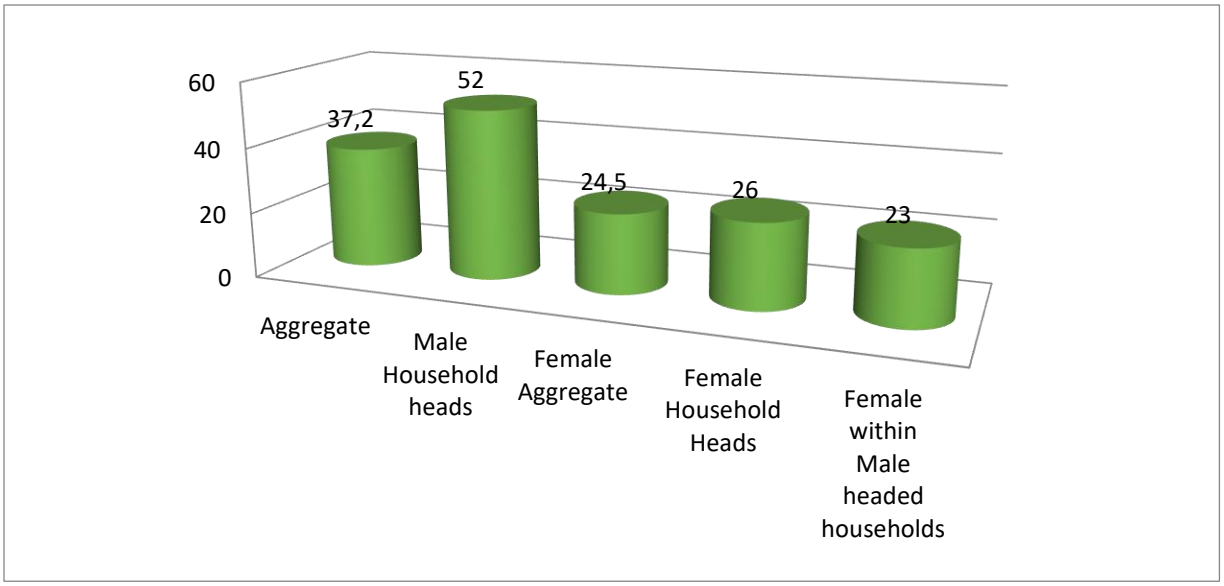

Figure 9: Proportion of respondents with climate information access

4.3.2 Perceived changes in climate variables (Rainfall amount, Rainfall length, Temperature, soil moisture, Air moisture)

The respondents were asked how the climate variables changed over the last decade in their areas so as to assess their perception of climate change. Table 6/Figure 10 presents the aggregated perceived changes on climate variables. The climate variables basically can be grouped into amount of rainfall during the short and long rainy seasons, the length of the rainy seasons, temperature, soil moisture and air moisture. Majority of the respondents perceived the rainy seasons are becoming shorter and rainfall amount, soil and air moisture are decreasing (Table 6). On the other hand, a large proportion of the respondents perceived no change (40.2%) and increasing and heavily increasing (48.7%) trends of temperature. The results highlighted the perceived change of the climate that is becoming drier and warm.

Table 6: Perception of respondents on the changes in climate variables

	Perceived change (% of respondents)					
Climate variable	Don't know	Heavily decreasing	Decreasing	No change	Increasing	Heavily increasing
Amount of *Belg* rain (short rainy season)	4.4	11.8	55.4	5.0	12.0	11.1
Amount of *Maher* rain (long rainy season)	2.4	28.8	10.2	14.9	29.9	13.4
Maher rain length	2.2	31.2	11.8	9.3	29.8	14.2
Temperature	1.9	5.6	1.9	40.2	35.0	13.7
Belg rain length	4.5	54.8	11.0	2.7	11.8	14.8
soil moisture	3.6	44.9	19.2	3.4	8.7	18.4
Air moisture	7.4	45.9	14.6	4.3	7.7	18.2

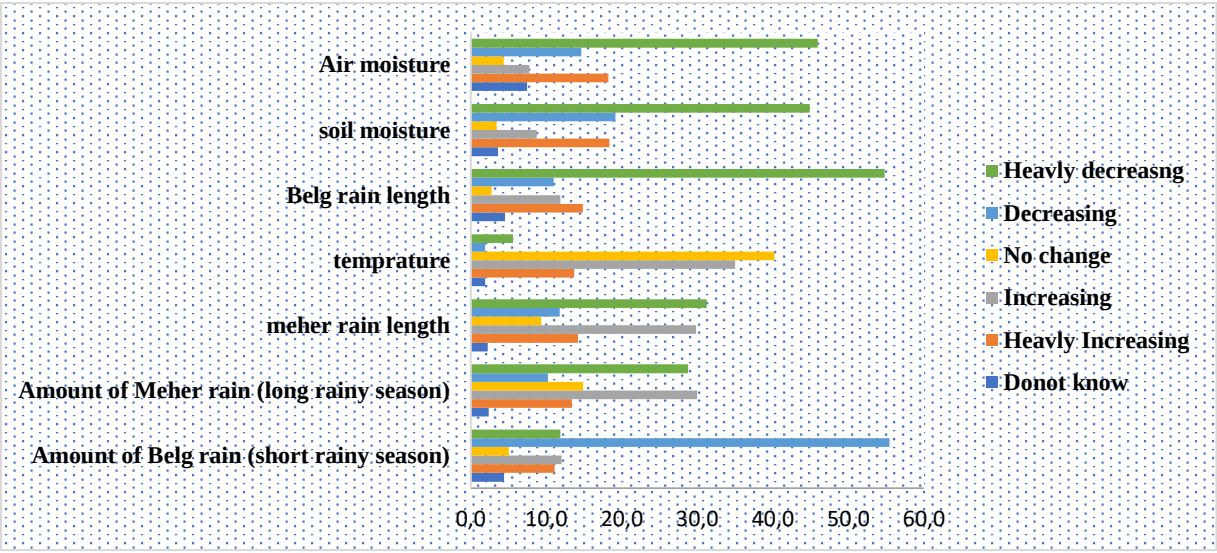

Figure 10: Perception of respondents on the changes in climate variables

The perceived changes in the climate elements were further grouped into precipitation variables and temperature for better assessment of the perception of the respondents. Majority of the respondents perceive changes over the last decade in climate elements. About 98.72 % (n= 1544) of the respondents perceive changes in climate elements related to precipitation and soil and air moisture and 98.04% (n=1555) of the respondents perceive changes in temperature over the last decade (Table 7). The rest of the respondents do not report any indication of changes in climate change variables. The perceived change in the climate elements was in different directions as illustrated in detail in Tables 6 and 7. Of those who perceived change in precipitation and moisture conditions, 70.33 % indicated the climate condition is getting drier (decreasing and heavy decreasing) while 19.82% indicated it is getting wetter. In terms of temperature, 76.54% of the respondents perceive an increasing trend while 7.56% perceived a decreasing trend of temperature.

The data was further disaggregated by gender groups and districts (agro ecology) so as to investigate variations in the perceived changes of climate elements. The disaggregation by gender group revealed that female household heads are less likely to perceive changes in climate elements than male household heads and women within male headed households (X^2 p=0.000) (Table 7). Similarly, the majority (98.04 %) of the respondents perceive changes in the temperature trend over the last decade. Of these, about 76.93 % perceive an increasing trend in temperature. The chi-square test indicates statistically significant association between the perception of changes in climate elements and gender groups and agro ecologies for most of the variables (Table 7).

Table 7: Perceived changes in climate variables disaggregated by gender groups and agro-ecology

		Perception by gender (% of respondents (n))			***x^2 p value***	***Perception by agro ecology/ district (% of respondents (n))***			***x^2 p value***
Change category	Aggregate	Male household heads	Female within male Household heads	Female household heads		Dabat	W. Belessa	E. Belessa	
RF and moisture change	98.72 (1544)	100 (723)	98.03 (464)	96.06 (134)	Pr = 0.000	100 (294)	96.8 (676)	98.6 (564)	Pr = 0.000
Temperature change	98.04 (1555)	100 (731)	96.75 (655)	94.94 (169)	Pr = 0.000	97.62 (288)	98.2 (696)	98.1 (571)	Pr = 0.000
Increasing Temperature	76.54 (1214)	78.93 (577)	75.03 (508)	72.47 (129)	Pr = 0.090	56.61 (167)	84.3 (598)	77.1 (449)	Pr = 0.000
Decreasing Temperature	7.56 (120)	7.93 (58)	6.94 (47)	8.42 (15)	0.702	15.25 (45)	4.1 (29)	7.9 (46)	Pr = 0.000
Increasing Belg rain fall	16.89 (272)	18.1(135)	16.69(114)	12.70 (23)	0.218	26.93(80)	11.9 (87)	17.8 (105)	Pr = 0.000
Decreasing Belg rain fall	66.65 (1073)	68.76 (513)	64.12(438)	67.40 (122)	0.174	54.54 (162)	74.51(541)	63.0 (370)	Pr = 0.000
Increasing Belg rain fall length	14.61 (235)	14.78 (110)	15.37(105)	11.04 (20)	0.337	24.37 (68)	9.24(67)	17.0 (100)	Pr = 0.000
Decreasing Belg rain fall length	65.98 (1061)	69.48 (517)	61.93(423)	66.85 (121)	0.01	53.87 (160)	75.72(549)	60.06 (352)	Pr = 0.000
Increasing Maher rain fall	45.02 (723)	46.16 (343)	46.12(315)	36.11 (65)	0.039	50.16 (149)	44.90(326)	42.53 (248)	Pr = 0.099
Decreasing Maher rain fall	39.17 (629)	39.43 (293)	37.62(257)	43.88 (79)	0.303	32.99 (98)	40.90 (297)	40.1 (234)	Pr = 0.052
Increasing Maher rain fall length	39.69 (631)	40.92 (300)	40.85(277)	30.16 (54)	0.022	44.10 (131)	38.55 (273)	38.8 (227)	Pr = 0.224
Decreasing Maher rain fall length	43.65 (694)	45.15 (331)	40.70(276)	48.6 (87)	0.089	38.38 (114)	46.04 (326)	43.4 (254)	Pr = 0.082
Increasing soil moisture	12.38 (196)	14.09 (103)	11.90(13)	7.2 (13)	0.038	14.28 (42)	9.05 (64)	15.5 (90)	Pr = 0.001
Decreasing Soil Moisture	65.26 (1033)	66.89 (489)	64.43(111)	61.11 (111)	0.352	58.50 (172)	71.00 (502)	61.6 (359)	Pr = 0.000
Increasing Air moisture	12.3 (195)	15.57 (114)	10.23(12)	6.66*12(	Pr = 0.000	16.21 (48)	8.33 (59)	15.1 (88)	Pr = 0.000
Decreasing Air Moisture	61.6(977)	63.38 (461)	59.19(117)	65 (117)	0.211	48.64 (144)	67.79 (480)	60.6 (353)	Pr = 0.000

4.3.3 Perception on the frequency of occurrences of climate induced disasters and impacts of climate induced disasters

The frequency of the occurrences of climate induced disasters and their impacts can be used as an indicator of climate change. Hence the respondents were asked how frequently climate induced disasters occur and how frequently climate induced disaster impacts occur in their areas over the last decade. As perceived by a large proportion of the respondents, there are frequent occurrences of climate induced disasters and impacts of the climate induced disasters in the study areas (Figure 11 and Table 8). Frequent prevalence of drought, rainfall fluctuation and non-seasonal rain fall are perceived by 73.98%, 67.54 % and 62.09% of the respondents, respectively. Further, strong significant association was observed between the perception on the occurrences of climate induced disasters and gender and agro-ecologies.

Moreover, more than half (55.30%) of the respondents perceive frequent occurrence of human and livestock damage due to climate change disasters. Similarly, insect outbreak and crop productivity loss were perceived as frequent climate induced disaster impacts as perceived by 60.32% and 83.43% of the respondents, respectively. A significant association was observed on the perceived frequency of the impacts of climate induced disasters and gender groups and agro ecologies except for crop productivity loss. This can reveal the common observation of crop reduction in the study areas by all groups.

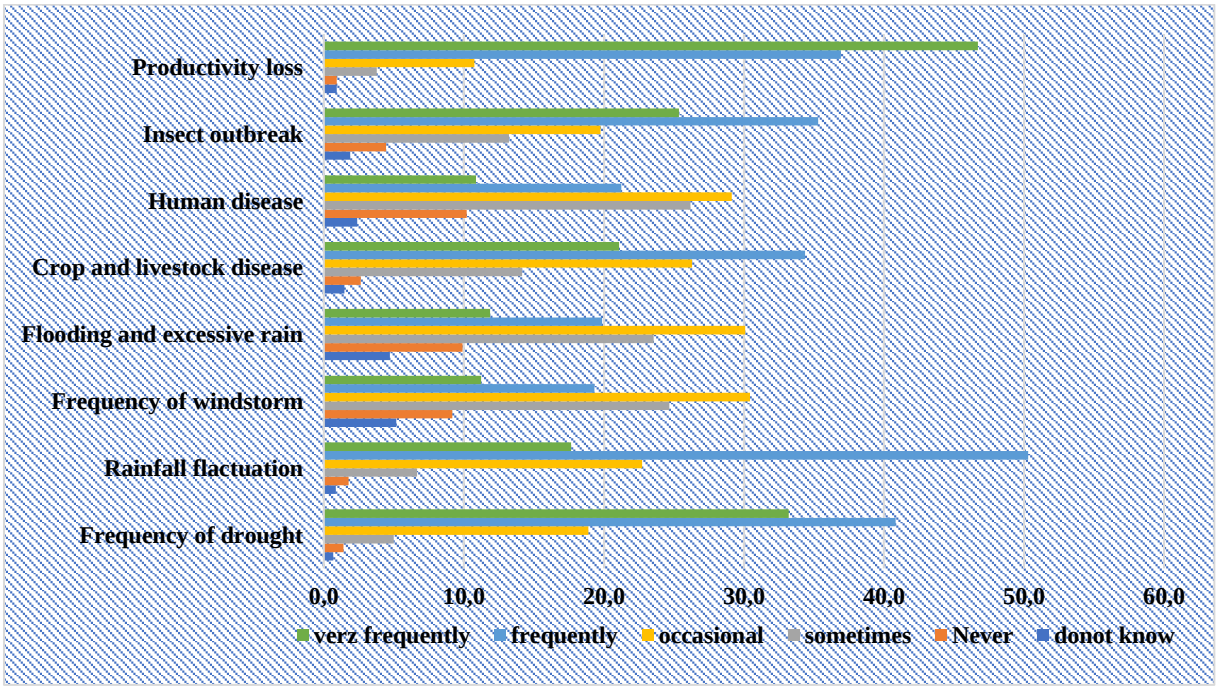

Figure 11: Perceived frequency of occurrence of climate induced disasters and their impacts (% of respondents, N=1613)

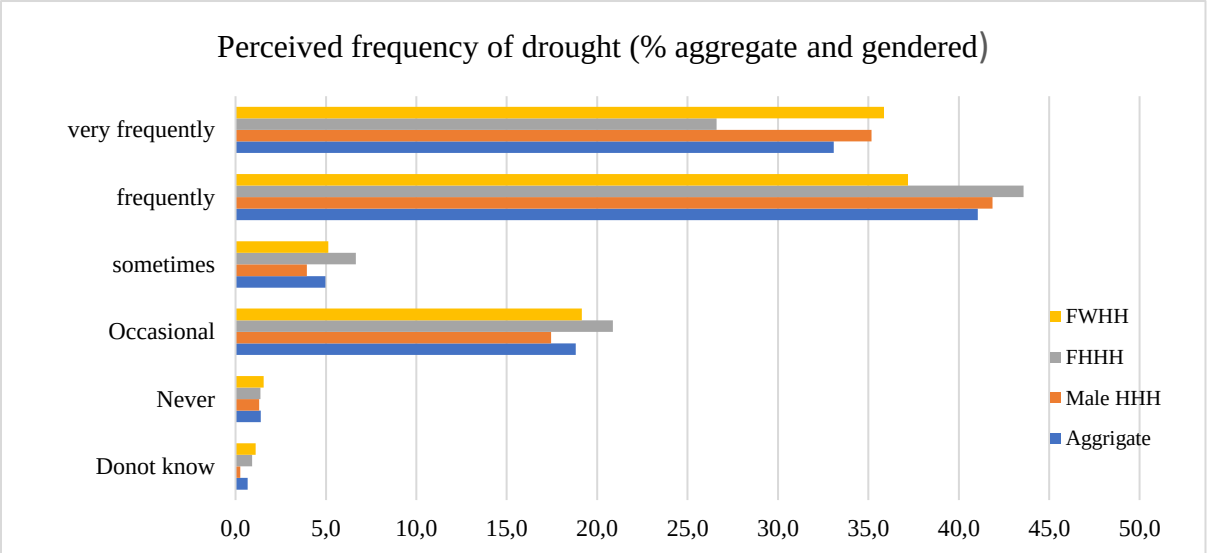

Figure 12: Perceived frequency of drought (% aggregate and disaggregated according to gender groups)

Table 8. Perceived frequency of occurrence of climate induced disasters and their impacts

	Perceived frequency % (n)				P-value X^2 test perceived frequency vs. gender group	P-value X^2 test perceived frequency vs. district
Climate induced disasters	Never	Sometimes/ occasional	Frequently	Don't know		
Drought frequency	1.43 (23)	23.91(385)	73.98(1191)	0.68(11)	0.047*	0.082
Rainfall amount fluctuation	1.75(28)	29.83(477)	67.54(1080)	0.88(14)	0.012*	0.009**
Non-seasonal rainfall	1.63(26)	35.78(571)	62.09(991)	0.5(8)	0.306	0.04*
Mean score of Climate induced Disaster's frequency	9.91(157)	37.31(591)	52.59(833)	0.19(3)	0.000**	0.121
crop and livestock damage	2.57(41)	40.63(648)	55.30(882)	1.5(24)	0.000**	0.000**
Insect outbreak	4.37(70)	33.37(535)	60.32(967)	1.93(31)	0.007**	0.000**
Human death	10.24(164)	55.22(884)	32.1(514)	2.44(39)	0.195	0.000**
Crop productivity loss	0.94(15)	14.7(235)	83.43(1599)	0.94(15)	0.555	0.136
Mean score of climate induced disasters' impact frequency	18.3(289)	46.42(733)	35.15(555)	0.13(2)	0.007**	0.000**

4.3.4 Perceived impacts of climate change

Table 9: Climate change as perceived in terms of its impact magnitude at household level

Climate change impact	Perceived magnitude of impact at household level (% of respondents				X^2 test p value
	No impact	low impact	Moderate impact	high impact	
Crop damage	1.12	3.04	12.61	83.23	
Livestock damage	3.85	6.84	18.89	70.42	
Livestock health	5.67	10.27	27.21	56.85	
Human health	6.6	26.23	35.7	31.46	
Water scarcity	1.93	5.3	18.22	74.55	
Infrastructure	10.27	14.65	29.74	45.34	
Mean score	0.19	3.74	18.4	77.66	
Male Household heads	0	2.75	15.13	82.12	0.002**
Female within Male Household heads	0.45	4.61	22.02	72.92	
Female headed Households	0	4.52	18.08	77.4	
Dabat	0	4.75	23.05	72.2	0.002**
East Belessa	0.14	1.96	16.13	81.77	
West Belessa	0.35	5.46	18.84	75.35	

It was noted that more than 83% of the farm households acknowledged high impact of climate change and variability on crop damage (Table 9). Livestock damage was one of the impacts of climate change perceived by the smallholder farmers i. The majority of the respondents in the study districts perceived high level of climate impact on the livestock. It was also noted that more than 56% of farm households in the study districts perceived the impact of livestock disease as a result of climate change and variability. This may be ascribed to favorable conditions created by the changes in rainfall and temperature for the proliferation of diseases.

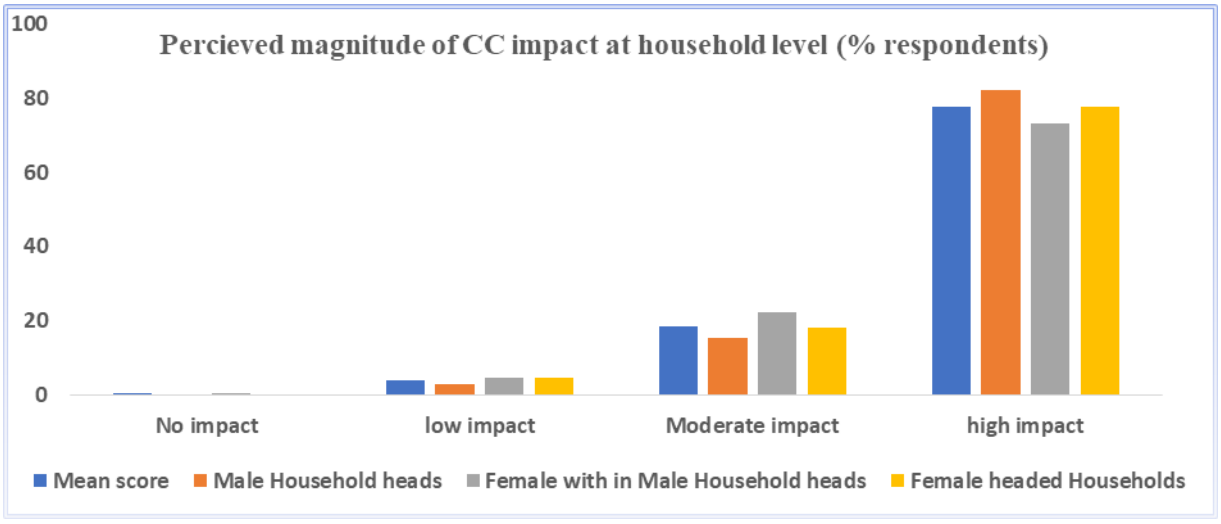

Figure 13: Perceived magnitude of CC impact at household level (% respondents)

Is there variation in climate change perception across districts (agro-ecologies) and gender groups? Multivariate analysis of variance (MANOVA) was computed to determine whether there is significant variation in perception on climate change variables and to what extent gender and location of the respondents contributes to variation on perception.

Table 10: Perception difference in terms of gender and location through Multivariate analysis

Source		SS	df	Mean Square	F	Sig.
Corrected Model	Belg_rain (short rainy season) amount	32.220a	8	4.028	2.522	0.010
	Belg (long rain season) rainfall length	59.051b	8	7.381	4.515	0.000
	Meher_rain (long rainy season) amount	43.473c	8	5.434	2.999	0.002
	Meher Rainfall length	38.980d	8	4.873	2.537	0.010
	Temperature trend	12.622[e]	8	1.578	1.136	0.336
	Soil moisture	9.787[f]	8	1.223	0.605	0.774
	Air moisture	10.291[g]	8	1.286	0.626	0.757
	Perception mean score classified	51.687[h]	8	6.461	6.952	0.000
Intercept	*Belg*_rain (short rainy season) amount	10933.359	1	10933.359	6846.125	0.000
	Belg (long rain season) rainfall length	10990.106	1	10990.106	6721.986	0.000
	*Meher*_rain (long rainy season) amount	10803.401	1	10803.401	5961.186	0.000
	*Meher*_rlength (Rainfall length)	10896.715	1	10896.715	5674.690	0.000
	Temperature trend	11156.683	1	11156.683	8030.803	0.000
	Soilmoistu_trend (Soil moisture)	8258.150	1	8258.150	4084.057	0.000
	Air moisture	9780.169	1	9780.169	4759.160	0.000
	Perception mean score classified	10107.144	1	10107.144	10876.021	0.000
Sex group	*Belg*_rain (short rainy season) amount	8.273	2	4.137	2.590	0.075
	Belg (long rain season) rainfall length	16.642	2	8.321	5.090	0.006
	*Meher*_rain (long rainy season) amount	9.253	2	4.627	2.553	0.078
	*Meher*_rlength (Rainfall length)	2.949	2	1.475	0.768	0.464
	Temperature trend	1.763	2	0.881	0.634	0.530
	Soilmoistu_trend (Soil moisture)	1.008	2	0.504	0.249	0.779
	Air moisture	4.106	2	2.053	0.999	0.369
	Perception mean score classified	6.531	2	3.266	3.514	0.030
District	*Belg*_rain (short rainy season) amount	8.161	2	4.080	2.555	0.078
	Belg (long rain season) rainfall length	25.571	2	12.785	7.820	0.000
	*Meher*_rain (long rainy season) amount	16.356	2	8.178	4.513	0.011
	*Meher*_rlength (Rainfall length)	20.086	2	10.043	5.230	0.005
	Temperature trend	8.087	2	4.043	2.911	0.055
	Soilmoistu_trend (Soil moisture)	2.353	2	1.177	0.582	0.559
	Air moisture	0.809	2	0.405	0.197	0.821
	Perception mean score classified	30.324	2	15.162	16.315	0.000
Sex group * district	*Belg*_rain (short rainy season) amount	3.042	4	0.761	0.476	0.753
	Belg (long rain season) rainfall length	7.671	4	1.918	1.173	0.321
	*Meher*_rain (long rainy season) amount	15.402	4	3.850	2.125	0.075
	*Meher*_rlength (Rainfall length)	17.204	4	4.301	2.240	0.063
	Temperature trend	0.798	4	0.199	0.144	0.966
	Soilmoistu_trend (Soil moisture)	4.768	4	1.192	0.590	0.670
	Air moisture	5.076	4	1.269	0.618	0.650
	Perception mean score classified	1.967	4	0.492	0.529	0.714
Error	*Belg*_rain (short rainy season) amount	2445.029	1531	1.597		

	Belg (long rain season) rainfall length	2503.107	1531	1.635		
	*Meher*_rain (long rainy season) amount	2774.617	1531	1.812		
	*Meher*_rlength (Rainfall length)	2939.874	1531	1.920		
	Temperature trend	2126.921	1531	1.389		
	Soilmoistu_trend (Soil moisture)	3095.752	1531	2.022		
	Air moisture	3146.236	1531	2.055		
	Perception mean score classified	1422.766	1531	0.929		
Total	*Belg*_rain (short rainy season) amount	21878.000	1540			
	Belg (long rain season) rainfall length	21680.000	1540			
	*Meher*_rain (long rainy season) amount	22683.000	1540			
	*Meher*_rlength (Rainfall length)	22729.000	1540			
	Temperature trend	22416.000	1540			
	Soilmoistu_trend (Soil moisture)	18273.000	1540			
	Air moisture	20399.000	1540			
	Perception mean score classified	20137.000	1540			

a. R Squared = .013 (Adjusted R Squared = .008), b. R Squared = .023 (Adjusted R Squared = .018), c. R Squared = .015 (Adjusted R Squared = .010), d. R Squared = .013 (Adjusted R Squared = .008), e. R Squared = .006 (Adjusted R Squared = .001), f. R Squared = .003 (Adjusted R Squared = -.002), g. R Squared = .003 (Adjusted R Squared = -.002), h. R Squared = .035 (Adjusted R Squared = .030)

- There was significant difference across gender groups in perception of *Belg* rain amount change (*P=0.075*), *Belg* rain length change (*P=0.006*), *Maher* rainfall amount change (*P=0.078*), and mean score of climate variables (*P=0.03*)
- There was significant difference across districts in perception of *Belg* rain amount change (*P=0.078*), *Belg* rain length change (*P=0.000*), *Maher* rainfall length change (*P=0.078*), temperature trend (*P=0.055*) and mean score of climate variables (*P=0.000*)

4.4 Qualitative Analysis of households' perception of climate change

To triangulate the qualitative data and understand the perception differentiation related to climate change in-depth, data was collected from focus group discussions and key informant interviews. Thus, there were a total of twelve (12) focus group discussions in which four FGDs were held in each of the respective districts. In each group, the participants were female household heads, male household heads and women within the male headed households, as well as one mixed group. Each group consisted of eight (8) participants. The data collection started from West *Belessa* participating 12-15 people from each category of our participants (from male headed households, women headed households and women within the male headed

households). Thus, 37 farmers (11 women headed, 13 male headed and 13 women within the male headed household) were selected and participated. A discussion guide was used to facilitate the focus group discussions. All the discussions were recorded by audio and sometimes with video. Two facilitators (male and female) were involved in facilitating the FGD.

The Key informant interview was also conducted through open ended questions. The interviewees were agriculture office head, safety net coordinators, women`s affair office head and natural resource management head. The total numbers of interviewees were nine (9). All interviews were first recorded by voice recorder and then transcribed. The participants` own statements and meaningful units were coded and analysed through thematic analysis using **Nvivo**. The language used for focus group discussions and interviews was Amharic that was recorded and transcribed into English. Duration of interviews ranged between 55-70 minutes. For both the FGD and the Key informant interviews, the respondents participated by willingness through oral consent.

In what follows we provide an overview of the main findings.

4.4.1 Main livelihood activities

The safety net coordinator of *Dabat* agriculture office explained that the society`s livelihood exclusively depends on agriculture and livestock. They perceived that since their production exclusively depends on the rain season, which is short and once a year, the rest of their efforts will be on irrigation. On the other hand, the women`s affair head of *Dabat* district stated that mostly those who are at youth age migrate to different cities and work. For instance, the girls went to cities and engaged in household works or become daily labourers. Whereas, boys engage in agricultural activities in large farm areas which are owned by investors. Here we can see, men`s migration seems seasonal; but girls migrate all the year.

The safety net coordinator of East *Belessa* reported that the majority of the community makes living by agriculture which is usually plantation of crops and animal rearing. The farmers are dependent on mixed farming, but when facing challenges, farmers involve in small scale trade activities based on the existing situation.

> *…… it is the situation that obliges the farmers to do so. For example, when there is a drought, the farmer has no alternative, so he/she shifts to trade. Yet, the majority makes living by agriculture. The*

season varies in months due to the condition of the rain. If there is a drought, there is an obligatory condition that puts them in trouble. Especially in the months of July, August, September, and October they shift to the agriculture. When the dry season comes, if there is suitable condition they will turn to trade and also, sometimes they will work as daily labourer.

In similar vein, the agriculture office head of East Belessa expressed 99% of the society`s livelihood depends on agriculture and another is trading with no seasonal variation. The head also explained those agricultural activities that are affected by climate change are related to cropping and livestock. He added that "the activities which are familiar to women include growing vegetables and poultry, but I can say there is *`no women only activity`*, women involve in any activity that men are doing."

In the case of West Belessa, the agriculture office head said that people`s livelihood rely on agriculture, trading and weaving which varies seasonally.

4.4.2 Perception about the trend of Safety Net

A safety net program started by the government to support those people found suffering from the consequences of climate change induced hazards. The program is run by the agriculture offices of districts having guidelines on the criterion for various groups to be included, graduated, and replaced.

The Agriculture office head of East Belessa district stated that from a total of 142,174, currently there are more than 28,000 safety net users with few household graduating (when they become self-sufficient). Accordingly, he reflected the number of beneficiaries is not decreasing as there more new entrants. Besides, he reported there are also around 12,000 households who received support via emergency support which is on top of what they have through the Safety Net program. Proportionally, the number of women beneficiaries is high as they are vulnerable; he said.

The safety net coordinator of the same district also confirmed the high number of safety net beneficiaries and women are the major users. He said, *"women are subject to many problems in several ways, both in household and outside activities. Since the program favours such women, they are beneficiary."*

On the other hand, the safety net coordinator of West Belessa mentioned out of 195,676 the

number of safety net beneficiaries in West Belessa is about 14,785; however, the number of people supported by safety net is decreasing. He added that one group under safety net program stays for five years and they will graduate and be replaced by other potential beneficiaries.

4.4.3 Understanding cultural practices in the context of CC

- *Age to get into marriage*

The average marriage age for both sexes is different where males get married at 18 and females at 13, reflected the head of Agriculture office, East *Belessa*. The safety net coordinator of East Belessa said that such kind of practices are getting improved, and a male usually gets married above 18. Thus, he concluded that a female gets married at least from the age of 18 and males at 20.

> *Before it was a bit difficult, even in her infancy, a female would be arranged for marriage. Now, this practice has stopped. Primarily, it has stopped because of the awareness being given, especially, associated with females, youths, and children. The attention paid by the government has also contributed. There are also different programs such as Safety Net, S.L.M. [Sustainable Land Management], and O.R.D.A. [Organization for Rehabilitation and Development in Amhara] which are doing enormous tasks. Besides, associated with nutrition, a huge task is being done and these organizations are changing the existing circumstances.*

- *Practice of polygamous marriage*

Regarding polygamous practices the Agriculture head of East Belessa indicated polygamous marriage is practiced rarely, not more than 2% especially by some kebele leaders/administrators.

> *When some men appointed in some positions of the kebele, they will get the chance to travel to the urban areas for meeting, training, and other related government cases. And they start thinking to have an additional wife in Amharic `ቀምጥ" with women found in the cities and engaged into the practice.*

The safety net coordinator of East Belessa also revealed that the practice of

polygamous marriage exists in their district with managing difficulties of husbands towards their wives/ children as:

> *Women face a big challenge, including children. In this regard, there is a big, a big problem. The problem is there, and it is difficult for him to manage the wives, and also schooling of their children on time is another big problem. So, it is difficult to manage. But these days awareness is being created by the Culture and Tourism office but there is a little change.*

- *Gender division of labour*

The safety net coordinator of East Belessa said the gender division of labour varies depending on the season. For example,

> *……during the winter, both sexes go for outdoor activities or to the farmland, and in summer, females usually stay at home while males engage in outdoor activities. For instance, if the man ploughs the land, the woman does the household activities. The whole household activities are her responsibilities: she prepares food, collects firewood, and fetches water, all these are her duties. The men are simply in charge of either ploughing the land or going to the harvesting field. During the winter season, there are weeding activities. So, the female works both in the household and outdoor activities, but the male works only on the farm.*

Accordingly, the agriculture office heads of East Belessa said that like men, women stayed from morning to evening doing agricultural activities. Except ploughing, women do all the farm related stuffs. In addition to this, women are engaged in household chores and caring for children after farm works. *"Men are basically spending their time on farm related activities;*

they are busy during harvest times. Their burden decreasing in winter times, so the burden varies by season."

The head of East Belessa reported that the drinking water access coverage is from 50-60%. Hence, there are many kebeles in the district, especially those found in lowland that are without even single water pump. And some very large kebeles have only one water pump. He additionally expressed "as fetching water takes up to three hours, and firewood collection up to seven hours in most kebeles of the `district" and fetching water is considerably women`s task. People in rural kebeles don`t have access to water, the place for water is too far. However, in summertime, such problems are relatively solved as the streams and rivers became full.

Concerning the responsibility of collecting firewood, the safety net coordinator explained that women and children have major responsibilities. The time spent to collection takes an average of half and an hour based on the availability of wood that varies seasonally.

"During the winter season, it is very difficult to find. But during the summer, though it takes too long hours its availability will be better. There is high demand of firewood, but there is a shortage in its availability and supply. There is a huge difference."

The Agriculture head of East Belessa described *"Women are in charge of collecting firewood three times a week, and up to 5 hrs every day."*

Related to collecting water, the safety net coordinator of East Belessa said

> *Usually, women and children, including both female and male, fetch water. The time spending to access water varies. Some of them can access water sources near their houses, while those who live in lowlands travel long distance to access water sources, and this will take them about 12 hours. The average is two hours. This varies seasonally. For instance, during the summer season, particularly throughout the months from June to December, it is relatively good. Except those months, it gets worse. It is not as simple as to speak about. It is very tough and challenging.*

The Women`s Affair delegate of *East Belessa* also revealed both water and firewood access is getting tough due to the effect of climate change. According to him, both of these tasks are commonly managed by women by travelling long distance to fetch water and collect firewood.

He said: *"men fetch water and collect firewood only if the area to be collected is risky for women."*

- *Gender differentiation during disaster*

Climate change induced disasters are the problems of rural people challenging their life. The problem affects both sexes and varies among women/men. Thus, women are the first victims and among women, the elderly, the orphans, and the girls are disadvantaged facing various problems. These groups have no one to help, but the males and youths have their own options. However, among men, it is the elderly and the adults who encounter problems, particularly if the latter one does not have land and becomes daily labourer. Those groups that succeed in coping most with the influences of climate change are thus those that are at the middle age, not too old, not too young, said the safety net coordinator of East Belessa.

- *Social capital and Associations*

There are different associations and self-help groups in East Belessa district such as saving association, social union association, renaissance Association (which even gives credit), and traditional gatherings such as `*Senbete*`, `*iddir*`, and religious events, the head reported.

`*Iddir*` and `*Debo*` (working together/campaign) also exist in West Belessa, as described by the safety net coordinator of West Belessa. With regard to gender-specific associations, there are women-centered credit associations in five kebeles of *Dabat* district, and also there are gender-mixed associations in case of micro enterprises and trading, the safety net coordinator expressed.

The Safety net coordinator of East Belessa pointed out that there are farmers' associations in each kebele like farmers' cooperatives. Their functionality varies from one kebele to the other. *"Though there is the organizational structure, its functionality varies due to the chairperson's potential and the capacity of the kebele."* There are also women's associations, youth association and traditional associations in which they organize themselves. *"The women`s association is run by men and most of the responsibilities rely on them rather than women, therefore, the women just act as a member, but women have their own money saving association."* Women also can join any association as a member like farmers saving association. Both men and women equally participate in local community associations such as *Iddir* (i.e., social support group).

4.4.4 Expression of weather conditions

The general agro-ecological characteristics of the East Belessa district is 90% `*kola*` (Tropical zone), and 10% `*Woina-Dega*` (sub-tropical zone); "climate change is becoming bad and basically damaging crops, animals and water resources that varies seasonally" the agriculture head of East Belessa expressed.

According to the safety net coordinator of East Belessa, the district is typically lowland having very less humidity, and the weather varies each time adversely affecting the community.

> *Even you are feeling by yourself. If it is such burning in the winter, how is it going to be when the summer comes? It is very difficult in April and May; it is very difficult. It is becoming tougher even to put on some clothes. It is really challenging. Climate change varies with season. During summer and dry seasons, the time is too long, and the winter is shorter. It varies every time. The winter's onset was in June but last year it was in July, it varies, there is nothing constant. If there is no measure to be taken and continues in this condition, it is very difficult. It is difficult for me even to imagine that there will be the existence of human beings in this area.*

4.4.5 Mode of communication

The agriculture head of East Belessa indicated that the people have various ways to access information. He replied:

> *The main sources of information for the residents are the government employees in Agriculture, education, health… etc. offices in each kebele. The government workers are very close to information via Radio, TV, internet, etc. Thus, the community is getting information access via this group. Besides, the community gets information from their children too.*

The head added that the community practice of using radio is too low (around 2%). He also mentioned that having a mobile phone is very uncommon in their districts. On the other hand, the safety coordinator of West Belessa said the major sources of information in the district are mobile, radio, and government communication office. Similarly, the safety coordinator of Dabat replied that most of the people in the rural use radio, TV and government employees were pointed out as a major source of information.

4.4.6 Influences of climate change

In East Belessa district, a natural resource that becomes depleted is the forest and land. While those agricultural practices affected by climate change are crops and animals. On the other hand, when it comes to humans, the safety net coordinator expressed.

> *Women and children are the one who suffer a lot, because men are engaged in other activities, women have to do the household activities and at the same time they look after the animals, and fetch water, all those tasks are the duties of women and children. But, to the maximum men`s active workload stays up to four months. Except for these months, they do not have many duties to perform.*

The damage of climate change extended to cause social crisis during heavy wind and destructive rain. *"*Did you not come that way? If you have come that way you could have observed, it is surprising, there are no roads, no farmlands, and houses and they are being lost. Hence, the community is being affected*."* the safety net coordinator of East Belessa added.

The head of agriculture office, East Belessa reported that the people are facing the challenges of climate change. The temperature in the district is becoming very high, and rain is very rare even in rainy season in which some households requested the leaders a village change.

> *Animals are number one victims of the climate change. In this July 14,500; and 20,000 goats and sheep left one kebele because of lack of rain. This is a big loss to us, as many of them die on the way, and some are sold at low market price. Another big problem that we are facing is school dropouts. Children couldn`t attend their school as they have to go to look out for water. We are also having serious health problems due to lack of clean drinking water. Many households are facing the problem of skin rash. This happened because of the climate change. Leave alone the increased number of forests. Indeed, there is no sign of forest because of the enlargement of small towns and the expansion of farmland. Unless around the*

Orthodox Church and in common lands, there are no trees

4.4.7 Gendered differentiation to survival

To survive from influences of climate change, men in East Belessa district consider market-oriented cereals and animals which are drought resistant. For instance, from animals, there is a type of goat called `*Amerbele*` that is highly drought resistant. This type of goat is unavailable in the district, but men buy from somewhere else and resell it. In case of crops, there is `*Masho*` a hybrid type of seed and sesame. Therefore, the number of animals is decreasing. They minimize the number of animals, not because they are willing and comfortable, but because the situation urged. However, women are engaged in oil extraction from seeds of desert areas and sell it, safety net coordinator of East Belessa explained.

The coordinator also added that in the process of shifting survival strategies, women are overloaded with many activities working day and night. Thus, both men and women discuss together about preferential strategies, but mostly decisions are made by men alone.

The head of Agriculture office in East Belessa also said that men have better coping mechanisms (as they can even easily migrate to work), compared to women. He said, the reaction of the women to the problem is almost null. On the other hand, the delegate head of East Belessa women`s affair office mentioned that as a survival strategy of climate change shocks men went for additional non-agricultural works such as trade, daily labour, guarding, etc. But the women are using "wrong" mechanisms like migrating to urban areas and are becoming engaged in prostitution.

- *Cultural norms*

There is cultural influence that discourages women`s behaviour in East Belessa district, the head of agriculture office explained. For instance,

> *when a wife of a man goes to the meeting with other people and stays there, it will be considered as a taboo. Even though there is the opportunity to participate for women, traditional attitudes within the culture could not be changed. They will say, `Oh, _____ wife takes time with those _____` and will have negative connotations. The culture treats both sexes differently; it is a bit difficult.*

The head of East Belessa additionally articulated that even though women can move wherever they want even with their donkeys for marketing purposes, there is a cultural influence that ban women not to move after 6 o`clock in the evening.

In the same manner, the culture of East Belessa is explained as difficult that doesn`t encourage women to go to public areas such as trainings. Those women who go to public and speak on stage are discriminated and has a name in Amharic "ወንዲላ". This means, unmannered women. In this regard, these women are categorized as attention seekers of men for sexual relationship, the delegate head of Women`s Affair office reflected.

Regarding the possibility of gathering both men and women in group discussions, the safety net coordinator of East Belessa replied as it is possible to gather men and women together, but one may not get the responses in detail as one wants.

> *If you have a discussion with males and females separately and bring them together, women will not repeat what they have said earlier in females' group. This influence discouraged women not to be interested in speaking in the presence of men. Their speech, and decisions vary when they discuss alone and when they are mixed with men. Women perceived that if they speak, people might say, `Oh, how could she say this? `and they always wait for the feedback and show emotional disturbance.*

Thus, it is possible to gather both men and women in a group discussion. But it is impossible to get actual information, women fear men. If women are with men, they give chances for men to speak. To conduct effective discussions, arranging women separate from men is the best, the agriculture head of East Belessa concluded.

- *Communal land administration and participation of women*

The communal lands are managed by the community being with the area environmental authority, but there is low participation of women. "It can be said that such common land is 100% utilized by men and also the decisions are fully controlled by men." said the head of Agriculture office, East Belessa. Parallelly, the safety net coordinator of East Belessa replied men are the decision makers regarding the land, they manage a common land by their land boundaries.

For example, if a farmer has farmland, he would then possess the

land next to it, the other will do the same and manages as own land. But usually, there is no such a thing [like committee]. Farmers [are being told that they] do not have to possess the land which is not their own. So, currently, a farmer will be given land ownership certificate and manages accordingly. But during previous times, there was a trend called 'push the chair' among the farmers which is possessing the common land (ቀይጦ በያዘ) next to their farmland just by own will. This was a tendency to stay legal while possessing land illegally, but now this is somehow being managed.

- *Farmer's training center and sex of trainees*

The agriculture office heads of East Belessa indicated as they have twenty-five (25) farmer training centers in 25 kebeles. Both men and women take trainings with difference in participation as 30% are women and 70% are men. He said:

Before, most of the trainee were men, but now we are balancing the number. If we plan to train 200 farmers, we are giving half of the quota to women. And we are training the women separately. I mean women household heads and women in the household are getting separate trainings. As a result, we have even women who engaged in the farming activities, though that is not very common.

On the one hand, safety net coordinator of East Belessa said,

"……. even though there are farmers' training institutions, all of them are not functional. They are only 10 in which training is provided in an organized way and by agriculture experts. There are also representatives of each Kebele from three departments: kebele experts, health extension workers, and teachers who give training related to their field. Sometimes, the University of Gondar in collaboration with the Technical and Vocational college gives trainings, especially, on enabling the farmers".

He concluded that the access to trainings vary depending on the type of training, yet it favours men. Though women are given the chance using a quota system, they may or may not be present. Therefore, even though opportunity is given, women are not using their chance.

Concerning trainings, the agriculture office head of East Belessa said that even though both women and men have equal access, those women whose husbands are participating do not have equal access to trainings. Unlike this, female household heads have equal access.

4.5 Intrinsic Vulnerability Analysis

This section summarises the findings and contributions made to vulnerability literature. Intrinsic vulnerability index values are presented for adaptive capacity and sensitivity of households separately below. The contributing factors/variables of intrinsic vulnerability under each component are also discussed.

4.5.1 Component loadings under adaptive capacity category

Table 11 shows the rotated component loadings of the nine components extracted with varimax rotation using CATPCA syntax (Annex II). The intermediate composite indices were constructed by grouping variables with the highest component loadings together (Table 11). Descriptive names were given to each of the intermediate composite indices. Table 14 shows the final adaptive capacity indices of the three agro-ecological zones of northwestern Ethiopia.

Table 11: Rotated component loadings of adaptive capacity of North-western parts of Ethiopia.

	Components								
	1	2	3	4	5	6	7	8	9
Age	.137	-0.06	**.808**	.074	.095	.189	.059	.032	.032
Sex	.534	-.277	.488	.155	-.280	-.032	.048	.102	**.901**
Female household head	-.076	-0.033	**.795**	.090	-.050	.066	-.016	-.103	.012
Level of education	-.190	0.04	**-.408**	.147	-.115	.151	-.104	-.283	.243
Main occupation type	.109	-0.04	.077	.166	.090	.018	.127	**.672**	-.054
participation in planning	.026	-0.035	-.177	-.016	-.130	**.688**	.147	-.055	.127
Membership status to *Edir*	.086	0.03	.055	**.654**	-.084	-.148	.154	-.080	-.108
Membership status to *Ekub*	.078	-0.043	-.130	**.632**	.250	-.279	.026	.015	.016
Membership status to *Senbete*	.123	0.024	-.088	**.539**	.254	.270	.099	-.054	-.031
Livelihood diversification	.075	**0.726**	.097	.704	-.040	.074	.019	.110	-.043
Decision making role	.087	0.045	.407	-.128	.188	**-.426**	-.024	-.024	.212
Credit access	-.029	0.027	.096	-.202	**.735**	-.121	.116	-.165	-.043
Fertilizer application	.226	0.018	-.112	.168	**.498**	.403	-.019	.070	.072
Improved Seed application	.094	-0.02	.118	.252	**.552**	-.056	-.058	.298	.022
Dependency ratio	-.052	0.079	**.802**	-.014	-.058	-.049	.055	.033	.048
Family size	.157	-0.041	**.704**	.068	.102	.175	.107	.027	-.110
Annual Crop yield	.057	**0.990**	-.03	.025	.019	.022	.022	.016	.041
Crop Diversification	-.021	**0.989**	-.025	-.03	-.021	-.023	.025	-.013	-.04
Livestock ownership TLU	**.900**	0.022	.055	.123	.078	.100	.040	-.025	-.048
Number of Livestock Died TLU	**.594**	-0.027	.014	.117	.072	.059	.171	-.254	.073
Number of ploughing Animals	**.875**	-0.015	-.014	.031	.023	.112	-.024	-.028	-.119
Annual farm income	.284	0.069	.127	.110	.026	-.168	**.892**	.171	.038
Annual nonfarm income	.020	-0.07	.043	-.090	.026	-.040	**.505**	-.015	-.030
leadership role in social associations	.021	0.019	.110	.088	.210	**.607**	-.084	.105	-.112

Rotation Method: Varimax with Kaiser Normalization.

Note: The Kaiser–Meyer–Olkin (KMO) criterion approves that CATPCA is an appropriate method to estimate the composite index of adaptive capacity with a value of 0.785. In addition, Bartlett's test of sampling adequacy $x^2 = 11298.4$ with P-value <0.00 confirming highly correlation of adaptive capacity indicator variables and adequate sample for the analysis.

Source: Authors' computations based on the 2019 survey data

The first component alone explains about 13.7% of the variation in the data out of the seven dimensions extracted and is heavily and positively loaded on the variables; livestock ownership in TLU (0.900), number of livestock died in TLU (0.594) and number of ploughing animals (0.875). Therefore, this component stands for an intermediate composite index called livestock

ownership. The finding concerning the importance of this dimension in explaining the level of vulnerability of households is consistent with previous studies (Asrat & Simane, 2017; Tesso et al., 2012). According to Asrat and Simane (2017) vulnerability and adaptive capacity are more attributed to livestock ownership and cultivated land size.

The second component which explained 8.45% of the variance had high and positive loadings on the variable's livelihood diversification index (0.76), annual crop yield (0.99) and crop diversification index (0.989). The second principal component represents livelihood and crop diversification. It was assumed that agriculture-dependent households may be able to reduce their overall vulnerability to climate variability by diversifying their livelihood strategies. Similar findings on the importance of these indicators to explain vulnerability differences within and across communes have also been reported in previous studies (Huong et al., 2019; Shah, Dulal, Johnson & Baptiste, 2013).

The third component which explained approximately 7.65% of variance in the dataset were combined to compute an intermediate composite index called socio-demographic profile. It is evident that the third component had high and positive loadings on age (0.808), female headed household (0.795), dependency ratio (0.802) and family size (0.704) while it had negative loadings on level of education (-0.408). It is vital to note here the negative sign of the component loading for education variable which means that districts or households perform poorly in terms of education. In line with this result, the findings of Shah et al. (2013) indicate that the dependency ratio, age of the household, family size and educational status of the households are an important determinant of vulnerability.

The fourth component which explained nearly 7.12% of the variance had high loadings from indicators representing membership status to *Edir*[1] (0.654), *Ekub*[2] (0.632) and *Senbete*[3] (0.539). These variables represented an intermediate composite indicator named social capital and those indicators under this composite index represent the connections and networks of households that are available to them during climate shocks and disasters. In line with this result, a study conducted by Adger (2003) and Antwi-Agyei, Dougill, Fraser & Stringer (2015) reveal that

[1] The Edir/iddir is indigenous financial and social institution or cultural cooperatives in Ethiopia that offers mutual aid and financial assistance for those group members who need support (Aredo, 1993).

[2] Ekub is a form of capital formation where community members gather and contribute a fixed amount of money to be paid weekly or monthly to a pool which is then rotated amongst the members until all get paid (Jembere, 2009).

[3] Senbete is a religious and ceremonial occasion which is cooperatively formed by group of people and celebrated every Sunday to socialise (Rahmato & Kidanu, 1999).

households belonging to a high number of social networks and associations are more resilient to the impacts of climate change.

The fifth component with 5.98% variance had positive loadings on variables like credit access (0.735), fertilizer application (0.498), and improved seed application (0.552). These variables represent an intermediate composite indicator named agricultural inputs. It is assumed that households with access to agricultural inputs will be less vulnerable to climate risks and shocks.

The previous research with regard to the vitality of agricultural inputs explaining the difference in the level of vulnerability of a household to climate change shows that households' access to agricultural inputs and credit plays a key role in shaping and influencing the adaptive capacity of communities (Sathyan, Funk, Aenis & Breuer, 2018). However, during the FGD sessions in the three districts, participants were mentioning that they were sceptical towards applying new and improved crop varieties despite having suitable soils and climatic conditions. This was partly due to fear of losing the local varieties over the new one and they believed that old varieties are easily adaptable to local harsh climate extreme conditions. Therefore, it is assumed to threaten the adaptive capacity of the smallholder farmers in the north-western parts of Ethiopia.

In the sixth dimension, the indicators with the highest component loadings were decision making role (-0.426), participation in planning and policy making (0.688) and leadership role in social associations (0.607). These variables represent an intermediate composite sub-component called institutional capital. This dimension explained nearly 5% of the variance in the dataset. It is assumed that households' positions as a decision maker, local chiefs, association leader give them access to climate information, physical and financial resources which will improve the adaptive capacity of households. In line with this result, a previous study revealed that institutional conditions impact on local responses to climate shock and ability to diversify livelihoods (Osbahr et al. cited in Shah et al., 2013).

The seventh component which explained 4.35% of the variance had high and positive loadings on the variables like annual income from farm activities (0.892) and annual income from nonfarm activities (0.505) representing an intermediate composite indicator called financial capital. It is assumed that households that have higher income from both farm and nonfarm activities will be less vulnerable and whilst those with lower income will be more vulnerable to climate change. This finding reaffirms previous researches which pointed out that the higher

the income of households, the less it is affected by climate shocks (Alemayehu & Bewket, 2016; Bogale, 2012; Deressa, 2010; Tesso et al., 2012).

All the above component loading analysis were used to group together individual indicators that are correlated to form a composite index. The composite index of adaptive capacity of households was constructed by weighting and aggregating each of the intermediate composite indices.

Table 12: Matrix of Squared Factor Loadings Scaled to Unit Sum (Adaptive Capacity).

	Components						
	1	2	3	4	5	6	7
Age	0.0057	0.0017	**0.3553**	0.0032	0.0062	0.0297	0.0033
Sex	0.0868	0.0378	0.1296	0.0140	0.0545	0.0008	0.0022
Female household head	0.0017	0.0005	**0.3440**	0.0047	0.0017	0.0036	0.0002
Level of education	0.0109	0.0007	**0.0906**	0.0126	0.0092	0.0190	0.0103
Main occupation type	0.0036	0.0007	0.0032	0.0161	0.0056	0.0002	0.0154
participation in planning	0.0002	0.0006	0.0170	0.0001	0.0117	**0.3947**	0.0207
Membership status to *Edir*	0.0022	0.0004	0.0016	**0.2504**	0.0049	0.0182	0.0227
Membership status to *Ekub*	0.0018	0.0009	0.0092	**0.2338**	0.0435	0.0649	0.0006
Membership status to *Senbete*	0.0046	0.0002	0.0042	**0.1700**	0.0449	0.0608	0.0093
Livelihood diversification	0.0017	**0.2600**	0.0051	0.2901	0.0011	0.0045	0.0003
Decision making role	0.0023	0.0009	0.0901	0.0095	0.0246	**0.1513**	0.0005
Credit access	0.0002	0.0003	0.0050	0.0238	**0.3762**	0.0122	0.0129
Fertilizer application	0.0155	0.0001	0.0068	0.0165	**0.1727**	0.1354	0.0003
Improved Seed application	0.0026	0.0001	0.0075	0.0371	**0.2121**	0.0026	0.0032
Dependency ratio	0.0008	0.0030	**0.3501**	0.0001	0.0023	0.0020	0.0029
Family size	0.0075	0.0008	**0.2697**	0.0027	0.0072	0.0255	0.0109
Annual Crop yield	0.0009	**0.4835**	0.0004	0.0003	0.0002	0.0004	0.0004
Crop Diversification	0.0001	**0.4825**	0.0003	0.0005	0.0003	0.0004	0.0005
Livestock ownership TLU	**0.2467**	0.0002	0.0016	0.0088	0.0042	0.0083	0.0015
Number of Livestock Died TLU	**0.1074**	0.0003	0.0001	0.0080	0.0036	0.0029	0.0280
Number of ploughing Animals	**0.2332**	0.0001	0.0001	0.0005	0.0003	0.0104	0.0005
Annual farm income	0.0245	0.0023	0.0087	0.0070	0.0004	0.0235	**0.7628**
Annual nonfarm income	0.0001	0.0024	0.0010	0.0047	0.0004	0.0013	**0.2445**
leadership role in social associations	0.0001	0.0001	0.0065	0.0045	0.0307	**0.3072**	0.0067

Source: Authors' computations based on the 2019 survey data

The normalized squared component loadings of the 7-dimensional solution were computed using equation 3.1 (see introduction). However, the seven intermediate composite indicators are aggregated using (equation 3.2). This is due to the fact that the vitality of the variance accounted by each component loadings measuring the overall adaptive capacity index is not the same (Dharmaratne & Attygalle, 2018).

Table 13: Weights assigned for each component loadings (Adaptive capacity indicators)

Components	Weights assigned
Component 1	0.2619
Component 2	0.1617
Component 3	0.1466
Component 4	0.1363
Component 5	0.1146
Component 6	0.0957
Component 7	0.0832

Source: Authors' computations based on the 2019 survey data

Hence, the seven intermediate composites are aggregated by attaching a weight. Each variable weight was multiplied by the corresponding factor weight for the final index calculation (equation 3.3).

Table 14: Final Weights for the 24 Indicators of Adaptive capacity

Variable	Weight scaled to unit sum one	Weight in percent
Age	0.0579	5.79
Sex	0.0000	0
Female household head	0.0562	5.62
Level of education	0.0148	1.48
Main occupation type	0.0000	0
participation in planning	0.0421	4.21
Membership status to *Edir*	0.0380	3.8
Membership status to *Ekub*	0.0355	3.55
Membership status to *Senbete*	0.0258	2.58
Livelihood diversification	0.0440	4.4
Decision making role	0.0161	1.61
Credit access	0.0480	4.8
Fertilizer application	0.0220	2.2
Improved Seed application	0.0271	2.71
Dependency ratio	0.0572	5.72
Family size	0.0440	4.4
Annual Crop yield	0.0871	8.71
Crop Diversification	0.0869	8.69
Livestock ownership TLU	0.0719	7.19
Number of Livestock Died TLU	0.0313	3.13
Number of ploughing Animals	0.0680	6.8
Annual farm income	0.0707	7.07
Annual nonfarm income	0.0227	2.27
leadership role in social associations	0.0327	3.27
Total	**1.0000**	**100%**

Note: To preserve comparability final weights are rescaled to sum up to one.
Source: Authors' computations based on the 2019 survey data

The contribution of sub-indicators to overall adaptive capacity at the household level is presented in a spider radar plot, where the final weights and significance of each sub-indicator's contribution to intrinsic vulnerability are plotted (Figure 13).

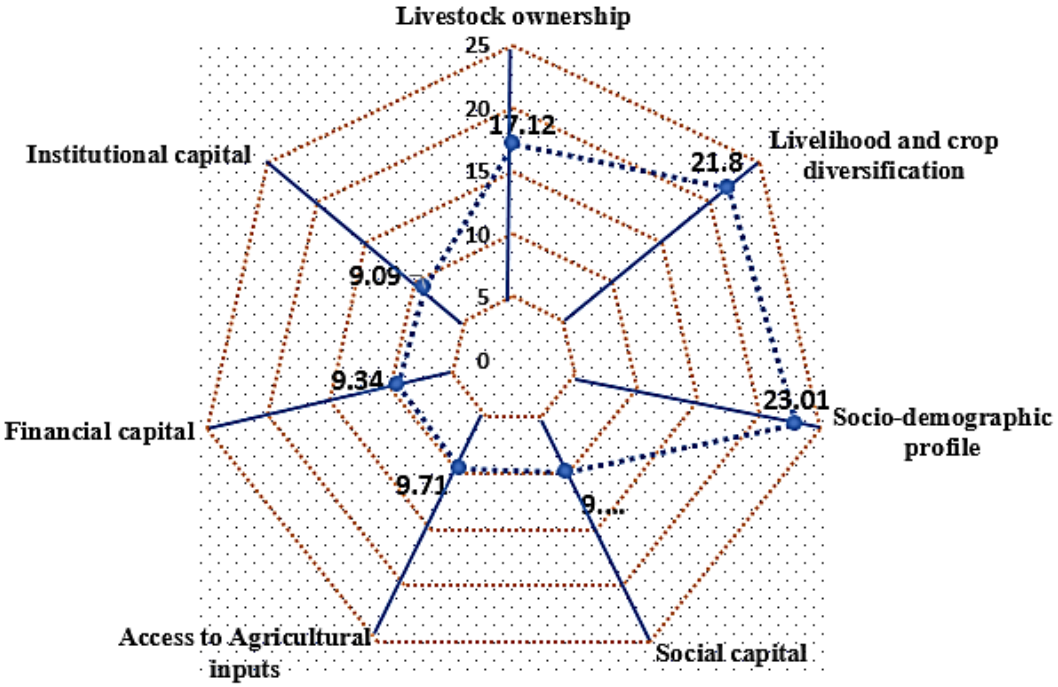

Figure 13: Spider diagrams of the sub-components' weight of adaptive capacity in Northwest Ethiopia

The final weights attached to the indicators under the first component loading were: livestock ownership in TLU (7.19%), number of livestock died in TLU (3.13%) and number of ploughing animals (6.8%). The indicators under the second component were squared and scaled to unity sum to drive weight for each variable. Accordingly, 4.4% for the livelihood diversification index, annual crop yield (8.71%) and crop diversification index (8.69%) were derived.

In the same manner, the weights attached to each of the indicators under the third component were 5.79%, 5.62%, 1.48%, 5.72% and 4.4% for age, female headed households, level of education, dependency ration and family size respectively. Under the fourth component, final weight allocated to membership status to *Edir* was 3.8% while membership to *Ekub* and *Senbete* weighted 3.55% and 2.58% respectively. Similarly, the weights assigned to credit access, fertilizer application and improved seed application were 4.8%, 2.2% and 2.71% respectively. The weights allocated to each indicator variable under the sixth component loading were 4.21%, 1.61% and 3.27% for participation in planning, decision making role and leadership role in social associations respectively. For the last component loadings, the final weights of the variables in the composite index were annual farm income (7.07%) and annual nonfarm income (2.27%).

4.5.2 Sensitivity Index: Component Loadings of Variables under Sensitivity Category

Similar to the adaptive capacity, the number of components extracted for the sensitivity index were seven based on the results obtained from Kaiser's eigenvalue rule (i.e. values greater than one) after running the maximum number (18) of dimensions. Scree plot rule, and interpretability criteria. The scree plot suggests six dimensions. Because the two criteria used gave conflicting suggestions, the interpretability criterion was used. After inspecting the component loadings, five dimensions were retained to maintain the interpretability of the solutions. The final solution is accounted for nearly 40% of the dataset and a Cronbach's a of 0.762.

Table 15: Rotated component loadings of Sensitivity of Northwest Ethiopia.

	Components						
	1	2	3	4	5	6	7
Access to climate information	.291	.301	-.290	.247	**.779**	-.083	-.188
Number of months with food shortage	**-.608**	.081	-.020	.353	.144	-.038	.043
Distance to the nearest market	-.164	.111	-.320	.291	**-.872**	.463	.378
Frequency of food intake per day	**.428**	.099	.319	.156	-.351	.089	-.064
Reserve food	**.631**	.098	.062	-.163	-.081	-.160	.180
Total farmland in *Timad*	.312	.184	**-.526**	-.059	-.183	.503	-.170
Land certification	-.028	-.092	**-.545**	-.245	-.288	.161	-.126
Farmland exposed to erosion	-.043	-.223	**.554**	.277	-.412	-.259	.373
Productivty of farmland	.374	.076	**.406**	-.210	.235	.201	.018
Seed reserve	**.534**	.170	-.025	.248	-.105	.016	.076
Fuelwood access	.238	.007	.003	**-.749**	.425	.021	.591
Distance to the nearest fuelwood source	-.230	.354	.556	**.657**	-.143	.074	-.012
Tree planting (Annual)	.336	.147	-.270	**.438**	.078	-.213	-.222
Access to river water sources	-.174	**.764**	-.309	-.339	-.206	-.216	.251
Water shortage	-.111	**.450**	.033	-.296	-.074	-.291	-.289
Distance to the nearest water source	-.235	**.684**	.121	-.196	-.199	.036	.074
Irrigated land in *Timad*	.333	.087	**-.726**	.139	-.239	-.317	.145
Water conflict	-.073	**.514**	-.107	.224	.296	.065	.189

Note: The Kaiser–Meyer–Olkin (KMO) criterion approves that CATPCA is an appropriate method to estimate the composite index of sensitivity with a value of 0.639. In addition, Bartlett's test of sampling adequacy $x^2 = 1336.75$ with P-value <0.00 confirming highly correlation of sensitivity indicator variables and adequate sample for the analysis.
Source: Authors' computations based on the 2019 survey data

As can be seen from Table 15, the indicator variables with the highest component loadings on the first extracted dimension were number of months with food shortage (-0.608), frequency of food intake per day (0.428), seed reserve (0.534) and food reserve (0.631). This component represents a composite index named food assets. The first component alone explains about 11.24% of the variation in the data out of the five dimensions extracted. The result related to the vitality of this dimension is the same with previous studies (Asrat & Simane, 2017; Bizimana, Twarabamenye & Kienberger, 2015; Tesso et al., 2012). According to Bizimana et al. (2015) sensitivity of a household to climate change is more attributed to access to food assets.

For instance, a study conducted by Notenbaert, Karanja, Herrero, Felisberto & Moyo (2013) revealed that a lower level of vulnerability of households is associated with a lower lack of food.

The second principal component represented a composite index called access to water resources. This component had high loadings on access to river water (0.764), water shortage (0.450), and distance to the nearest water source (0.684) and water conflict (0.514). Similar reports on the importance of these indicators to explain sensitivity differences among households have been reported in previous researches (Bizimana et al, 2015; Notenbaert et al., 2013; Schilling, Hertig, Tramblay & Scheffran, 2020; Yadava & Sinha, 2020). According to Yadava and Sinha (2020) distance to drinking water sources and time taken to collect water had significant contributions to explain the level of vulnerability. The third component which explained approximately 7.5% of variance in the data set had high and negative loadings on total farmland in *Timad* (-0.526), land certification (-0.545), and positive loadings on farmland exposed to erosion (0.554) and productivity of farmland (0.406). In line with this result previous studies had reported that land with no access to irrigation (Huong, Yao & Fahad, 2019) and land with no tenure security (Teshome, 2016a) could exacerbate the sensitivity of smallholder farmers to climate-induced shocks.

The fourth component represented access to energy sources with the highest factor loadings on fuelwood access (-0.749), distance to the nearest source of fuelwood sources (0.657) and tree planting activities (0.438). This dimension explained nearly 6.65% of the variance in the dataset. It is assumed that households who are only depending on forest-based energy for cooking and lighting purpose are more sensitive to the climate extremes. The same result has been reported by Yadava and Sinha (2020) revealing that access to energy sources transforms households' livelihood from traditional to modern which ultimately leads to an enhanced coping capacity of households when faced with climate extremes.

The fifth component which explained 6.2% of the variance had high loadings on access to climate information (0.779) and distance to the nearest market (-0.872). This component represents an intermediate composite indicator called infrastructure. It is assumed that access to the market and climate information is an important factor in mainstreaming development for marginal and inaccessible rural area. This concurs with studies by Opiyo et al. (2014) and Alemayehu and Bewket (2016) which similarly observed that distance to the nearest market and access to climate information are the key factors that determine households' intrinsic vulnerability to climate extremes in rural communities.

Table 16: Matrix of Squared Factor Loadings Scaled to Unit Sum (Sensitivity indicators)

	Components				
Variables	**1**	**2**	**3**	**4**	**5**
Access to climate information	0.0418	0.0616	0.0622	0.0508	**0.5433**
Number of months with food shortage	**0.1823**	0.0045	0.0003	0.1039	0.0186
Distance to the nearest market	0.0133	0.0084	0.0757	0.0706	**0.6807**
Frequency of food intake per day	**0.0903**	0.0067	0.0753	0.0203	0.0103
Reserve food	**0.1963**	0.0065	0.0028	0.0222	0.0059
Total farmland in *Timad*	0.0480	0.0230	**0.2046**	0.0029	0.0299
Land certification	0.0004	0.0058	**0.2197**	0.0501	0.0743
Farmland exposed to erosion	0.0009	0.0338	**0.2270**	0.0639	0.1519
Productivity of farmland	0.0689	0.0039	**0.1219**	0.0368	0.0494
Seed reserve	**0.1406**	0.0196	0.0005	0.0513	0.0099
Access to fuelwood	0.0279	0.0003	0.0006	**0.4679**	0.1617
Distance to the nearest fuelwood source	0.0261	0.0851	0.2287	**0.3600**	0.0183
Tree planting	0.0557	0.0147	0.0539	**0.1600**	0.0054
Access to River water	0.0149	**0.3965**	0.0706	0.0958	0.0379
Water shortage	0.0061	**0.1376**	0.0008	0.0731	0.0049
Distance to the nearest water source	0.0272	**0.3178**	0.0108	0.0320	0.0355
Irrigated land in *Timad*	0.0547	0.0051	**0.3898**	0.0161	0.0511
Water conflict	0.0026	**0.1795**	0.0085	0.0418	0.0784

Source: Author's computation based on the 2019 survey data

Then, each of the sensitivity indicators were squared and scaled to unity sum (Table 16) and the final weights of the indicators were derived by combining the squared factor loadings and component weights (Table 17).

Table 17: Weights assigned for each components of Sensitivity indicators

Components	**Weights assigned**
Component 1	0.282924
Component 2	0.205357
Component 3	0.188616
Component 4	0.167271
Component 5	0.155831

Source: Author's computation based on the 2019 data

As can be seen from Table 17 above, the vitality of the factors measuring the overall sensitivity is not the same. Hence, each of the indicators were aggregated by attaching a weight equal to the percentage of the variance explained in the dataset. The percentage of the explained variance was calculated using the same procedure used to compute adaptive capacity (equation 3.4).

Then, each variable weight computed from squared factor loadings was multiplied by the corresponding factor weight for the final index calculation (Table 18).

Table 18: Final Weights attached to sensitivity indicator variables

Variables/indicators	Weight scaled to unit sum one	Weight in percent
Access to climate information	0.153706	15.3
Number of months with food shortage	0.036433	3.6
Distance to the nearest market	0.10408	10.4
Frequency of food intake per day	0.025456	2.5
Reserve food	0.055547	5.5
Total farmland in *Timad*	0.038599	3.9
Land certification	0.041438	4.1
Farmland exposed to erosion	0.042818	4.3
Productivity of farmland	0.022996	2.3
Seed reserve	0.039782	3.9
Access to fuelwood	0.076265	7.6
Distance to the nearest fuelwood source	0.060219	6
Tree planting	0.026764	2.6
Access to River water	0.081431	8
Water shortage	0.026251	2.6
Distance to the nearest water source	0.06427	6.4
Irrigated land in *Timad*	0.073432	7.3
Water Conflict	0.036858	3.7

***Note**: To preserve comparability final weights are rescaled to sum up to one.*

Based on the result of the statistical computation, higher weight was assigned to access to climate information (15.3%), distance to the nearest market (10.4%), access to fuelwood (7.6%), access to river (8%) irrigated land in *Timad* (7.3%) and distance to the nearest water source (6.4%).

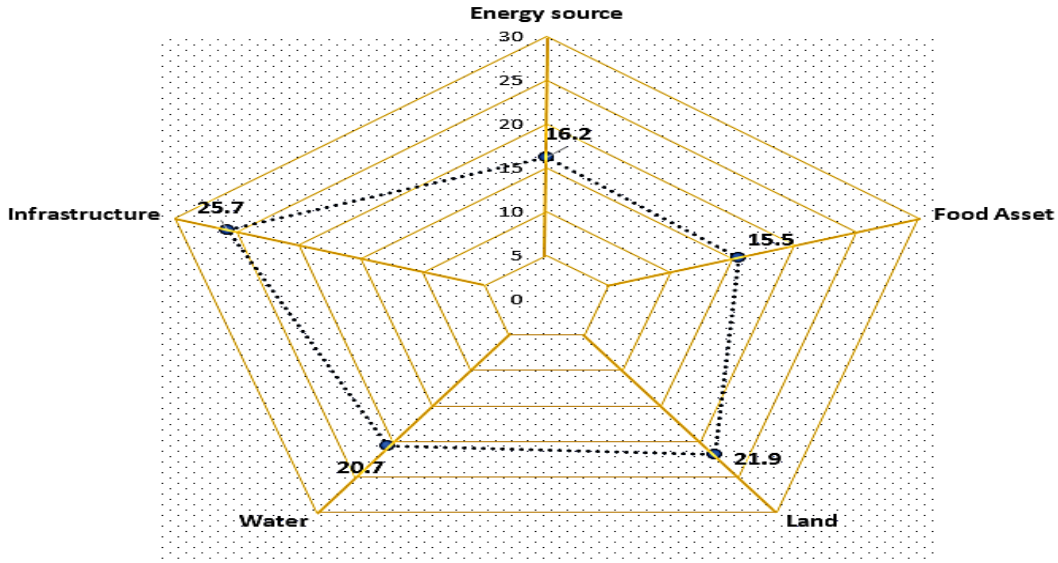

Figure 14: Spider diagrams of the sub-components' weight of Sensitivity Indicators

Figure 14 elucidates the contribution of intermediate composite index of overall sensitivity at the household level as a radar plot, where the weights of each sub-indicator's contribution to

the sensitivity of households to climate change are plotted as a radar plot. Accordingly, infrastructure sub-indicator has the highest weight with 25.7% contribution to households' vulnerability in North-western parts of Ethiopia.

4.6 Adaptation Strategies and Preferences

This section summarises the findings of both the descriptive and inferential statistics. The first sub-section presents the descriptive analysis findings that focus on socio-demographic characteristics of the respondents, respondents' information regarding climate change adaptation strategies, households' adaptation practices and preferences, and hindrance factors for not using preferred adaptation strategies. Cross-tabulation results of some variables such as the perception regarding adaptation possibility with district, gender, marital status, educational status, and having a mobile phone is presented in sub-section two. The third sub-section focuses on the findings of multivariate analysis which is fitted into four models: Model_1: aggregated adaptation strategies, Model_2: farming related adaptation strategies, Model_3: livestock related adaptation strategies, and Model_4: non-agricultural adaptation strategies.

4.6.1 Univariate analysis

Univariate analysis is essential to have appropriate further bivariate and multivariate analysis with the variables studied. Thus, in this section, the distributional responses of each variable (the dependent as well as the independent variables) are discussed using frequency tables and charts to obtain summary information about the data. Mainly, the section focuses on the socio-demographic characteristics of the respondents, the respondents' adaptation practices, their adaptation preference, and its disparity with what they are practicing, and the hindrance factors for practicing their adaptation preferences.

4.6.1.1 Socio-demographic characteristics of the respondents

In this study, a total of 1620 households with 99.5% response rate participated. Of all the study participants 867 (53.75%) were female; and the mean age of the respondents was 39.48 (±11.25). The majorities of the respondents were Orthodox Christians by religion 1,563 (96.9%) and married 1,418 (87.9%). In regard to main occupation, majority of the respondents were farmers. The mean family size was found 5.42 (±2.32), majority of the respondents, i.e., 1083 (67.14%) have no schooling/not able to read and write (Table 19).

Table 19: Demographic and socioeconomic characteristics of the study participants in North Gondar Zone, northwest Ethiopia, 2019 (n=1620)

Variable	Category	District			Total
		East-*Belessa*	West-*Belessa*	*Dabat*	
Sex	Female	400 (46.14 %)	308 (35.52%)	159 (18.34 %)	867 (53.75%)
	Male	329 (44.10 %)	279 (37.40%)	138 (18.50%)	746 (46.25%)
Target group	Male household heads	329 (44.10%)	279 (37.4%)	138 (18.5%)	746 (46.2%)
	Female household heads	86 (47.51%)	66 (36.46%)	29 (16.02%)	181 (11.2%)
	Female in the male headed hhs	314 (45.77%)	242 (35.28%)	130 (18.95%)	686 (42.5%)
Age of the respondent	18- 30 years	203 (27.85 %)	167 (28.45 %)	67 (22.56 %)	437 (27.09%)
	31-45 years	344 (47.19 %)	251 (42.76 %)	140 (47.14 %)	735 (45.57 %)
	46-65 years	182 (24.97 %)	169 (28.79%)	90 (30.30 %)	441 (27.34 %)
Religion	Orthodox Christian	714 (97.94%)	575 (97.96%)	274 (92.26 %)	1,563 (96.9%)
	Muslim	15 (2.06 %)	12 (2.04 %)	23 (7.74 %)	50 (3.1%)
Marital status	Married	639 (87.65 %)	514 (87.56%)	265 (89.23 %)	1,418 (87.9%)
	Widowed	38 (5.21 %)	31 (5.28 %)	17 (5.72 %)	86 (5.33%)
	Divorced	41(5.62%)	37 (6.30 %)	7 (2.36 %)	85 (5.27%)
	Separated	11 (1.51%)	5 (0.85 %)	8 (2.69 %)	24 (1.49%)
Education	No schooling	479 (65.71 %)	398 (67.80%)	206 (69.36%)	1083 (67.14%)
	Able to read and write	81(11.11%)	77 (13.12 %)	36 (12.12 %)	194 (12.03%)
	Primary education (1-8)	133 (18.24%)	87 (14.82 %)	51(17.17 %)	271 (16.08%)
	Secondary school & above	36 (4.94%)	25(4.26%)	4(1.35 %)	65 (4.02%)
Occupation	Farmer	653(89.57%)	484(82.45%)	280(94.28%)	1,417 (87.85%)
	Housewife	43(5.90%)	55(9.37%)	13 (4.38%)	111 (6.88%)
	Daily laborer	9 (1.23%)	20 (3.41%)	0 (%)	29 (1.8%)
	Carpenter	3 (0.41%)	0 (%)	1(0.34%)	4 (0.25%)
	Others	21(2.88%)	28(4.77 %)	3 (1.01%)	52 (3.22%)
Family size	<5 members	390 (53.50 %)	288 (49.06 %)	173 (58.25 %)	851 (52.76%)
	5-10 members	324 (44.44 %)	286 (48.72%)	117 (39.39 %)	727 (45.07%)
	>10 members	15 (2.06 %)	13 (2.21%)	7 (2.36%)	35(2.17%)

4.6.1.2 Information regarding climate change adaptation strategies

Despite their traditional knowledge and practices, the respondents were asked if they ever heard about climate change adaptation strategies to assess their awareness. The reponse for majority (70.7%) of the female respondants was `no`. Of the male respondents 56.1% replied yes for the question. While there is a large percentage of men who are also not aware of climate change adaptation strategies, this clearly indicates that females have weak information access comparing to their counterparts. This could be due to the domestic work burden females have which gives no/little time for other engagements.

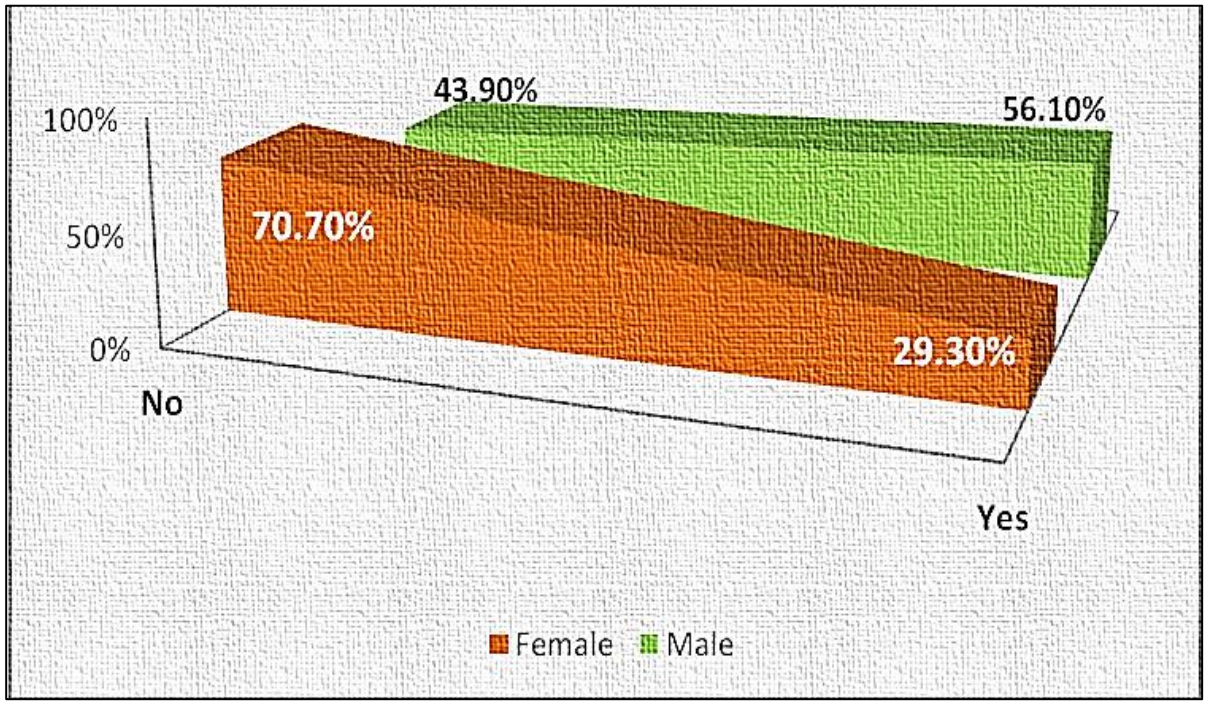

Figure 15: Information regarding climate change adaptation strategies by gender

On the other hand, households in West-*Belessa* were found with higher information regarding the climate change adaptation strategies. Around 64.7% of respondents from the district replied yes. On the contrary, around half (47.8%) of the participants from East-*Belessa* reported they didn`t hear about the issue before (Figure 16).

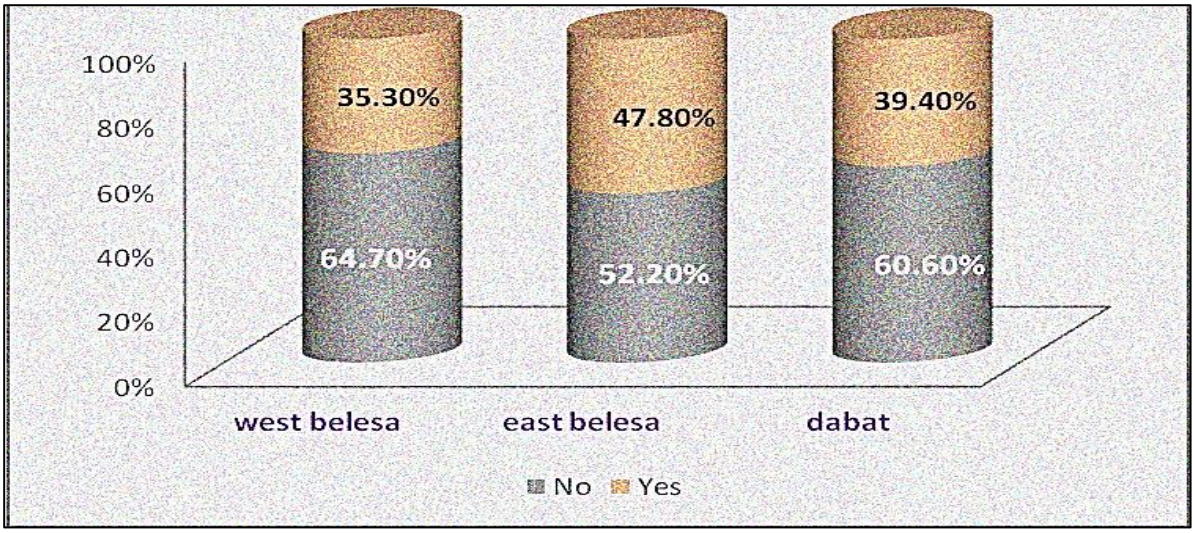

Figure 16: Information regarding climate change adaptation strategies by district

This district-to-district variation could be due to the geographical locations of the areas, as districts close to zones/cities and with good infrastructural facilities could have higher information access and exposure to different opportunities. In this regard West *Belessa* has relatively more location advantage than East *Belessa*.

4.6.1.3 Households' adaptation practice

Adapting to climate changes seem to be the most appropriate and responsive way for households to lower the negative impacts of climate change. Based on literature reviewed on the area, three adaptation strategy categories (i.e. farming related, livestock related, and non-agricultural strategies) were used to assess the households' adaptation practices. The descriptive results show that, the participants are practicing more adaptation strategies which are related with farming. This is supported by many literatures on the area. That is, agricultural measures such as the use of improved crop varieties, planting trees, soil conservation, changing planting times, and irrigation are the most widely used adaptation strategies (Menike, 2016). On the other hand, the non-agricultural related strategies were found the least practiced strategies. Even though, adaptation is location-specific and influenced by different factors, accessibility of the adaptation methods could be the key driver for this finding [Gebre, 2015; Simane, 2018]. That is, the non-agricultural adaptations strategies require financial capacity of the households, which makes it not preferable for households which are highly economically challenged.

A. Households' farming related adaptation practice

Among the farming related adaptation strategies, soil conservation measures such as contour ploughing, terrace farming, windbreaks, crop rotation, and mineralization were found highly practiced among the households. Of the respondents 1131 (70.16%) replied they practiced the strategies related with farming frequently and very frequently (Table 20). This could be due to the districts agro-ecological settings including climate condition, soil type and other natural resource endowments [Gebre, 2015].

Table 20: Households farming related adaptation strategy practice in North Gondar Zone

Strategy	Frequency	5-scale Proportion (%)	3-scale Proportion (%)
Planting of drought resistant crop varieties	Never	464 (28.80 %)	41.7%
	Rarely	208 (12.91 %)	19.12%
	Occasionally	308 (19.12%)	39.18%
	Frequently	232 (14.40%)	
	Very frequently	399 (24.77%)	
Change planting/cropping time	Never	316 (19.69%)	28.72%
	Rarely	145 (9.03%)	25.23%
	Occasionally	405 (25.23%)	46.04%
	Frequently	322 (20.06%)	
	Very frequently	417 (25.98%)	
Crop diversification towards high value crops	Never	329 (20.58%)	34.77%
	Rarely	227 (14.20%)	20.2%
	Occasionally	323 (20.20%)	45.03%
	Frequently	331 (20.70%)	
	Very frequently	389 (24.33%)	
Mixed cropping/ intercropping	Never	485 (30.22%)	40.81%
	Rarely	170 (10.59%)	15.83%
	Occasionally	254 (15.83%)	43.36%
	Frequently	320 (19.94%)	
	Very frequently	376 (23.43 %)	
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	Rarely	208 (12.91 %)	19.12%
	Occasionally	308 (19.12%)	39.18%
	Frequently	232 (14.40%)	
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	Rarely	170 (10.59%)	15.83%
	Occasionally	254 (15.83%)	43.36%
	Frequently	320 (19.94%)	
	Very frequently	376 (23.43 %)	

Growing short season crops and vegetables	Never	281 (17.56 %)	27.94%
	Rarely	166 (10.38 %)	17.94%
	Occasionally	287 (17.94 %)	54.12%
	Frequently	354 (22.13 %)	
	Very frequently	512 (32%)	
Tree planting: Planting trees around and within crops	Never	761 (47.83 %)	58.96%
	Rarely	177 (11.13%)	14.2%
	Occasionally	226 (14.2 %)	26.84%
	Frequently	220 (13.83 %)	
	Very frequently	207 (13.01 %)	
Using micro irrigation	Never	1,068 (67.09%)	74.5%
	Rarely	118 (7.41 %)	8.73%
	Occasionally	139 (8.73 %)	16.77%
	Frequently	143 (8.98 %)	
	Very frequently	124 (7.79 %)	
Adopting soil conservation measures such as contour ploughing, terrace farming, windbreaks, crop rotation, mineralization,	Never	196 (12.23 %)	17.98%
	Rarely	92 (5.74 %)	11.86%
	Occasionally	190 (11.86 %)	70.16%
	Frequently	364 (22.72 %)	
	Very frequently	760 (47.44%)	

NB. *In the 3 scale `never` and `rarely` are merged and reported as less practiced strategy. On the other hand, `frequently` and ` very frequently` are merged and reported as commonly practices strategy.*

Micro-irrigation was one of the farming related strategies asked to the participants. However as shown in the figure below, it was found among the least practiced strategy. Around 1200 (74.5%) of the respondents stated they never and rarely use it as a strategy (Figure 18). In addition to other factors, this could be due to the nature of the strategy. That is, previous studies indicated that, most adaptation strategies are driven by the immediate change in the climatic situation. That is, planned measures such as irrigation works are not preferred by the households as short term remedy (Asfaw et al., 2013).

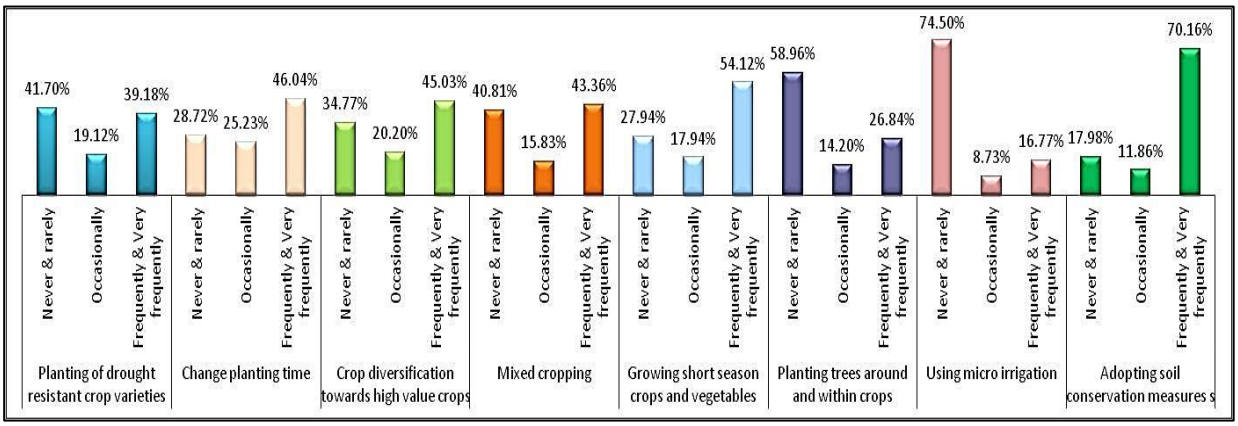


Figure 17: Households' farming related adaptation strategy practice

On the other hand, considerable difference was found among the districts regarding practicing micro-irrigation. Around 48% of households in West *Belessa* still practiced (occasionally and above) the strategy. As availability of nearby river facilitates practicing irrigation traditionally and economically, a river in West *Belessa* named *`Hota river`* could motivate households in the district to practice the strategy (Figure 18). A recent intervention by the NGO called *Ameld* for appropriate utilization of the river and terracing further encourages households in West *Belessa* to practice micro-irrigation as climate change adaptation strategy.

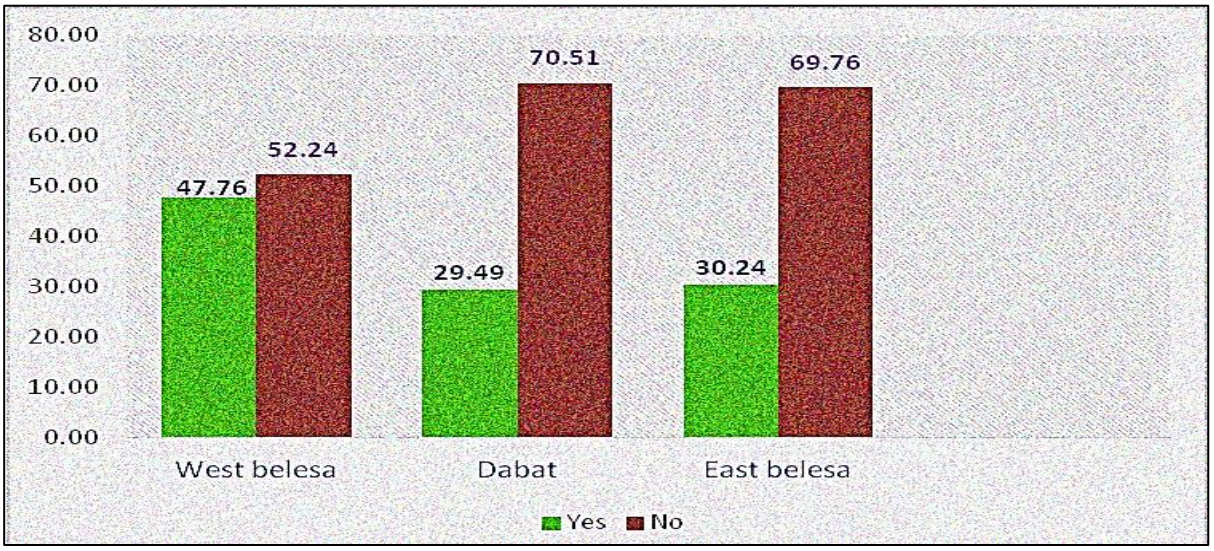


Figure 18: Households micro-irrigation practice by district

Even though, districts vary in practicing some farming strategies, overall, they seem more or less similar in practicing the farming related strategies (Figure 19).

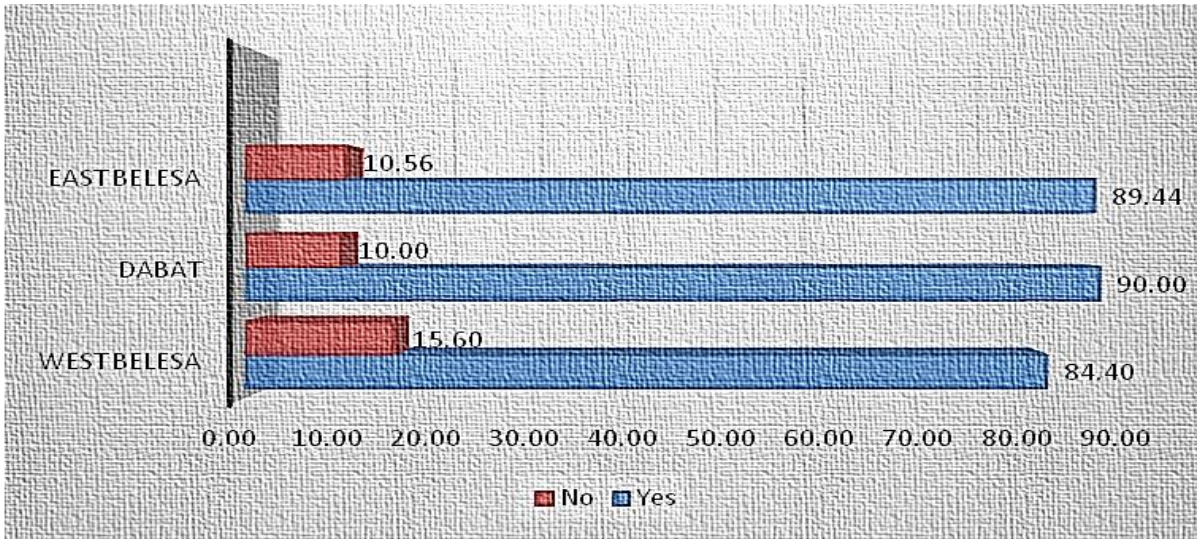


Figure 19: Households' practice of farming related strategies by district

B. Households' livestock related adaptation practice

Among the livestock related adaptation strategies, implementing cut and carry system for improved feeding was found the most practiced strategy among the households. This finding is in line with a study conducted in Ethiopia by Amonge in 2018. In this study, of the total participants, 1043 (64.7%) replied that they used the strategy frequently and very frequently. On the other hand, improving local genetics through crossbreeding with heat and disease tolerant breeds was found the least practiced strategy among the livestock related strategies; never and rarely practiced by 80.2% of the respondents (Table 21). This could be due to the accessibility of the adaptation method (getting heat and disease tolerant breeds) and financial capacity of the households to afford purchasing.

Table 21: Household's livestock related adaptation strategy practice in North Gondar Zone

Strategy	Frequency	5-scale Proportion (%)	3-scale (%)
a. Making livestock production adjustments			
Livestock Diversification	Never Rarely Occasionally Frequently Very frequently	733 (45.93 %) 234 (14.66 %) 272 (17.04%) 227 (14.22 %) 130 (8.15%)	60.59% 17.04% 22.37%
Livestock Intensification	Never Rarely Occasionally Frequently Very frequently	754 (47.15 %) 227 (14.20 %) 256 (16.01 %) 229 (14.32 %) 133 (8.32 %)	61.35% 16.01% 22.64%
Integration of pasture management	Never Rarely Occasionally Frequently Very frequently	954 (60.04 %) 186 (11.71 %) 213 (13.40 %) 155 (9.75 %) 81 (5.10 %)	71.74% 13.4% 14.86%
Altering the timing of operations	Never Rarely Occasionally Frequently Very frequently	945 (59.55 %) 164 (10.33 %) 192 (12.10 %) 156 (9.83 %) 130 (8.19 %)	69.88% 12.1% 18.02%
b. Livestock breeding			
Improving local genetics through crossbreeding with heat and disease tolerant breeds.	Never Rarely Occasionally Frequently Very frequently	1,113 (70.85 %) 147 (9.36 %) 150 (9.55%) 107 (6.81 %) 54 (3.44 %)	80.2% 9.55% 10.25%
c. Livestock management systems			
Provision of shade and water to reduce heat stress from increased temperature.	Never Rarely Occasionally Frequently Very frequently	682 (42.89%) 158 (9.94 %) 211 (13.27 %) 247 (15.53 %) 292 (18.36 %)	52.83% 13.27% 33.9%
Destocking/Reduction of livestock numbers	Never Rarely Occasionally Frequently Very frequently	752 (47.21 %) 166 (10.42 %) 218 (13.68 %) 220 (13.81 %) 237 (14.88%)	57.63% 13.68% 28.69%
Changing the Type of livestock	Never Rarely Occasionally Frequently Very frequently	844 (52.45%) 155 (9.63%) 223 (13.86%) 213 (13.24%) 174 (10.81%)	62.08% 13.86% 24.06%
Implementing cut and carry system for improved feeding	Never Rarely Occasionally Frequently Very frequently	297 (18.21%) 100 (6.13%) 182 (11.16%) 335 (20.54%) 717 (43.96%)	24.34% 11.16% 64.7%

To assess variation among districts in practicing the livestock related strategies, cross tabulation analysis was conducted. Around 51% of households in Dabat were found practicing the strategy (Figure 20). *Dabat* is *Dega* which is conducive for grassing lands, water access, and health condition of livestock. Hence, this could be due to the fact that households consider their agro-ecological settings and climatic conditions to practice livestock related strategies. The strategy is highly practiced by West *Belessa* compared to East *Belessa* which relatively owns a good climatic condition.

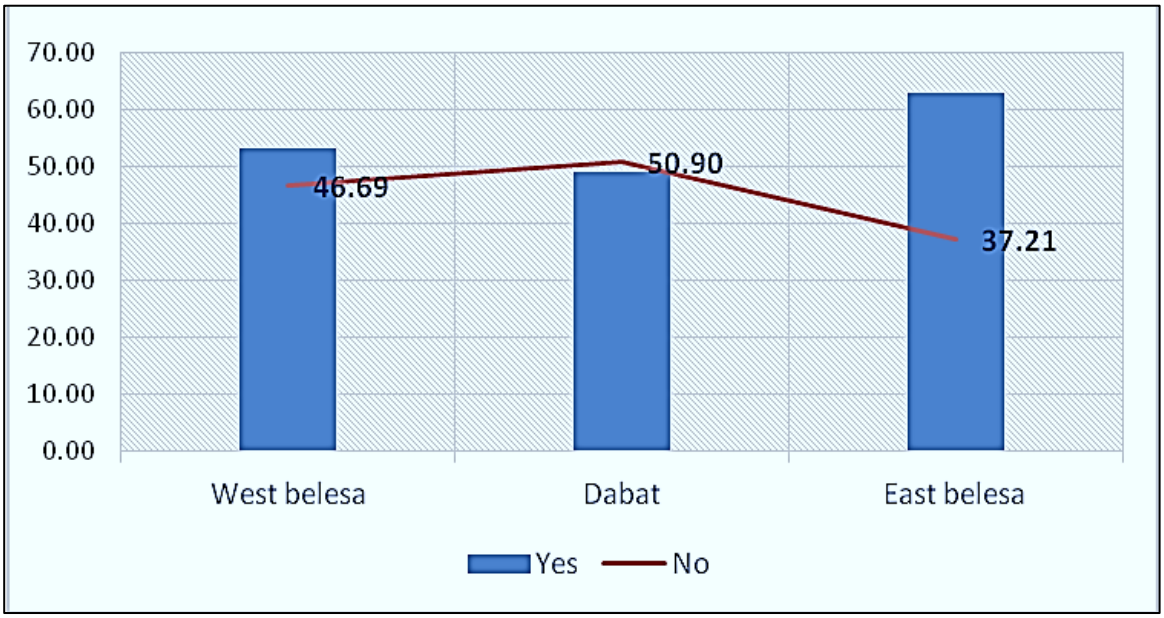


Figure 20: Households' practice of livestock related strategies by district

C. Households' non-agricultural related adaptation practice

Diversifying non-agricultural income sources and migration were included in the survey to assess the households' practice of non-agricultural climate adaptation strategies. Both the strategies were found rarely practiced among the households. In particular, migration was found never and rarely practiced by 79.5% (and never practiced by 73.7%) of the respondents (Figure 22). Temporary and permanent migration in search of employment is widely practiced as an adaptive response to climate change. However, the ability to migrate requires financial capacity to cover transportation, accommodation, and related costs. Thus, households who are very poor were not able to migrate even though they prefer to do it.

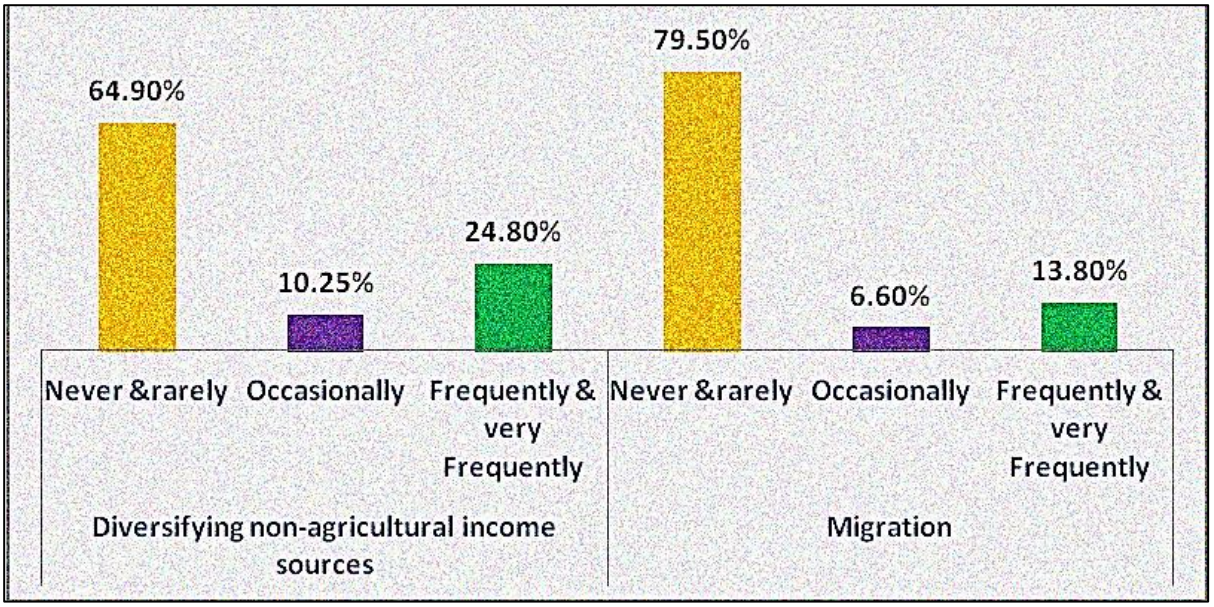


Figure 21: Households' non-agricultural related adaptation practice

Variation among districts was observed in practicing the non-agricultural strategies. The strategies were found relatively highly practiced in *Dabat* which could be due to the accessible location and better infrastructure of the district comparing with west and east Belessa (Figure 22).

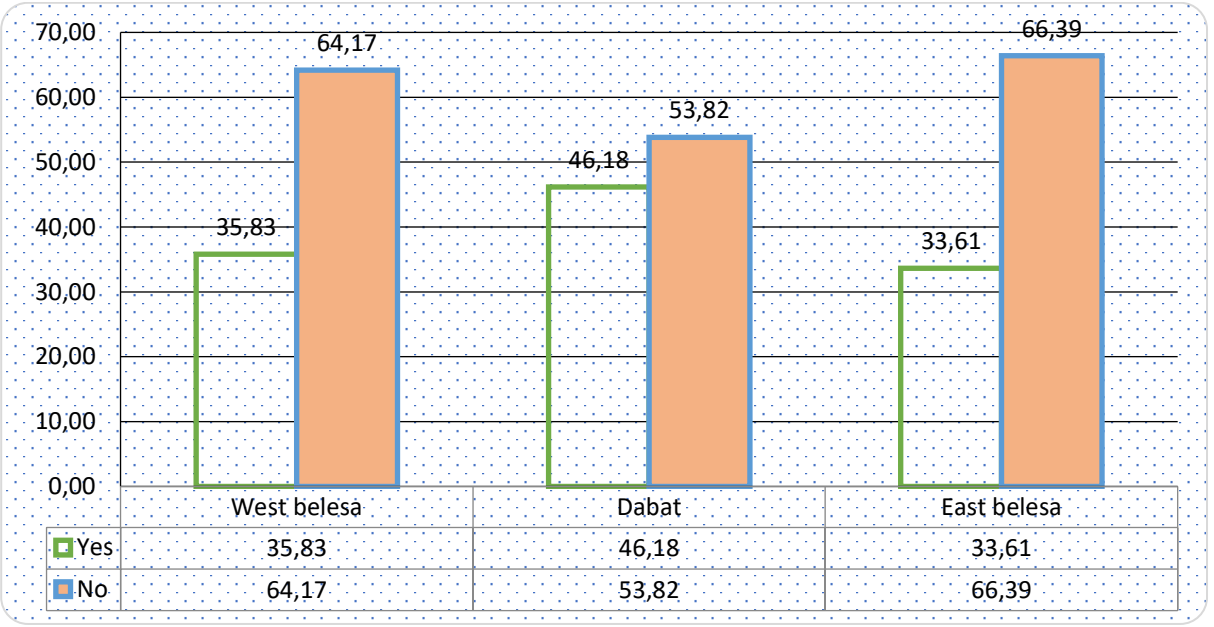


Figure 22: Households' non-agricultural related adaptation practice by district

Among the non-agricultural related adaptation strategies, migration was again found relatively highly practiced among households in *Dabat* district (Figure 23). Around 37% of households in the district were found practicing the strategy. In addition to the accessible location and better infrastructure of the district, existence of a close by port to Sudan via *Metema* could facilitate the practice of the strategy.

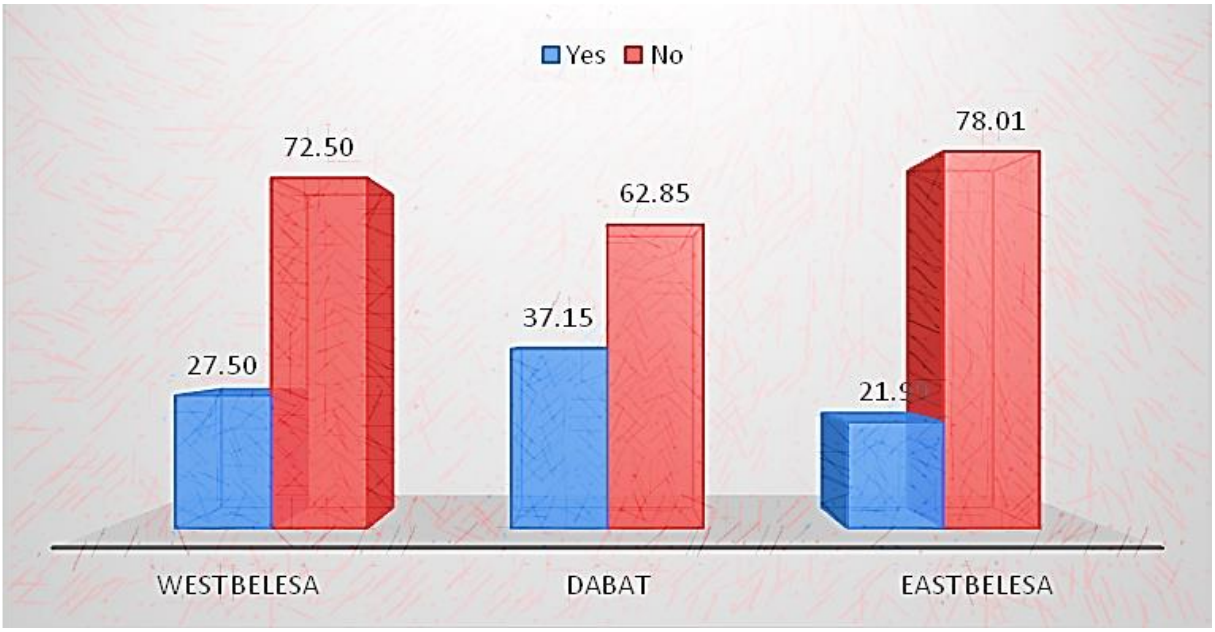


Figure 23: Households' migration practice by district

4.6.1.4 Households' adaptation preferences

Scholars agree that, for different reasons households' adaptation practices might differ from what they prefer to practice. Among others natural systems, financial, cognitive behavioural, social and cultural factors are commonly used to explain the difference between the currently practiced household strategies and their preference.

In this research, a question to address their adaptation preference was included in the survey. Thus, of the three adaptation strategy categories such as farming related, livestock related, and non-agricultural strategies, the farming related strategies were found more preferred, followed by livestock related strategies (Figure 24).

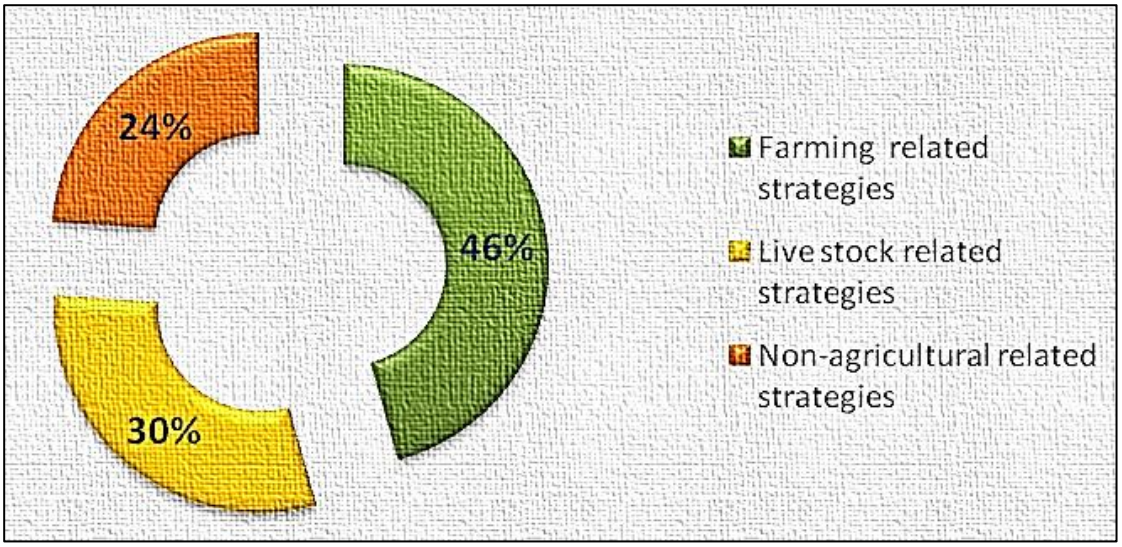


Figure 24: Households' adaptation preference by strategy category

Among the farming related adaptation strategies, adopting soil conservation measures such as contour ploughing, terrace farming, windbreaks, crop rotation, mineralization, was found the most preferred strategy among the farming related strategies. This result is in line with the findings of previous studies by Amonge (2018), Paulos (2018), and Melese (2018) which indicate that farmers are more likely to implement soil conservation.

The descriptive results also highlight that crop diversification towards high value crops is the second preferred (next to adopting soil conservation measures) farming related strategy. On the other hand, micro-irrigation was found the least preferred farming related strategy (Figure 25).

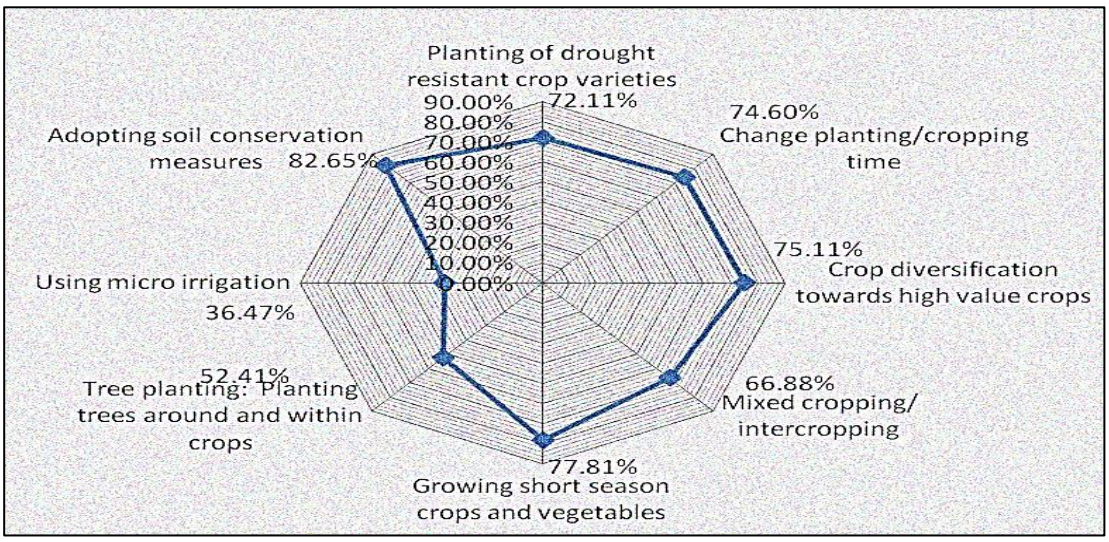


Figure 25: Households' farming related adaptation preference

Regarding livestock related adaptation strategies, households mostly preferred the implementing cut and carry system for improved feeding strategy. That is, around 74% of the respondents indicated their preference to the strategy. The provision of shade and water to reduce heat stress from increased temperature strategy was found the second relatively highest strategy that was preferred by the respondents (Figure 26).

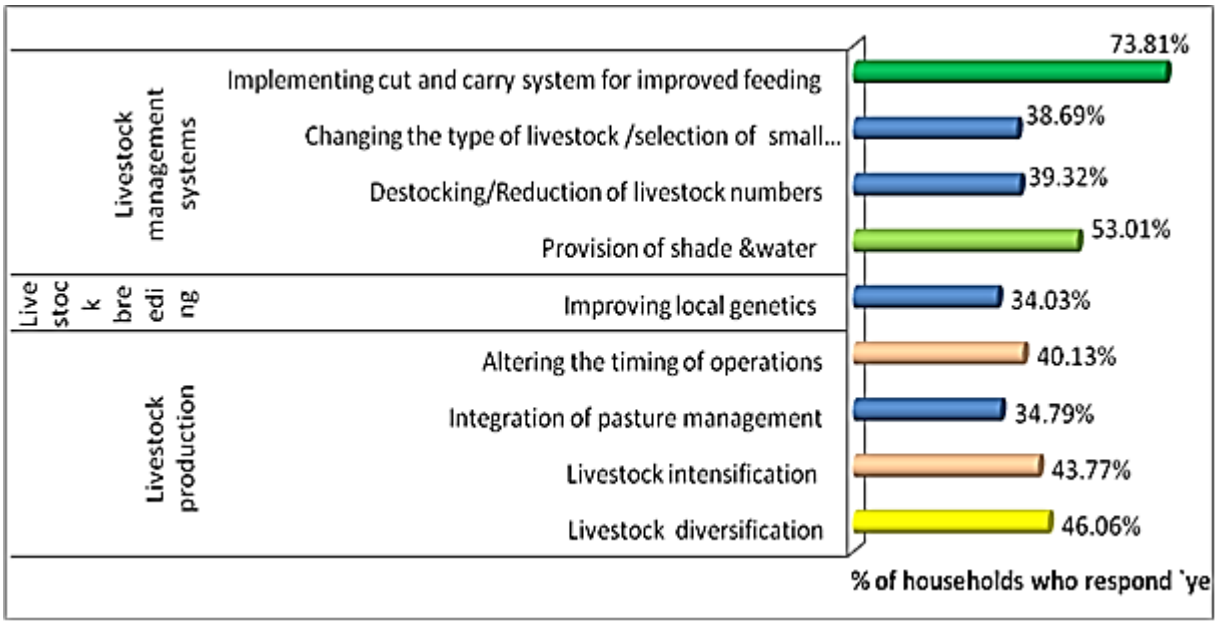


Figure 26: Households livestock related adaptation strategy preference

On the contrary, livestock strategies such as integration of pasture management and improving local genetics through crossbreeding were found the least preferred by the respondents; where only 34.79% and 34.03% of the respondents showed a positive response, respectively. In this study, the non-agricultural related strategies such as diversifying non-agricultural income sources and migration were also found the least preferred among the strategy categories. Only 43.6% of the study participants showed positive preference to diversifying non-agricultural income sources as a strategy. And migration was found the most least preferred strategy among the entire category, and all strategies included in the study (Figure 27).

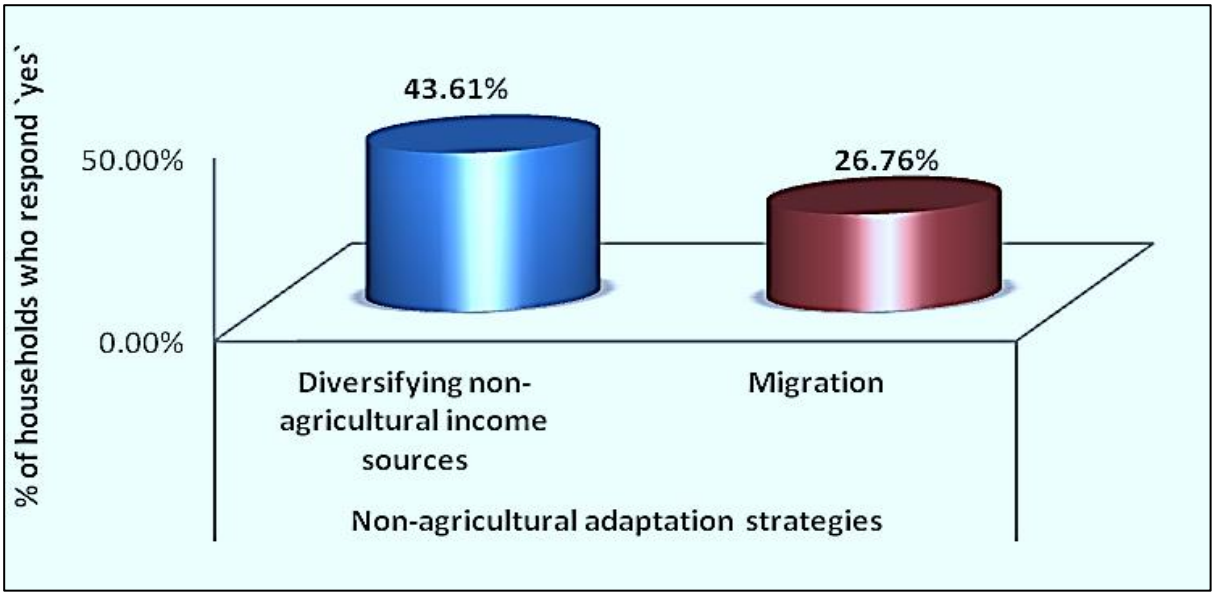


Figure 27: Households' non-agricultural adaptation strategy preference

4.6.1.5 Practice-preference disparities

Though practice-preference similarities were found for some strategies, still a disparity was observed in other strategies. Of the total respondents 1,156 (72.11%) preferred planting of drought resistant crop varieties; but it was found practiced very frequently and frequently by 631 (39.18%) respondents. Similarly, growing short season crops and vegetables were found preferred by 1,245 (77.81%) of the respondents; but very frequently and frequently practiced by 872 (54.12%) of the study participants. On the other hand, 1,136 (73.24 %) of the respondent replied as they do not prefer migration as adaptation strategy; and was found practiced never and rarely by 86.16 % of the respondents (Figure 28).

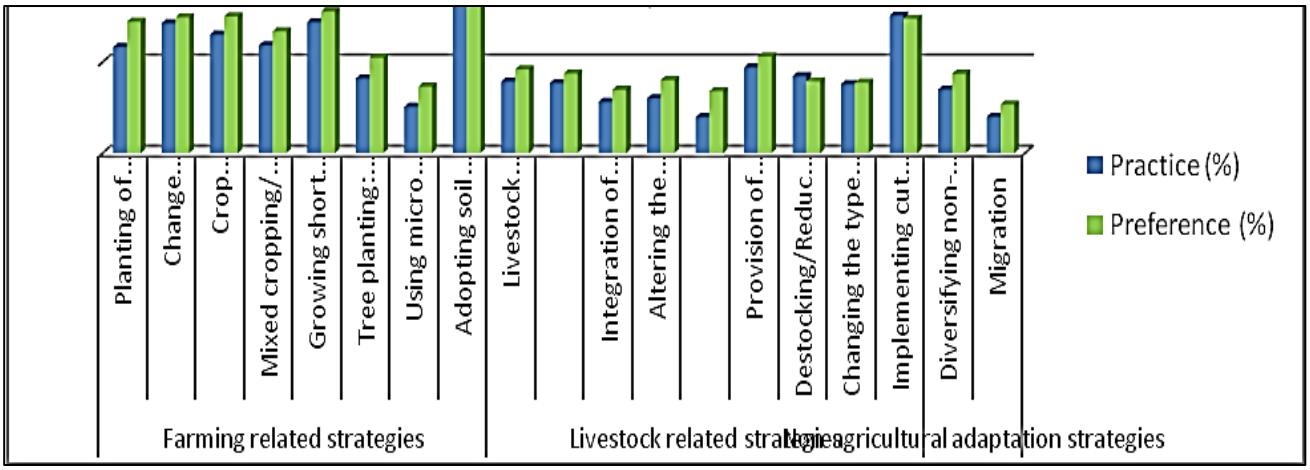


Figure 28: Households' adaptation Practice vs. Preference

In all the strategy categories, preference of the respondents was found higher than their actual practice. On average, 67.2% of the households prefer to practice the farming related strategies. However, only 59.3 % of the respondents are practicing it. Regarding livestock related strategies, 44.8 % of the respondents preferred it and the strategy is found practiced by 39.8%. Similarly, 35.1% of the households prefer to practice the non-agricultural related strategies; and only 28% of them are practicing it (Figure 29).

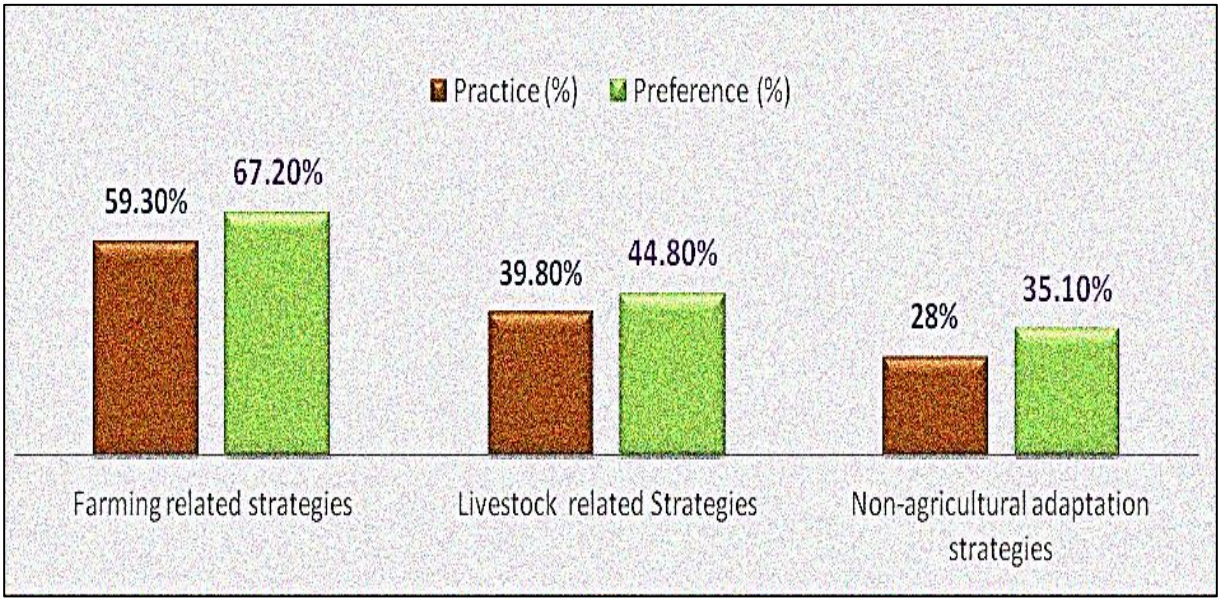


Figure 29: Households' adaptation Practice vs. Preference by strategy category

4.6.1.6 Hindrance factors for not using preferred adaptation strategies

Among the ten hindrance factors considered in the study, lack of money was found the main hindrance by 94% of the respondents, followed by having small/no land and lack of irrigation replied by 88% and 87% respectively. This is in agreement with the finding of Elizabeth (2009), Abrham (2017), Zerihun (2018), and Melese (2019) who reported that financial barriers are one of the barriers that restrict implementation of adaptation strategies.

On the other hand, lack of time and lack of decision-making power were least justified as hindrance factors. That is only 49% of the respondents replied for the lack of time as a hindrance, and 52% for lack of decision-making power (Figure 30).

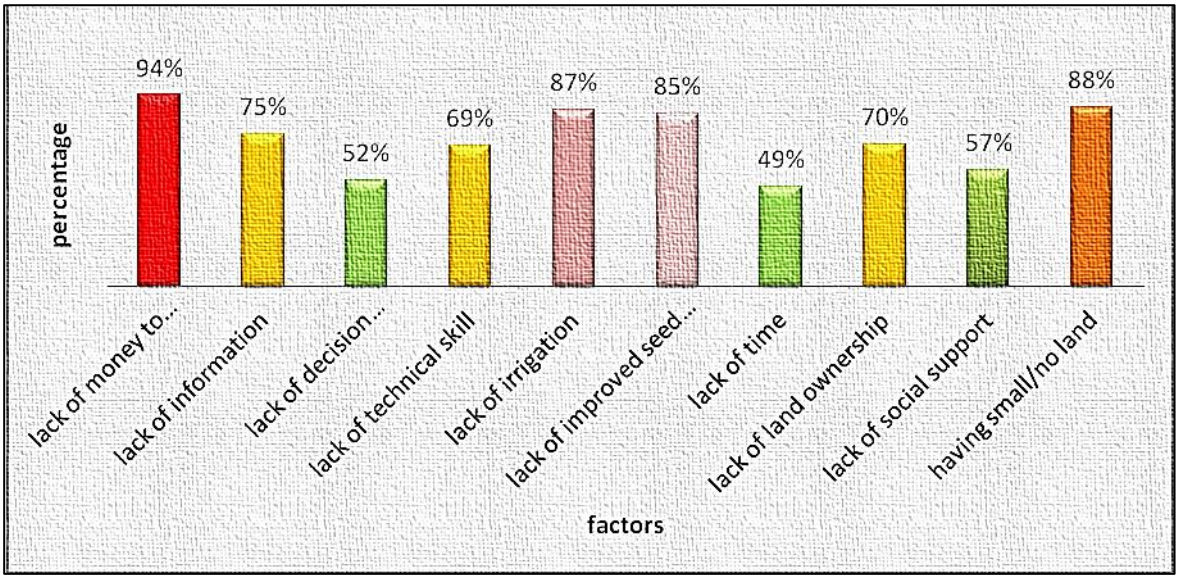


Figure 30: Hindrance factors for not using preferred adaptation strategies

4.6.2 Bivariate Analysis

In this section the association of the independent variables with the dependent variable was assessed. Respondents' perceptions of the possibilities of mitigating the risk posed by climate change are essential to undertake further adaptation strategies. Hence, special emphasis is given to the cross tabulation of the `respondents perception on the possibilities of mitigating the risk` with variables such as district, gender, marital status, education, and ownership of mobile phones. Bivariate logistic regression was also run to identify the potential factors for the multivariate analysis.

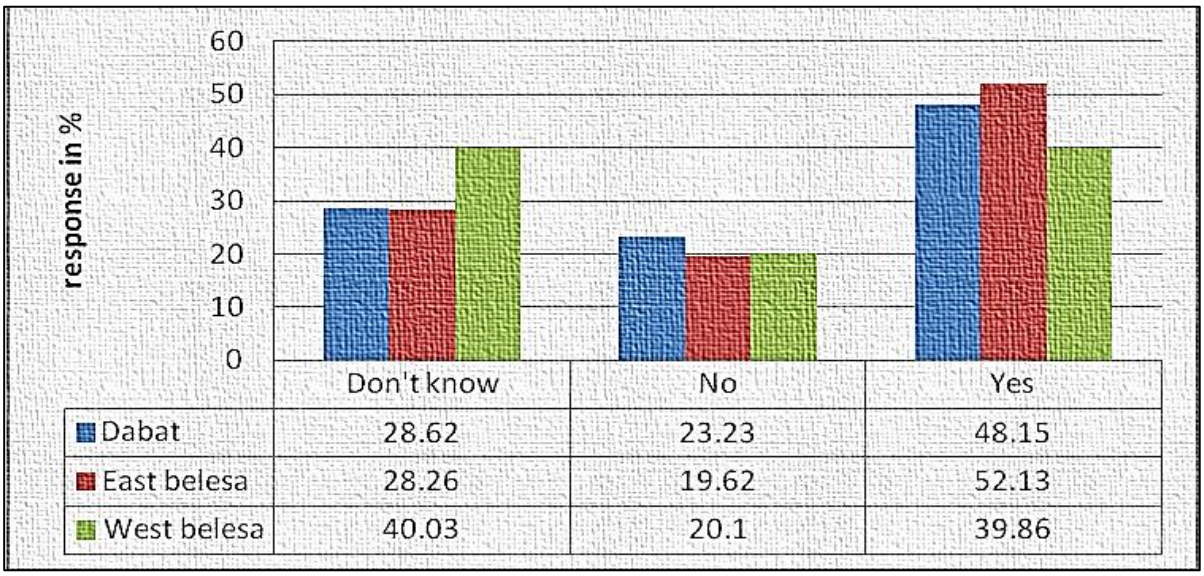
4.6.2.1 Households' perception of the possibilities of adapting climate change

Adaptation measures could play a potential role in mitigating/minimizing the impacts of climate induced disasters. Households, government organizations, and practitioners can predict the disasters that might be caused; and minimize the damage. Using scarce water resources more efficiently; adapting building codes to future climate conditions and extreme weather events; building flood defences and raising the levels of walls; developing drought-tolerant crops; choosing tree species and forestry practices less vulnerable to storms and fires; and setting aside land corridors to help species migrate are among the common possible adaptation measures stated in many literatures.

However, public perceptions of the risk posed by climate change and possibilities of mitigating the risk vary between individuals and countries. Thus, in this research, a question was posed to

the study participants to assess their perception regarding the possibility of taking measures to mitigate the risks. Of the total respondents, 32% gave 'I don't know' answer and 20 % believed it is not possible to prevent the climate induced disaster. Assessing the association of perception with some socio-demographic and communication related variables was another objective of the study. Religion was found not having any association with the "adaptation possibility" perception. However, evidence of association was found with variables such as district, gender, marital status, educational status, and having mobile phones as discussed below.

Adapting possibility perception Vs. District: The awareness regarding the possibility of adapting the impacts of climate-induced hazards in *East Belessa* was found relatively higher. That is, around 52% of the study participants replied yes to the possibility (Figure 32).



	Don't know	No	Yes
Dabat	28.62	23.23	48.15
East belesa	28.26	19.62	52.13
West belesa	40.03	20.1	39.86

Figure 31: Households perception on adapting climate impacts possibility by district

On the other hand, a significant number of households (40%) in West *Belessa* indicated they don't know the possibility of adapting the impacts of climate-induced hazards. Still 20% of the participants in this district replied 'No' to the possibility. The possible explanations for this variation could be the extent of the challenges the households in the districts faced. As the agro-ecological settings of East *Belessa* is relatively poor with unfavourable climate condition, ground water availability, soil organic matter, soil type, etc., the households in the district could opt for other adaptation strategies; and have higher perception on the adaptation possibility (i.e. challenge driven awareness).

Adapting possibility perception Vs. gender: Regarding gender, males gave a positive response to the possibility of adapting the impacts of climate induced disasters. That is, 59% of

the male respondents replied for the adapting possibility. On other hand, 44% of female respondents stated they don't know (Figure 32).

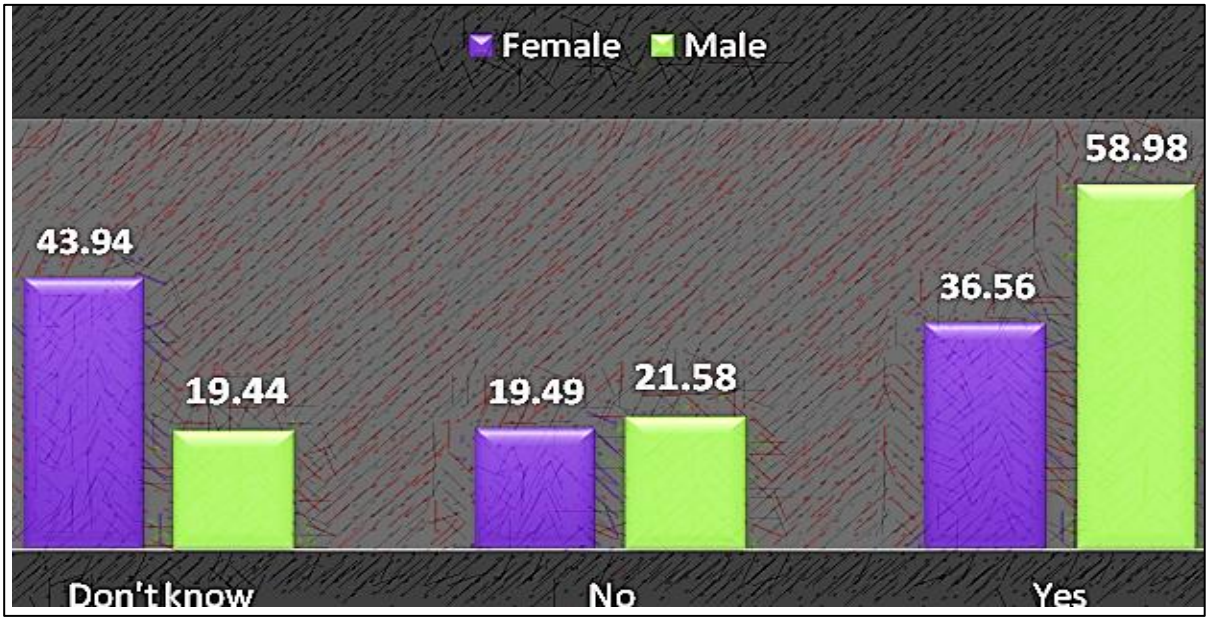


Figure 32: Households' perception on adapting climate impacts possibility by gender

Besides, 21.6% of male and 19.5% of women believed it is not possible to prevent the climate induced disasters.

Adapting possibility perception vs Marital Status: Significant association was found between participants' marital status and their perception regarding the possibility of taking measures to mitigate the risks. Those who are widowed were found with higher perception awareness. Around 47% of this group responded it is possible to adapt; and 32.6% and 20.5% replied 'I don't know' and 'No' respectively. Among all the groups, low awareness was found in those who are separated. That is 51.2% replied they don't know; while this figure is only 20.8% for those who are married. Those who are married replied the highest number (37.5%) for the 'not possible' option (Figure 33).

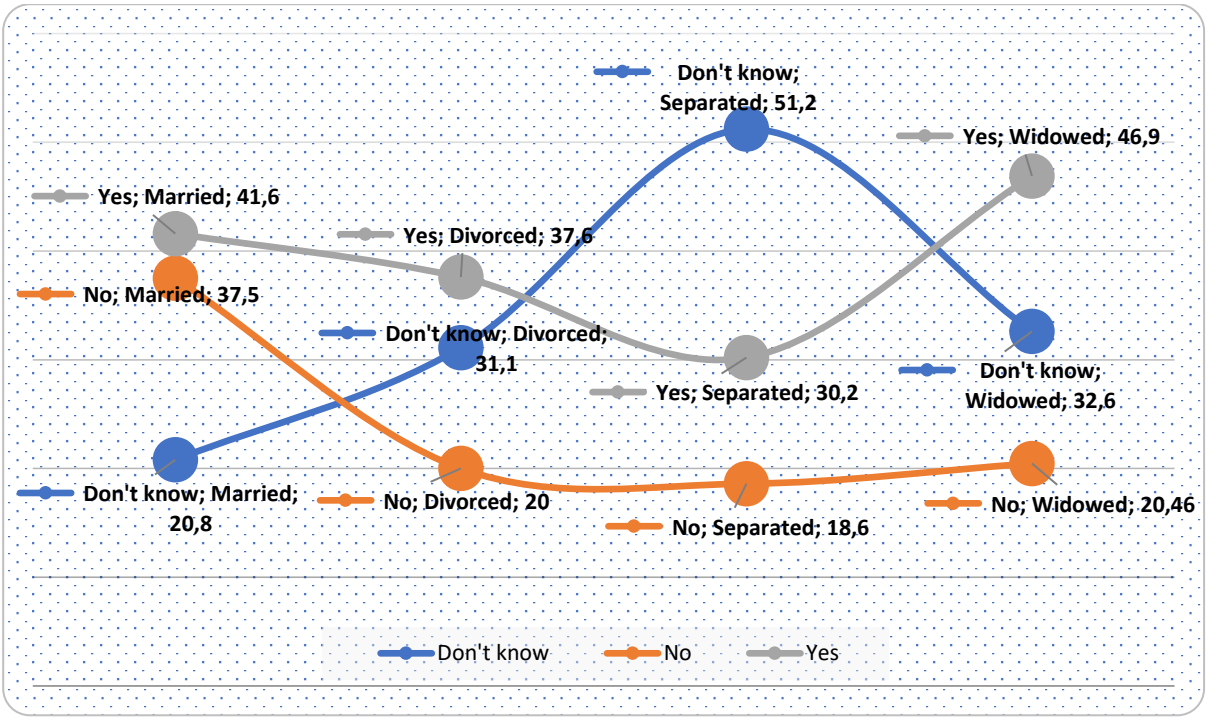
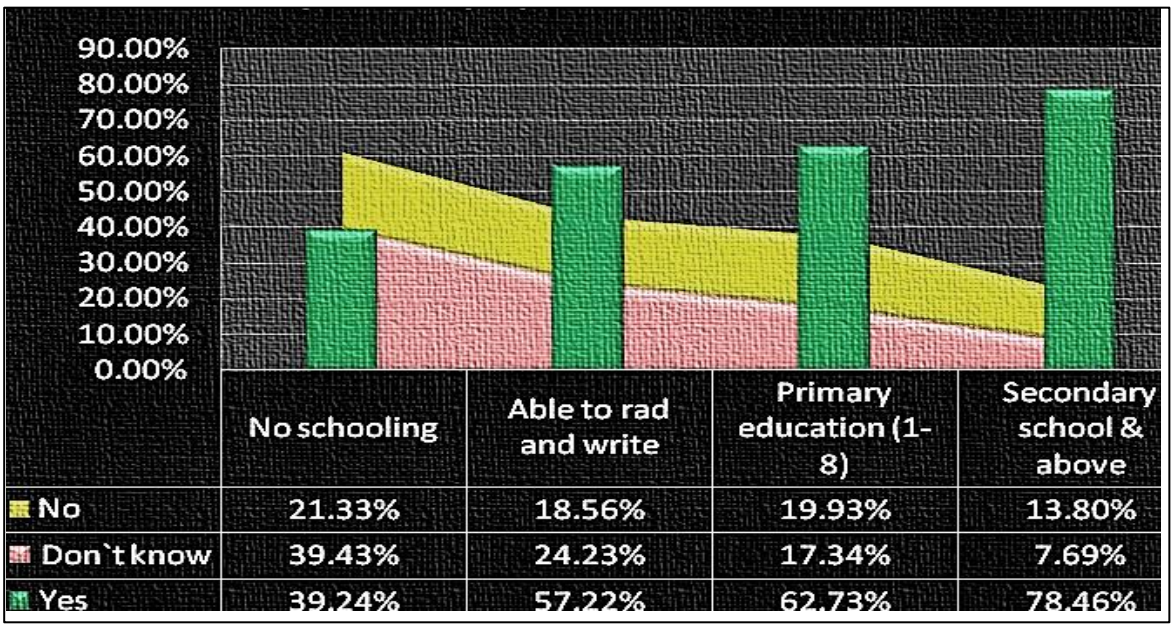


Figure 33: Households' perception on adapting climate impacts possibility by marital status

Adapting possibility perception Vs. Education: A significant direct association was found between adapting possibility perception and educational status. A positive response to the possibility continuously increased when educational status increases. 39.43% of those with no-schooling replied they don't know about the issue. Still 21.33% in this group stated it is not possible to adapt to the climate induced disasters (Figure 34).



	No schooling	Able to rad and write	Primary education (1-8)	Secondary school & above
No	21.33%	18.56%	19.93%	13.80%
Don`t know	39.43%	24.23%	17.34%	7.69%
Yes	39.24%	57.22%	62.73%	78.46%

Figure 34: Households' perception on adapting climate impacts possibility by Educational status

As shown in the above figure, majority (78.46%) of the respondents with secondary school and above stated it is possible to have adaptive measures. Only 7.69% of the respondents in this group replied they don't know. Comparing those who are able to read and those with primary education; the latter group was found with higher awareness.

Adapting possibility perception Vs. having Mobile Phone: Those who own mobile phones have found with higher awareness than those who don't have. Of the total respondents who have mobile phones, only 16.9% replied they don't know; however, this figure is 38.6% for those who don't have mobile phones (Figure 35).

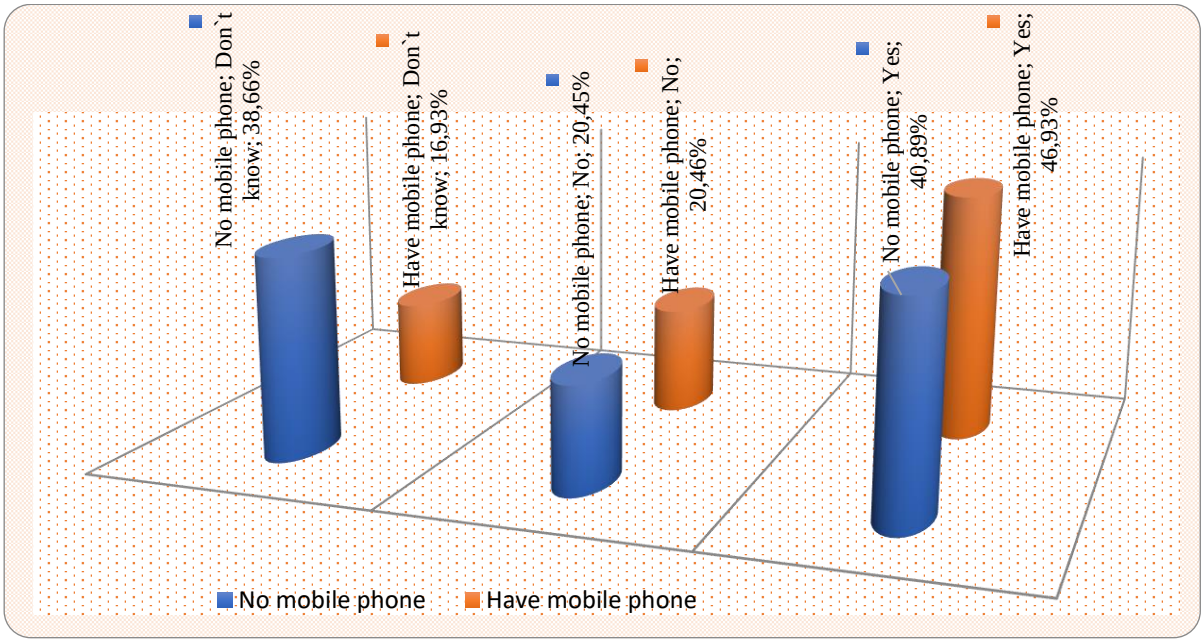


Figure 35: Households' perception on adapting possibility by Mobile phone owning

4.6.2.2 Bivariate regression results

Bivariate logistic regression was run to assess the factors associated with households' adaptation strategies practice. Among the 21 explanatory variables, 17 variables were found statistically associated (with P-value < 0.2) with the outcome variable (strategies practice). The regression results p-value is stated in brackets for each variable. That is Gender (0.000), Household head position (0.135), Age of the respondent (0.132), Religion (0.048), Marital status (0.006), Education (0.000), Main occupation (0.000), Having land certificate (0.000), Farm land size (0.000), Home area vulnerability to flood incidence (0.171), Participation in social gatherings (0.000), Owning mobile phone (0.000), Credit access (0.000), Adaptation possibility perception (0.000), Family size (0.020), Climate induced impact (0.000), and

Perception on climate variability (0.000). On the other hand, variables such as District (0.914), Geography of farmland (0.289), and Credit adequacy (0.566) were found insignificantly associated. However, all the variables found significant and insignificant in the bi-variate analysis were fitted to the multivariate analysis.

4.6.3 Multivariate Analysis

Multivariate ordered logistic regression was done to assess the factors associated with the household's adaptation strategy practices. Twenty one explanatory variables such as district, gender, household head position, age of the respondent, religion, marital status, education, main occupation, family size, having land certificate, farm land size, home area vulnerability to flood incidence, geography of farm land, geography of home, participation in social gatherings, owning mobile phone, credit access, information about adaptation strategies, adaptation possibility perception, self-reported climate induced impact, and perception on climate variability were fitted to the regression model.

The table below is an ordered logistic regression result of the outcome variable regressed into four models: Model1/aggregated adaptation practices, Model2/Farming related adaptation practices, Model3/Livestock related adaptation practices, and Model4/Non-agricultural adaptation practice.

In this study, variables such as district, gender, main occupation, having land certificate, mobile phone ownership, having credit access, good social participation, and perception on climate induced impact and climate variability were found statistically significant in almost all the models. On the other hand, marital status, education, having information on the available strategies was found statistically insignificant across all the models. Age of the respondent was also found insignificant factor except in model 4 (non-agricultural related strategies model). The results in the non-agricultural model indicated that, when age increase by one year, the probability of using the non-agricultural strategies decreased by 0.98 times (Table 22).

Table 22: Ordered logistic regression analysis of adaptation strategies in Northwest Ethiopia, 2019 (n=1620)

Variable	Model_1: aggregated adaptation strategies			Model_2: farming related adaptation strategies			Model_3: livestock related adaptation strategies			Model_4: non-agricultural adaptation strategies		
	OR	P>|z|	[95% CI]	OR	P>|z|	[95% CI]	OR	P>|z|	[95% CI]	OR	P>|z|	[95% CI]
District	-	-	-	-	-	-	-	-	-	-	-	-
E*ast Belessa*	1.298164	0.042**	1.01003	1.269649	.043**	1.008102	.8995073	0.457	.6804231	1.913607	.000***	1.329749
	1.182964	0.178	1.668494	517683	.000***	1.599054	.8399156		1.189133	1.333902		2.753822
Dabat			.926285			1.205155		0.145	.6644163		0.033**	1.024123
West Belessa			1.51077			1.911259			1.061771			1.737382
Gender	-	-	-		-	-	-	-	-			-
Male			.5252315	-		.5225144			.5604968	-	-	.7163076
Female	.6920271	0.009***	.9117914	.6920229	0.010**	.9165216	.7436669	0.040**	.986697	.974238	0.868	1.325045
HH_head			-			-	-	-	-	-	-	-
No	-	-	.5208493	-	-	.4662335	.8272678	0.191	.622611	1.137652	0.409	.8377475
Yes	.6930542	0.012**	.9221941	.6155827	0.001***	.8127732			1.099197			1.544919
Family size	.9725481	0.267	.925939 1.021503	1.027313	0.225	.9835958 1.072974	.962129	0.119	.9165872 1.009934	.9408609	0.015**	.8956117 .9883962
Age of respondent	.9950877	0.393	.9839157 1.006387	.9932428	0.229	.9823401 1.004267	.9985784	0.798	.9877396 1.009536	.9864654	0.023**	.9749626 .998104
Religion	-	-	-	-	-	-	-	-	-	-	-	-
Muslim			.8110568			1.339311			.6714376			.2950714
Orthodox	1.350116	0.248	2.247453	2.282093	0.002***	3.888527	1.119168	0.666	1.865456	.4949388	0.008***	.830186
Marital S							-	-	-	-	-	-
Married	-	-		-	-			0.151	.3534238			.789639
Divorced	.9713304	0.919	- .556167	1.033094	0.906	- .6003619	.6441849 .8259233	0.551 0.127		1.273382 .6217476	0.322 0.328	2.053472 .2398906
Separated	.7688539	0.390	1.696402 .422331	.926829	0.834	1.777735 .4557741	.673869		1.174155 .4406948 1.547895	1.161689	0.576	1.611443 .6866605
Widowed	.6501046	0.076	1.399699			1.884732			.4059877			1.96534

									1.118505			
			.4036998 1.046907	.8306823	0.415	.5320027 1.297048						
Education	-	-	- .6286049	-	-	- .645827 1.218183	-	- 0.402	- .6356508 1.199111	-	-	- .7169082 1.345664
Illiterate	.8664601	0.381	1.194316	.8869812	0.459	.5117636	.8730498	0.718	.2033247	.9822002	0.911	.403421
Read & write	1.155718	0.838	.7569368	1.530844	0.446		.7802576	0.833		1.539495	0.528	5.874867
Primary Edu.	1.087151	0.651	1.561422 .2889496	1.097539	0.615	4.57923 .7633459	1.039395		2.994235 .7258717	.9710825	0.875	.6731616
Secondary Edu & above			4.622551			1.578043			1.488338			1.400854
Main occup.	-		- .0000288 7454.668	-	-	- 1.43e-06 10247.65	-	-	- .0403389 1.707443	-	-	- 4.08801 147.8763 1.124018 5.200783
Farmer		-	.0602026			.0814943			.0379872			.7257741
Carpenter	.4629937	0.876	.3848592	.1209919	0.715	.494542	.2624432	0.162	.3687734	24.58698 2.417804	0.000*** 0.024	1.722224
Daily laborer	.1522154	0.000***	.3338036	.2007545	0.000***	.2873791	.1183582	0.000***	.4822294	1.11801	0.613	.6765857
Housewife	.5191078	0.004	.8072799 .1735162	.4499819	0.000***	.7045874. 1987839	.6868815	0.037	.9783855 .1703857	1.125494	0.649	1.872249
Other	.3536608	0.004	.7208316	.4176445	0.021	.8774703	.3339637	0.001	.6545839			
Land_certif	-	-	-	-	-	1.078844	-	-	-	-	-	-
No	-	-	1.183445	1.366667	0.010	1.731276	1.294742	0.029	1.027244	.921605	0.527	.7155048
Yes	1.500806	0.001***	1.903273						1.631896			1.187072
Geo_farml		-	.982185	-	-	-	-	-	.8235933			.9783284
Plain	-	0.068				.9643422	1.059473	0.653	1.36291	1.26846	0.073	1.644634
Gentle	1.275929		1.657525	1.234483	0.095	1.58029	1.006903	0.949	.8142905	1.096645	0.436	.8696015
Slope		0.300	.7225239	.8402585	0.106	0.680347						
Hill	.8936332		1.105265			1.037755			1.245076			1.382967

Home_vulne_flood		-	-			-	-	-	-	-	-	-1.315675
Not vulnerable	-	0.088	.6471103 1.030408	-	-0.000	.4789016 .7468242	1.034099	0.768	.8273201	1.673832	0.000	2.129486
less vulnerable	.8165705	0.034	.9721791	.5980429	0.150	.5450008	.7248404	0.039	1.29256 .5341928	1.04508	0.823	.7103122
highly vulne	.681032		.4770773	.773256		1.097108			.9835281			1.537624
Farm_size_tim ad	1.009707	0.247	.9933315 1.026352	1.010283	0.072	.99907 1.0216	1.008642	0.484	.9846326 1.033236	.9899158	0.757	.9283376 1.055578
Mobile own	-	-	-	-	-	-	-	-	-	-	-	-
No			1.186549	1.39077	0.006***	1.100744	1.368026	0.008**	1.085623	1.66766	0.000***	1.307267
Yes	1.495502	0.001***	1.8849			1.757212		*	1.723891			2.127408
Credit_Acc	-		-			-			1.357109			1.230468
No			1.152479			.915809	1.654472	0.000**	2.016991	1.519196	0.000***	1.875673
Yes	1.40506	0.001***	1.713002	1.11005	0.287	1.3459						
Info_on_ad			-			-	-	-	.7674818	-	-	.9821461
No	-	-	.8104079	-1.035859	-	.802377	.961609	0.734	1.204839	1.262173	0.069	1.62204
Yes	1.034419	0.786	1.32035		0.787	1.33729						
Adaptation_P		-	- .9085474	- .7602783	- 0.040	- .585342	-	-	.5538543 .9558776	-	-	.4943109 .8921458
No	-	0.003	1.570299			.987496	.7276105	0.022	.8983029	.6640764	0.007***	.6472302
I don`t know	.6454699	0.203	.4842515	1.319468	0.047	1.0039	1.155171	0.261	1.48549	.8568931	0.281	1.134474
Yes	1.194442		.8603615			1.73411						
Social_participation	2.80678	0.000***	1.92129 4.100376	1.635583	0.007***	1.14206 2.34237	3.386402	0.000***	2.314237 4.955291	.8969436	0.576	.6129051 1.312614
Climate_induced_impact	.8711183	0.003**	.7951679 .9543232	.8678491	0.001***	.795523 .94675	.8962551	0.013**	.8223785 .9767682	.9430742	0.197	.8628177 1.030796
Climate variability	1.241287	0.005**	1.065795 1.445676	1.20346	0.016**	1.035241. 39901	1.215608	0.005***	1.059222 1.395083	1.369182	0.000***	1.184008 1.583316

Model_1

Number of obs = 1,373
Wald chi2(31) = 255.68
Prob > chi2 = 0.0000

Model_2

Number of obs = 1,496
Wald chi2(31) = 223.36
Prob > chi2 = 0.0000

Model_3

Number of obs = 1,449

Wald chi2(31) = 249.43
Prob > chi2 = 0.0000

Model_4

Number of obs = 1,532
Wald chi2(31) = 184.45
Prob > chi2 = 0.0000

There are different factors that affect households' climate change adaptation practice. In this study district, gender, religion, main occupation, land size, land certificate, mobile phone ownership, access to credit, perceived social participation, and perceived climate induced impact are found significantly associated with the outcome variable.

District: The district variable was found statistically significant in all the models regressed except for the model on livestock related adaptation strategies. In the aggregated model, district was found statistically significant for Dabat district. That is, the likelihood of practicing adaptation strategies was 1.29 times higher for households who lived in Dabat comparing with those who live in East *Belessa*. In the farming related adaptation strategies model, the likelihood of practicing farming related adaptation strategies was 1.51 times higher for households who lived in West *Belessa* comparing with those who live in East Belessa. Regarding the non-agricultural adaptation strategies (diversifying non-agricultural income sources and Migration), the probability of using the strategy for households who lived in Dabat were found 1.91 times higher than households who lived in East *Belessa*. The possible explanation for the difference among the districts could be due to location-specific opportunities and challenges in addition to their difference in agro-ecological settings.

Gender of the respondent: Women play a major role in the agricultural sector, accounting for 43% of the agricultural labour force in developing countries (Deressa, 2010). However, in this study the gender variable was also found negatively, and statistically significant variable associated with the probability of the household's adaptation strategies practices. In all the models (except model 4), probability of practicing the strategies for female respondents was found 0.69-0.74 times less comparing with their counter parts. This is in line with studies conducted previously and reported that male headed households have higher probability of practicing climate change adaptation strategies (Gezie, 2019; Simane, 2018). This could be due to the fact that males have better access to information about available strategies, physical strengthen, and higher inclination to risky business. On the other hand, the variables were found insignificant in the non-agricultural related adaptation strategies model.

Main occupation: Main occupation was another variable that was found statistically significant across all the models. Farmers were found with higher probability to practice the strategies in the aggregated model, farming related model, and livestock model. However, the probability of the farmer household's practice for non- agricultural adaptation strategies was found less

comparing with all other occupation types. In the aggregated, farming related, and livestock related models, the probability of practicing those strategies for daily labourers was found 0.15, 0.20, and 0.11 times lesser comparing with farmer households respectively. On the other hand, in the non- agricultural adaptation strategies model, the probability for the daily labourers to practice the strategies was found 2.4 times higher comparing with the farmers.

Land size and land certificate: Having certificate of land was found positively and significantly associated with the household's adaptation practice. The probability of practicing the strategies was found 1.3-1.5 times higher among those with certificate comparing with their counter parts. The possible reason for this could be the fact of private ownership incentivizing proper asset management and investment. The variable on land size was found statistically significant only in model 2 (farming related strategies model). The results in that model indicated that, for one *Timad* increase in land size, the household's probability to practice the farming related strategies increased by 1.01 times. This is in line with a study by Elizabeth (2009), Amonge (2013), Birtukan (2016), and Zerihun (2018). This could be attributed to the fact that having large farms give households confidence to reliance on farming activities and then intensively work on the respective adaptation strategies to reduce the climate induced impact.

Mobile phone ownership: Households' mobile phone ownership was considered a proxy for access to information; and the variable was found positively significant across all the models. The probability of practicing the strategies for those who own mobile phones were found 1.36 -1.66 times higher than respondents without phones. This result confirms the findings of previous studies by Elizabeth (2009), Amonge (2013), and Gebre (2015) that revealed information on climate change facilitates households' adaptation practice. This could be associated with the probability of information access to mobile phones owning households.

Credit access: In the aggregated, livestock related, and non-agricultural related models, the probability of practicing the strategies for households who have access to credit was found 1.4-1.6 times higher than those who don`t have access. This result confirms the previous studies by Elizabeth (2009), Amonge (2013), Gebre (2015), Zerihun (2018) and Melese (2019). The possible explanations for this finding could be cost implications nature of most adaptation strategies. That is, even though household perceived the impact of climate change and decides to use adaptation measure, financial barrier could be bottlenecks. Farmers might prefer to use of improved varieties of crops such as high yielding and drought tolerant crops, but as their

price is high poor households may be prohibited from practicing. Hence, those who have access to credit facilities could have higher adaptation practices. Hence, access to affordable credit increases financial resources of households to cover costs associated with the adaptation strategies. However, the variable was found insignificant in the farming related strategies model.

Social participation: Social capital plays vital role in disseminating information and maintaining technical as well as financial support among its members. In this study, having good social participation was found a positive and significant contributor for households to practice the strategies. In the aggregated model, the probability for those with good social participation was found 2.8 times higher comparing with their counter parts. Similarly, in the livestock related model, the probability of practicing the strategies for households with good social participation was found 3.3 times higher comparing with those who don`t have the participation. This is in line with a study by Melese (2019). However, the variable was found insignificant in the non-agricultural related strategies model.

Perceived climate induced impact: The probability of using the adaptation strategies in all the models was found higher for households who perceived that the climate induced impact is high. Those who perceived low impact utilize 0.86-0.94 lesser times than those who perceived high. Similarly, the probability of using the strategies for households who perceived high climate variability was found 1.20-1.36 times higher comparing with their counter parts. According to the study of Nhemachena and Hassan (2007), cited in Abrham (2017), farmers who perceived change in climatic conditions and farmers who have access to climate change information have higher chances of taking adaptive measures in response to observable changes [3. This could be due to the two-stage decision making process of the climate change adaptation response. That is households should first perceive the climate variability and its impact in order to work on the adaptive response to climate stress.

Finally, variables such as family size and religion were found significant in the non- agriculture model and farming related model. That is family size was found statistically significant only in the non-agricultural related adaptation strategies model. For a unit increase in family size, the probability of practicing the strategies decreased by 0.98 times. On the other hand, religion was found statistically significant in the farming related strategies and non-agricultural related strategies models. The probability of practicing the farming related strategies for Orthodox Christians was found 2.28 times higher comparing with their counter parts. On the other hand,

the probability of practicing the non-agricultural adaptation strategies such as migration was found 0.49 times lesser for Orthodox Christians than their counterparts.

Limitation of the study: To correct for selection bias generated during the decision-making processes, it could have been good if the Heckman's sample selection model was employed to analyse the two-step processes of the issue. That is, perception on the climate change as step one regression (selection model) and, then adaptation to climate change practice as step two regression (outcome model).

4.6.4. Conclusion on and the way forward related to Adaptation Strategies

In response to their climate change and climate variability impact perception, households are using different adaptation strategies predominantly focusing on the farming related adaptation strategies.

Univariate analysis: Among the farming related adaptation strategies, soil conservation measures (contour ploughing, terrace farming, windbreaks, crop rotation, and mineralization) is found highly practiced among the households. On the other hand, micro-irrigation is the least practiced strategy. Implementing cut and carry system for improved feeding was found the most practiced strategy among the livestock related adaptation strategies. On the contrary, improving local genetics through crossbreeding with heat and disease tolerant breeds is found least practiced among the respondents. Regarding the non-agricultural climate adaptation strategies, both the strategies are found rarely practiced among the households.

Concerning preference of the household, the farming related strategies are found more preferred, followed by livestock related strategies. Among the farming related adaptation strategies, adopting soil conservation measures are found the most preferred strategy followed by crop diversification towards high value crops; and micro-irrigation least preferred. From the livestock related adaptation strategies, households mostly preferred `implementing cut and carry system for improved feeding strategy` followed by `provision of shade and water to reduce heat stress from increased temperature`. However, strategies such as integration of pasture management and improving local genetics through crossbreeding are found least preferred. Migration is the least preferred strategy among the entire category, and all strategies included in the study.

Regarding practice-preference disparity, in all the strategy categories preference of the respondents is found higher than their actual practice. And lack of money is found the main

hindrance factor followed by having small/no land that prohibits households not to practice what they prefer.

Bivariate analysis: In the bivariate analysis, the awareness regarding the possibility of adapting the impacts of climate-induced hazards in *East Belessa* is found relatively higher; and lower in West *Belessa*. From the perspectives of gender and marital status: males are found with higher awareness than their counter parts; and those who are widowed are found with higher perception awareness. Educational status and owning mobile phones have also direct association with adapting possibility perception.

Multivariate analysis: In this study, variables such as District, Gender, main occupation, having land certificate, mobile phone ownership, having credit access, good social participation, and perception on climate induced impact and climate variability are found statistically significant in almost all the models. On the other hand, marital status, education, and having information on the available strategies are found statistically insignificant across all the models. Age of the respondent is also found insignificant factor except in model 4 (non-agricultural related strategies model).

The following recommendations are forwarded based on the study findings.

- Policy makers and practitioners should consider the evidence regarding the farmers' adaption practice and the factors that determine their practice. Promoting the importance of social capital, improving access to credit, establishing information sharing plat forms, increasing awareness on the perception, and awaking the households on the impacts of climate change is very important.
- The misperceptions regarding the possibility of adapting the impacts of climate-induced hazards require government intervention. Thus, the district administrators should increase local people's awareness on the possibility of adapting the impacts of climate-induced hazards; and increase the availability of climate change related information to the community.
- Addressing the barriers (especially lack of money and having small/no land) that prohibit households not to practice what they prefer is very essential. Thus, the government should introduce mechanisms such as revolving fund and collective farming.
- Though women are disproportionately affected by climate change, in this study the probability of practicing the strategies for women is found less. Hence, it would help to

design gender strategies that can provide technical and financial support for women to engage them more on climate change adaptation initiatives/practices.

- There is a need of improving credit access, strengthening the social gathering networks of the local communities, and improving information disseminating strategies.
- Finally, we would like to recommend similar studies on the study area to be conducted that mainly focus on the effectiveness and efficiency of the adaptation strategies so as to guide the households to practice on the recommended strategies.

4.7 Pairwise Matrix Ranking of Adaptation Strategies

Pairwise ranking matrix was used to identify the strongest barriers to climate change adaptation strategies in the three selected areas of north-western Ethiopia. Pairwise ranking matrix is a scientific tool for comparing entities in pairs to judge which of the entity is preferred. The group is divided by gender and by agro-ecological zone (from the resource mapping exercise). Group participants then list all agriculture practices that they are aware of. Facilitators retain practices from the group list that qualify as climate change adaptation practices, based on literature sources (FAO, 2013). Researchers can also complement this list with other adaptation practices that have been identified as particularly relevant for the site (i.e. during key informant interviews or practices that are being promoted by government or non-governmental organizations in the districts). The participants are asked to consider one pair of practices at a time and for each pair of practices, consensus-oriented discussion is used to determine which of the three practices is preferred until the matrix is completed. A count is taken of the number of times each practice appears in the matrix. Practices are ranked by the total number of times they appear in the matrix.

Table 23: Pair Wise Matrix Ranking of Adaptation Strategies of Climate change in North-western Ethiopia, West Belessa district

Adaptation Strategies	Natural resource conservation 1	Fertilizer 2	Intensifying farming 3	Best seeds 4	Irrigation 5	Livestock 6	Perennial crop 7	Safety net 8	**Total**	**Rank**
Natural Resource conservation		1	3	1	1	1	1	1	6	1
Fertilizer			2	2	2	2	2	2	6	1
Intensifying farming				3	3	3	3	3	6	1
Best seeds					5	6	4	4	2	6
Irrigation						5	5	5	4	4
Livestock							6	6	3	5
perennial crop								8	1	7
Safety net									0	8

A mixed group of 15 people, five people from each group (male household heads, female household heads and women within the male headed households) were included in the group discussion and pairwise ranking. As indicated in Table 23 above, the pairwise ranking shows that the three most preferred adaptation strategies identified by the farmers were natural

resources conservation, intensification of farming, and fertilizer (with 6 points for each). This followed by irrigation and livestock production with 4 and 3 points respectively. The least preferred among the long list of adaption preference from the group were perennial crops (1 point) and the safety net (0 point).

Justifications were provided on why they prefer one adaptation strategy over another, though all of them were not in total agreement. For instance, when one men participant preferred fertilizer over natural resource conservation, other men opposed and claimed they would prefer natural resource conservation. This claim was supported by a group of women after they were asked to forward their interest. As a result, fertilizer was selected over natural resources. The participants denoted that without natural resources conservation, the fertilizer couldn't be useful.

In another instance, two men were in a high level of disagreement between choosing intensification of farming and natural resource conservation. The first discussant claimed, "*if there is no natural resource, it will be hard to produce cereals"*, whereas another men discussant strongly argued that,

> "*though it is yes [that natural resource is good to conserve], but an intensification of cereal production is the most important. It is cereal. If there is no cereal, what is the use of natural resource conservation? Though it goes hand in hand, the priority has to be to the intensification of cereal production".*

The first discussant then reclaimed stating his point:

> *"for me, the natural resource has to come first. If the natural resources are not preserved, there will be climate change, and if there is climate change, we can't produce cereal. But if we preserve the natural resources, the rain season will not change. So, we will not be productive if we didn't preserve our natural resources. So, for me, the conservation of natural resources has to be the priority".*

In a counter-reaction, the man who claimed intensification of cereal production should come first argued that;

> "*Cereal comes first. Why? Cereal production is seasonal. If the rainy season passed, it would not come back. For instance, if we have to harvest teff (a stable Ethiopia cereal) in June, and we didn't do it on that month, that will not work. Cereal production is the*

one feeding the whole population of Ethiopia. Yes, natural resource conservation is very important, helps us to rain, gives us fresh air, but cereal should come first".

After these back and forth, the women participants were asked to participate and to forward their suggestions, in a group, they preferred intensification of cereal production over natural resources. Then by vote, 'intensification of cereal production' got majority vote. However, in computing with the intensification of a farming (which among the three most preferred with 6 points) versus fertilizer, fertilizer was preferred by all the participants. The participants pointed out that, without fertilizer, intensification of farming can't be productive.

As depicted in the above Table 23, natural resource conservation was preferred over other adaptation strategies; like from best seeds, vegetation production, perennial crop and safety net with total agreement of the group. With the case of safety net preferred and presented by women household heads, the group was laughing when the safety net is compared with the other adaption strategies. Even the ones who agreed upon safety net to be their number one preference (see Table 20) in the group discussion everyone laughed including the women household heads. Most of them argued that the safety net is an emergency measure more than as an adaptation strategy. The woman who raised the idea also agreed to the group's claim. That is why safety net identified by a group of women household heads and women within men household heads has scored least in the mixed group discussions (see also Table 24 of group pairwise ranking of East Belessa).

There was a total agreement of the group discussants in preferring fertilizer over many other adaptation strategies they enlisted, except with natural resource conservation. Two women justified why irrigation is a second preferred adaptation strategy, the first women commented in preferring fertilizer over irrigation stating that *"if there is no fertilizer irrigation is useless".* Another woman added, "*fertilizer is very important to harvest good yield*."

In computing livestock production versus irrigation works, two men answered irrigation and one of them mentioned that irrigation is bringing a good income in their area. Though livestock production is less preferred (only with three points), but it was preferred over best seeds. A male participant justified by stating that *"animal husbandry is a good practice to resist the consequences of climate change. We can get good income from livestock*." Livestock is also preferred over perennial crop and safety net. As depicted in the above table, best seeds (with 2 points) perennial crop (1 point) and safety nets (0 point) were the least preferred adaptation strategies by the participants.

Lack of participation of the women group when they were with the group of men was observed. Except for one woman who presented the safety net as an adaptation strategy, in which it was identified by the women household head participants but presented last in the brainstorming by the woman, tyranny of a group where two-three men dominated the group discussion was observed. However, with the help of the facilitators, the other men and women participants were getting chances to reflect their interests.

Table 24: Group pairwise ranking East Belessa

Adaptation Strategies	Natural resource conservation 1	Fertilizer 2	Intensifying farming 3	Best seeds 4	Irrigation 5	Livestock 6	Perennial crop 7	Safety net 8	**Total**	**Rank**
Natural Resource conservation		1	1	1	1	1	1	1	7	1
Fertilizer			2	2	2	2	2	2	6	2
Intensifying farming				4	5	6	3	3	2	6
Best seeds					5	6	4	4	3	4
Irrigation						6	6	5	3	4
Livestock							6	6	5	3
perennial crop								8	1	7
Safety net									0	8

In a group of 15 people, five from each group (women household heads, men household heads and women within male household heads) in East Belessa *Woreda*, *Shemish Kebele*, the following 8 adaptation preferences to climate change were identified by the participants: natural resource conservation, fertilizer, best seeds, high value crops, growing short-season crops, livestock (small animals), safety net and trade. From longer debate and discussion among the group, the scores and ranking are as follows: natural resource conservation (7 points); fertilizer (6 points); livestock (5 points); and high-value crops and growing short-season crops (3 points each) were the most preferred adaptation strategies. Whereas, trade (0 point), safety net (1 point), best seeds (2 points) were least preferred respectively.

Both women heads and women within the male household heads were actively participating in the group discussion. However, inconsistency in their argument was observed, which might be related to the unequal power relations in the community. At the time when most of the women preferred fertilizer over natural resource conservation, a men discussant opposed and argued that natural resources conservation should come first. Immediate, a woman discussant (woman

head), supported him by arguing that *"if we don't conserve the natural resources using fertilizer will not be productive".* Another men participant added *"the first strategies [to adapt the climate change) commonly used in this area is planting a tree. […] we mobilize in mass to plant trees and natural resource conservation works."* Another woman added, "*to prevent drought, we do different natural resource conservation mechanisms."* The group agreed and voted for natural resources conservation compared to fertilizer.

With the full agreement of the group, natural resources conservation was preferred over any other kind of adaption strategies mentioned above. Likewise, fertilizer was preferred over the other adaptation strategies, except for natural resource conservation. Similar to the case of the group discussion in West Belessa, most of them laughed when fertilizer was compared with the safety net. However, a woman head participant, point out saying "*how can we buy fertilizer without a safety net? 'Where can we get the money?'".* This was also mentioned at brainstorming time that, a women discussant mentioned that "*most of the society seems rich but without safety net support we have nothing. If the Safety net support terminated, everyone will sale their ox to survive the month of August".* No one opposed her claim, however, as an adaptation strategy it was not preferred by most of the participants. She pointed out how the farmers are dependent on the safety net and the worst season they face food insecurity is the rain season (summer in Ethiopia). As to the researchers' observation, the women participants in East *Belessa* were very active, freely discussed, debated, and make points including in the group discussion that included men.

Likewise, after the landless women head claimed safety net over fertilizer, a group of women living in the male headed household opposed and preferred fertilizer. This is due to the reason that the women household heads were landless, and fertilizer has no significance to their livelihood. Preferring safety net over fertilizer was also opposed by a male participant and he claimed that "*safety net is good to the people who have nothing to eat, but since it leads you to be lazy and dependent, fertilizer is better than safety net".* Thus, with the strong assertion of the male discussant, fertilizer was preferred over the safety net.

High-value crops, growing short-season crops, and livestock (small animals) were preferred over best seeds. A man discussant mentioned the importance of livestock production, he affirmed that "*we farm sheep and goats; we breed small size animals rather than large size animals, it helps us to generate income in a short period. And this place is very comfortable to breed chicken, sheep and goat. Large size animals are expensive".* Another woman discussant also mentioned on how they select short season crops to adapt with the climate change, *"there*

are two different types of "Teff" such as "small size Teff" and "large size Teff". One of which is a short season crop. We plant those crops alternatively depending on the rain season." In addition to this, another woman added, *"we do plant different crops such as "Selit" [*Ethiopian sesame*] and "Masho" [*this crop is a newly introduced crop which is a very short seasoned and with high yields, which we found it only in this district*]. We do plant improved seeds and we use fertilizers. We do crop rotation."* The women participants were found very knowledgeable of seed and seed selection, it was evident from the comments and suggestions they were making.

Best seed was preferred over safety net and small trade; the male farmers denoted that since it is relevant to them, they preferred best seed. Alike to a safety net, small business/trade was mentioned by women household heads and they were dominantly landless. As we observed the locality, a kind of very small rural town is in a making around the schools and clinic. The women household heads mentioned that they lead their life from the income of selling potable water; work as a daily labourer in agricultural fields; sell tea and coffee in the schools, and sell local beer etc. However, in the group discussion, they were dominated by the farmers (both men and women within men household heads) who prefer best seeds over small business.

Short season crops were preferred over high-value crop growing. This is due to the short rain season of the locality. Livestock (small animals) was preferred over high-value crop growing. But high-value crop growing was preferred over small business and safety net. Livestock was preferred over short-season crops, but short season crop was preferred over small business. A small trade was preferred over safety net, though one woman mentioned those who can't involve in trade might prefer to receive safety net support.

Table 25: Group pairwise ranking, Dabat

Adaptation Strategies	Natural resource conservation 1	Contour ploughing 2	Fertilizer 3	Compost 4	Small enterprise 5	Improved seed 6	Heat resistant crops 7	livestock 8	**Total**	**Rank**
Natural Resource conservation		1	1	1	1	1	1	1	7	1
Contour Ploughing			2	2	2	2	2	2	6	2
Fertilizer				4	3	3	7	3	3	4
Compost					4	4	7	4	3	4
Small Enterprise						6	7	8	0	8
Improved Seed							7	8	1	7

Drought- resistant crops								7	5	3
Livestock									2	6

A group of 15 people, five from each group (women heads, men heads and women within male headed households) from Dabat Woreda, *Defia* Kebele, sit in a separate discussion session to discuss and rank adaption strategies. As clearly depicted in the Table 25 above, natural resource conservation, improving the farming system (contour ploughing), fertilizer, compost, small enterprise, improved seed, drought-resistant crops, and livestock were identified as adaptation strategies to climate shocks in their locality.

From the final ranking, natural resource conservation (7 points); improving farming system-contour ploughing (6 points); drought-resistant crops (5 points); and fertilizer, and compost (3 points each) are the most preferred adaptation strategies by the participants. Small enterprise (0 point), and improved seed (1 point), livestock (2 points) are least preferred adaption strategies respectively.

As justification in preferring to work hard over natural resource conservation, one of the participants (men) asserted that "*ploughing land and sowing will have no yield unless we conserve the natural resource, if we don't terrace our soil it will be eroded and yield us nothing".* The participant also agreed on changing the farming system (contour ploughing) to reduce the consequences of flooding. This case is unique to this area comparing to the other study sites (the low land and midland) due to the physical nature of the area which is highland, and flooding and windstorms are prevalent.

In comparing fertilizer with drought resisting crops, the women participants claimed using fertilizer is useless if you have no drought-resisting crops. Likewise, comparing between livestock and fertilizer, even though, one men suggested livestock, the women group dominated in answering the questions and one particular participant (within a male household head, with better education (8^{th} grade)), responded that "*fertilizer is important that allow us to harvest better yield and find food to our animals"*

Natural compost was preferred over the livestock production, small business and fertilizer. An active woman household head (who dominated the group discussion and was very assertive) justified that, *"compost keeps soil fertility continuously, and fertilizer may not be available always."* However, a drought-resistant crop was preferred over compost and best seeds. Small business was the least preferred adaptation strategy in the group discussion which was

mentioned by women household heads. It was evident in almost all the study areas that women, predominantly women household heads, tend to look to diversify their livelihood to overcome the consequences of rampant drought in the areas and that due to pre-existing challenges women have to fully engage in agriculture and control means of production.

Livestock was preferred compared to best seed, but the drought-resistant crop was preferred over livestock with the full agreement of the discussant.

Table 26: Comparison of adaptation preferences by a different group of people and the three agro-ecological zones

	Dabat			**West Belessa**			**East Belessa**		
Group	***1st adaption strategy***	***2nd***	***3rd***	***1st***	***2nd***	***3rd***	***1st***	***2nd***	***3rd***
Female within male headed hhs	Poultry (4 pt)	natural resource conservation; small enterprise & vegetable(3 point each)		Fertilizer (7pt)	watershed management activities, and water harvesting (5 point each)		Fertilizer (6 pt)	natural resource protection (5 pt)	Soil conservation measures (4 pt)
Female hhs	natural resource (6 pt)	Improving farming system (like Contour ploughing)-(5 pt)	Compost (4 pt)	Safety net (6pt)	Livestock (5 pt)	Best seed (4pt)	small income-generating business (3 pt)	livestock production (poultry)- (2 pt)	Labour migration (1 pt)
Male hhs	Livestock (6 pt)	Soil and water conservation. (5 pt)	diversify crop (4 pt)	natural resources management (6 pt)	improved management of grazing lands, and Improved farm management (4 pt each),		fertilizer (5 pt)	growing short-season crops (4)	natural resource conservation and drought-resistant crop (3 pt each)
Mixed Group of the three groups	natural resource conservation (7 pt)	contour ploughing (6 pt)	Drought-resistant crops (5 pt)	Natural Resource, Fertilizer and farm intensification (6pt each)			natural resource conservation (7 pt)	fertilizer (6 pt)	livestock (5 pt)

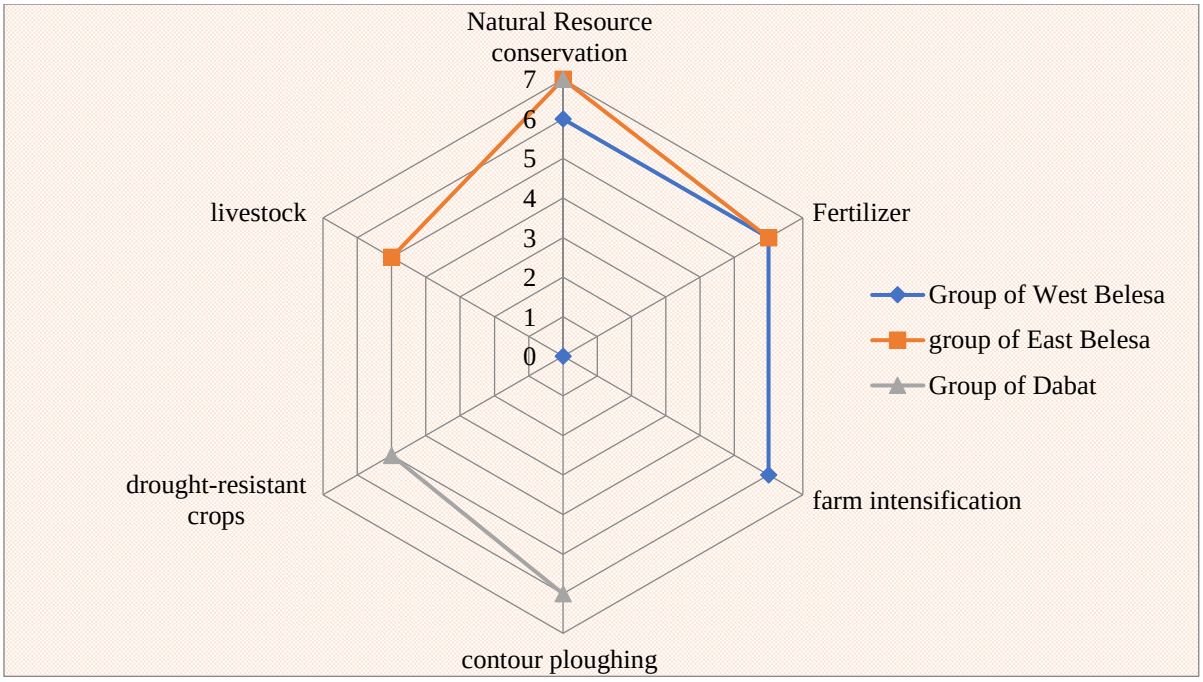


Figure 36: Group comparison of the pairwise ranking among the districts

As the above table and graph indicate, among the three most preferred adaptation strategies by all group of participants (women and men household heads, and women within the men headed households) natural resources conservation is the most preferred adaptation strategy among the three districts. This is highly related to the awareness level of the participants regarding the adverse impact of climate change, the interventions by a governmental and non-governmental organization in these poverty prone areas. As discussed above, the farmers of West Belessa mentioned how depletion of the natural resource (here dominantly the forest) could affect their daily life and their future livelihood. This was clearly articulated by a men farmer from West Belessa who advocated for the conservation of natural resources to compact the adverse effect of climate change. He stated:

> "[…] *If the natural resources are not preserved, there will be climate change, and if there is climate change, we can't produce cereal. But if we conserve the natural resources, the rain season will not change. So, we will not be productive if we didn't preserve our natural resources. So, for me, the conservation of natural resources has to be the priority".*

There is higher similarity in preference of adaption strategies between West Belessa (midland) and East Belessa (low land), by preferring fertilizer as the second preferred strategy (6 points

for each district), whereas Dabat district (highland) is different in the second preference which is contour ploughing (6 points). This is due to the altitude of the area which is highly vulnerable to flooding and windstorms of unpredictable rain. This was evident in the focus group discussion that the participants were reputedly mentioning that they lose their yields due to heavy rain and windstorms. As the two Belessa have a relatively depleted and highly defrosted environment, the communities prefer to use fertilizer to increase their soil productivity. The participants assured that in addition to the use of fertilizer, they indicated that they are working to rehabilitate the soil quality and they are highly aware of the importance of reforestation and afforestation.

Livestock (East Belessa), farm intensification (West Belessa), drought-resistant crops (Dabat) are the outlier adaptation strategies preferred by the three districts differently.

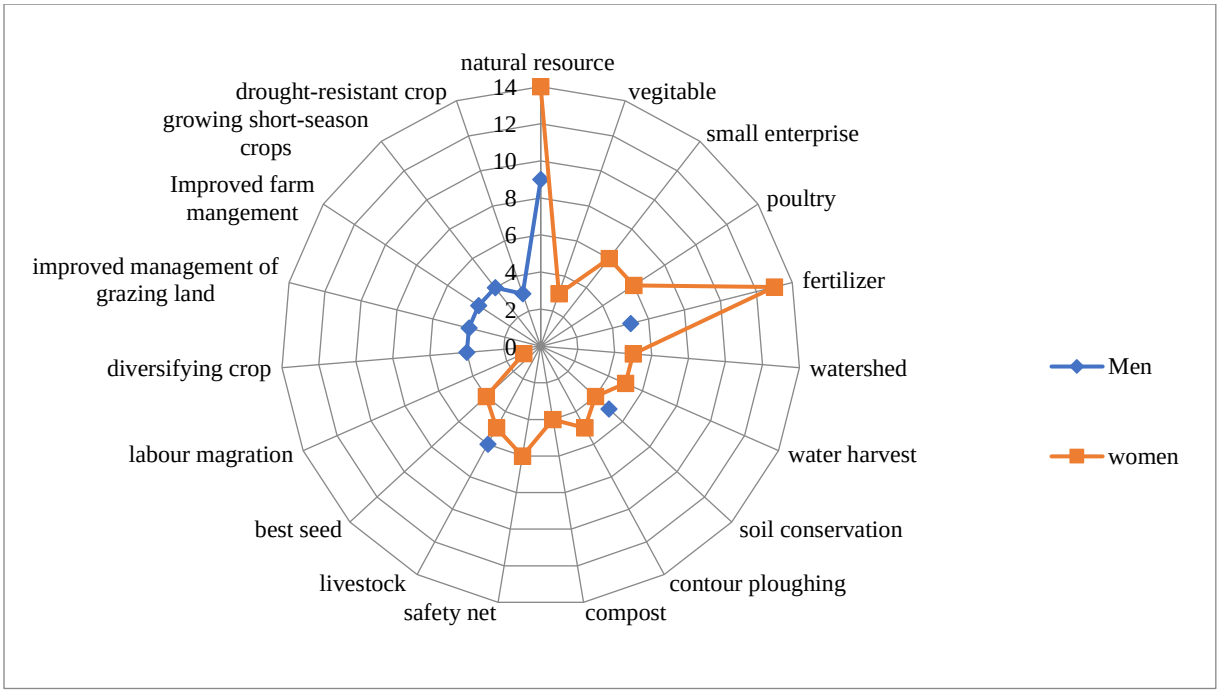


Figure 37: Comparison of adaption preference between men and women of the three districts

As the above graph depicts, the women participants gave higher concern for natural resource conservation than the men participants, 14 points by the female group and 9 points by the male group. Except for a very close inclination of both to prefer natural resource conservation as an adaption strategy to compact climate change, their preference in other adaptation strategies is quite diverse. The men group highly preferred farm and farm-related adaptation strategies (improved farm management, growing short-season and drought-resistant and crop diversification), the women group seems interested to diversify their livelihood options

including looking for non-agricultural income-generating activities such as small income-generating business, safety net, labour migration and vegetable planting. This difference emanates from the structural constraints that privileges men's access and control over larger production assets such as land.

Pairwise ranking exercise with male headed households in Misrak Belessa (Photo: Dereje A., 2019)

One of the significant and most visible differences between men and women observed from the pairwise raking exercise is the division of men and women regarding livestock production. As the above graph shows, no group of men from the three districts preferred poultry, however, women exclusively preferred poultry. This is evident in the growing number of literature.

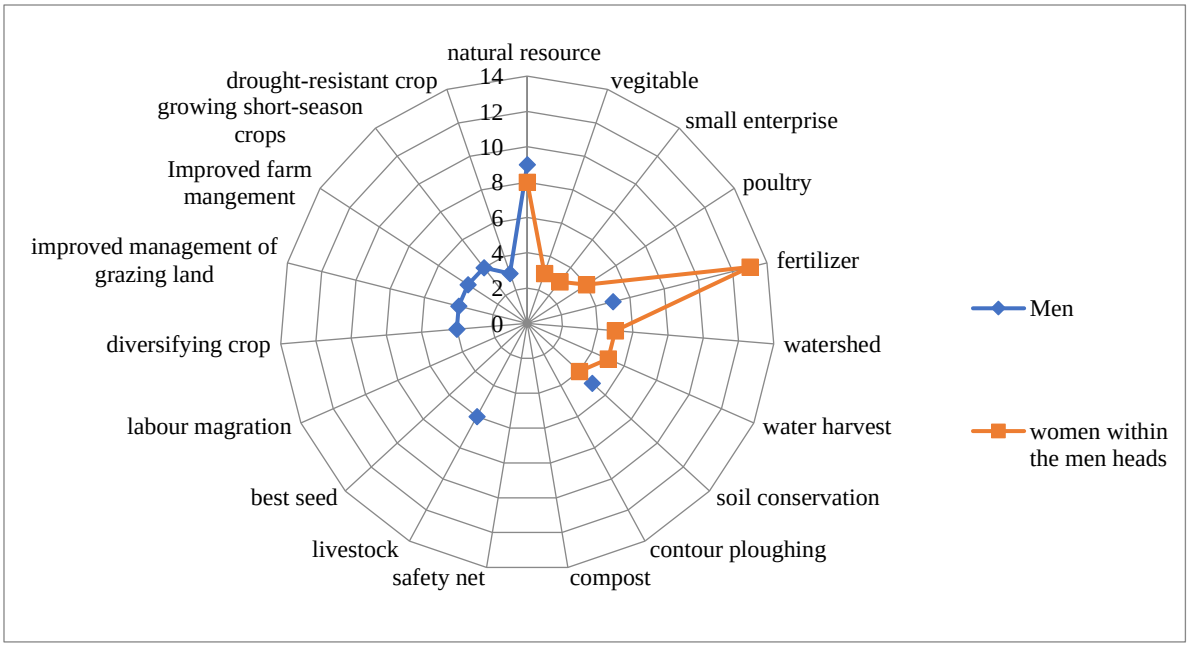


Figure 38: Comparison between men and women within the men headed households

As the above graph shows, alike the comparison of women and men in general, the women within men headed households almost equally preferred natural resource conservation with their male counterparts. There are also communalities on preferring some of the adaptation strategies such as soil conservation and fertilizer. However, as discussed in the above section, the men farmers tend to prefer farm and farm-related adaptation strategies (improved farm management, growing short-season and drought-resistant and crop diversification), whereas the women within the men headed households seem to prefer to diversify their livelihood including an interest to involve in small enterprise, poultry and vegetable planting.

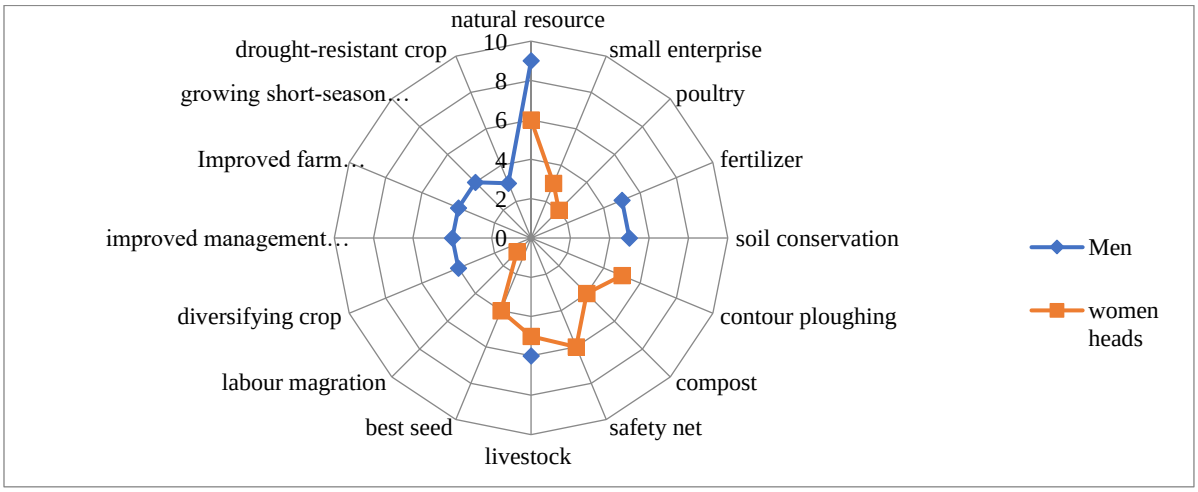


Figure 39: Comparison between male and female household heads

As depicted in the above graph, except in natural resource conservation (which the women heads tend to support in larger number as the men group) and livestock production, the men and women heads have diverse preferences. Like the other women group, the women household heads showed interest to diversify their livelihood by engaging in more non-agricultural income-generating activities such as small enterprise and labour migration and including interest to continue with safety net support. However, the men groups' preference is on the farm and farm-related adaptation strategies.

Pairwise ranking exercise with female headed households in Misrak Belessa (Photo: Dereje A., 2019)

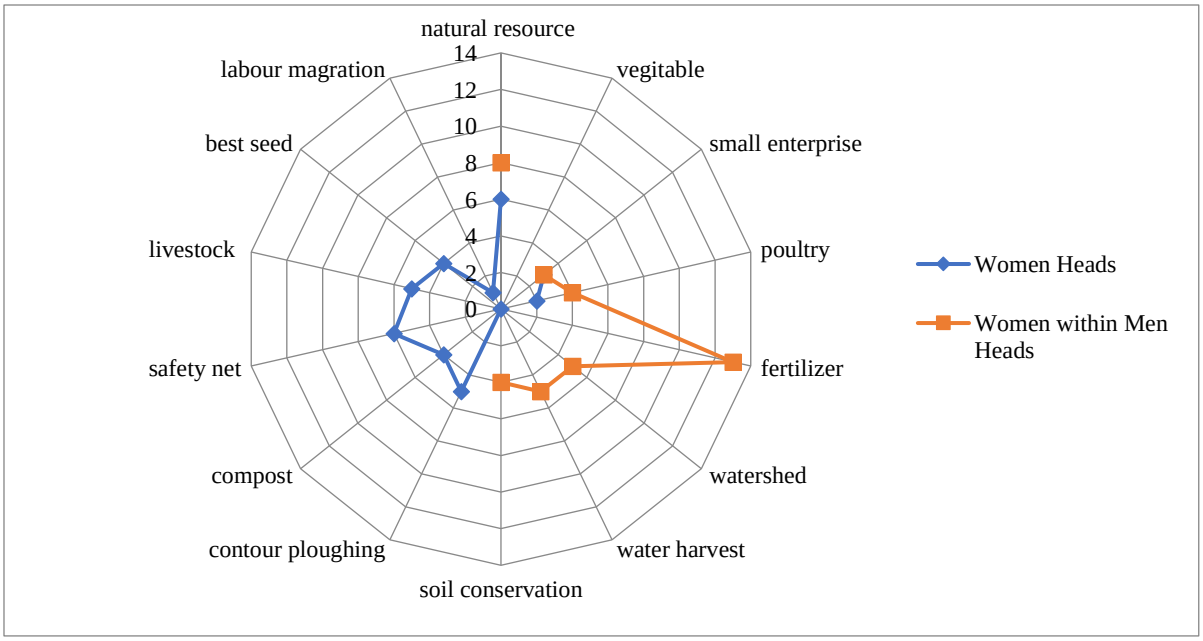


Figure 40: Comparison between female household heads and women within male headed households

As depicted in the above graph, except for natural resource conservation, the adaptation preferences of women household heads and women within male headed household of all the sample districts were found different. This could be better explained through their difference in decision-making power, and access and control over resources. As a growing body of studies are indicating and observed in the FGDs, women household heads have more freedom to choose among the adaptation strategies. For instance, the safety net which was highly criticized by the men group, was presented by women heads and its importance was debated, as they are highly dependent on the safety net. The second most evident instance of difference between both group of women is their difference in preferring relatively larger animals like sheeps, goats and cows (livestock). While the latter is preferred by the women heads, women within male headed households preferred poultry (see the above graph) which demands lower capital, and the turn is lower than the larger animals. Likewise, the freedom of movement of the women heads was also evident from the fact that labour migration is sought as an adaption strategy by the women heads.

Pairwise ranking exercise with women within male headed households in Mirab Belessa (Photo: Dereje A., 2019)

5. CONCLUDING REMARKS AND RECOMMENDATIONS

5.1 Concluding Remarks

Providing policymakers operative information on intrinsic vulnerability is vital to address the issue of climate-induced shocks. In this study, some conclusions have been drawn about the degree of intrinsic vulnerability of small-scale farming households in the North-western parts of Ethiopia and the degree to which households' gender intersects with marital status in determining the level of their vulnerability. The district level vulnerability analysis shows that households in *Mirab Belessa*/midland agro-climatic zone are living in the least vulnerable area compared to others in North-western parts of Ethiopia. Results also show that indicators such as access to drinking water, access to credit facilities, access to fuelwood and access to climate information significantly affects vulnerability of households in North-western parts of Ethiopia. It is therefore necessary for governments at all levels to develop policies and programmes that will address the massive infrastructural deficit in North-western parts of Ethiopia, as this will not only reduce vulnerability to climate extremes, it will also reduce the huge poverty level.

The study also concludes that there is disparity in the vulnerability levels of households within districts. Resilience interventions should therefore be specific, targeting villages within the districts and also particular households within the communities. Interventions such as women empowerment, access to extension agents, provision of basic facilities such as water, alternative sources of energy other than fuelwood, good market facilities and access to credit facilities will increase adaptive capacity to the effect of climate-induced shocks.

This study also contributes to the existing vulnerability literature by showing how a new paradigm of vulnerability assessment adopted by the IPCC 2014 is important in providing more fundamental treatment of vulnerability and identifying the drivers of vulnerability. From a policy intervention vantage point, addressing the drivers of vulnerability provides a reliable approach to reduce the current vulnerability level and manage potential climate change-induced risks of a system.

In addition, it is vital to recognise that any temptation to view women within male headed households and female headed households as homogeneous categories would lead to inappropriate climate policy actions due to the fact that the interplay between climate change and gender is multifaceted. The study shows that the household's marital status was an important factor in determining to what extent they are vulnerable to climate-induced shocks

due to differences for a number of socio-economic and gendered privileges. Using an intersectionality approach, this study revealed that the interplay of gender and other factors including marital status, age and agro-climatic zone suggest the need for differentiated gender needs and actions in the face of climate change. In this context, it is imperative to take caution against a narrowly consideration of gender mainstreaming that disregards intersections with other dimensions, for that might eventually lead to ineffective policies and the further marginalization of certain groups of women and men.

More specifically, it can help policy makers to broaden their understanding of households' differential needs and allow for more precise targeting. Given the enormous diversity of rural smallholder farming households in north-western parts of Ethiopia, it would be simplistic if researchers and policy makers assumed that level of vulnerability among females are uniform. Therefore, this study adds to the intersectionality literature by showing how different social identities related to age, gender and marital status interact to bring about different outcomes for different people in relation to their ability to cope with and adapt to climate change impacts.

The present analysis has some limitations that need to be addressed by future researches. First, due to lack of longitudinal data, the causal directions are unclear. Second, this study did not distinguish among different forms of marriages who might face different challenges in coping with and adapting climate change impacts. Therefore, future research is expected to further understand the challenges faced by rural smallholder farmers in enhancing their adaptive capacity that may vary by several intersectional factors. More specifically, further study should explore whether the position of women in a marriage, being the first, older or younger wife, for example, leads to differences in the freedom to make decisions on the use of household goods. This may not only be due to cultural factors but also relate to a husband's preferences.

In addition, caution must be taken related to the external validity of the findings because findings may be limited to the study areas and to other communities with similar cultural backgrounds in other corners of Ethiopia and East Africa. The generalization of these findings to other areas with different cultures might be impossible. However, further research using larger samples that include different ethnic groups to explore the importance of cultural and other regional differences is highly recommended and appreciated.

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APPENDIX

APPENDIX I: HYPOTHESIZED FUNCTIONAL RELATIONSHIP OF INTRINSIC VULNERABILITY INDICATORS

Table A: List of variables and their hypothesized functional relationship with vulnerability grouped by vulnerability sub-index

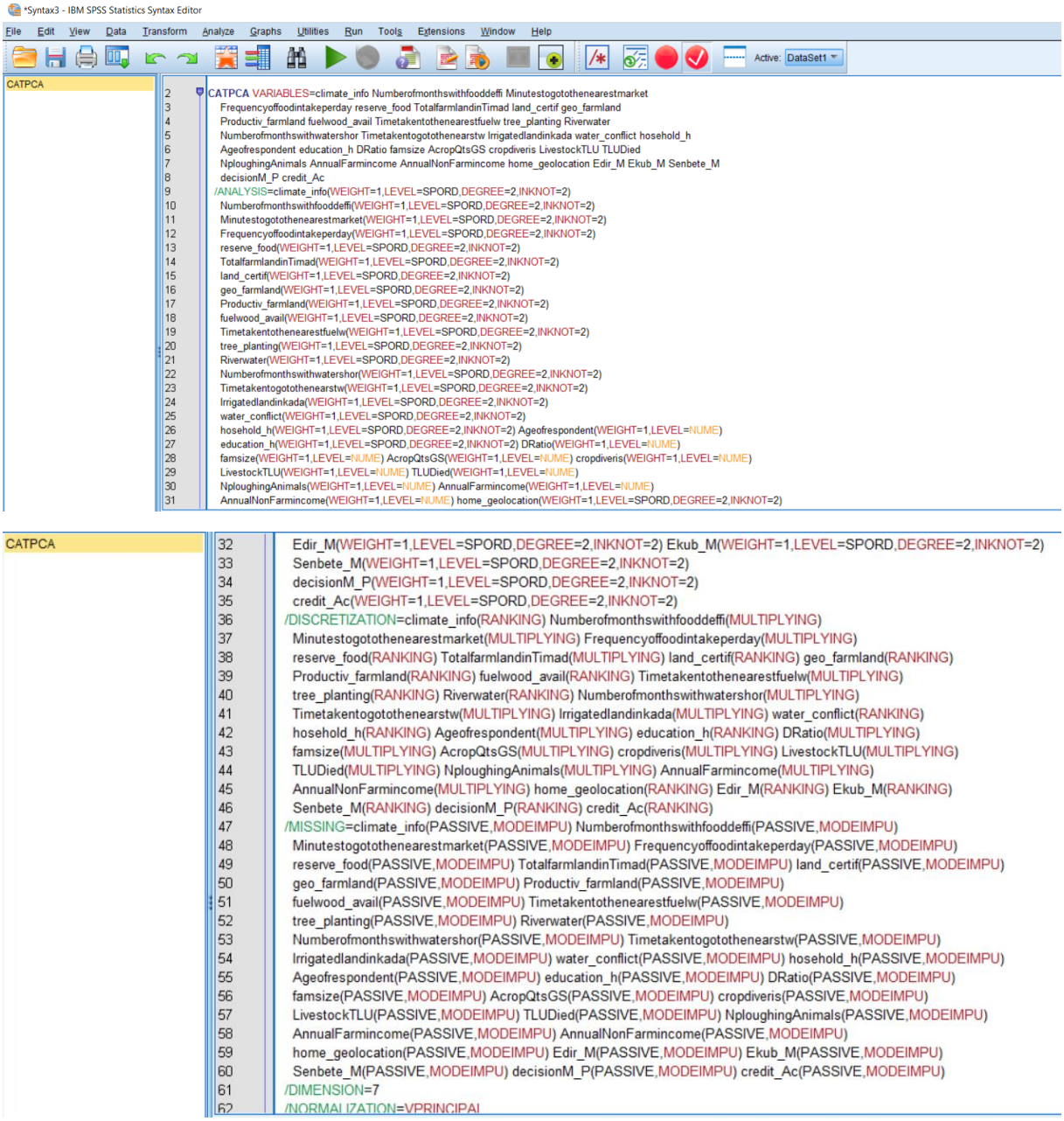
Contributing factors	Code	Sub-components and the unit of measurement	Assumed functional relationship of variables with vulnerability
Adaptive capacity (AC)	AC_1	Dependency ratio	Higher value reflects less capacity to adapt the changing climate
	AC_2	Percentage of female headed households	Higher value reflects less adaptive capacity
	AC_3	Literacy ration (female to male)	Higher value reflects high capacity to adapt the changing climate
	AC_4	Average Family size in the household	Higher value reflects less adaptive capacity
	AC_5	Percentage of households who has not yet attended school	Education makes people to take informed decisions on the changing climate.
	AC_6	Livestock died in TLU for the last 6 years	The shorter the distance, the higher the adaptive capacity
	AC_7	Inverse livelihood diversification Index	Higher value reflects more capacity to adapt
	AC_8	Inverse crop diversification index	Crop diversification increases adaptive capacity
	AC_9	Livestock ownership in TLU (inverse)	Higher value reflects more capacity to adapt
	AC_{10}	Number of plaguing animal owned (inverse)	Higher value reflects less capacity to adapt
	AC_{11}	Households who do not have off-farm employment	Higher value reflects less capacity to adapt
	AC_{12}	Households only depend on agricultural income	Higher value reflects less capacity to adapt
	AC_{13}	Households who did not participate in decision making process	Higher value reflects less capacity to adapt
	AC_{14}	Households who have no leadership role in the community	Higher value reflects less capacity to adapt
	AC_{15}	Households who do not have access to credit to any financial institution	Higher value reflects less capacity to adapt
	AC_{16}	Households who have no participation in local development planning	Higher value reflects less capacity to adapt
	AC_{17}	Households who do not have access to fertilizer	Higher value reflects less capacity to adapt
	AC_{18}	Households who are not member of Edir	Higher value reflects less capacity to adapt
	AC_{19}	Households who are not member of Ekub	Higher value reflects less capacity to adapt
	AC_{20}	Households' annual income from farm activities	Higher value reflects higher capacity to adapt
	AC_{21}	Households' annual income from off-farm activities	Higher value reflects higher capacity to adapt
	AC_{22}	Households who are not member of Senbete	Higher value reflects less capacity to adapt
	AC_{23}	Households who do not have access to improved seeds	Higher value reflects less capacity to adapt

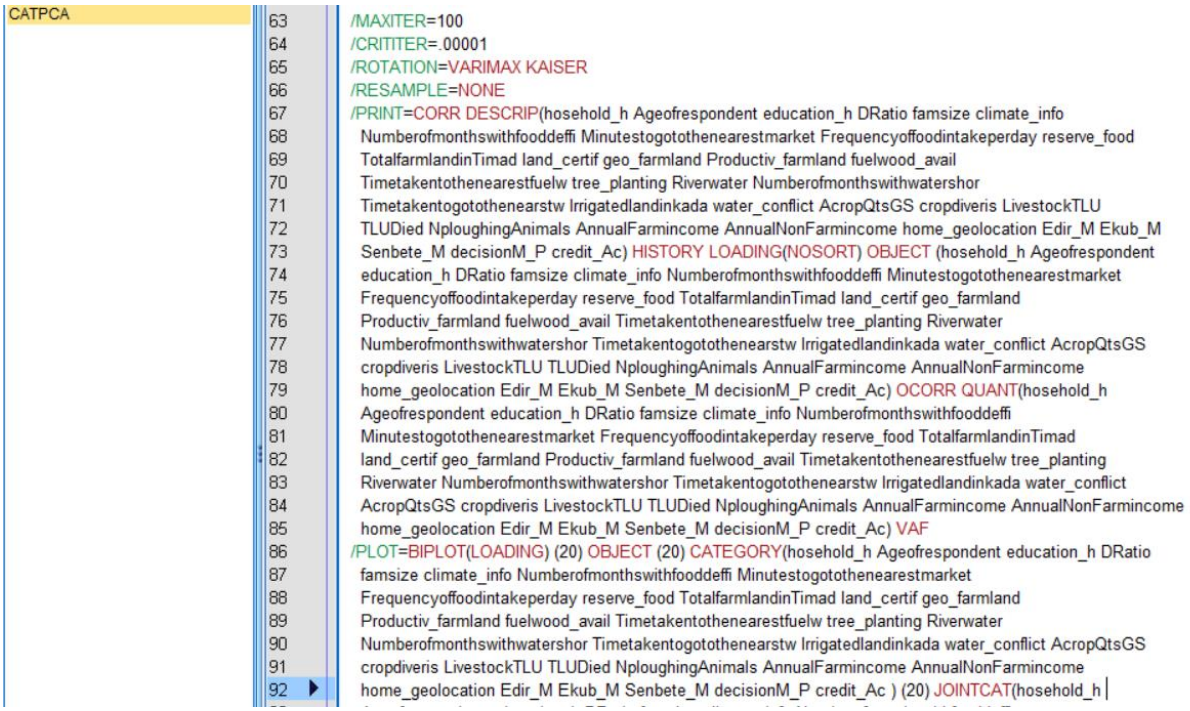
	AC_{24}	Households' age	Higher value reflects low capacity to adapt
Sensitivity (S)	S_1	Households reported decreased firewood supply	Lower value implies higher sensitivity to the changing climate
	S_2	Households who did not plant trees	Lower value implies higher sensitivity to the changing climate
	S_3	Average time to collect firewood in minutes	Shorter time implies lower sensitivity
	S_4	Households reported to have drinking water availability problem	Lower value implies lower level of sensitivity to the changing climate
	S_5	Households faced/heard any conflict over water in the community	Lower value implies higher sensitivity to the changing climate
	S_6	Average travel time to fetch water	The shorter the distance implies the lower the sensitivity
	S_7	Inverse of HHs daily water consumption in liter	Higher value indicates lower sensitivity
	S_8	Households faced food shortage	Higher value indicates more sensitivity
	S_9	Food insufficient months per year	More months implies the higher the sensitivity
	S_{10}	Distance to food market facility	Shorter distance implies lower sensitivity
	S_{11}	Frequency of meal intake per day	More intake implies less sensitivity
	S_{12}	Households unable to save crops for bad year	Higher value indicates more sensitivity
	S_{13}	Inverse of irrigable farmland size of the household in hectare	Higher value indicates lower sensitivity
	S_{14}	Households with high farmland erosion	Higher value indicates more sensitivity
	S_{15}	Households' farmland in hazardous locations	Higher value indicates more sensitivity
	S_{16}	Inverse crop yield per hectare	Higher value indicates lower sensitivity
	S_{17}	Households who are unable to save seeds	Higher value indicates more sensitivity
	S_{18}	Households reported with no land certification	Higher value indicates more sensitivity

*The data source for all of the above variables are the survey

The TLU conversion factors used are as follows: oxen = 1.1, cow = 1.0, heifer = 0.5, calves = 0.2, goats/sheep = 0.1, poultry = 0.01, donkeys =0.5, horse/mule = 0.8 (Shiferaw, 1999). One TLU equals 250 kg of a live animal weight.

Appendix II: Syntax of CATPCA





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