



**COLLEGE OF DEVELOPMENT STUDIES
CENTER FOR FOOD SECURITY STUDIES**

**CLIMATE VARIABILITY: IMPLICATIONS TO HOUSEHOLD FOOD
SECURITY AND COPING STRATEGY IN SOUTH-MECHA WOREDA, ABAY
RIVER BASIN**

**BY
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Climate Variability: Implications to Household Food Security and Coping
Strategy in South-Mecha Woreda, Abay River Basin, Ethiopia

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DECLARATION

I, **Yeshi Mulatu**, do hereby declare to Addis Ababa University School of Graduate Studies that this thesis is a product of my original research work, and it has not been submitted to any other university for any academic degree. Materials and information other than my own are duly acknowledged.

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This is to certify that the above declaration made by the candidate is correct to the best of my knowledge as an advisor.

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ACRONYMS

| | |
|---------------------|--|
| CSI | Coping Strategy Index |
| FAO | Food and Agricultural Organization |
| FCS | Food Consumption Score |
| FGD | Focus Group Discussion |
| HIFAS | Food Insecurity Access Scale Score |
| KII | Key-informant Interview |
| SLA | Sustainable Livelihood Approach |
| SMW _o A | South-Mecha woreda Administration |
| SMW _o AO | South-Mecha Woreda Agriculture Office |
| UNFCCC | United Nations Framework Convention on Climate Variability |
| USAID | United States Agency for International Development |
| WCED | World Commission on Environment and Development |
| WMO | World Meteorological Organization |
| NMI | National Metrological Inistitue |

Abstract

Climate variability is a very important issue- in terms of the global context and its effect on food security and livelihoods. The dynamic of this factor is currently affecting food security and livelihoods in an unbalanced way. This study aimed to assess the effect of climate variability on household food security. The study used metrological data from the period 1981 to 2017. Monthly rainfall and temperature data from NMI were used for the analysis. The standardized anomalies of temperature and rainfall variability using the Mann-Kendal and Sen'slope estimator were applied to evaluate the occurrence of dry and wet periods. Primary data was gathered from 261 sample households, FGD and KII. Data were analyzed using descriptive and inferential statistics. Accoridngly, the result revealed that during the study period (1981-2017), there were exceedance dry periods (963.2%) as compared with the occurrence of wet periods (36.8%) meanwhile, mean annual temperature varies spatially across the study area from 0.0170C to 0.0350 C, which all variations subjected to potential high evapotranspiration to potential high evapotranspiration with a consequent effect on crop production in the study area. The analysis of people's perception of the manifestation of climate variability and the coping mechanisms deployed to deal with its effect on food security revealed that among others, changing planting date measures has been used by 15.9% of respondents as mitigation for climate variability effect. As regards the role of climate variability perception and household food security, the data analysis doesn't show the perception of climate variability as a significant variable. While in general, more food-secure households happen to be more perceivers of climate variability. Analysis of data on climate variability on household food security revealed that there is no striking difference in the proportion of households that were in acceptable, borderline, and poor food consumption categories/levels. In fact, more than 75% of the studied population falls under acceptable and moderate food security levels. Hence, strong iniatives that strengthen the food production system is required and should exhaustively invest in agricultural research, extension, and techiques for lowering food production lossess, and work on climate adaption and weather variability adaption strategies at local level to maintain food security in the study area.

Keywords :*Climate variability, Food security, Abay River basin*

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CHAPTER ONE: INTRODUCTION

1.1 Background and justification

Climate variability and associated effects on food security are being a big issue in recent years. This can be due to the direct or indirect impacts brought by land use and temperature change which have contributed to food security problems. Much of the world's natural land cover has been transformed by human activities (Morton et al., 2006), leading to ecosystem degradation and biodiversity loss worldwide (Green et al., 2005) and hence, global warming.

The direct and indirect effects of climate variability and extremes cause crop yield reduction (Ibrahim & Iyela, 2012; Da Cunha et al., 2015; Rajib et al., 2016). In developing countries, farmers are heavily dependent on rain-fed agriculture (Briassoulis, 2000; Birara et al., 2015; Coulibaly, 2015). Thus, climate variability could compromise the agriculture sector's performance and worsen food insecurity (Butt et al., 2005; Ibrahim & Iyela, 2012; Weldearegay & Tedla, 2018). In developing countries there is a consensus within the scientific community also indicates that ever-rising of temperatures and changing precipitation are serious challenges to ensuring food security and improving livelihoods (Ibrahim & Iyela, 2012; Alemu & Mengistu, 2019).

Developing nations, especially those in Sub-Saharan Africa, are more susceptible to the results of ecological change and climate variability (Akinagbe & Irohibe, 2014; Chakilu & Moges, 2017), mainly due to their geographical location and weather conditions, high dependence on agriculture, natural resources-driven activities, and weak adaptive capacity to the variability in climate (Eriksen et al., 2008).

Ethiopia has tremendous agricultural potential with vast areas of fertile land, a diverse climate, abundant rainfall, and a large labor force. Yet agriculture remains underdeveloped and poverty persists, especially in rural areas. Drought continues to affect the country, causing considerable damage to rain-fed agriculture. Severe famines have greatly affected the lives of the people and have also hampered socio-economic development. While the vast majority of the population is engaged in agriculture as the major base of livelihood, food insecurity remains a serious problem. Put differently, the smallholder farmers who have substantial experience practicing agriculture as their major livelihood for generations are among the most vulnerable to food

insecurity and are unable to produce sufficient food to feed throughout the year (Agidew & Singh, 2017). Food insecurity is one of the defining features of poverty, particularly in the farming community in the Abay basin. The Abay basin is characterized by rugged topographic features and is uniquely susceptible to land-use conversion and climate variability and extreme events including drought, flood, landslide, gully formation, invasion of invasive species, and crop diseases (; Woldeamlak, 2009; Demeku, Addisu & Husen, 2015).

Despite understanding the multidimensional nature of food insecurity, it remains a key concern affecting the livelihoods of small farmers. Therefore, understanding the effect of climate variability on household food security and food-coping responses is critical to look for options to mitigate the impacts (Ibrahim & Iyela, 2012). Like in most areas of the River Abay basin, the study district is characterized by a heavily fragile natural resource base, shortage of agricultural land, and speedy deforestation which resulted in land degradation and climate extreme events. This study explores the effects of climate variability - on food security and coping mechanisms for food insecurity/shortage.

1.2. Statement of the problems

Climate variability and human-induced land degradation have become key challenges for the global and national sustainable development and food security threats (Bewket et al., 2013; IPCC, 2019; 2014; Filho et al. 2020). These mutually reinforcing physical factors are causing soil erosion, water depletion & pollution, and reduction of crop and livestock productivity in many parts of the world including Ethiopia; and it is expected to become severe in the future (IPCC, 2018).

Agriculture has been the backbone of Ethiopia's economy, and will remain so for the foreseeable future – dominated by small scale farmers who employ largely rain-fed and traditional practices – a state which renders Ethiopia subject to unstable climatic condition and most vulnerable to climate variability and land degradation related risk, which has a significant implication on food security (Alebachew, 2011). Rainfall varies from year to year, especially in the semiarid lowlands where even minor climatic shocks have been repeatedly translating to food insecurity (World Bank, 2011).

Food insecurity is an integral part of poverty in Ethiopia. Desertification, brought by human land use pressure and recurrent drought occasioned by climate variability has consumed significant land area and continues to threaten arable lands that are already fragmented, thus threatening the source of income of the small-scale farmer.

To the best of my knowledge, previous empirical studies have been done on global warming and the effect of climate variability on food security in many parts of the world (Deressa et al., 2008; Garedew et al., 2009). However, the environmental effect of future climate variability are still contentious issues and unresolved problems and require further research (Simane et al., 2013; Demessie, 2015). As a result, this study adds to existing information by assessing the effect of climate variability on household food security.

1.3. Objectives

1.3.1. General objective

The general objective of this study is to assess the effect of climate variability on household food security and coping strategies in the woreda.

1.3.2. Specific objectives

More specifically, this study is planned to:

1. examine the trends and variability of temperature and rainfall from 1981-2017,
2. explore the perception of trends in climate variability and related coping strategies,
3. determine household food security status and food coping responses.

1.4. Research questions

1. How has climate (temperature and rainfall) varied in South-Mecha woreda between 1981-2017?
2. How do households perceive temperature and rainfall trends of their locality? Which climate adaptation strategies are practiced by households of South-Mecha woreda?
3. How is the state of food security among households of South-Mecha woreda?

4. How has climate variability affected food production (food security) in South-Mecha woreda?

1.5. Significance of the Study

In taking sound measures towards achieving “sustainable food security” and climate variability mitigation, a clear understanding of the effect of climate variability on food security have considerable significance. Climate variability is connected with socio-cultural, economic, political realities and natural resources. Human activities have been accelerating greenhouse gases emission thus worsening poverty and food insecurity. Farmers should know their capacity to ensure their food security in the face of variability climate. Thus, the study helps to understand how climate variability is increasing the vulnerability of households due to its effect on their food security, and therefore, it can contribute to the effectiveness of the governmental, non-governmental and community-based organization in their effort in bringing about sustainable food security. This is because this cannot effectively be done unless policymakers have adequate information about the effect of the climate variability on food security. The study provides empirical information useful to make some contribution to the ongoing effort of combating the recurrent food security problem of farmers in the highlands of Ethiopia. On the other hand, there are limited research on the assessment of the food security and coping strategies thereby making the study relevant and timely.

1.6. Scope of the Study

The scope of the study is limited to climate variability and its implication to household food security and it is mainly to assess such issues based on the situation in South-Mecha woreda suited in Abay River basin. The research has encompassed a review of secondary information, focus group discussion and key- informant interviews with individuals who have knowledge and information about the issue. Most importantly, the study has a scope of survey using structured questionnaire to collect quantitative data to better understand the issue under investigation. The temporal scope of the study is restricted to the past thirty years.

1.7 Limitation of the study

The study limitation is related to methodological where it uses small sample size (n=261) this is because the lack of resource and time available for field research has led to conduct the study in one of the woreda suited in Abay River basin but this is good to provide insights about Abay River basin.

1.8 Ethical consideration

In the whole process of the research (in the process of data collection and analysis), the privacy, anonymity, and confidentiality of the participants and data was given due consideration. Issues of anonymity, confidentiality, and 'informed consent' were carefully considered. The name of the respondents hasn't been disclosed in the whole process of the research. Verbal consent has been secured to maintain confidentiality and respect their privacy. The proposal and the tools have reviewed and approved by the center and college of development studies Ethical board.

CHAPTER TWO: REVIEW OF RELATED LITERATURE

2.1. Definition of key concepts

Climate refers to the characteristic conditions of the earth's lower surface-atmosphere at a particular location; weather refers to the day-to-day fluctuations in these conditions at an identical location. air temperature, precipitation such as rain, sleet, snow, hail, gas pressure, humidity, wind, and sunshine are normally used by meteorologists to measure daily weather conditions. Climate variability is a variation in the mean state of the climate on all temporal and spatial scales beyond that of individual weather events attributed to natural or anthropogenic activities (IPPC,2014).

Climate variability: refers to the climatic parameter of region varying from its long-term mean. Every year in specific time period, the climate of location is different. Some years have average rainfall, some have average or above average rainfall (IPCC, 2007). Climate variability affects ecosystems. It is anticipated to, directly and indirectly, impact ecologies by altering disturbance patterns, species distributions, and also the suitability of land for specific uses. (Sleeter et al., 2018).

Food security: food security revolves around complex issues that encompasses a wide range of interrelated environmental (and climatological), economic, social and political factors. The current widely accepted definition of food security came from the Food and Agriculture Organization (FAO) annual report on food security “The State of Food Insecurity in the World 2001”. Food security [is] a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2002). The last revision to this definition happened at the 2009 World Summit on Food Security which added a fourth dimension – stability – as the short-term time indicator of the ability of food systems to withstand shocks, whether natural or man-made (FAO, 2009). More recently, it has been suggested that sustainability be added as a fifth dimension to encompass the long-term time dimension (Berry et al., 2015). Devereaux & Maxwell (2001) defined food security as the success of local livelihoods to guarantee access to sufficient food at household levels. Agriculture has been identified by the FAO as having a vital role to play in food security.

Four dimensions of food security have been identified according to the definition (FAO, 2008). 1) Physical availability of food, 2) economic and physical access to food, 3) food utilization, 4) the stability of those other dimensions over time.

Food availability: Food availability refers to the presence of food, e.g. when “Sufficient quantities of appropriate, necessary kinds of food from domestic production, commercial imports, commercial aid programs, or food stocks are consistently available to individuals or within their reach. “Hence, food availability is essentially a function of macroeconomic factors (Anderson et al., 2015).

Food access: Food access refers to the resources the households need to obtain foods, either through own production or through purchase. “individuals have assets or incomes to produce, purchase, or barter to get levels of appropriate foods needed to sustain consumption of an adequate diet/nutrition level, food access is essentially related to household income and own production (Anderson et al., 2015).

Food utilization: Being able to produce or purchase food is not sufficient to ensure a healthy life: food needs to be selected and prepared appropriately, with adequate health care, child care and water and sanitation conditions in place (Anderson et al., 2015).

The fourth domain of Stability, deals with the ability of the nation/ community/(household) person to withstand shocks to the food chain system whether caused by natural disasters (climate, earthquakes) or those that are man-made (wars, economic crises) (FAO, 2009). Thus, it may be seen that food security exists at a number of levels. Availability - National; Accessibility – Household; Utilization – Individual; Stability – may be considered as a time dimension that affects all the levels. All four of these dimensions must be intact for full food security.

More recent developments emphasize the importance of sustainability, which may be considered as the long-term time (fifth) dimension to food security. Sustainability involves indicators at a supra-national/regional level of ecology, biodiversity and climate change, as well as socio-cultural and economic factors (Berry et al., 2015). These will affect the food security of future generations.

2.2. Climate variability on food security

There is clear scientific evidence that the earth's climate is varying (IPCC, 2007). The variability occurs mainly because of increasing concentration of greenhouse gases emitted from various activities of human beings. These variabilities have had impact on the natural equilibrium at the risk of the survival of human beings. The problem is recognized as one of the most serious global challenges of the 21st century with multiple effects on basic human support systems such as agriculture, forest, water resources, and the ecosystem (Aklilu & Alebachew, 2008). Climate variability is a major threat to food security in Africa and many regions of the developing world, which are largely dependent on rain-fed and labor-intensive agricultural production (Parry et al., 2004; IPCC, 2014). Within the African region, the Horn countries are among the most vulnerable but least prepared for adverse global environmental change in the world. Among the horn countries, Ethiopia is one of the most poverty stricken, ecologically fragile and weak economies are heavily impacted by climatic events (Aklilu & Alebachew, 2008).

In Ethiopia, there is a general trend of increasing temperature, decreasing precipitation and increasing frequency of droughts and floods (World Bank, 2003; NMA, 2007). These situations have led to shortage of food, a decline in biodiversity, and increases in human and livestock health problems, rural urban migration and dependency on external support. Moreover, there exists a dearth of empirical evidences regarding the relationship between climate variability and food security at local and household levels. Therefore understanding the implication of climate variability for household food security at local level is critical to looking for options to adaptation as well as mitigation of climate variability effects.

2.3. Empirical literature

According to Djaman et al. (2016), the climate is the main determinant of food production and the inter-annual variability in socioeconomic and environmental systems associated to the availability of water resources. Climate variability, as defined by the United Nations Framework Convention on Climate Change (UNFCCC), is defined as a change in the climate that can be directly or indirectly attributed to human activity that modifies the global atmosphere's composition in addition to natural climate variability seen over comparable time periods. The global surface mean temperature (T_{mean}) has risen by 0.85 C between 1880 and 2012, according

to the IPCC Fifth Assessment Report (AR5), which is most likely because to the observed rise in anthropogenic greenhouse gas concentrations. Greenhouse gases contributed to the 0.5 to 1.3 degrees Celsius global mean surface warming (66%) between 1951 and 2010, increasing the likelihood of drought and intensifying storms like tropical cyclones with increased wind speeds (IPCC 2013).

Many studies have been carried out worldwide to uncover potential solutions to lessen the threat of climate variability (Li et al., 2013). Climate variability is a global issue that is endangering human survival in various parts of the world (Farauta et al., 2012). There have been reports of an increase in air temperature across the globe, notably in Africa's tropical region. Another important element of the hydrologic cycle that is impacted in various places of the world is precipitation. Precipitation decreases are getting more frequent, and many nations are worried about the idea of climate change, which is becoming a major problem at the international level.

Extreme drought conditions and flooding have been brought on by climate variability in many parts of the world (Van de Giesen et al., 2010). Rainfall in Africa is largely responsible for environmental changes (Zheng et al., 1997). Numerous studies have shown that precipitation in Africa has drastically decreased (Hubert et al., 1089). In several nations, the SPI has been utilized as a tool to identify and evaluate drought situations (Mahfouz et al., 2016). This drought analysis method's key benefits are simplicity and temporal flexibility because it simply requires historical precipitation data.

To evaluate the past and make plans for the future, it is becoming more and more crucial to have accurate statistics. It is crucial to research trend analysis in the standardized precipitation index (SPI) and standardized anomaly index (SAI) in order to better understand climate change, its manifestations, and to further monitor flood and drought occurrences and facilitate agricultural planning. Therefore, climate change affects human health, livelihood resources, food production and distribution systems, as well as shifting consumer demand and market dynamics. The immediate risk of increasing crop failure, new pest and disease patterns, a lack of suitable seeds and planting material, and livestock loss exists in agriculture-based livelihood systems that are already at risk of food insecurity (FAO, 2008).

Climate variability are expected to alter in the future as a result of human activities (Field and Barros, 2014) and are expected to influence food security. Human activities that have significant impact on forest fragmentation, land degradation, and biodiversity loss (Maitima et al., 2009; Haegewyn et al., 2014).

Climate variability affects land use and ecosystems. Climate variability is predicted to, directly and indirectly, impact ecology by altering disturbance patterns, species distributions, and suitability of land for specific uses. The composition of the natural and human landscapes, and the way society uses the land, affects the power of the Nation's ecosystems to supply essential goods and services (Sleeter et al., 2018).

Abay basin is one of the foremost diversified and noteworthy river basins in Ethiopia (Bewket & Teferi, 2009; Melesse et al., 2009; Demessie, 2015; Yalew et al., 2016; Gelete et al., 2019) characterized by rugged topographic features and is uniquely prone to climate variability extremes including drought, flood, landslide, gully formation, invasion of invasive species, and disease epidemics. The farming community within the basin is usually affected by these multifaceted biophysical factors that induced food insecurity (Sharp, Devereux, & Yared, 2003; Woldeamlak, 2009; Demeku, Addisu, & Husen, 2015).

Numerous studies in Ethiopia showed that variation in climate could significantly affect household food security at various spatiotemporal scales. As an example, studies on Food insecurity caused by climate variability were conducted in Ethiopia (eg. Elisabeth, 2004; Beyene, 2007; Deressa et al., 2009; Alebachew, 2011; Chalachew et al., 2014; Weldearegay & Tedla, 2018). Studies by Weldearegay & Tedla (2018) showed that by keeping all other factors constant, the climatic variability could decline yield and reduce the provision of foods which aggravates household food insecurity. Elisabeth, 2004; Beyene, 2007; Alebachew, 2011 reported that Ethiopia is mainly agrarian, dominated by small scale farmers who employ largely rain-fed and traditional practices a state which renders Ethiopia to experience unstable climatic conditions and land degradation which ultimately undermine food security. The present study aimed to evaluate: the variability of annual rainfall using Standardized Precipitation Index (SPI); the variability in temperature using Standardized Anomaly Index (SAI); the trend of wet and dry periods using the Man-Kendall statistical test; and the probability of occurrence of different categories of wet and dry periods and its implication on housefood security in the study area.

2.4. Theoretical framework

This section outlines the main theoretical perspectives from which this study will be conducted. The objectives and questions of the research are very likely to have been guided by its theoretical underpinning. At the analysis stage, data will be compared and contrasted with what the theoretical models have predicted, and suppositions made about the extent to which the original propositions can be supported or rejected.

Reducing peoples' vulnerability to shocks from climate-related disasters requires understanding the direct and indirect effect of climate variability and adaptation response to food security. By understanding why people are vulnerable to climate shocks and none climate stressors are utmost important to improve the livelihood and food security of the poor. Accordingly, this study can then identify entry points for adaptation strategies. This study utilizes the Sustainable Livelihood Approach (SLA) to develop this knowledge.

2.4.1. Sustainable livelihood approach (SLA)

The concept of sustainable livelihoods has its origins in the work of the World Commission on Environment and Development (WCED), which highlighted the importance of “sustainable livelihoods security” in achieving sustainable rural development (Chambers & Conway, 1991; Shankland, 2000). A widely accepted definition of livelihoods states that “a livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a way of living” (Chambers & Conway, 1991: 6) and continues by stating that a livelihood is sustainable:

“if it can address and recover from stress and shocks, maintain or enhance its capabilities and assets, and supply sustainable livelihood opportunities for the next generation; and...contributes net benefits to other livelihoods at the local and global levels and in the short and long term” (Chambers & Conway, 1991: 6).

USAID (2009), states that vulnerability refers to a household's susceptibility to a future acute loss and its capacity to sustain its livelihood and food security over time. Vulnerability is defined as: “the household's susceptibility to shocks and stresses that affect the household's ability to make sufficient income to earn a livelihood and achieve an intensity level of nutritional

requirements for a healthy life both now and within the future.” Vulnerability could be a day-to-day reality for several households.

Consequently, household’s vulnerability context is influenced by factors both outside of and within its control. Thus, in this study smallholder farmers’ exposure to climate variability and extremes is vulnerability context. Those factors outside of its control include stresses and shocks still as external structures and processes. Structures and processes include factors just like the public and private sectors, civil society, laws, policies, culture, and social institutions that affect how households accumulate and utilize assets and respond to the adverse impact of climate variability. Stresses include long-term trends or recurring events that put ongoing pressure on the household’s livelihood and food security. In other words, shocks are unanticipated (often dramatic) adverse events that undermine the household’s livelihood and food security. Stresses and shocks emanate from a range of sources within the economic, natural, health, political, and social environments including food insecurity. The current research adopts both agricultural diversification and livelihood diversification, while the outcome of the research is food security.

It needs to be emphasized that the SLA, or simply the livelihoods approach, is not one single approach but various organizations and agencies are applying the key concepts of the SLA in several ways, some placing more emphasis on certain aspects instead of on others. Nevertheless, these approaches share the aim of a more holistic approach to poverty reduction, borne out of criticism of earlier approaches and experiences of rural development and poverty reduction (Ellis, 2000; Hussein, 2002).

2.4.2 Conceptual framework

Climate variability and extremes adversely affect four pillars of food security – availability, access, utilization and stability-and their interactions (FAO et al., 2018). It affects the quantities and kinds of food produced and also the adequacy of production-related income. It could also damage infrastructure and hence the transportation agricultural inputs and productions. Moreover, the impacts of climate variability are likely to cause adaptive responses that influence the environmental and socio-economic drivers of food security in negative ways. Low-income producers and consumers are likely to be most affected due to a scarcity of

resources to take a position in adaptation and diversification measures (Bailey et al., 2015; UNCCD, 2017).

To analyze household food security, different aspects of climate variables so that the direct or indirect threats of household food security can be understood. The subsequent conceptual framework, which attempted to point out the effects of climate variability on household food security, is formulated by the researcher based on related literature. The arrows indicate the expected direction of effect on the corresponding variables.

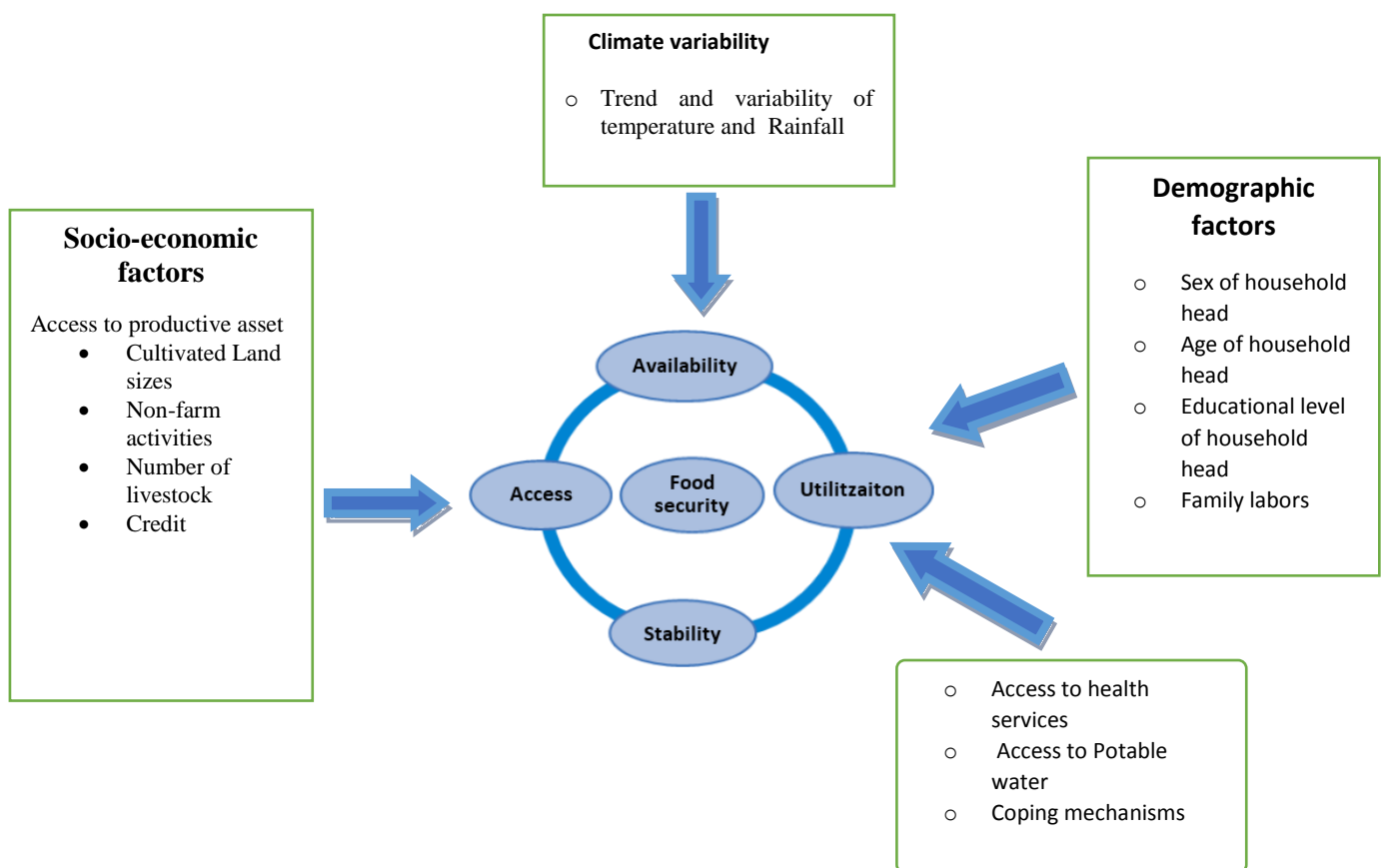


Figure 2:1. Conceptual framework

Source: Researcher own understanding by identified different similar literature

CHAPTER THREE: DESCRIPTION OF THE STUDY AREA, RESEARCH DESIGN AND METHODOLOGY

3.1. Description of the study area

The study site is located in South-Mecha woreda which is situated in the Abay river basin. The Abay river basin is the largest basin in the country. South-Mecha is one of the woredas in the West Gojjam Administrative Zone of Amhara Region and located at 540 km Northwest of Addis Ababa, the capital of Ethiopia and 75km to the East of Bahir Dar, the capital of Amhara Region. The woreda is divided in 14 rural and 1 urban kebeles. The total households which gets agricultural extension services are 13,547, of which 11,653 are males and 1,894 are females (SMW_oAO, 2014). The woreda has a total area of 45,297.5 hectares, of this area a total of 20,352 hectares are covered by crops. The study area located between 37°23'00''E and 11°25'00''N (ArcGis ,2022).

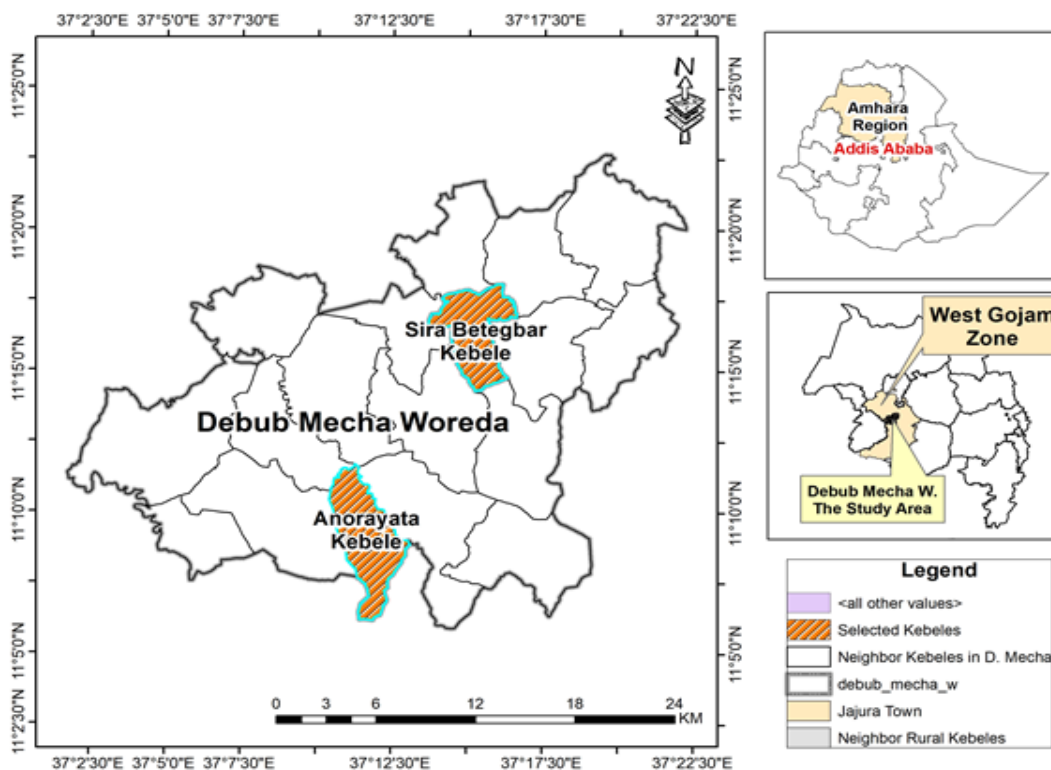


Figure 3:1 Map of the study woreda and kebeles
Sources: ArcGIS (2023)

3.2. Methodology

3.2.1 Research design

The study used both descriptive and explanatory research design to best explore and explain the issue (Creswell & Plano Clark, 2011). The study used both quantitative and qualitative research approaches to explain and explore the information (Creswell 2002; Johnson & Onwuegbuzie 2004). Cross-sectional and longitudinal data were collected from various sources using different tools and analyzed through quantitative and qualitative methods.

3.2.2 Sampling techniques and sample size determination

The sampling frame included study sites and sample households. The multi-stage sampling technique was used for the study. The first stage involved the purposive selection of the South-Mecha woreda for its diverse ecosystems and socio-economic importance. It is significantly important to study this area since this area is characterized by a landslide, gully formation, extensive deforestation, and expansion of settlement which challenges the community food security.

In the second stage, two rural kebeles with diverse ecosystem, flood and drought hotspots sites, food security prone sites were selected purposefully. The total sample size was distributed to each sample kebele based on the proportion of total number of households in each selected kebele. Finally, sample households were selected by simple random sampling technique from the sampling frame households. This enabled the researcher to fully understand the effect of climate variability on food security and livelihood settings. Moreover, agricultural experts, community key-informants, and focus group discussion participants were selected using purposive sampling design based on their expertise, experience, and involvement.

Kebele Anorayata and Sera betegbar were selected purposefully based on information from SMWoAO. This ensured most representation stratum than the total population and results in more reliable and detailed information. The list of total households was obtained from the SMWoAO, and the total number of farming households in the two sample kebeles is 1690. The sample size was determined using the formula recommended by Yamane (1967) as follows:

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

Where n= Sample size

N= Population size

e=level of precision which is 0.05%

Since the sample kebeles is 1690 households, the formula was applied as follows:

$$n = 1690 / (1 + 1690 (0.05)^2)$$

This gave a sample size of 323 respondents. However, only 261 (81 %) questionnaires were administered due to unavailability of respondents in their homesteads at the time of the study. Kelley et al. (2003) recommends that 75% response rate is adequate for a study; thus a total of 261 respondents as was considered adequate.

Table 3:1. Sample size

| Name of sample kebeles | Number of farming household | | | Number of sample farming household | | | % of sample farming household |
|------------------------|-----------------------------|--------|-------|------------------------------------|--------|-------|-------------------------------|
| | Male | Female | Total | Male | Female | Total | |
| Anorayata | 481 | 505 | 986 | 88 | 63 | 151 | 58 |
| Sera betegbar | 343 | 361 | 704 | 46 | 64 | 110 | 42 |
| Total | 824 | 866 | 1690 | 134 | 127 | 261 | 100% |

In order to triangulate household data and gain a better understanding of the link between climate variability and food security, 2 focus group discussion (1 per sampled kebeles) and were made.

3.2.3 Data sources and data collection techniques

The required data was generated both from primary and secondary sources. Both quantitative and qualitative data were collected simultaneously. Sample household surveys, focus group discussions (FGD), and key-informant interviews (KII) were the main means of generating data from primary sources. A structured questionnaire was used to collect information in relation to the opinion of participants about long-term climate variability and its impacts on food security. Moreover, secondary data was collected and reviewed as part of the literature review of the study. Relevant literature of both theoretical and empirical nature was the focus of the literature review to understand the subject matter from a theoretical and empirical foundation.

Time series rainfall and temperature data for South-Mecha woreda were collected from Naitonal Metrological Inistitute (NMI) in the Abay basin. The data cover the period from 1981 to 2017.

I. Questionnaire-based survey

A questionnaire-based survey was carried out in order to gather quantitative information from sample households to statistically analyze responses (Kabir, 2016). With this data collection technique, 261 sample respondents were surveyed to collect information-related data level questions. The questionnaire was translated into local languages spoken by the respondents. The survey questionnaire was pre-tested using 5 to 10 non-selected sample respondents from non-selected kebele in the same woreda and corrections were made to improve the relevance of the questions for the study area. In order to undertake the survey, data collectors were recruited and trained on the questionnaire in order to ensure data quality.

II. Key-informant interview (KII)

Key-informants who have firsthand knowledge about the community were interviewed. The interview was conducted face to face to facilitate open discussion. According to Guest *et al.* (2006), 12 interviews are sufficient to reach 92% of saturation meaning that 92% of the issues under discussion are covered. So, leaders, and experts were interviewed face to face based on the KII guide- line. These community experts including, leaders and food security experts, DA (development agent), environment experts with their particular knowledge and understanding, have provided insight on climate variability, and climate adaptation strategy.

III. Focus group discussion (FGD)

To triangulate the information obtained from the household survey, metrological data and 2 focus group discussions (1 per sampled kebeles) were carried out on the group of eight participants. The main issues covered were a change in temperature, precipitation and adaptation strategies developed in response to climate variability at the household and community level. Mainly, the group members were selected from elders, community leaders, and women leaders to intensively collect their views.

3.2.4 Data analysis methods

The data collected regarding the effect of climate variability on household food security was analyzed using standard qualitative and quantitative analysis methods. The qualitative data that

was collected using key-informant interview, and focus group discussion was analyzed using the thematic content analysis method.

In this particular research, the quantitative and qualitative data were analyzed separately and integrated during interpretation phase. The approach enhances the validity and minimizes the risk of inaccurate interpretation (Creswell and Plano Clark,2007). Data collected using key-informant interview, and FGD were edited and cleaned, and used for qualitative.

All dimensions of food security were estimated. The household food security status was measured by direct survey of household consumption (Idris & Adem, 2013; Abu & Soom, 2016; Ahmed et al., 2018). **The Household Food Balance Model** was employed to estimate the net quantity of per capita food for household members. The model was used to measure availability dimension of food security (Demeku, Addisu, & Husen 2015). The net food available per 100 kilograms per household member was converted into dietary energy equivalent using the Food Composition Table for Ethiopia (EHNRI/FAO, 1997). Accordingly, 2200kcal/day/person for Ethiopia i.e. this value of minimum subsistence requirement is used as a cutoff point for food secure and food insecure households or individuals.

The per capita food available was calculated using a modified version of an equation known as the Household Food Balance Model, which was originally adapted by Degefa (1996) from the FAO Regional Food Balance Model and subsequently used by several researchers in this field (Eshetu 2000, Mesay 2001/09).

Household Food Balance Model:

$$NGA=(GP+GB+FA+GG+)-(HL+GU+GS+GV)$$

Where, NGA= Net Grain available (100kg/household/year)

GP: Total grain production

GB: Total grain bought

FA: Quantity of food aid obtained

GG: Total grain obtained through gift or remittance

HL: Post harvest losses/year

GU: Quantity of grain reserved for seed/year/

GS: Amount of grain sold

GV: Grain is given to others within a year

Food Insecurity Access Scale Score: the HFIAS is a continuous measure of the degree of food security (access) in the household in the past four weeks (30 days). Four types of indicators (i.e. food secure, mild food insecure, moderately food insecure and severely food insecure) can be calculated to help understand the characteristics of and changes in household food insecurity (access) in the surveyed population. A HFIA score variable is calculated for each household by summing the codes for the 9 food insecurity-related conditions.

In this study, the HFIAS shown in table 3.2 was used as a continuous measure of the degree of food insecurity in the HH in the last four weeks. First, the collected responses were coded as 0 or 1 corresponding to the occurrence question and as 1, 2, 3, corresponding to the frequency question (i.e., if Q1=0 then Q1a=0, but if Q1=1 then Q1a could be 1 or 2 or 3 etc.). The maximum score for a HH is 27 (the HH response to all nine frequency-of-occurrence questions was “often”, coded with response code of 3); the minimum score is 0 (the HH responded “no” to all occurrence questions). The higher the score is the more food insecurity the HH experienced, and the lower the score is the less food insecurity a HH experienced. After summing the codes for each frequency-of-occurrence question, HHs were categorized into four food security categories according to their insecurity severity giving the HFI access prevalence.

Table 3.2 Classification of Households based on their food security status using HFIAS

| Category | Food security Status | Criteria |
|----------|--------------------------|--|
| 1 | Food Secure | If (Q1a=0 or Q1a=1) and Q2 –Q9 = 0 |
| 2 | Mildly Food Insecure | If (Q1a=2 or 3 or Q2a=1 or 2 or 3 or Q3a=1 or Q4a=1) and Q5- Q9=0 |
| 3 | Moderately Food Insecure | If (Q3a=2 or 3 or Q4a=2 or 3 or Q5a=1 or 2 or Q6a=1 or 2) and Q7- Q9=0 |
| 4 | Severely Food Insecure | If (Q5a=3 or Q6a=3 or Q7a=1 or 2 or 3 or Q8a=1 or 2 or 3 or Q9a=1 or 2 or 3) |

Source: FANTA (Coates et al.,2007)

Food Consumption Score (FCS) is an index that was developed by the World Food Programme (WFP) in 1996. It is a composite score based on dietary diversity, food frequency, and relative nutritional importance of different food groups. Food items are grouped into eight standard food groups with a maximum value of 7 days/week. To calculate FCS group food items in the specified food group, sum all the consumption frequencies of food items within the same group, multiply the value of each food by its weight then sum the weighted food group scores to obtain FCS finally determine the household's food consumption status based on the following thresholds: 0-21: poor; 21.5-35: Borderline; >35: Acceptable.

Coping strategy of food insecurity: Coping strategy defined as a mechanism by which household or community members meet their relief and recovery needs and adjust to future disaster related risks by themselves without outside support (Tesfaye, 2005).

Furthermore, the data was analyzed using descriptive and inferential statistics developed by the South Texas Art Therapy Association (STATA) version 14. The descriptive and inferential methods were employed to analyze demographic and socioeconomic factors affecting household food security. Logistic regression was applied to analyze quantitative data that was collected from sample questionnaire respondents.

Descriptive statistics were used to show the effects of continuous and descriptive variables of the study on sample household food security, while inferential statistics like logistic regression was used to know the association between dependent and independent variables upon determinants of food security in rural farm households. For the logistic regression model, household food security status was used as the dependent variable (1 is food secured, and 0 is for not-secured). The logistic regression model was employed to determine the determinants of food security at the household level. According to Gujrati (2004) during the estimation of logit model, the dependent variable should be dummy. Therefore, in this case, food security will be measured as a dummy that takes the value of 1 for household calorie intake of greater or equal to 2200 kcal per day and 0 for less than 2200 kcal/adult equivalent/day. This is Mathematically expressed as:

$$pi = \frac{e^{zi}}{1 + e^{zi}} \quad (1)$$

Then, $1 - pi$ represents the probability of being food secured and can be written as:

$$1 - pi = \frac{1}{1 + e^{zi}} \quad (2)$$

Dividing equation (1) by equation (2) and simplifying gives:

$$pi/1-pi = 1+e^{zi}/1+e^{-zi} = e^{zi} \quad (3)$$

Equation (3) indicates the odds ratio in favor of being secured. It is the ratio of the probability that the farmer being food secured to the probability of not secured. Finally, the logit model is obtained by taking the logarithm of Equation (3) as follows:

$$\text{Ln}(pi/1-pi) = \text{Ln} (e^{\beta_0 + \sum_{j=1}^n \beta_j X_{ij}}) = \text{Ln} (e^{z_i}) \quad (4)$$

Where Ln is the log of the odds ratio, which is not only linear in X but also linear in the parameter. Thus, when the stochastic disturbance term u_i is included.

$$Z_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_n X_{in} + u_i \quad (5)$$

Before fitting variables into logistic regression model, variance inflation factor (VIF) and contingency coefficient (CC) were employed to check multicollinearity among continuous and dummy variables, respectively.

Meteorological data obtained from the National Meteorological Institute (NMI) was used, and hence, suggest current and future food security situation in the Abay basin. To check the real existence of climate variability, 30 year's data was accessed from National Metrological Institute. As a parameter, trends in rainfall and temperature were analyzed in annual (Belg and Meher) bases (Feleke et al., 2016).

3.3.4 Statistical methods for evaluation of climate variables

Sen's technique (Sen 1968) and the modified Mann-Kendall (MK) test were employed in this work to analyze the temporal trend in T_{Max} and T_{Min} . The MK test, first developed by Mann and Kendall in 1945 and 1975, is a non-parametric test technique. Since the MK test assumes that the time series under study are stable, independent, and random with equal probability distribution, it is least impacted by the existence of outliers in the data. Serial correlation in time series, however, can either boost or diminish the likelihood of spotting important trends (Yue et al., 2003). Cunderlik and Burn (2004) advised utilizing the Pre-whitening approach to remove serial correlation from time series before applying the MK test to the resulting uncorrelated time series. However, pre-whitening was found to have lowered the rate of detection.

However, it was discovered that pre-whitening had decreased the MK test's ability to detect significant trends (Yue et al., 2003). Hamed (2018) presented a modified MK test for serially correlated data based on a variance (S) correction for the effective number of observations to account for this. In the MK test, test statistics Z are used to examine monotonic trends in time series, while Sen's slope estimator (Q) is utilized to calculate the magnitude of change (Ali et al., 2019).

In hydrological studies, it's crucial to evaluate the data on extreme rainfall. According to specific characteristics like mean, variance, standard deviation, coefficient of variation, and coefficient of skewness, etc., the statistical behavior of any hydrological series may be explained (2016_ICAET_RainfallAnalysisDharamshala). In order to evaluate the trend analysis of the station's rainfall, the following equations were used.

$$\bar{X} = \frac{1}{N} \sum_{i=1}^N X_i \dots\dots\dots 1$$

Where: \bar{X} is mean, X_i is variable, and N is the total number of observations.

$$S = \sqrt{\frac{\sum_{i=1}^N (X_i - \bar{X})^2}{(N-1)}} \dots\dots\dots 2$$

Mann-Kendall test and Sens’s slope

In the present study, trend analysis was done using the non-parametric Man-Kendall test (Kendall, 1975; MANN.H, B. 2013).MK is a statistical method used to study hydroclimatic series’ spatial variation and temporal trends.

The Mann-Kendall S Statistic is mathematically computed as follows

$$S = \sum_{i=1}^{N-1} \sum_{j=i+1}^N sgn(x_j - x_i) \dots\dots\dots 3$$

Where N is the number of data points. Assuming $(x_j - x_i) = \theta$, the value of $sgn(\theta)$ is computed as follows:

$$sgn(\theta) = \left\{ \begin{array}{l} 1 \text{ if } (x_j - x_i) > 0 \\ 0 \text{ if } (x_j - x_i) = 0 \\ -1 \text{ if } (x_j - x_i) < 0 \end{array} \right\} \dots\dots\dots 4$$

Where: Seasonal and annual values in years j and $i, j > i$ respectively. $(x_j - x_i)$ is the signum function. The test statistic (S) has been assumed to be asymptotically normal. A positive value of S indicates an increasing trend, whereas a negative value indicates a declining trend in the data. For $n \geq 10$, the statistic S is approximately normally distributed with the mean and mean, and $E(S)$ becomes 0 (M. G. Kendall, 1975). It is necessary to compute the probability associated with S and the sample size, n, to quantify the significance of the trend statistically.

According to Chattopadhyay (2015), the statistical Kendall's τ (tau) test can be compared as:

$$\tau = \frac{S}{N(N-1)/2} \dots\dots\dots 5$$

Where the null hypothesis of no trend is rejected when S and τ are significantly different from zero.

Sen's slope estimator

Sen's estimator (Kocsis et al., 2017) has been widely used to detect the trend direction and determine the magnitude in meteorological time series (Chattopadhyay and Vennila,2015; Pal *et al.*, 2017). It is the non-parametric method that can calculate the change per unit time. This method assumes a linear trend in the time series (Pal et al., 2017b). In this method, the slopes T_i of all data pairs are calculated as flows:

$$T_i = \frac{x_j - x_i}{j - i} \dots\dots\dots 6$$

For $i = 1, 2, \dots, N$

Where x_j and x_i are data values at a time j and $i(j > i)$, respectively. If there are n values x_j in the time series and obtained $N = n(n-1)/2$ slope estimates S_i . The median of these N values of T_i is Sen's estimator of the slope, which is calculated as

$$T_{Med} = \begin{cases} T_{\frac{N+1}{2}} & N \text{ is odd} \\ \frac{1}{2} \left(\frac{T_N}{2} + \frac{T_{N+2}}{2} \right) & N \text{ is even} \end{cases} \dots\dots\dots 7$$

A positive median value indicates an upward (increasing) trend and a negative value indicates a downward (decreasing) trend in the time series. Finally, the median is tested with a two-sided

test at the $100(1-\alpha)$ % confidence in the true slope may be obtained with the nonparametric test (Mondal et al., 2012).

3.4 Organization of the paper

This thesis contains five chapters. The first chapter contains the background of the study, the problem statement, and objective of the study, significance of the study, scope of the study, limitations, and ethical considerations. Chapter two introduces the literature review, theoretical framework, and the conceptual framework. Chapter three contains methodologies, description of the study area, research design, sampling design, sources and type of data, method of data collection and data analysis. Chapter four deals with the result and discussion. The last chapter is conclusion and recommendations.

CHAPTER FOUR: RESULT AND DISCUSSIONS

4.1. Introduction

This chapter presents a discussion of the final results and the process through which the results were obtained. First, the background information of respondents is presented. Finally, it presents and analyses the data collected, which included a descriptive analysis and regression analysis through stata version 14.

4.2. Descriptive statistics analysis

This section basically analyzed primary data for generating descriptive statistics whereby frequencies and percentages were used to present quantitative data in the form of tables for demographics of respondents.

4.2.1. Demographical characteristics of respondents

Two hundred sixty-one questionnaires were distributed to the sample households and information were collected with a response rate of 100 percent. The demographic characteristics includes sex age and size of household. This aspect of the analysis deals with the personal data of sample households to the questionnaires given to them.

The demographic profile of the respondents which is considered vital for this study is presented as follows. Table 4:1 below shows that the gender composition of respondents is almost proportional where the male and female respondents constitute 51.3 and 48.7% of the total respondents respectively. Therefore, the data collected can be considered as free of gender base.

Table 4: 1 Sex of the respondent

| Sex | Percent |
|------------|----------------|
| Male | 51.3 |
| Female | 48.7 |
| Total | 100.0 |

Source: Survey Data (2022)

Table 4:2 shows that the average age of the sample household heads was 48 and the standard deviation is 12.230. the maximum age observed was 89 and the minimum age was 20 years old. It also shows that the average family size of the sampled households is five per family.

Table 4:2 Family size and age of household head

| | N | Minimum | Maximum | Mean | Std. Deviation |
|-----------------------|----------|----------------|----------------|-------------|-----------------------|
| Age of the respondent | 261 | 20 | 89 | 48.21 | 12.230 |
| Household size | 261 | 1 | 13 | 5.27 | 2.397 |

Source: Survey Data (2022)

Table 4:3 below shows that of the survey data collected in South- Mecha woreda about 98% of the respondents are engaged in agricultural activities.

Table 4:3 Income source of sampled households

| Source of income of the household | percent |
|--|----------------|
| Formal employment | .4 |
| Casual labor | .8 |
| Agriculture | 97.7 |
| Trading | 1.1 |
| Total | 100.0 |

Source: Survey Data (2022)

4.3. Rainfall and temperature variability in south Mecha woreda

The rainfall and temperature data were collected from National Metrological Institute of Ethiopia for the study area. Table 4:4 shows the monthly minimum and maximum annual rainfall variations. Accordingly, the rainfall in the study area increased in all months except January, October, and December; however, the decrease in these three months was insignificant. The annual rainfall in Mecha increased significantly by 3.98mm/year.

Table 4:4 Descriptive statistics of monthly minimum and maximum annual rainfall of south Mecha woreda

| Variable | Minimum | Maximum | Mean | Std. deviation | Kendall's tau | Sen's slope | p-value |
|----------|---------|---------|---------|----------------|---------------|-------------|---------|
| Jan | 0.04 | 49.67 | 7.36 | 9.35 | -0.09 | -0.06 | 0.42 |
| Feb | 0.05 | 32.72 | 4.25 | 6.05 | 0.15 | 0.05 | 0.19 |
| Mar | 0.23 | 101.87 | 21.93 | 20.86 | 0.10 | 0.15 | 0.41 |
| Apr | 3.11 | 106.66 | 33.35 | 28.21 | 0.06 | 0.17 | 0.62 |
| May | 11.32 | 187.95 | 96.73 | 52.10 | 0.19 | 1.23 | 0.10 |
| Jun | 113.46 | 308.94 | 213.97 | 46.53 | 0.10 | 0.67 | 0.38 |
| Jul | 254.29 | 514.54 | 368.19 | 65.32 | 0.00 | 0.00 | 1.00 |
| Aug | 238.89 | 425.88 | 328.65 | 51.39 | 0.03 | 0.25 | 0.78 |
| Sep | 123.55 | 275.21 | 192.94 | 37.69 | 0.19 | 0.98 | 0.09 |
| Oct | 12.61 | 228.49 | 84.02 | 48.94 | -0.02 | -0.04 | 0.90 |
| Nov | 3.07 | 61.96 | 21.47 | 12.00 | 0.19 | 0.22 | 0.10 |
| Dec | 0.15 | 34.52 | 10.72 | 10.11 | -0.08 | -0.09 | 0.47 |
| Annual | 1056.03 | 1779.60 | 1383.58 | 149.61 | 0.21 | 3.98 | 0.07 |

Source: Survey Data (2022)

Table 4:5 shows the monthly minimum and maximum annual temperature variation. Accordingly, the t_{Max} in the study area increased significantly in January, March, April, and annually. Mainly the annual t_{max} increase in the study area significantly by $0.02^{\circ}\text{C}/\text{year}$. The mean monthly temperature ranges from 22.54 to $28.28^{\circ}\text{C}/\text{year}$.

Table 4:5. Descriptive statistics of monthly minimum and maximum annual temperature of south Mecha woreda

| Time | Minimum | Maximum | Mean | Std. deviation | Kendall's tau | Sen's slope | p-value |
|--------|---------|---------|-------|----------------|---------------|-------------|---------|
| Jan | 23.65 | 28.45 | 25.95 | 1.05 | 0.03 | 0.00 | 0.78 |
| Feb | 25.39 | 29.39 | 27.49 | 0.99 | 0.26 | 0.04 | 0.02 |
| Mar | 24.71 | 30.27 | 28.09 | 1.22 | 0.35 | 0.05 | 0.00 |
| Apr | 25.72 | 30.80 | 28.28 | 1.23 | 0.25 | 0.04 | 0.03 |
| May | 24.08 | 30.87 | 27.15 | 1.58 | 0.16 | 0.04 | 0.15 |
| Jun | 22.70 | 27.88 | 25.03 | 1.06 | 0.16 | 0.02 | 0.16 |
| Jul | 20.54 | 26.98 | 22.74 | 1.41 | 0.12 | 0.02 | 0.29 |
| Aug | 20.46 | 26.51 | 22.54 | 1.28 | 0.00 | 0.00 | 0.98 |
| Sep | 20.40 | 28.03 | 23.51 | 1.36 | 0.15 | 0.03 | 0.18 |
| Oct | 21.35 | 29.23 | 24.47 | 1.43 | 0.19 | 0.04 | 0.10 |
| Nov | 21.92 | 28.51 | 25.05 | 1.24 | 0.04 | 0.01 | 0.72 |
| Dec | 22.55 | 27.58 | 25.19 | 1.11 | -0.02 | 0.00 | 0.90 |
| Annual | 24.02 | 27.90 | 25.46 | 0.80 | 0.21 | 0.02 | 0.07 |

Source: Survey Data (2022)

Table 4:6 shows the monthly and annual temperature variation. Accordingly, the t_{\max} in the study area increased significantly in February, March, April and May. The annual t_{mean} increased significantly by $10.41^{\circ}\text{C}/\text{year}$. The monthly mean temperature of the area ranges from 7.67 to $12.12^{\circ}\text{C}/\text{year}$.

Table 4:6. Descriptive statistics of monthly and annual minimum temperature of South-Mecha woreda (1981-2017)

| Variable | Minimum | Maximum | Mean | Std. deviation | Kendall's tau | Sen's slope | p-value |
|----------|---------|---------|-------|----------------|---------------|-------------|---------|
| Jan | 5.87 | 11.80 | 7.67 | 1.15 | -0.16 | -0.02 | 0.17 |
| Feb | 6.69 | 12.24 | 8.82 | 1.09 | 0.05 | 0.01 | 0.69 |
| Mar | 8.12 | 14.57 | 10.24 | 1.34 | 0.14 | 0.03 | 0.22 |
| Apr | 8.80 | 15.59 | 11.51 | 1.61 | 0.24 | 0.05 | 0.04 |
| May | 8.94 | 15.59 | 12.12 | 1.45 | 0.29 | 0.05 | 0.01 |
| Jun | 6.53 | 15.67 | 11.68 | 1.57 | 0.24 | 0.04 | 0.03 |
| Jul | 6.47 | 15.66 | 11.34 | 1.60 | 0.13 | 0.02 | 0.25 |
| Aug | 6.01 | 16.66 | 11.41 | 1.72 | 0.10 | 0.01 | 0.38 |
| Sep | 6.03 | 18.78 | 11.24 | 2.01 | 0.18 | 0.02 | 0.11 |
| Oct | 7.39 | 18.17 | 10.83 | 1.82 | 0.27 | 0.04 | 0.02 |
| Nov | 5.39 | 18.24 | 9.81 | 2.24 | 0.14 | 0.02 | 0.23 |
| Dec | 4.65 | 18.87 | 8.26 | 2.15 | 0.05 | 0.01 | 0.65 |
| Annual | 7.31 | 15.16 | 10.41 | 1.32 | 0.23 | 0.02 | 0.04 |

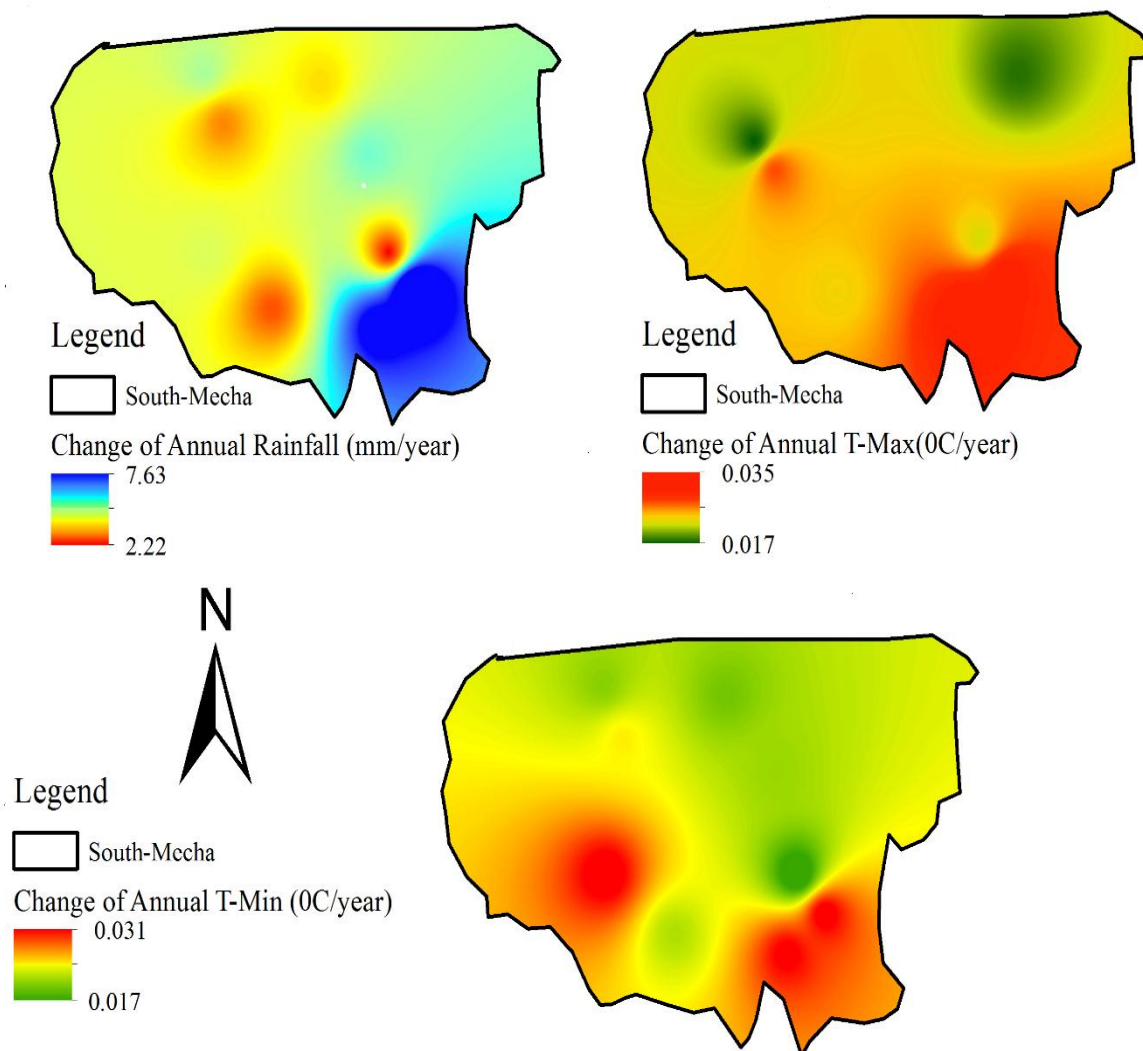
Source: Survey Data (2022)

4.3.1. The spatial distribution and change of annual rainfall, t-max and t-min

Figure 4:1 illustrates the spatial and temporal variability and trend of minimum, maximum, and annual mean temperature of summer, spring and winter seasons (1981–2017). The result revealed that mean annual change of rainfall varies from 2.22 mm/year to 7.63mm/year. The mean annual temperature of the study area also varies from 0.0170C to 0.0350C, while the mean annual minimum temperatre varies from 0.0170C to 0.0310C. The result showed that high temperature distribution fluctuation was observed in the minimum temperature in the study area.

This dynamic temperature change against the mean value would lead to the occurrence of precipitation change and variability in the study area. The increasing trend of mean annual maximum temperature is consistent with findings in different part of the world (Shrestha et al., 2017; IPCC, 2014). The anticipated reduction in mean annual minimum temperatre could be due to the presence of highly protected natural resource and presence of permanent forests in the study area. However, it requires further investigation to un cover the cause of mean annual minimum temperatre reduction. This results are consitent with the finding of increasing trend of mean annual maximum temperature and and mean annual minimum temperatre reduction by researchers (Shrestha et al., 2017; Wei et al., 2019; Gebremeskel et al., 2019; IPCC, 2014).

Figure 4:1 also depicts that the region experienced great variation and distribution and changes of rainfall, t_{max} and t_{min} . In the Southeastern part of Mecha, annual rainfall significantly increases by 7mm/year. The magnitude of the rainfall decreased towards the north and some pocket areas. The trend of annual t_{max} and t_{min} show a similar pattern, and a significant increase in minimum and maximum temperature is shown in the south-east of the region ($0.31^{\circ}\text{C}/\text{year}$ to $0.035^{\circ}\text{C}/\text{year}$ (figure 4:1).



Source: ArcGis (2022)

Figure 4:1 The annual rainfall, t_{max} , and t_{min} spatial trend

4.3.2. The seasonal and annual variability of rainfall in South -Mecha woreda

The results of the SPI for 12-month time scale of South-Mecha woreda are shown in figure 4:2. The SPI 12-month time scale revealed a sustained dry period starting from 2007-2017. The severely dry period in 2007 sustained for several months before it ends in 2011 and went up again in 2015. The result also revealed that out of 38 cases, there were 14 wet period / positive anomalies which represents 36.8 % of the study period. On the other hand, out of 38 cases, there

were 24 dry periods/ negative anomalies which represents 63.2% of the study period. The results of this study showed higher frequency of dry periods than wet periods in the study area. The incidence of the decrease of wet periods can be observed by the reduction of the crop growing season. The anomaly of Belg season rainfall increased continually from 2014 to 2017. Generally, total annual rainfall anomalies of the study area decrease towards the end of the study periods.

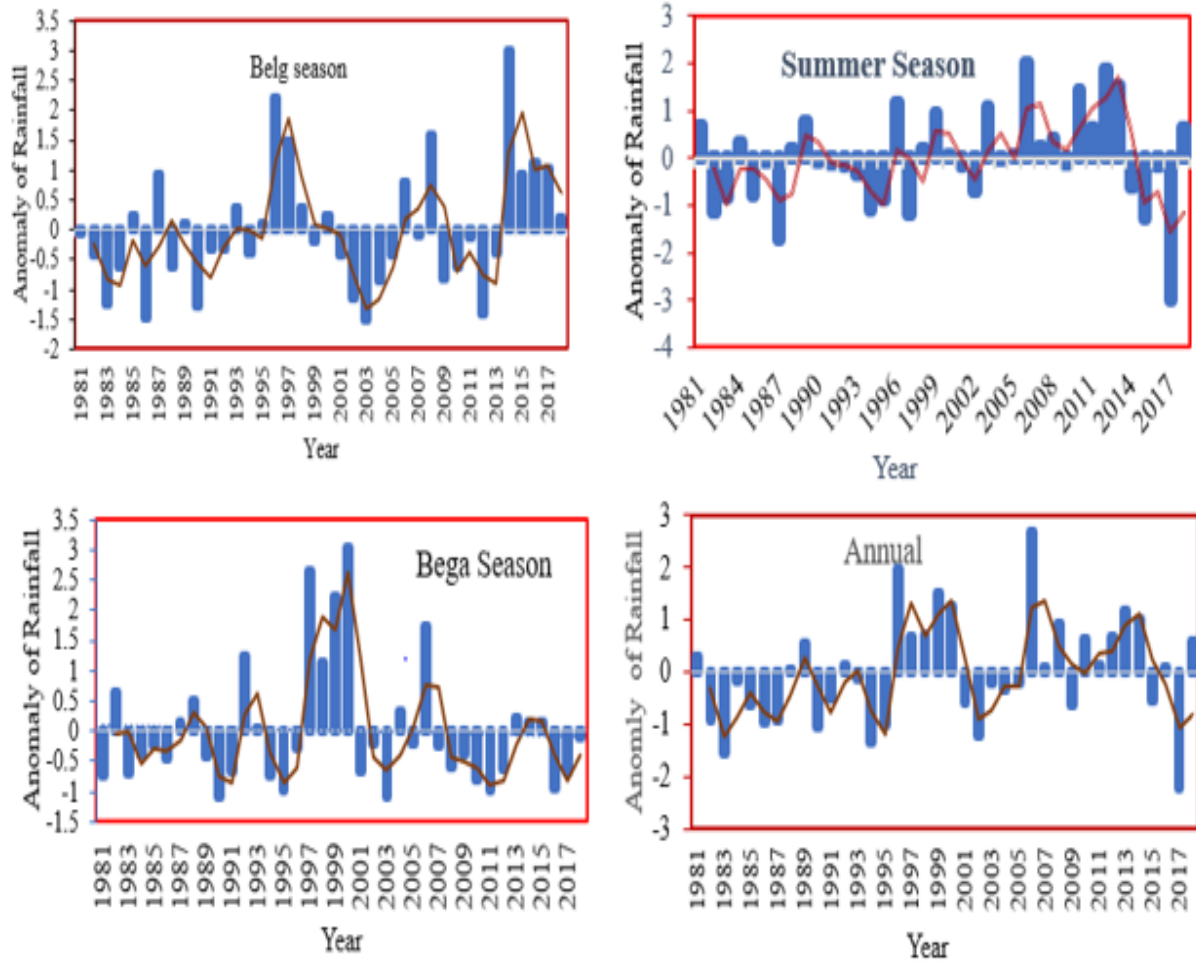


Figure 4:2: The anomaly of seasonal and annual rainfall and two years moving average

4.3.3. The seasonal and annual fluctuation of temperature in south-Mecha woreda

The temperature anomalies which occur in South-Mecha woreda during 1981-2017 periods were described for the mean annual; mean annual minimum and maximum temperatures. Figures 4:3 shows Standardized Anomaly index for the mean annual, minimum and maximum temperature of the study area. For mean annual temperature, all results of the summer season were marked

with below long average except 2002 and 2014-2017 indicating periods of cooling. The Annual temperature variation also showed that, the cooling period which started in 2002 continued with few intervals (2003-2004) and start cooling in 2012 and 2024 until 2017.

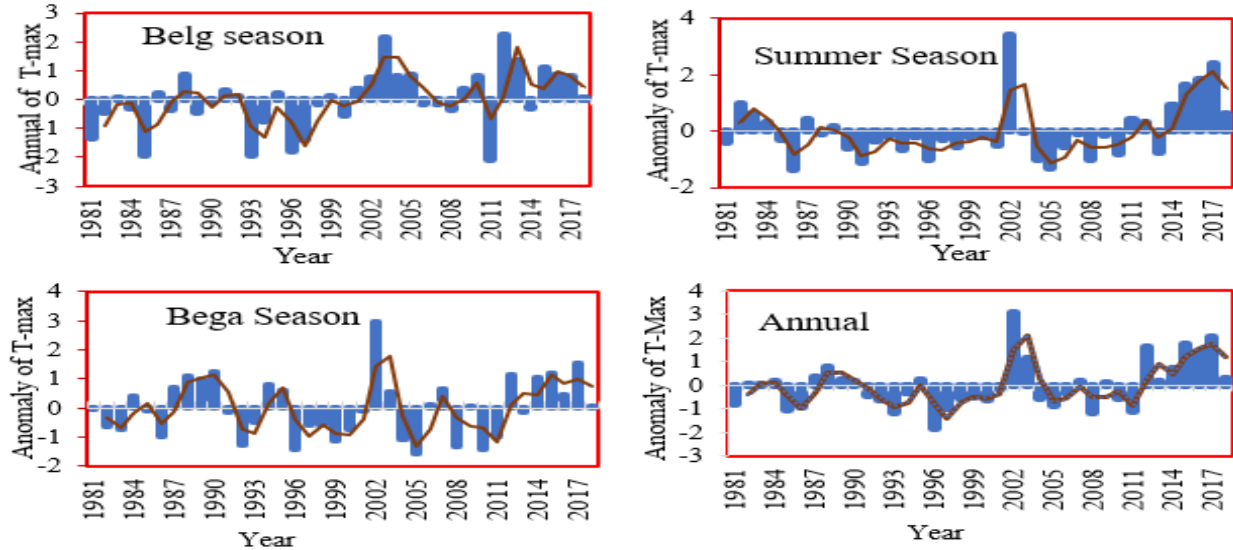


Figure 4:3. The anomaly of seasonal and annual t-Max and two years moving average

4.3.4. The seasonal and annual fluctuation of t-min

The variation of seasonal and annual t_{\min} or anomaly has been diminished since 1993, except for the Belg season (figure 4:4).

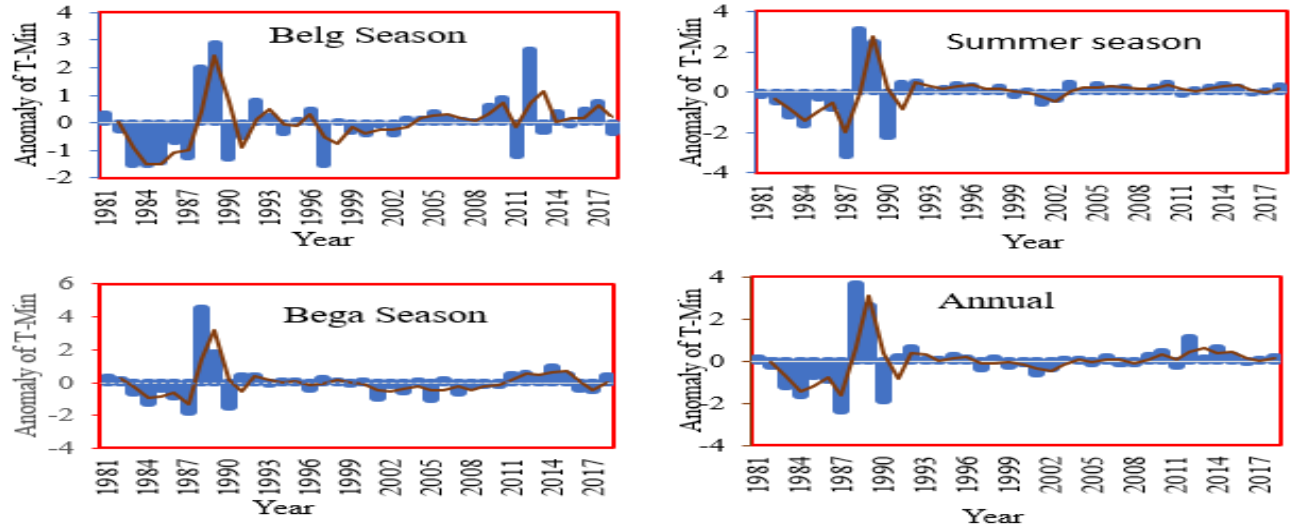


Figure 4:4. The anomaly of seasonal and annual T-Min and two years moving average

Generally, the study looked at trends in rainfall and temperature in the South-Mecha woreda of the Western Gojjam Zone of the Amhara Regional State of Ethiopia between 1981 and 2017. Based on the main data, it is concluded that summer gives the most yearly rainfall to the study area, with the least fluctuation and a statistically significant upward trend. The research area experienced lower long-term annual rainfall primarily in the years 1983, 1994, 2002, and 2017, which suggests that these years correspond to the area's occurrences of drought with varying intensities.

Results from the yearly rainfall in the majority of the region, South-Mecha woreda exhibit statistically significant growing tendencies. The research area's mean annual maximum and lowest temperatures exhibited a warming tendency during the winter. When compared to their counterparts in the west, the maximum temperature change occurs across the eastern section of the region at a faster rate. During the study period, the annual lowest temperature over the study area significantly increased by $0.031^{\circ}\text{C}/\text{year}$.

Rainfall variability varies significantly by season over the research area with substantial variability. As the area is one of the centers for agricultural products, the whole situation necessitates continuous monitoring of government and other stakeholders because trends in temperature have shown a significant increase over the past three decades and because rainfall is extremely erratic. For making agricultural decisions and planning for water and climate change adaptation options, local-level studies are necessary because the variability and trends in climatic variables are localized. Therefore, it is essential to implement localized policy interventions to lessen the effects of impending disasters brought on by climate change on the socioeconomic activities of the smallholders in the study area.

4.4. Climate adaption strategies of households in south Mecha woreda

As depicted in table 4:7, in response to variation in climate, farmers employed climate adaption strategy. Among others, changing planting date measure has been used by 15.9% of responses as mitigation for climate variability impacts. In response to climate variability, participants in FGDs and KIIs were asked adaptation measures in the study area. Result reveal that changing planting date was the highest measures adopted by most farmers. It is evident from the researcher survey that, temperature and rainfall is changing from time to time, farmers of the study area are

developed the adaptations mechanisms mainly focused on changing the date of planting, change crop variety, building water harvesting schemes, implement soil conservation schemes, diversification of crop varieties, irrigation, diversity from farming to non-farming activities (table 4:7).

KIIs result also show that land use is a main problem that affects soil fertility and agricultural production. So in response to land use problem, farmers need to employ land management practice this is because some part of the area is steep sloped in nature so it requires establishing an anti-erosive structure that integrates forests. This practice allows reduction soil erosion and improving temperature and rainfall. The main benefit of implementing land use management practice is expected to be higher and more stable crop yields, increased system resilience and, therefore, enhanced livelihoods and food security, and reduced production risk (Vallis et al. 1996; Thomas 2008; Woodfine, 2009).

In the study area land management practices including micro-basins/eye-brow, hillside terracing, gully check dams, gully rehabilitation, area closures, revegetation/afforestation, improved (environment-friendly) agricultural practices, agroforestry, rainwater harvesting, and fallowing techniques are mainly used by limited number of households. If this scenario is allowed to continue, it is evident that the problem of food insecurity will increase as environmental degradation continues.

Table 4.7. Climate adaption strategies of farm hosholds in south Mecha woreda

| Climate adaption strategy | Responses | | |
|--|-----------|---------|------------------|
| | N | Percent | Percent of cases |
| Change crop variety | 187 | 15.2 | 75.7 |
| Build water harvesting schemes | 144 | 11.7 | 58.3 |
| Implement soil conservation schemes | 174 | 14.2 | 70.4 |
| Diversification of crop varieties | 182 | 14.8 | 73.7 |
| Changing planting dates | 195 | 15.9 | 78.9 |
| Irrigation | 186 | 15.1 | 75.3 |
| Diversify from farming to non-farming activities | 160 | 13.0 | 64.8 |
| Total | 1228 | 100.0 | 497.2 |

Source: Survey Data (2022)

It is evident from the researcher survey that temperature and rainfall is changing from time to time, farmers of the study area are developed the adaptations mechanisms mainly focused on changing the date of planting change crop variety, building water harvesting schemes, diversification of crop varieties, irrigation, diversity from farming to non-farming activities. The least land use management employed by 58% of the respondent was building water harvesting schemes while the land use management used by the majority of the respondents (79%) was changing planting dates. This is in line with most studies in Ethiopia (Azemir et al., 2021; Desalegn et al., 2023, Deressa et al., 2009). On the whole, there is encouraging effort to be done to promote the use of all land use management practices by more than 80 percent of households.

4.5. Household's perception to temperature and rainfall change in south Mecha woreda

4.5.1. Household's perception to temperature change

Understanding farmers' perception of climate variability is as equally vital for designing local adaptation and coping strategies. Farmers who perceive climate variability is assumed to make adjustments in their farms to reduce climate variability-induced impacts unless they do face some barriers. In this study, household perception to temperature and rainfall changes in the locality was analyzed so as to examine the food security status of households using a chi-square test. The results on perception of temperature variability revealed that, 261 (100%) perceived temperature changes in the last decades.

Among the food secure household, 16.95 % of respondents were strongly agreed that there was an increment in temperature from time to time, 59.32% agree, 18.64% Neutral, 5.08% disagree and 0% strongly disagree in an increment of temperature from time to time. On the other hand, among the food insecure households, 17.82 % of respondents were strongly agreed that there is an increment of temperature in last decade, 69.8% agree, 7.92% neutral, 1.49% disagree and 2.97 % strongly disagree with an increment of temperature in last decade. The result revealed that there is no significant difference on the perception of temperature variability across households with different food insecurity status (Appendix 4).

Among the food secure households, 18.64% of respondents strongly agreed that the rise in temperature can negatively affect agricultural production, 59.32% agree. 16.95 % neutral, 5.08 %

disagree and 0% strongly disagree. On the other hand, among the food insecure households, 27.72% strongly agree, 57.92% agree 11.88% neutral. 0.99% disagree and 1.49 % strongly disagree. Achi-square test revealed that there is no significant difference on the perception across households with different food insecurity status (Appendix 4).

The FGDs and KIIs participants were asked questions to give evidence on temperature variability they observed/experienced in the last three-decade. The results described an increment temperature and its negative effects on farming activities.

Of 18.64% of food secure households strongly agreed that the frequency of drought occurrence increased with an increase in temperature, 62.71 % agree, 13.56 % natural, 5.08% disagree and 0% strongly agree. Among food insecure households, 24.75% of them strongly agreed, 61.88% agree, 9.9% neutral, 1.98% disagree and 1.49% and strongly disagree. A Chi-test revealed that there is no significant influence across food secure and food insecure household perception (Appendix 4).

The result also revealed that among food secure households, 22.03% of them strongly agreed that land use patterns changes due to increasing temperature, 50.85 % agree, 16.95% neutral, 10.17% disagree and 0% strongly disagree. Among food insecure household, 27.23% of them strongly agreed, 50% agree, 17.33% neutral, 4.46 % disagree and .99% strongly disagree. Therefore, most respondents perceived that land use patterns changed due to increasing temperature. A chi-square test revealed that there is no significant influence across households with different food insecurity status (Appendix 4).

The study result revealed that, among food secure households 16.95% of them strongly agree that increment in temperature increases not only scarcity but the quality of grazing land would decrease in their locality, 59.32 % agree, 18.64% neutral, 5.08% disagree and 0% strongly disagree. Hence, majority of the respondents have perceived that increment in temperature increases scarcity of grazing land and decreases the quality of grazing land in their locality. A chi-square test revealed that there is no significance influence across households with different food insecurity status (Appendix 4).

Among the respondents, 35.59% of food secure household strongly perceived that changes in temperature could result in a change in their cropping pattern, livestock size, and variety, 40.68% agree, 15.25% neutral, 8.47% disagree and 0% strongly disagree. Among food insecure households, 24.26% of them strongly agree, 51.98% agree, 16.34% neutral, 5.94% disagree and 1.49% strongly disagree. A chi-square test also revealed that there is no significant difference between food secure and food insecure households about their perception of the impact of temperature increase (Appendix 4).

Most respondents have also perceived that the changes in temperature would cause changes in livelihood strategies, among food secure households, 20.34% of them strongly agreed, 49.15% agree, 16.95% neutral, 6.78% disagree and 6.78% strongly disagree. On the other hand, among food insecure households, 19.31% of them strongly agreed, 53.95% agree, 17.33% neutral, 6.44% disagree and 2.97% strongly disagree. A chi-square test result revealed that there is no significant influence across households with different food insecurity status (Appendix 4).

Among food secure households, 25.42% of them strongly agreed that the rise of temperature results in a shortage of food in our locality, 61.02% agree, 10.17% neutral, 1.69% disagree and 1.69% strongly disagree. On the other hand, among food insecure households, 22.28% of them strongly agree, 50% agree, 20.79% neutral, 5.94% disagree and 0.99% strongly disagree. A chi-square test result revealed that there is no significant influence across households with different food insecurity status (Appendix 4).

4.5.2. Household's perception of rainfall variability

The results revealed that, among food secure households 22.03% of respondents strongly agreed that the rainfall pattern affects the cropping and grazing calendar (cropping and site of grazing time). 61.02% agree, 15.25% neutral, 1.69% disagree and 0% strongly disagree. On the other hand, among food insecure households 19.80% of respondents strongly agreed, 58.42% agree, 16.83% neutral, 3.96% disagree and 0.99% strongly disagree. Therefore, most respondents have perceived that rainfall pattern affects the cropping and grazing calendar but the Chi-square test result revealed that there is no significant influence across households with different food insecurity status (Appendix 5).

Among food secure households 20.34% of them strongly agree that the amount of rainfall can decrease from time to time, 69.49% agree, 6.78% neutral, 3.39% disagree, 0% strongly disagree. On the other hand, 26.24 % of food insecure respondents have strongly perceived, 52.97% agree, 15.84 neutral, 3.96% disagree and 0.99% strongly disagree but the chi-square test result revealed that there is no significant influence across households with different food insecurity status (Appendix 5).

The result also revealed that 15.25% of food secure respondents strongly agreed that the frequency of drought occurrence increases as rainfall amount decreases, 66.10 %agree, 11.86% neutral, 5.08% disagree and 1.69% strongly disagree. On the other hand, among food insecure 18.32% of them were strongly agree, 59.41% agree, 15.35% neutral, 4.46% disagree and 2.48% strongly disagree. And, the chi-square test result revealed that there is no significant influence across households with different food insecurity status (Appendix 5).

Most respondents have also perceived that the land use has changed due to variations in rainfall distribution. Among food secure respondents 16.95% of them were strongly agreed, 57.63% agree, 13.56% neutral, 6.78% disagree and 5.08% strongly disagree. 19.80% of food insecure respondents strongly agreed, 55.94% agree, 13.86% neutral, 6.93% disagree and 3.47% strongly disagree. And, a chi-square test was examined and the result revealed that there is no significant influence across households with different food insecurity status (Appendix 5).

Among food secure respondents 23.73% of them were strongly agreed that when rainfall decreases the availability of water for agricultural production and other uses in our locality also decreases, 61.02% agree, 8.47% neutral, 1.69% disagree and 5.06% strongly disagree. Among food insecure respondents 26.73% of the, were strongly agreed, 58.42% agree, 9.41% neutral, 4.95% disagree and 0.50 strongly disagree. A chi-square test result revealed that there is no significant influence across households with different food insecurity status (Appendix 5).

The result also revealed that the majority of the respondents have perceived that when the rainfall decreases the quality of grazing land also decreases in their locality. Among food secure respondents 20.34% of them were strongly agreed, 49.15% agree, 20.34% neutral, 5.08% disagree and 5.08 strongly disagree. On the other hand, among food insecure respondents 28.71% strongly agree, 49.01%agree, 14.85% neutral, 4.95% disagree and 2.48% strongly

disagree. A chi-square test result revealed that there is no significant difference across households with different food insecurity status (Appendix 5).

Most respondents have also perceived that rainfall variability influences the cropping pattern, livestock size, and variety. Among food secure households 30.51% of them were strongly agree with this idea, 50.85% agree, 13.56% neutral, 3.39% disagree and 1.69% strongly disagree. 28.71% of food insecure respondents strongly agree, 50.5% agree, 13.37% neutral, 5.94% disagree and 1.49% strongly disagree. A chi-square test result showed that there is no significance difference across households with different food insecurity status (Appendix 5).

On the relationship between rainfall and agricultural production, among food secure respondents, 25.42% of them were strongly believed that rainfall and agricultural production are directly associated with each other, 61.02% agree, 10.17% neutral, 3.39% disagree and 0.00% strongly disagree. Among food insecure respondents 28.71% strongly agreed 45% agree, 10.40% neutral, 4.46% disagree and 0.99% strongly disagree. A chi-square test result revealed that there is no significant difference across households with different food insecurity status (Appendix 5).

The outcome showed that the study area's food deficit is a result of rainfall unpredictability. 32.20% of respondents who reported being food secure highly agreed, 54.24% agreed, 11.86% neutrally agreed, 1.69% disagreed, and 0.0% strongly disagreed. A chi-square test result showed that there is no significant difference across households with different levels of food insecurity (Appendix 5), with 27.23% of food insecure respondents strongly agreeing, 52.97% agreeing, 16.34% neutral, 2.97% disagreeing, and 0.50% strongly disagreeing (Appendix 5)..

The majority of respondents also agreed that they believed heavy rains could make soil erosion worse. 22.03% of respondents who perceived themselves as having access to food highly agreed, 66.10% agreed, 8.47% neutrally agreed, 3.39% disagreed, and 0.00% strongly disagreed. A chi-square test result showed that there is no significant difference across households with different levels of food insecurity. However, among respondents who reported experiencing food insecurity, 27.72% of perceivers strongly agreed, 51.49% agreed, 14.36% neutral, 4.46% disagreed, and 1.98% severely disagreed (Appendix 5).

However, some respondents have perceived that annual rains do not support the crop and livestock production as was the case in the past in their locality. 15.25% of food secure

perceivers strongly agreed with this idea, 44.07% agree, 10.17% neutral, 6.78% disagree and 23.73% strongly disagree. Among food insecure respondents, 13.37% of perceivers strongly agreed, 31.19% agree, 16.34% neutral, 9.41% disagree and 29.70% strongly disagree. And, a chi-square test result showed that there is no significant difference across households with different food insecurity status (Appendix 5).

KIIs and FGDs participants reported that variability in rainfall observed in their locality. They explained that rainfall and agricultural production are directly associated with each other. Agricultural activity has been negatively affected by such change. The result of farmers' perception was similar with the metrological observation of rainfall and temperature variability in the study area.

The perception of farmers toward the variability in climate in this study is similar with researches reported by Deressa et al. (2008) and Mengestu (2011) in Ethiopia who showed that there was a climate variability implication due to increase in temperature and decreasing the amount of rainfall. Moreover, studies conducted in South Africa (Mandleni & Anim, 2011a) also reported the same result.

4.6. Food security status of the households in south Mecha woreda

All dimensions of food security were estimated. The households of food security status were measured by direct survey of household consumption (Idris & Adem, 2013; Abu & Soom, 2016; Ahmed et al., 2018).

4.1.6. Food availability dimension

Land use land cover and climate variability results in yield reduction which affects farmers' food availability and accessibility. This has also an implication on food security status of the household. The Household Food Balance Model was employed to estimate the net quantity of per capita food for household members. The model was used to measure availability dimension of food security (Demeku, Addisu, & Husen 2015).

In determining availability dimension of food security, total amount of crop production, grain loss due poor post-harvest management, amount of seed reserved, and grain bought and grain sold could be considered.

The most important method of estimating availability dimension of food security was net dietary energy available measured in kilocalorie. The net food available per 100 kilograms per household member was converted into dietary energy equivalent using the Food Composition Table for Ethiopia (EHNRI/FAO, 1997). Accordingly, 2200kcal/day/person for Ethiopia i.e. this value of minimum subsistence requirement will be used as a cutoff point for food secure and food secure households or individuals.

After data collection from sample respondents, the researcher converted available food grain into kilogram and multiplied by the conversion factors of major grains, they were changed into kilocalories. This was done after calculating the balance between lost and gained using household food balance model. The converted results were then divided by the number of household members as adult equivalent and the number of days in the recall period.

Consequently, the results were compared with the minimum requirements per day per adult equivalent unit. According to Mesay (2011) the medically recommended level of calorie per adult equivalent (2200kcal/day/person for Ethiopia) is used as a cut-off point for food insecure and food secure households. So those households who are at and above 2200kcal are food secure. On the other hand, those households who are below 2200kcal are categorized as food insecure.

After categorizing households as food secure and food insecure, the next step was to identify variables which have association in determining food security. The logit regression model was used, the dependent variable, food security is dichotomous in nature (food secure and food insecure households). Hence food security status was expressed dummy variable (0=food insecure households and 1=food secure households). During conversion of grains from kilogram into kilo calories, common cultural foods 100gm energy conversion factor considered as follows.

The food energy available for a household was compared with the minimum energy required for a household. According to the survey conducted, 56 or 21.7% of sample household heads who

participated in this study reported that their food security was ensured, while the other 205 or 78.3 % said that their food security was not ensured.

As described in table 4.8, based on the data collected and converted into kilocalories, from 261 interviewed households, about 78.3% of them consumed less than the minimum standard of adult equivalent calorie intake per day (2200 kcal/day), whereas 21.7% consumed more than 2201–2500 kcal/day which is recommended for healthy life. The result is in line with a study conducted in South Wollo zone, Ethiopia it was found that 20.9% and 79.1% of the sample households were food secure and food insecure, respectively (Alem-meta and Singh, 2018).

Table 4.8 Food availability dimension of food security status

| Food_security | Percent |
|----------------------|----------------|
| 0 | 78.3 |
| 1 | 21.7 |
| Total | 100.00 |

Source: Survey Data (2022)

The result obtained from the calculated household available energy was compared with the minimum subsistence requirement per day (2200 Kcal). Therefore, the result showed that, out of the total (261) sample households, 77.39% of them consumed lower than the recommended kilo calories, that is, 2200 Kcal, whereas 22.61% of them consumed food above the minimum requirements. As can be observed from table 4.9, out of 9 variables placed in the logistic regression model, 7 variables significantly affected food insecurity status of the households in the study area. Based on the findings from table 4.9, the discussion was made below.

Gender of head of household: There were 134 (51.3%) male-headed families and 127 (48.7%) female-headed households out of the 262 sampled households. The likelihood of male farmers applying adaptation strategies to climate variability and its consequences is positively correlated with food security. Households with female heads were more vulnerable to climate variability. This may be because women are traditionally expected to perform domestic tasks and have restricted access to essential resources (land, money, and labor), which frequently impairs their

capacity to perform labor-intensive tasks that would otherwise place them economically beneath their husbands. This finding is in line with the results of Kebede (2013) and Mihiretu et al. (2019) who reported that male farmers are more likely to access information on climate variability and pleased to take risks than their counterparts. Moreover, with regard to farming experience, males were better than the female. According, to Aschalew Feleke (2006), the sex of the household head has statistically significant positive effect on food insecurity when female headed household.

Age of the household head: rises, one can gain more expertise and experience in management, make cash or kind savings, and apply these skills effectively. By 0.0812964, this variable considerably and favorably influences the level of food security. By utilizing their adaptive mechanisms, households headed by elderly adults are more likely to have food security (Frehiwot, 2007). In the study area, the older family head had better-sized land, more cattle, and an in-kind savings system than the younger age.

Marital status: The study revealed that the majority (63.2%) of sample household respondents were married, while out of the total sample household 96.048 (36.8%) were single/divorced/widowed. In this study, marital status was strongly associated with food security. In my study area, the divorced household heads had lost most of the assets and resources during separation because females have no right to share most of the permanent assets like land and house trees. The study conducted by the pervious researcher Mequanent et al., (2014) showed that married persons were more food insecure than divorced once, contradict to this my study revealed divorced families were more food insecure than married.

Educational status: The educational status of the household heads was found to be vital in determining their food security situation. Those with better educational status were more likely to be food secure. Keeping other factor constant, an literate household head or an increased in a year of schooling of the household head, improves the likelihood of the households being food secured by .0199763. Since, the level of education should positively affect the income earning capacity and level of efficiency in managing the household's food resources, the effect of education on food security works indirectly by influencing the actions of the person in how to earn a living. Literate individuals were very motivated to get information and very curious to accept agricultural extension services, and soil and water conservation (SWC) practices and any

other income generating activities. It was expected that educated households were directly associated to food security and negatively associated with food insecurity. This study agrees with the previous studies done by (Aschalew, 2006).

Cultivated land size: Positive relationship has been established between farm size and improvement in household income and food security (Jayne et al., 2005). It was hence expected, of a household with a larger farm land size to be more food secure than a household with smaller farm land size. In this study area, it was revealed having large cultivable land was strongly associated with food secure. This means that for a one-unit increase in cultivated land size, we expect a .0138372 increase in food production. This could mean that households with more cultivable land may produce more food, purchase food for consumption from the income earned from their land, or even diversify their crop to insure for crop failure. Hence, ways should be sought to lift off the pressure of farmland size. The possible explanation that the major source of food in the study area was own production (agriculture) and there was limited access to other means of income generating activities (Table 4.3). So the household who has large size of cultivated land could have better production which in turn gives the household a better opportunity to be food secured. This result is in agreement with the findings of (Yilima and Tesfaye, 2005).

Access to irrigable land: The finding shows an unexpected result that an increase in access to irrigable land is inversely associated with food secure. This could imply that we should anticipate a -0.4489291 decrease in food production for every unit increase in access to irrigable land. This is as a result of the farmers' products being produced using more expensive and readily available inputs. As a result, the price of contemporary input keeps them in a debt cycle, which causes food insecurity.

Livestock Owned: A unit of increase in livestock owned, we expect a 0 .0534788 increase in food secure. It was revealed that availability of livestock may improve the food security status of households in different ways such as by providing cash income, nutrition (meat, milk, etc.). draft power, manure etc. in the study area. Also livestock could be used for coping food insecurity problems for the period of food scarcity and served as savings of assets. The households with lard herd size has better chance to earn better income from livestock production. This in turn enabled them to purchase food when they were in short of their stock, and invest in buying of

farm inputs that could increase food production, and thus ensuring food security at household level. This result is in agreement with the findings of Shiferaw et al (2003).

Table 4.9: Parameters estimation of logit model

| food_ins_status | Robust Coef. | Std. Err. | z | P>z | [95% Conf. | Interval] |
|---|-------------------------|------------------|----------|---------------|-------------------|------------------|
| Gender | -.1010744 | .3769311 | -0.27 | 0.789* | -.8398457 | .6376969 |
| HH size | .1566871 | .077112 | 2.03 | 0.042 | .0055503 | .3078239 |
| Age of household head | .0812964 | .1443202 | 0.56 | 0.573* | -.201566 | .3641587 |
| Marital status | -.43038 | .4256903 | -1.01 | 0.312* | -1.264718 | .4039576 |
| Educational level | .0199763 | .2493936 | 0.08 | 0.936* | -.4688261 | .5087787 |
| Cultivated land size | .0138372 | .2422718 | 0.06 | 0.954* | -.4610068 | .4886812 |
| Irrigable land | -.4489291 | .3720861 | -1.21 | 0.228* | -1.178204 | .2803462 |
| Livestock owned | .0534788 | .0558299 | 0.96 | 0.338* | -.0559458 | .1629035 |
| Access to market | 1.060402 | .4200967 | 2.52 | 0.012 | .2370273 | 1.883776 |
| n=261 Prob > chi2 = 0.0013 Pseudo R2 = 0.1089 | | | | | | |

Source: Researcher survey, 2022

4.6.2. Food access dimension

Food Insecurity Access Scale Score was used to measure the degree of access dimension of food security in the household in the past four weeks (30 days). Four types of indicators (i.e. food secure, mild food insecure, moderately food insecure and severely food insecure) can be calculated to help understand the characteristics of and changes in household food insecurity (access) in the surveyed population. A HFIA score variable is calculated for each household by summing the codes for the 9 food insecurity-related conditions. The lower the score (0-27), the less food insecurity (access) a household experienced. We determine the indicator's value by summing up the scores of all households and then dividing the result by the number of interviewed households.

Based on the response to the nine HFIAS questions and their frequency of occurrence over the past 30 days, HHs were assigned a score that ranges from 0 to 27. A higher HFIAS is indicative of poorer access to food and greater HHs food insecurity. Based on their responses to the

occurrence and frequency questions, HHs were classified into four categories of food security. As shown in table 4.10, of the total 261 households, about 7 (2.5%) HHs were food secure, while 47 (18.09%), 97 (37.17%) and 110 (42.21%) HHs were mildly food insecure, moderately and severely food insecure respectively.

Table 4.10 Household Food Insecurity Access Score (HFIAS)

| Food insecurity status | Percent |
|-------------------------------|----------------|
| 1 | 2.51 |
| 2 | 18.09 |
| 3 | 37.19 |
| 4 | 42.21 |
| Total | 100 |

Source: Survey Data (2022)

4.6.3 Food utilization dimension

Data on the food consumption of the 261 households was collected in South-Mecha woreda, capturing the variety and frequency of different foods consumed over a 7-day recall period. The approach in the calculation of the FCS is discussed in subsection 3.3.3 of the Chapter 3. The table 4.11 below presents the results of households' food insecurity classified based on FCS computation, according to food consumption groups from a sample of 261 households interviewed in South-Mecha woreda.

Table 4.11. Food consumption score (FCS)

| Food consumption score (FCS) | Percent |
|-------------------------------------|----------------|
| Acceptable | 37.2 |
| Borderline | 38.3 |
| poor | 24.5 |
| Total | 100.0 |

Source: Survey Data (2022)

Using the Food consumption score cut-off, the results show that the households with poor food consumption in South Mecha woreda were 24.5 percent, while 38.3 percent have borderline consumption and the households with acceptable food consumption were 37.2 percent. According to the FCS, households with poor consumption are regarded as food insecure, while the households with borderline consumption are categorized as moderate food insecure and the households with acceptable food consumption are considered as food secure.

The study found that the diet of the households with poor food consumption was entirely based on staples food, and such households consumed, on average, cereals and tubers (7 days) and some vegetables and oil consumed one day in a week. The consumption of meats, fish, milk, sugar and fruits was zero. This result indicates that the quality of the diet of the households in this category is very poor, due to lacking in both protein and micronutrients.

Table 4.12 Food consumption groups

| Food group (weekly consumption) | | | | | | | | | | | |
|--|------|------------------|--------|-------------------|------|-----|------|-------|-----|-------|-----|
| Food consumption groups | hh % | Tubers & cereals | Pulses | Fish and Red meat | Milk | Egg | Vegs | Fruit | Oil | Sugar | FCS |
| Acceptable food consumption | 37.2 | 7 | 2 | 3 | 3 | 2 | 3 | 0 | 7 | 2 | 97 |
| Border-line food consumption | 38.3 | 7 | 0 | 0 | 2 | 1 | 2.3 | 0 | 3 | 0 | 100 |
| Poor food consumption | 24.5 | 7 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 64 |

Source: Survey Data (2022)

It was also found that, among households with borderline consumption, tubers and cereals were consumed over 7 days per week, but there is an improvement in terms of milk, egg, vegetables and oil consumption (2 days per week) compared to the households with poor consumption. However, consumption of pulses, meat and fruits still remains infrequent being about zero day per week. This result indicates that the households with borderline consumption score still lack food that is rich in protein and micronutrients. However, for the households with acceptable consumption score, the results show that all food groups except fruit were consumed in

significant amounts over the seven days in a week, during which the consumption of animal proteins and milk attained an average of three days a week.

4.7. Coping strategies used by households for food insecurity

According to studies done in Ethiopia, households use a variety of coping strategies when there is a food shortage or insecurity (Sewnet, 2015; Arega, 2015). The study's findings showed that households in South-Mecha woreda developed a variety of coping strategies when faced with food scarcity or instability.

Based on the responses provided by the sample families in South-Mecha woreda, coping techniques were divided into twelve groups and are shown in Table 13. As a result, 82.3% of sample households rely on less desirable and less expensive foods 3-6 days per week as a coping strategy, which is followed by borrowing food from friends or relatives constantly (14.5%). This suggests that the majority of households used coping techniques to deal with the food shortage or food insecurity, such as choosing less desired and less priced meals, borrowing food, or asking a friend or relative for assistance.

Table 4. 13 Frequency of coping strategies for food insecurity

| Coping Strategy | Never | "Hardly at all" less than 1 day/week | "Once in a while"1- 2days/week | "Pretty often" 3- 6 days/week | All the time/Everyday |
|---|-------|--|-----------------------------------|----------------------------------|--------------------------|
| | | | | | |
| Rely on less preferred and less expensive foods? | 0 | 14.6 | 3.1 | 82.3 | 0 |
| Borrow food, or rely on help from friend or relative? | 47.5 | 30.7 | 4.2 | 3.1 | 14.5 |
| Purchase food on credit? | 52.5 | 37.9 | 5.4 | 0 | 4.2 |
| Gather wild food, hunt, or harvest immature crops? | 55.2 | 28 | 15.7 | 0 | 1.1 |
| Consume seed stock held for next season? | 64.8 | 21.8 | 11.5 | 0 | 1.9 |
| Send household members to eat elsewhere? | 66.7 | 17.3 | 7.7 | 3 | 5.3 |
| Send household members to beg? | 69 | 22.6 | 6.1 | 0 | 2.3 |
| Limit portion size at mealtimes? | 71.6 | 20.7 | 5.4 | 0 | 2.3 |
| Restrict consumption by adults in order for small children to eat? | 50 | 26.4 | 10 | 4.4 | 9.2 |

Source: Survey Data (2022)

The study also revealed that, as coping strategies against food shortage and food insecurity in the study area, 15.7, 14.6, 16.1, and 16.9% of the sampled households were hunting, harvesting immature crops, feeding working members of the household at the expense of non-working members, rationing the money they had, buying prepared food, and reducing the number of meals eaten per day, respectively.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

The main objective of the study was to assess climate variability implication to household food security and coping strategies in South-Mecha woreda, Abay River basin. The study used the Mann-Kedall test and Sen's slope estimator to analyze the spatiotemporal patterns of temperature and rainfall change. The result showed that there exists long dry and short wet periods (1981-2017) as illustrated by positive and negative anomalies. The result revealed that there is a considerable spatial variation in temperature and rainfall anomalies over the studied area. From the finding, it can be concluded that there is a spatial and temporal variation in trends of temperature and rainfall across South Mecha woreda, Amhara region, Ethiopia. These variabilities in climate are highly interlinked with crop production in the study area. Therefore, variations in climate greatly affect crop production which further affects household food security of the farm households of the study area.

The information provided by this study can support at local level decision-makers in order for monitoring flood and drought occurrences. Therefore, agricultural planning and government policies in this area should be based on recent rainfall, and temperature trends. Moreover, the study implies the influence of the climate variability on crop yields that could impact household food security of the farm households in the study area.

Analysis of data also revealed that there is no striking difference in the proportion of households that have acceptable, borderline, and poor food consumption. In fact, more than 75% of the studied population fall under acceptable and moderate food security levels.

Moreover, the study explored households' perception of the manifestation of climate variability and the coping mechanisms deployed to deal with its impact on food security. The result, therefore, revealed that about 15.9% sampled households confirmed that changing planting date has been used as a coping strategy to mitigate climate variability effects. In other words, households that perceived the occurrence of rising temperature, and frequency of drought at different magnitudes barely suffer from food security. This reveals that food security differences among households can hardly be attributed to perception differences and other socio-economic variables.

5.2. Recommendations

From the conclusions drawn above, possible recommendations were forewarned:

- Although, the respondents have very limited land management practices which would ruin the very foundations of food security and environmental wellbeing, it is imperative that local agricultural offices should take steps to diversify land management techniques in the study area.
- Having the information on the effect of temperature and rainfall anomalies on crop production and food security status of farming community in the study area, the farming community and decision-makers should adopt climate variability adaption strategies such as changing planting date, changing and diversifying crop varieties in their farm lands.
- Furthermore, agricultural experts need to be aware and informed the different cope with the changing weather conditions and help the farming community in getting access to sufficient information about the change in temperature and rainfall anomalies. Moreover, the farmers need to explore more coping strategies with due caution to combat moisture deficit, and damages from onset of rain events.
- Lastly, in order to increase the study area's ability to tolerate rainfall instability, it is crucial to support initiatives that strengthen the food production system. Investing in agricultural research, extension, and techniques for lowering food production losses due to climatic variability is one strategy.

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ANNEX 1: SURVEY QUESTIONNAIRE

Dear respondent,

My name is _____. I am a post graduate student (Master of food security and development studies) in Addis Ababa University conducting research on the effect of climate variability on household food security and food coping strategy. The overriding objective of this questionnaire survey is to collect data for my MSc thesis. Therefore, your response to the questions are valuable and will be held in utmost confidentiality to be used only for the analysis of this research. If you accept to participate in this research, you will be doing so voluntarily, and there will not be any monetary returns. You are also free to refuse to respond any questions you do not feel comfortable answering or to withdraw from the research altogether. This interview will take about an hour of your time to respond to the questions.

Thank you in advance for your cooperation

HH_ID: _____ Enumerator's Name: _____ Phone Number #: _____

District: _____ Kebele _____ Village: _____ Date: _____

| No | Questions | Category | Code |
|----------|---|---------------------------|------|
| A | Demographic information | | |
| 1 | Sex of the respondent | Male | 1 |
| | | Female | 2 |
| 2 | Age of the respondent (Write in numerical value) | | [] |
| 3 | Household size (write in numerical value) | | [] |
| 4 | Marital status of the respondent | Married | 1 |
| | | Single/Divorced / Widowed | 2 |
| 5 | How many years have you lived in this area (write in numerical years) | | [] |
| 6 | The education level of the respondent | Cannot read and write | 1 |
| | | Read & write | 2 |
| | | Grade 1 – 4 | 3 |
| | | Grade 5 – 8 | 4 |
| | | Grade 9 – 12 | 5 |
| | | Diploma/Levels | 6 |
| | | BSc/MSc | 7 |
| | | Above BSC/MSc | 8 |
| B | Socio-economic information | | |

| | | | |
|-------------------|--|---------------------------------------|---|
| 7 | Do you have access to the following services? (If “yes”, write 1 if “No”, write 2) | | |
| | Potable water in your residence within 1 km? | | |
| | Health center? | | |
| | Nutritional training within your residence? | | |
| | School? | | |
| | Veterinary center | | |
| | Agricultural inputs? | | |
| | Irrigable land ? | | |
| | Forest product ? | | |
| | Communal grazing land ? | | |
| Access to market? | | | |
| 8 | What is the size of the land you own in ha? | ≤0,5 | 1 |
| | | 0.51-1 | 2 |
| | | above 1 | 3 |
| | | Land less | 4 |
| 9 | What is the type of land that you own? Multiple responses possible | Inheritance | 1 |
| | | Purchased | 2 |
| | | Gifted | 3 |
| | | Rented | 4 |
| 10 | What are the types of crops you grow? (Multiple responses possible) | Cereals | 1 |
| | | Pulses | 2 |
| | | Tubers | 3 |
| | | Vegetables and fruits | 4 |
| 11 | What are the types and numbers of livestock that you own? | Cattle(<i>Put in numeric value</i>) | |
| | | Goat(<i>Put in numeric value</i>) | |
| | | Sheep(<i>Put in numeric value</i>) | |
| | | Camel(<i>Put in numeric value</i>) | |
| | | Others(<i>Put in numeric value</i>) | |
| | | Cattle(<i>Put in numeric value</i>) | |
| D | Climate Variability | | |

This section seeks to assess the perception of farmers on climate variability and its impact on food production. The section encompasses two parts i.e. farmers' perception on temperature and rainfall. Accordingly, some possible statements are listed in the table below.

Not for field enumerator: Please read each item separately and indicate their opinion by putting a tick (✓) mark under one of these alternatives. 1. Strongly disagree 2. Disagree 3. Neutral (undecided) 4. Agree 5. Strongly agree.

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| No | Statements | 1 | 2 | 3 | 4 | 5 |
|----|---|---|---|---|---|---|
| 1 | I am well aware that the temperature in this area increases from time to time | | | | | |
| | I am aware that the rise of temperature can negatively affect agricultural production | | | | | |
| 3 | I am of the opinion that the frequency of drought occurrence increases with an increase in temperature | | | | | |
| 4 | I am of the opinion that land use patterns change due to increasing temperature | | | | | |
| 5 | I am well aware that when temperature increases not only scarcity but the quality of grazing land would decrease in my locality | | | | | |
| 6 | I know that changes in temperature could result in a change in my cropping pattern, livestock size and variety. | | | | | |
| 7 | I do not think that changes in temperature would cause changes in livelihood strategies | | | | | |
| 8 | The rise of temperature results in a shortage of food in our locality | | | | | |
| 9 | I know that rainfall pattern affects the cropping and grazing calendar (cropping & site of grazing time) | | | | | |
| 10 | I think that the amount of rainfall can decrease from time to time | | | | | |
| 11 | I have observed that the frequency of drought occurrence increases as rainfall amount decreases | | | | | |
| 12 | I have observed that land use has changed due to variations in rainfall distribution | | | | | |
| 13 | I understand that when rainfall decreases the availability of water for agricultural production and other uses in our locality also decreases | | | | | |
| 14 | I am not of the opinion that when the rainfall decreases the quality of grazing land also decreases in our locality | | | | | |
| 15 | I know that rainfall variability influences the cropping pattern, livestock size and variety | | | | | |
| 16 | I am aware that rainfall and agricultural production are directly associated to each other | | | | | |
| 17 | I am aware that rainfall variability contributes to food shortage in our locality | | | | | |
| 18 | I am aware that high intensity of rainfall can aggravate soil erosion | | | | | |
| 19 | I believe that the annual rains do not support the crop and livestock production as was the case in | | | | | |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--|--|---|-----------------------------|---|---|--------------|--------------------------------|----------------------|-------------|---|-------------------------------------|---------|--------------------------------------|---|-----------------------------------|---|---|--------------------|-------------------------|---|---|---|----------------------------------|---|---|---|--|---------------------|---|---|---|---|-----------------|---|---|---|---|--|---|---|---|---|--------|---|---|---|---|--|--|--|--|
| | | the past in my locality | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 23 | | <p>What adjustments have you made in your farming practices to changes in temperature and rainfall? Please tell me how often you use them? 1.Never 2. Occasionally 3. Always</p> <table border="1"> <tr> <td>Change crop variety</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>Build water harvesting schemes</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>Implement soil conservation schemes</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>Diversification of crop varieties</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>Changing planting dates</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>Irrigation</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>Diversify from farming to non-farming activities</td> <td>1</td> <td>2</td> <td>3</td> </tr> </table> | Change crop variety | 1 | 2 | 3 | Build water harvesting schemes | 1 | 2 | 3 | Implement soil conservation schemes | 1 | 2 | 3 | Diversification of crop varieties | 1 | 2 | 3 | Changing planting dates | 1 | 2 | 3 | Irrigation | 1 | 2 | 3 | Diversify from farming to non-farming activities | 1 | 2 | 3 | | | | | | | | | | | | | | | | | | | | | |
| Change crop variety | 1 | 2 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Build water harvesting schemes | 1 | 2 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Implement soil conservation schemes | 1 | 2 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Diversification of crop varieties | 1 | 2 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Changing planting dates | 1 | 2 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Irrigation | 1 | 2 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Diversify from farming to non-farming activities | 1 | 2 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24 | | <p>What would you consider to be the main cause of food shortages? Please tell me whether 1. Often true 2. Sometimes true 3. Never true 4. Don't Know</p> <table border="1"> <tr> <td>Changes in weather patterns</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> </tr> <tr> <td>Poor farming methods</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> </tr> <tr> <td>Land degradation and soil exhaustion</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> </tr> <tr> <td>Pests and diseases</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> </tr> <tr> <td>Reliance on rain-fed agriculture</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> </tr> <tr> <td>High cost of inputs</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> </tr> <tr> <td>Land not enough</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> </tr> <tr> <td>Insufficient harvest from previous seasons</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> </tr> <tr> <td>Others</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> </tr> </table> | Changes in weather patterns | 1 | 2 | 3 | 4 | Poor farming methods | 1 | 2 | 3 | 4 | Land degradation and soil exhaustion | 1 | 2 | 3 | 4 | Pests and diseases | 1 | 2 | 3 | 4 | Reliance on rain-fed agriculture | 1 | 2 | 3 | 4 | High cost of inputs | 1 | 2 | 3 | 4 | Land not enough | 1 | 2 | 3 | 4 | Insufficient harvest from previous seasons | 1 | 2 | 3 | 4 | Others | 1 | 2 | 3 | 4 | | | | |
| Changes in weather patterns | 1 | 2 | 3 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Poor farming methods | 1 | 2 | 3 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Land degradation and soil exhaustion | 1 | 2 | 3 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pests and diseases | 1 | 2 | 3 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reliance on rain-fed agriculture | 1 | 2 | 3 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| High cost of inputs | 1 | 2 | 3 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Land not enough | 1 | 2 | 3 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Insufficient harvest from previous seasons | 1 | 2 | 3 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Others | 1 | 2 | 3 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| E | | Food Security | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | i. | ii. Household Consumption Balance questions | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24 | What are your or your household's primary source of income and/or livelihoods? | <table border="1"> <tr> <td>Formal employment</td> <td></td> <td>1</td> </tr> <tr> <td>Casual labor</td> <td></td> <td>2</td> </tr> <tr> <td>Agriculture</td> <td></td> <td>3</td> </tr> <tr> <td>Trading</td> <td></td> <td>4</td> </tr> <tr> <td>Other; Specify_____</td> <td></td> <td>5</td> </tr> </table> | Formal employment | | 1 | Casual labor | | 2 | Agriculture | | 3 | Trading | | 4 | Other; Specify_____ | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Formal employment | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Casual labor | | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Agriculture | | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Trading | | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Other; Specify_____ | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25 | What is your annual expenditure to land use revenue, school payment in Birr? | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 26 | What is your monthly expenditure to your home consumption in Birr? | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27 | What is your expenditure to your household clothes, student's educational tools in Birr? | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| | | | | |
|----|---|--|-------|----------|
| 28 | What is your expenditure to agricultural inputs (fertilizer and seed) per year in Birr? | | | |
| 29 | What is the amount of crops you produce in quintal/year? 1000*100*5 | Wheat | 5 | 3.623grm |
| | | Teff | 3 | 3.588 |
| | | Feba bean | 2 | 3.498 |
| | | Lentils | 2 | 3.44 |
| 30 | What is the amount of grain you reserve for seed purpose in quintal per year? | | 4 | |
| 31 | How many quintals grain you loss after production by pest, diseases per year (post-harvest loss)? | | | |
| 32 | How many quintals grain you give to your friends or relatives per year? | Wheat | | |
| | | Teff | | |
| | | Feba bean | | |
| | | Lentils/m\ | | |
| 33 | How many quintal grain you sell from your production per year in quintal? | Wheat | | |
| | | Teff | | |
| | | Feba bean | | |
| | | lentils | | |
| 34 | If there is other expenditure, mention -----how many Birr-----? | | | |
| 35 | How many quintal grain you bought per year? | Wheat | | |
| | | Teff | | |
| | | Feba bean | | |
| | | Lentils | | |
| 36 | How many quintal grain or cash you get from your friends or relatives per year? | Cash | | |
| | | Grain (in quintal) | | |
| 37 | How many kilogram dairy product you get per year? | Milk (in liter) | 0.737 | |
| | | Butter (in kg) | 0.386 | |
| | | Cheese (in kg) | 0.737 | |
| | | Honey (in kg) | 3.04 | |
| 38 | What is your monthly income from off-farm activities (daily labor, pity trading etc.) in Birr? | | | |
| 39 | What is your monthly income from PSNP or other aid per month? | | | |
| 40 | If there other income, mention-----how many Birr-----? | | | |
| | iii. | iv. Food Consumption Score data collection tool | | |

I would like to ask you about all the different foods that your household members have eaten in the last 7 days. Could you please tell me how many days in the past week your household has eaten the following foods? (for each food, ask what the primary source of each food item eaten that week was, as well as the second main source of food, if any).

| Food item | Weight | How many days over the last 7 days, did you and members of your household eat? (0-7) | Did you eat in the last 24 hours? 1. Yes 2. No | Sources of food (see Food item codes below) | |
|--|--------|--|--|---|-----------|
| | | | | primary | secondary |
| #1-. Teff/injera, Maize, sorghum, barely, millet | 2 | | | | |
| #.2 – Rice | | | | | |
| #.3 – Bread/wheat, pasta, porridge | | | | | |
| #.4 – Tubers such as potato, yam, cassava, white sweet potato | | | | | |
| #.5 – Beans, peas, groundnuts, and other pulses | 3 | | | | |
| #.6 – Fish (eaten as a main food) | 4 | | | | |
| #.8 – Red meat (sheep/goat/beef, chicken, other) | | | | | |
| #.10 – Oils, fat and butter | 0.5 | | | | |
| #.11 – Eggs | 4 | | | | |
| #.12 – Milk and dairy products (main food) (milk, yoghurt, cheese and other milk products) | 4 | | | | |
| #.14 – Vegetables and leaves such as spinach, onion, tomatoes, carrots, peppers, green beans, lettuce, etc.? | 1 | | | | |
| #.15 – Fruits: banana, apple, lemon, mango, papaya, avocado, guava, etc | 1 | | | | |
| #.16 – Sweets, sugar | 0.5 | | | | |

Food source codes:

Own production 2. Purchase 3. Barter 4. Borrowed 5. Received as a gift 6. Food aid 7. Other; specify

v.

vi. Household Food Insecurity Access Scale (HFIAS) Questions

Each of the questions in the following table is asked with a recall period of four weeks (30 days). The respondent is first asked an occurrence question – that is, whether the condition in the question happened at all in the past four weeks (yes or no). If the respondent answers “yes” to an occurrence question, a frequency-of-occurrence question is asked to determine whether the condition happened rarely (once or twice), sometimes (three to ten times) or often (more than ten times) in the past four weeks

| Occurrence Questions | | 1. Yes 2. No If no, skip to Next question. | How often did this happen? 1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks) |
|----------------------|--|--|--|
| 1. | In the past four weeks, did you worry that your household would not have enough food? | | |
| 2. | In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources? | | |
| 3. | In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources? | | |
| 4. | In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food? | | |
| 5. | In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food? | | |
| 6. | In the past four weeks, did you or any household member have to eat fewer meals in a day because there was not enough food? | | |
| 7. | In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food? | | |
| 8. | In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food? | | |
| 9. | In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food? | | |

| | vii. | viii. Consumption Coping Strategy Responses (CSI) | | | | | |
|--|------|--|----------------------------|----------------------------|-------------------------------|------------------------------|------------------|
| | | In the past 30 days, if there have been times when you Relative Frequency did not have enough food or money to buy food, how often has your household had to: | All the time? Every day | Pretty often? 3-6*/week | Once in a while? 1-2*/week | Hardly at all? <1 */ week | Never 0*/week |
| | | a. Rely on less preferred and less expensive foods? | 7 | 5 | 2 | 1 | 0 |
| | | b. Borrow food, or rely on help from a friend or relative? | | | | | |
| | | c. Purchase food on credit? | | | | | |
| | | d. Gather wild food, hunt, or harvest immature crops? | | | | | |
| | | e. Consume seed stock held for next season? | | | | | |
| | | f. Send household members to eat elsewhere? | | | | | |
| | | g. Send household members to beg? | | | | | |
| | | h. Limit portion size at mealtimes? | | | | | |
| | | i. Restrict consumption by adults in order for small children to eat? | | | | | |
| | | j. Feed working members of HH at the expense of non-working members? | | | | | |
| | | k. Ration the money you have and buy prepared food? | | | | | |
| | | l. Reduce number of meals eaten in a day | | | | | |
| | | m. Reduce number of meals eaten in a day? | | | | | |

ANNEX 2: KEY INFORMANT INTERVIEW GUIDE

Dear respondent,

The main objective of this KII is to collect data for a research. The information will be used for MSC thesis entitled “Climate Variability: Implication to Household Food security and Food Coping response”. Therefore, your response to the questions are valuable and will be held in utmost confidentiality to be used only for the analysis of this research. If you accept participating in this interview, you will be doing so voluntarily, and there will not be any monetary returns. You are also free to refuse to give ideas in case you do not feel comfortable and free to withdraw from the interview anytime you want. This interview will take about an hour of your time.

Thank you in advance for your cooperation

KII Questions

A. Socioeconomic background of the respondents

1. Sex of the respondent:
2. Gender
3. Educational level:
4. Work of experience:
5. Name of the organization
6. Current position:
7. Contact address:

B. Climate variability

1. How have rainfall trends in this area changed over time?
2. How have temperature trends in this area changed over time?
3. Based on your observations, how are the impacts of this trend on household food security in this area?
4. Which are likely predicted future trends? i. positive ii. Negative
5. Which adaptation and mitigation strategies have you witness being employed by household to counter effects of climate variability?

ANNEX 3: FOCUS GROUP DISCUSSION GUIDE

Dear respondent,

The main objective of this FGD is to collect data for a research. The information will be used for MSC thesis entitled “Climate Variability: Implication to Household Food security and Food Coping response”. Therefore, your response to the questions are valuable and will be held in utmost confidentiality to be used only for the analysis of this research. *If you accept participating in this interview, you will be doing so voluntarily, and there will not be any monetary returns. You are also free to refuse to give ideas in case you do not feel comfortable and free to withdraw from the interview anytime you want. This interview will take about an hour of your time.*

FGD Questions

Name of the moderator: _____

Place of discussion:

Date of the discussion: _____

Length of the discussion:

A. Profile of the participants

| S/n | Code of the participants | Age | Gender | Educational status | Occupation |
|-----|--------------------------|-----|--------|--------------------|------------|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |

B. Climate variability

1. How have rainfall trends in this area changed over time?
2. How have temperature trends in this area changed over time?
3. Based on your observations, how are the impacts of this trend on household food security in this area?
4. Which are likely predicted future trends? I. positive ii. Negative
5. Would you please tell me what the farmers’ Climate Smart Agricultural practices in the area?
6. Do you see a relationship between the adaptation and mitigation strategies used in respond to climate variability and food availability/security?

Appendix4. Household perception of Temperature

| | Food security Status | Strongly disagree | Disagree | Neutral | Agree | Strongly agree | Chi-square (p values) |
|--|----------------------|-------------------|----------|---------|-------|----------------|-----------------------|
| I am well aware that the temperature in this area increases from time to time. | Food secure | 0 | 5.08 | 18.64 | 59.32 | 16.95 | 0.038 |
| | Food insecure | 2.97 | 1.49 | 7.92 | 69.8 | 17.82 | |
| I am aware that the rise in temperature can negatively affect agricultural prod. | Food secure | 0 | 5.08 | 16.95 | 59.32 | 18.64 | 0.123 |
| | Food insecure | 1.49 | 0.99 | 11.88 | 57.92 | 27.72 | |
| I am of the opinion that the frequency of drought occurrence increases with an increase in temperature. | Food secure | 0 | 5.08 | 13.56 | 62.71 | 18.64 | 0.431 |
| | Food insecure | 1.49 | 1.98 | 9.9 | 61.88 | 24.75 | |
| I am of the opinion that land use patterns change due to increasing temperature. | Food secure | 0 | 10.17 | 16.95 | 50.85 | 22.03 | 0.454 |
| | Food insecure | 0.99 | 4.46 | 17.33 | 50 | 27.23 | |
| I am well aware that when temperature increases not only scarcity but the quality of | Food secure | 0 | 5.08 | 18.64 | 59.32 | 16.95 | 0.616 |
| | Food insecure | 1.49 | 4.46 | 14.36 | 55.45 | 24.26 | |
| I know that changes in temperature could result in a change in my cropping pattern, livestock size, and variety. | Food secure | 0 | 8.47 | 15.25 | 40.68 | 35.59 | 0.316 |
| | Food insecure | 1.49 | 5.94 | 16.34 | 51.98 | 24.26 | |
| I do not think that changes in temperature would cause changes in livelihood strategies | Food secure | 6.78 | 6.78 | 16.95 | 49.15 | 20.34 | 0.742 |
| | Food insecure | 2.97 | 6.44 | 17.33 | 53.96 | 19.31 | |
| The rise of temperature results in a shortage of food in our locality | Food secure | 1.69 | 1.69 | 10.17 | 61.02 | 25.42 | 0.206 |
| | Food insecure | 0.99 | 5.94 | 20.79 | 50 | 22.28 | |

Appendix 5. Household perception of rainfall

| | Food security Status | Strongly disagree | Disagree | Neutral | Agree | Strongly agree | Chi-square (p values) |
|---|----------------------|-------------------|----------|---------|-------|----------------|-----------------------|
| I know that rainfall pattern affects the cropping and grazing calendar (cropping and site of grazing time) | Food secure | 0 | 1.69 | 15.25 | 61.02 | 22.03 | 0.827 |
| | Food insecure | 0.99 | 3.96 | 16.83 | 58.42 | 19.8 | |
| I think that the amount of rainfall can decrease from time to time | Food secure | 0 | 3.39 | 6.78 | 69.49 | 20.34 | 0.186 |
| | Food insecure | 0.99 | 3.96 | 15.84 | 52.97 | 26.24 | |
| I have observed that the frequency of drought occurrence increases as rainfall amount decreases. | Food secure | 1.69 | 5.08 | 11.86 | 66.1 | 15.25 | 0.891 |
| | Food insecure | 2.48 | 4.46 | 15.35 | 59.41 | 18.32 | |
| I have observed that land use has changed due to variations in rainfall distribution | Food secure | 5.08 | 6.78 | 13.56 | 57.63 | 16.95 | 0.97 |
| | Food insecure | 3.47 | 6.93 | 13.86 | 55.94 | 19.8 | |
| I understand that when rainfall decreases the availability of water for agricultural production and other uses in our locality also decreases | Food secure | 5.08 | 1.69 | 8.47 | 61.02 | 23.73 | 0.104 |
| | Food insecure | 0.5 | 4.95 | 9.41 | 58.42 | 26.73 | |
| I am not of the opinion that when the rainfall decreases the quality of grazing land also decreases in our locality | Food secure | 5.08 | 5.08 | 20.34 | 49.15 | 20.34 | 0.547 |
| | Food insecure | 2.48 | 4.95 | 14.85 | 49.01 | 28.71 | |
| I know that rainfall variability influences the cropping pattern, livestock size, and variety | Food secure | 1.69 | 3.39 | 13.56 | 50.85 | 30.51 | 0.961 |
| | Food insecure | 1.49 | 5.94 | 13.37 | 50.5 | 28.71 | |
| I am aware that rainfall and agricultural production are directly associated with each other | Food secure | 0 | 3.39 | 10.17 | 61.02 | 25.42 | 0.889 |
| | Food insecure | 0.99 | 4.46 | 10.4 | 55.45 | 28.71 | |
| I am aware that rainfall variability contributes to food shortage in our locality | Food secure | 0 | 1.69 | 11.86 | 54.24 | 32.2 | 0.813 |
| | Food insecure | 0.5 | 2.97 | 16.34 | 52.97 | 27.23 | |
| I am aware that high intensity of rainfall can aggravate soil erosion | Food secure | 0 | 3.39 | 8.47 | 66.1 | 22.03 | 0.304 |
| | Food insecure | 1.98 | 4.46 | 14.36 | 51.49 | 27.72 | |
| I believe that the annual rains do not support the crop and livestock production as was the case in the past in my locality | Food secure | 23.73 | 6.78 | 10.17 | 44.07 | 15.25 | 0.35 |
| | Food insecure | 29.7 | 9.41 | 16.34 | 31.19 | 13.37 | |