Addis Ababa University

College of Development Studies Centre for Rural Development

A comparative Study on Resilience of Pastoral and Agro-Pastoral Households to Climate-induced Shocks and Stresses in Asayita Woreda of Afar Regional State, Ethiopia

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This is to certify that the thesis prepared by Esmael Tessema Ali entitled "***A comparative Study on Resilience of Pastoral and Agro-Pastoral Households to Climate-induced Shocks and Stresses in Asayita Woreda of Afar Regional State, Ethiopia"*** and submitted in partial fulfillment of the Requirement for the Degree of Master of Art in Development studies (Rural Development) compiles with regulation of the university.

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ACRONYMS

AC	Adaptive Capacity
APS	Access to Public Services
ARS	Afar Regional State
CSA	Central Statistical Agency
ETB	Ethiopian Birr
EWI	Early Warning Information
FAO	Food and Agriculture Organization of the United Nations
FHH	Female-headed households
GDP	Gross Domestic Product
IFA	Income and food access
IPCC	Intergovernmental Panel in Climate Change
MHH	Male-headed households
MLR	Multiple linear regression
NGO	Non-Government Organization
NMA	National Meteorological Agency, Ethiopia
NMSA	National Meteorological Services Agency,
PCA	Principal Components Analysis
RI	Resilience index
SSN	Social Safety Nets
TLU	Tropical Livestock Unit
TLU	Tropical Livestock Unit
UNOCHA	United Nations Office for the Coordination of Humanitarian
UNFCCC	United Nations Framework Convention on Climate Change
VSFG	Vétérinaires Sans Frontières Germany

DEFINITION OF KEY TERMS

Adaptive capacity: The capability of a system, institutions, individuals and other organisms to adjust to potential harm, to exploit opportunities, or to react to outcome of hazards (Intergovernmental Panel in Climate Change (IPCC, 2014).

Climate change: An alteration in the conditions of the climate that can be distinguished (for example, by utilizing statistical tests) by alterations in the mean as well as the inconsistency of its properties, and that perseveres for a long-term period, normally for decades or more (IPCC,2007).

Climate variability: according to (IPCC, 2001) reports the differences in the mean state and other statistics (such as standard deviations, the incidence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. On the other hand, Variability may be happened due to natural internal processes within the climate system (internal variability), or to differences in natural or anthropogenic external forcing (external variability) (IPCC, 2001).

Exposure: The presence of livelihoods, individuals, environmental services and assets, biological communities, and infrastructure, or economic, social, or cultural assets in places that could be negatively impacted by a hazard (IPCC, 2014).

Resilience: The capability of a social and ecological system to absorb a range of perturbations and to support and build up its central structure, function, character, and responses through either a bounce back or reorganization in a new situation (Folke, 2006; Gunderson and Holling, 2002; Holling, 1986; Walker *et al.*, 2004).

Sensitivity: Denotes how much the social and ecological system, asset or species is influenced, either harmfully or usefully, by climate change and variability (IPCC, 2014).

Shocks and stresses: shocks refer to climate- related changes (sudden) such as droughts and floods (climate extremes) including climate-induced epidemic diseases outbreaks, while stresses refer gradual shifts in long-term mean of climate elements such as temperature and precipitation (climate change) and changes their seasonal/periodic patterns (climate variability) including the gradual bio-physical and socio-economic changes attributed to climate change and variability

Vulnerability: Refers to the characteristics of an individual or group and their circumstances that impact their ability to expect, adapt to, resist and bounce back from the effect of a characteristic risk (Blaikie *et al*., 1994).

ABSTRACT

Change in climate and climate extremes are acknowledged as a vital challenge to pastoral production systems. Alternative systems that are accessible to a household in order to make a living could determine the household's resilience at a given point in time. The present study was conducted in Asayita wereda of Afar region in Ethiopia to assess the resilience of pastoralists and agro pastoralist to climate induced shocks and stresses. A household questionnaire survey, key informant interview and focus group discussion were employed to collect primary data required for the study. A total of 115HHs (63 pastoral and 52 agro pastoral households) were sampled using stratified random sampling technique for household survey and purposive sampling for KI and FGD. The data collected were analyzed using descriptive statistics and a multivariate method called principal component analysis to determine the weight (factor loadings) of each resilience dimension and compute resilience index at household level. A multiple linear regression model was also used to assess factors determining the resilience of household to climate induced shocks and stresses in the study areas. Accordingly, asset, adaptive capacity, social safety nets, access to public services, income and food access and stability were identified to be the different dimensions used to estimate the resilience status of households in the study area. Further results revealed that pastoralists were less resilient than agro-pastoralists in all dimensions, except social safety nets. Enhancing livestock assets and productivity, social safety nets, access to market, credit, extension services and education, improving irrigation crop farming, and providing farm inputs significantly enhanced the resilience of households to climate induced shocks and stresses. irrigation crop farming, livestock ownership, education level, per capita income, mobility and herd splitting, herd composition change, labor, remittance, food aid, access to credit, market and formal early warning information were significant factors determining resilience of households to climate-induced shocks and stresses. Therefore, to improve the resilience of pastoral and agro pastoral households, the government and its development partners must target at strategies that address the above mentioned factors in general and factors related to the adaptive capacity and asset dimensions for pastoral households in particular in the study area.

Keywords: Agro pastoralist, Afar, Ethiopia**,** Livelihood, pastoralist, Resilience

CHAPTER ONE
1. INTRODUCTION

1.1. Background

There has been a growing consensus that, climate change is one of the major environmental threats facing the world today. It has long been known that increasing climatic variability across space and time, shifting of rainfall and temperature patterns and increasing frequency of climatic extremes to pastoral production systems. Despite the more general view of pastoralism as a system of human creative adaptations to hostile climate factors of dryland ecosystems, pastoral livelihoods have rather become increasingly vulnerable to climate change impacts due to the eroded adaptive capacities of pastoralist communities as a result of prolonged marginalization and harmful external interventions, which are generally exhibited by superficially imposed dissonant institutions, environmentally unsound program interventions and bad governance (Yanda and Mubaya, 2011; IPCC, 2014).

The incidence of climate shocks such as droughts and floods particularly become the features of the climate in Africa, often weakening and in some cases reversing the progress made in improving the socio-economic welfare of the countries. The current and predicted climate influences indicate that a severe impact will be observed more in Africa than in other continents as the livelihoods of the lion's share of the population is dominated by climate-sensitive sectors such as agriculture, apart from the continent's geographic exposure. Pastoralist communities are generally expected to be amongst the most affected groups, and therefore will need access to resources and services that help them cope with coming catastrophic shocks, protect their livelihood assets thereby increase their resilience status (Birch and Grahn, 2007).

Climate shocks may occur all over the world, in general however their harm is not as intense as in African countries like Ethiopia, where, climate-induced shocks and stressors such as drought, rising temperature and irregular rainfall patterns reduce pasture and water availability leading to animal losses through hunger and disease. The weather-related natural disasters frequently occur in pastoral areas, and are exacerbated by the depletion of the natural resources and destruction of ecosystems mainly due to anthropogenic activities. Comparatively, the southern and eastern parts of Ethiopia are worst affected by severe droughts, which are ravaging much of the horn of Africa (Funk et al., 2008 Seleshi and Zanke, 2004, Williams and Funk, 2011).

Ethiopia is particularly susceptible to drought, making it the most significant disaster influencing the country over time. Drought-induced famine has threatened lives and livelihoods of millions of rural people over the last several decades. Excessive floods due to the high intensity of rainfall in the Ethiopian highlands caused loss of life and damaged properties of the people who inhabited arid and semi-arid areas. Rainfall anomalies and the delayed onset of the rainy season along with rising temperatures have also led to impoverished grassland, lack of feed and water, and heat stress to livestock. This has, in turn, increased the mortality rate of herds, susceptibility of livestock to disease and emaciation as a result of the long distances they travel in search of pasture and water.

As with other pastoral areas in Ethiopia, Afar Region has a long history of marginalization although it is one of the surplus livestock producing areas, and characterized by arid and semi- arid climatic conditions. Despite the potential for livestock production; occurrence of diversified inherent resources of animals adaptable to the harsh environmental condition, high interest of people towards livestock production, huge areas of rangelands and proximity to export routes, the Afar region has the highest levels of poverty head count in the country36.1%. The successive crises between 1999 and 2015 combined with conflicts over resources have eroded asset bases of households across pastoralist and agro pastoralist communities, which in turn have reduced households' resilience and increase their vulnerability to future shocks (Ministry of Agriculture, 2012; Care Ethiopia, 2014).

The situation in Asayita Woreda, an area selected for the present study is not different from the general reality observed in the region, if not worse. According to disaster risk management sector (2014), Asayita Woreda is mostly affected by drought and floods, while livestock, crop and human diseases are extra hazards reducing the resilience of households to climate shocks and stressors. Water pollution, deforestation, soil erosion and the spread of *Prosopis Juliflora* are also major environmental challenges affecting the livelihoods, and thus resilience capacity of pastoralist and agro-pastoralist communities inhabiting the Woreda. Therefore, this study is intended to understand the resilience of pastoralist and agro-pastoralist households to climate change and variability in Asayita Woreda of Afar regional state, Ethiopia.

1.2. Statement of Problem

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report of 2007 gives convincing evidence that climate change is increasingly recognized as a serious challenge to

environmental health, human well-being and future development (IPCC, 2007). It is one of the most challenges of humanity, affecting both current and future generations. African countries are one of the most vulnerable continents to climate change which is manifested in the short term by climate variability. A condition forced by the interaction of multiple stresses in the form of weather uncertainties or unpredictable seasons, the constant climatic abnormalities which is resulting drought and floods, extensive environmental degradation and prominent food insecurity occurring at different levels, and low adaptive capacity to the impacts of these climatic related events (Boko et al., 2007).

In pastoral communities of Ethiopia, climate-induced shocks and stresses such as droughts, rising temperature and irregular rainfall-reduced pasture and water availability and lead to animal loss through hunger and disease (Conway, 2000). The weather-related natural disasters frequently occurred in pastoral areas of Ethiopia, which has been further exacerbated by the depletion of the natural resources and destruction of ecosystems due to anthropogenic activities (Tadege, 2007). Ethiopia is particularly very susceptible to drought, making drought the utmost significant disaster influencing the country over time (Seleshi & Zanke, 2004). Rainfall anomalies and the delayed onset of the rainy season, along with rising temperatures lead to impoverishment of grassland, lack of livestock feed and water and heat stress to livestock. This has, in turn, increased the mortality rate of herds, susceptibility of livestock to disease and emaciation as a result of the long distances they travel in search of pasture and water. Although the drought may occur all over the globe, in general its harm is not as intense as in Africa, particularly in Ethiopia (Funk et al., 2008; Seleshi & Zanke, 2004; Williams & Funk, 2011). Droughts, heat waves and floods have increased in Ethiopia over the past decades. Excessive floods due to the high intensity of rainfall in the Ethiopian highlands caused loss of life and damaged properties of the people who inhabited the arid and semi-arid areas (Tadege, 2008).

Although climate change is happening all over the world, it has been observed that its influence and extent differ across multiple levels and scales. Its impacts are not the same at local, regional, national and global level. Climate change would be the greatest challenge for people in Ethiopia, insufficient studies have been undertaken in the pastoral areas concerning resilience of households to climate induced shocks and stresses. Studies conducted on climate induced shocks and stresses often intended to assess vulnerability and resilience at national and regional levels in Ethiopia

(Parkins & MacKendrick, 2007; Deressa et al., 2008; Gutu, Bezabih and Mengistu, 2012). However, these national level studies often conceal or overlooked local variations in vulnerability and resilience since climate perpetuation varies with the scale of analysis. Thus, local level variations in vulnerability and resilience to climate-induced shocks and stresses were usually ignored in nationwide studies. Besides, many of the studies conducted at micro-scale were focused more on vulnerability than resilience with a particular emphasis on poverty and food security outcomes.

Since recently, the resilience of households and communities to climate-induced shocks and stresses has turned out to be critical for maintaining sustainable livelihood because a resilient household or community is able to respond to climate-induced shocks and stress in a positive way, and maintain its core functions as a household or community despite those shocks and stresses. This has marked the significance of the resilient approach in addressing climate-induced shocks and stresses, and the necessity of scale in resilience studies. Such an approach is essential to integrate worthwhile adaptation strategies in the development policy, which are specific to a particular scale of analysis.

Therefore, it is against this background that this study intended to analyze the resilience of pastoralists and agro- pastoralists to climate-induced shocks and stress in Asayita Wereda of Afar regional state, Ethiopia.

1.3. Research Objective

1.3.1. General Objective

The general objective of this study was to analyze the resilience of pastoralists and agro-pastoralists households to climate-induced shocks and stresses in Asayita Wereda of Afar Regional State.

1.3.2. Specific objectives

Specifically, the study intended to:

1. Analyze the different dimensions used to estimate resilience of households to climate induced shocks and stresses in the study area
2. Compare resilience status of pastoral and agro pastoral households in the study area
3. Assess factors determining the resilience status of households climate induced shocks and stresses in the study area

1.4. Research questions

This study sought answer the following research questions:

1. How do the weight of different dimensions of resilience vary in determining the overall resilience of pastoral and agro pastoral households in Asayita Woreda?
2. How do the statuses of resilience vary between pastoral and agro pastoral households?
3. What are the determinants of resilience of households to climate induced shocks and stresses in the study area?

1.5 Significance of the Study

Resilience is a context-specific concept. Profiling household resilience allows for interesting cross-group analysis, such as analyzing how different the resilience determinants are for each livelihood profile. The present study can help to improve understanding of resilience dynamics and the variations in resilience dimensions at micro-level (households and livelihood groups) by studying scientifically the resilience of pastoralists and agro-pastoralists in Asayita Wereda of Afar region.

The finding of this study can also serve as an input for various governmental and non-governmental development organizations operating in the area to identify entry points, design programs and implement context-specific interventions for specific groups in a community to improve resilience to climate-induced shocks such as droughts and floods, and stresses including climate change and variability. Likewise, it may also help them to avoid a blanket recommendation of one-type of intervention to all groups or communities across the region.

Apart from serving as a spring board for future studies by researchers interested to work in the same or related field of studies in Afar region or elsewhere in the country, the finding will support local development and humanitarian actors to make informed decisions while planning and executing their regular development activities in accordance with their level of importance and priority.

1.6 Scope of the Study

The Study was a micro-level study, and hence it was geographically delimited to the drought prone Asayita Wereda of Afar region. It thus were not allowed cross-area analysis as its primary focus was on analyzing resilience status from across livelihood groups struggling to survive in the same locality (Asayita Wereda).

1.7 Limitation of the Study

This study determined the current status of the resilience of pastoralists and agro pastoralist

community in the study area to climate-induced shocks and stress based on cross-sectional data. However, due to a lack of panel data sets, the present study did not analyses the dynamics of resilience to climate variability and change at different points in time.

1.8 Organization of the Thesis

The thesis is structured in five chapters. The first chapter describes the introduction of the study that includes the background, research problem, objectives, research questions, significance, scope and limitation of the study. Chapter two deals with review of related literature about change in climate and its impacts, and an overview of pastoralist and agro- pastoralist, concept of resilience and its measurement . Chapter three discusses the methodological approaches comprising a description of the study area, research design and data collection techniques and analysis. Chapter four discussed the Results obtained from the study about the influences of climate shocks and stresses on pastoral and agro pastoral livelihood, resilience status of pastoralists and agro pastoralist to climate shocks and stresses. Finally, conclusions of the study and recommendations are presented in Chapter five.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Conceptual Literature Review

2.1.1 Climate Change and Its Impacts

Climate change refers to a change in the state of the climate that can be recognized by the changes in the mean and/ or the variability of its properties, and that continues for an extended period of time, normally can takes decades or longer. It refers to any change in the climate over time, whether due to natural process or as a result of human process (IPCC, 2007).

Change in climate and climate variability is happening all over the globe (IPCC, 2013). A few realities about this change involve the following: rising of surface temperature on the globe (temperature has risen by 0.74 °C in the twentieth century); ice melting in the Polar Regions (an annual average rise in sea level by 3.1 mm) (Lemma et al., 2013). Change in climate has several components that impact human and biological systems in various ways. Change in climate and climate variability are frequently perceived as main threatening variables to food security in regions of the globe that are, to a great extent, subject to rain-fed farming systems (Parry et al., 2004).

Change in climate is happening, which impacts natural resources and food security (Brown & Funk, 2008; IPCC, 2012). Since the late nineteenth century, global temperature has been increasing, resulting in an increasing temperature for the previous thirty years, and the warmest decades had been observed during the twenty-first century (IPCC, 2013). The world's average temperature has risen by 0.72 °C since 1950 and caused a high incidence of warmer days and nights, and increased heat waves, and a decline in the incidence of cold days and nights (IPCC, 2013). The global temperature will continue to increase if no mitigation strategy is implemented to reduce the emissions of greenhouse gas. Temperature will rise in the range 0.3–4.8 °C close to the end/middle of the twenty- first century, based on greenhouse gas emission situations. In vast areas of the world, water cycle changes can also be observed due to global warming, such as changes in patterns and intensity of rainfall, an increase in atmospheric water vapor and a declined snow cover (Bates *et al*., 2008; IPCC,2013). As a result of changes in climate and variability, the severity of climate extremes will increase in Africa (IPCC, 2007). The people in Africa are largely dependent on rain-fed agriculture, which is characterized by low input and output, and thus, they are highly susceptible to changes in climate as their economy is climate

sensitive (Chauvin *et al*., 2012).

The human and natural systems can be impacted by change in climate and climate variability in various directions (IPCC, 2012). The impacts of climate change have been broadly studied at different spatial scales. The increases in average global temperatures are characterized by substantial variances in temperature increase between dry land and water bodies and between high- and lowland areas. On the other hand, it is more likely that rainfall increases in highland areas, while it declines in most of the tropics and subtropical land regions. The impact of climate change on the natural and human systems is linked to the duration and extent of droughts, floods and other climate-induced shocks and stresses (IPCC, 2007). It is projected that the incidences of heat stress, droughts and floods will increase in the future and will have more serious impacts than due to alterations in mean variables only (IPCC, 2012).

Changes and variability of climate can impact the quantity and quality of livestock feed. Recurrent and prolonged droughts can cause severe feed shortages which can affect livestock numbers, reproduction and productivity, especially in dry land areas (Thornton *et al.*, 2014). In pastoral lands of East Africa, when drought occurred once in five years, there was a possibility to maintain a constant number of cattle (Thornton *et al.,* 2010). However, when the incidence of drought increased from once every five years to once every three years, it would decrease livestock assets, making it difficult to recover (Thornton *et al.,* 2014). For example, in Kenya, a loss of 1.8 million additional cattle is expected by 2030 due to the recurrent droughts (Thornton *et al.,* 2014). Climate change and variability also considerably impacted the occurrence and spread of livestock diseases such as Rift Valley fever in East Africa and northern Europe, and African horse sickness in South Africa.

It is projected that the prevalence and distribution of Rift Valley fever in the northern part of Europe may increase due to future increases in the frequency of extreme weather events in the region. However, the impacts of future variability and change in climate on outbreaks of disease and pests are not well-known. In addition, climate variability also impacts crop yield quality and quantity. The findings reported by Porter and Semenov (2005) indicated that as the mean and variability of climate variables (rainfall and temperature) change, the protein content of wheat grain also changes; especially, a rising temperature during grain filling can impact the protein content of wheat grain. Rowhani *et al.* (2011) reported that the influence of climate variability on crop yields may be

undervalued in East Africa in the range of 4–27%, depending on the type of crops and taking the long-term mean variations in climate inconsideration.

Change in climate and variability has direct as well as indirect impacts on human health. The elders are more susceptible to climate shocks such as heat stress (McMichael & Kovats, 2000). Temperature and rainfall interacts with vector-borne and infectious diseases which directly affect the well-being of human beings. Costello *et al.* (2009) reported that the seasonal variability of rainfall and climate extremes such as floods and droughts affect the prevalence of cholera, malaria and dengue fever. McMichael and Kovats (2000) indicated that if variability of rainfall and temperature patterns causes changes in temporal and spatial variation in water distribution and vegetation, we would see more disease outbreaks as the vector moves to new areas. Furthermore, Nelson (2009) indicated that climate shocks and stresses will impact food production and have a continuous influence on the incidence of under nutrition, thereby increasing severe stunting by 55% in East and southern Africa and 62% in South Asia by the 2050s.

The history of climate extremes, particularly drought, is not uncommon in Ethiopia and the documented history indicated that drought in Ethiopia started before 250 BC (Webb & Braun, 1994). Though droughts are common natural hazards in Ethiopia, its frequency and extent of severity have increased over the past few decades, mainly in lowland areas of the country (Lautze *et al.*, 2003; NMSA, 2001).

In Ethiopia, the livelihood of the people has been seriously affected by variability and change in climate. According to Conway and Schipper (2011), Ethiopia's economy is dependent on climate-driven agriculture, which accounts for more than the gross domestic product (GDP) of 40%, and 90% of national profits from exporting. Hence, agriculture is highly vulnerable to climate-induced shock which may lead to severe food insecurity in the country. The NMSA (2001) revealed a declining trend in annual rainfall over the northern parts of the country and rising trends in the central parts of the country. Projections by means of General Circulation Models for the year 2030 indicated a rise in temperature by 1 °C and a decline of precipitation by 2%. The projections indicated that change in climate leads to severe climate-related shocks, making the food production sector more susceptible. This will definitely result in poor harvests and/or complete crop failure, leading to shortages of food and pastures (United Nations Framework Convention on Climate Change [UNFCCC], 2007).

Conway and Schipper (2011) reported that in Ethiopia, climate variability and incidences of floods

and droughts have increased over time. For instance, flooding has become a common problem and occurs in lowlands where rivers flow over the gentle slopes with higher volume of water from the highlands. The Awash River in the Afar region, the Baro River in the Gambela region, the Wabeshebele, Genale and Dawa Rivers in the Somali region, the Omo, Weyto and Segen Rivers in the South Omo region commonly flood large areas of grazing lands and cause heavy loss of life and damage to resources.. On the other hand, Conway and Schipper (2011) also indicated that there was a rise in the incidence of drought from one in 100 years in the first century to one in six years in the twentieth century ,and also once in three years towards the end of the twentieth century and the beginning of the twenty-first century. In general, the intensity, occurrence and the impacts of droughts have increased since the mid-1970s in Ethiopia. Besides climate variability, the dramatic increase in the frequency of drought in the past three decades is attributed to global climate change.

2.1.2 Resilience concept and its components

Resilience is the capability of a social–ecological system to continue after a shock and reorganize, while sustaining a fundamentally similar function (Folke, 2006; Holling, 1986; Walker *et al*. 2004). The idea of resilience was initially used by Holling (1986) to define ecosystem resilience and has currently been applied in other contexts, progressively in social sciences, to explain people or household resilience (Levin *et al.,* 1998). Assuming the wide variety of resilience thoughts, it is complicated to detect common characteristics; however, nearly all descriptions stress the ability for effective adaptation against shocks. Norris *et al.* (2008) suggested that an overall agreement occurs on two significant characteristics of the resilience definitions, namely: (i) it is better conceived as a capability or a process than as a result; (ii) it is well-conceptualized as adaptability than steadiness. A first step in the direction of understanding the resilience concept in a learning environment is to discourse the important characteristics and regulations of the investigated system. In order to enhance a common understanding of resilience in the situation of diverse systems, Norris *et al.* (2008) have identified the most important principles, namely: (i) a changing environment is given, (ii) systems are too complex to know or map all interdependencies, and (iii) there is not only one stable state in reality – alteration is the common state. Resilience therefore, is a learning process and knows that no stable state exists in reality.

There are two contrasting resilience concepts. The first concept is described by Gunderson *et al.* (1995) as resilience in engineering, and by (Cutter *et al.,* 2008) as the ability to persist and survive

with a disaster with slight influence and destruction. It includes the ability to lessen or evade damages, encompass the impacts of hazards, and bounce back with slight disturbances (Cutter *et al*., 2008). Rose (2009) also described it as the time taken by a system to recover to its earlier state after a disturbance. Furthermore, not only the time required for bouncing back, but also the pattern of bouncing back can be considered. According to the framework of engineering resilience, opportunities are not taken into account to adapt or learn from a previous disturbance and shift to an alternative state. On the other hand, the second resilience concept, called ecological resilience, is the amount of perturbation that a system can accommodate without redefining its structure and functions (Holling, 1986; Walker *et al.,* 2004). A concept regularly quoted when referring to resilience of an ecosystem is the *adaptive renewal cycle*, primarily developed by Holling (2001). The adaptive renewal cycle is an informative model, made from long-time measurements of ecosystem changes over time, such as the succession of species, in four phases of change forced by periodic disturbances and processes (Folke, 2006). Resilience refers to persistent or robustness of a system to disturbance and about the possibilities that disruption may lead to the occurrence of new trajectories. Therefore, resilience offers the ability of the system to adapt to disturbances that allows for sustainable development. It does not mean that resilience has always been a positive characteristic of the system (Folke, 2006).

According to O'Brien *et al.* (2004), adaptability, resilience, and vulnerability are highly interrelated and the difference between these terms is not clear yet for most researchers. Resilience and vulnerability are slightly broad theories, and the drivers regularly overlay, which makes the difference between them not understandable (O'Brien *et al.*, 2004). According to the IPCC (2007), vulnerability is the function of adaptive capacity (AC), sensitivity (S) and exposure (E). However, recently, resilience is interlaced with vulnerability and adaptive capacity and it has been discussed that resilience, as the all-encompassing idea, is a function of vulnerability and adaptive capacity (Wilson, 2012) as indicated below.

Resilience R = f (Adaptability A, Vulnerability V)

2.1.3 Theoretical approaches to resilience

As resilience theory gains traction as a theoretical framework for research in social science, it is important to engage with it critically. Understanding of the concept of resilience becomes complete when the worldviews associated with it are understood. Accordingly, two broad facets of resilience that can be considered as alternative worldviews are identified as engineering resilience and ecological resilience (Sakurai et al, 2012). Both deal with aspects of stability of equilibria providing alternative measures of a system's ability to maintain its functions following disturbance (Alinovi et al, 2009). Their definitions reflect which of the two aspects of stability of a system should be emphasized (Holling, 1996). The third facet, termed as resilience as adaptive system (i.e. closely related to ecological resilience) is also proposed (King, 2008). Such identification is useful for a researcher to choose among the respective underlying philosophical and methodological foundation of study. In order to understand the essence of the first two views, we can relate them to the engineers' desires when designing, for example a building, as fail-safe or safe-fail design, the former being equated with engineering resilience while the later with ecological resilience (Holling, 1996).

Engineering resilience can be defined as the speed of return to the steady state following a perturbation perceiving a system as existing close to a stable state (Sakurai et al, 2012). In this definition, resilience focuses on efficiency and assumes constancy and predictability of a system's properties (King, 2008). All of these attributes are at the core of engineers' desires for fail-safe design (Holling, 1996). It perceives a system to exist close to a known stable equilibrium steady state and its functions should be maintained to this state after a perturbation (Holling, 1996). Thus, an increased resilience implies the system's ability to bounce back faster after stress, enduring greater stress, and being disturbed less by a given amount of a stress (Holling, 1996).

Engineering resilience is therefore grounded more within the theory of positivist tradition, both epistemologically and ontologically (King, 2008). The epistemology and ontology of a positivist scientist aims at developing an objective understanding about a reality (a system) assuming that a system can be known and a truth exists suggesting there is one best management option for this system (King, 2008). In this tradition, people are also assumed to be separated from nature. A researcher adopting engineering resilience approach therefore searches for variables that contribute to the existence of a single stable state. A system's resilience is measured as a resistance

to disturbance and the speed of return to this steady state or recovery from a shock following a perturbation. In applying this approach in food system, household consumption resilience is defined as the speed of recovery of consumption from a shock assuming consumption as a single stable state (Sakurai et al, 2012: 9). In reality, however, a system has multiple states of equilibrium for which ecological resilience approach that assumes dynamism in the properties of a system is appropriate for analyzing and understanding a system.

Ecological resilience refers to the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist (Holling, 1973). It is simply the potential of the system to remain in a particular configuration and to maintain its feedbacks and functions, and involves the ability of the system to reorganize following disturbance-driven changes (Walker et al, 2002). In other words, ecological resilience model focuses on persistence despite changes in, and unpredictability of, a system's properties (King, 2008). It assumes multiple stability domains and is measured by the magnitude of disturbance that can be absorbed before instabilities shift/flip into another regime of behavior (Alinovi et al, 2009; Sakurai et al, 2012). Ecological resilience is dynamic model, rather than static, that captures properties of complex dynamic systems. This is closely related to what is termed as resilience as adaptive system, as third facet of resilience by (King, 2008). It conceives conditions far from any single stable steady state, where instabilities can flip a system into another regime of behavior and domain of stability (Holling, 1996). In general, three defining characteristics of ecological resilience are listed as: "the amount of change a system can undergo (and the amount stress it can sustain) and still retain the same controls on function and structure (still be in the same configuration-within the same domain of attraction); the degree to which a system is capable of self-organization…; and the degree to which a system expresses capacity for learning and adaptation" (Walker *et al.,* 2002).

The ecological resilience model is grounded in constructivist tradition epistemologically and ontologically (King, 2008). In this philosophical stance, knowledge or understanding of the property of a system is obtained through a social construction while reality/truth is ultimately subjective. Moreover, unlike positivism in which man is assumed to be separated from nature, constructivism assumes that people cannot be separated from nature, but are part of nature (King, 2008). Accordingly, researchers search for alternative stable states, the properties of the

boundaries between states, and the conditions that cause a system move from one stability domain to another (King, 2008). Resilience, according to this approach is therefore measured in terms of the magnitude of disturbance absorbed before the system is restructured with different controlling variables maintaining the existence of functions (King, 2008).

In sum, the choice between the two approaches for practical application in a field of research depends on the objective and methodological underpinnings of the study as well as the characteristics of the system under investigation. In this regard, social systems are so dynamic and have multi-state stability for which social and cultural capitals, networks, values and relationships and systems of knowledge determine resilience (Alinovi et al, 2009). Ecological resilience approach is therefore applied in this study assuming that different equilibria exist, at least, among different households under the two livelihood groups.

2.2. Empirical Literature Review

2.2.1 Overview of Pastoralism

Pastoralism is an extensive production system of herbivorous livestock, using pasture or browse on unimproved rangeland that has developed over centuries. It is practiced in the plains and mountains of Africa, Europe and Asia, usually in areas with adverse conditions that make them unsuitable for other types of production, such as low and variable rainfall, high or low temperature, or high altitude (Homewood 2008a). It is estimated that globally there are up to half a billion people involved in pastoralism, agro-pastoralism and ranching, occupying over a quarter of global land area (Davies et al. 2010, Niamir-Fuller 2016). Pastoralism can be defined in a number of ways; economically, in terms of the contribution of livestock and livestock-related activities to the household economy; ecologically, in terms of the production system; or culturally, in terms of the role of livestock in identity and social relations (Homewood 2008a). The natural environment is a major influence on the type of pastoralism that is practiced, but the pastoralist way of life is also influenced by the political, cultural and economic environment and the history of the area and the people (Hogg 1997).

In the arid and semi-arid areas of sub-Saharan Africa, which make up approximately two thirds of the land area, pastoralism is the predominant production system, because variability of rainfall makes rain-fed crop farming risky. Pastoralism makes an important contribution to food production and the economy by transforming forage from marginal areas into meat, milk and other

commodities (Homewood 2008c). In addition, pastoralist management practices contribute to maintaining the biodiversity of rangelands, and the conservation of important wildlife habitats, while the rangeland vegetation and soil are an important carbon repository (Seid et al. 2016).

Mobility is a common feature of pastoralism that allows the herds to take advantage of the variability and uncertainty of rainfall, and the associated availability of forage. Herds may also be moved to access minerals or to reduce the risk of disease and vectors, as well as to access markets, or participate in social events (Niamir-Fuller and Turner 1999). The degree and type of mobility varies between systems and over time. Some pastoralists are largely nomadic, but transhumance is more commonly practiced, with a fixed base and seasonal movement between lower and higher altitudes or latitudes. Transhumance can follow a fixed or variable route, over shorter or longer distances (Homewood 2008c, Davies et al. 2010). Livestock movements may be accompanied by the whole household, part of the household, or only the young men, while the rest of the household remain at the home base (Davies et.al. 2010 Homewood 2008c). Common property resource management of the rangeland by traditional institutions makes movement of livestock possible, by regulating who has access to resources and when they can be accessed, depending on need (Niamir-Fuller and Turner 1999, Homewood 2008c).

The contribution of livestock to the pastoralist livelihood relative to other activities varies between pastoralist groups depending on the environment, climate, forage availability, disease, security and other economic opportunities (Homewood 2008a). It is rare to have a completely livestock-based livelihood and most groups practice one or more additional activities; crop farming, fishing, hunting, gathering, artisanal and waged work. Pastoralist production varies from subsistence to partly commercial. Pastoralists have traditionally traded their animals and products for grain and other goods for the household, and been actively involved in trade networks, but the level of commercialization and market integration has been increasing in the past few decades (Kerven 1992, Homewood 2008c).

Most pastoralist groups keep a combination of livestock species that complement each other in their forage requirements, the rate and seasonality of reproduction, seasonality of milk production, and adaptation to the environment (Niamir-Fuller and Turner 1999, Homewood 2008e). The differing needs of each species may require different movements (Homewood 2008c). Animals may be split among several herds to spread the risk of drought or disease, and the herd may be

divided, with milking animals and young calves managed separately from the rest of the herd (Niamir-Fuller and Turner 1999). The herds have a high ratio of females to males to maximize milk production and reproduction, with high offtake of males (Homewood 2008e).

2.2.2 Changes and challenges in pastoral systems

Pastoralist systems face many challenges, most of which are inter-related and lead to increased vulnerability and poverty (Niamir-Fuller 2016). An underlying issue is that pastoralist systems have historically been, and continue to be, poorly understood, leading to inappropriate policy and development initiatives, weakening of pastoralist institutions, and political, social and economic marginalization (Niamir-Fuller and Turner 1999, Davies et al. 2010);

> *"One of the key challenges for dryland development has been the deeply entrenched prejudice that sees extensive pastoralism as "primitive", unviable, environmentally destructive and outmoded." (Niamir-Fuller 2016 pp 34)*

Although livestock in sub-Saharan Africa make an important contribution to the economy, there is underinvestment in pastoralist areas and they are generally less well developed than other areas, with weak infrastructure, such as roads and markets, and limited health and education provision (Vetter 2005, Davies *et al.* 2010, Niamir-Fuller 2016). Pastoralist systems are more able to adapt to climate variability and uncertainty than other production systems, but the effects of climate change and other challenges are pushing them to the limits of adaptation (Davies and Nori 2008, Galvin 2009). In Africa, there is already a trend of decreasing rainfall, increasing mean temperature and increasing incidence of drought (Homewood 2008c, Niamir-Fuller 2016). The effects of predicted further increases in temperature and atmospheric CO2 concentrations, and rainfall changes, are uncertain but are considered likely to have a negative effect on the quantity and quality of forage in arid and semi- arid rangelands (Thornton *et al.* 2010). There is likely to be an increase in temporal and spatial variability of rainfall in already highly variable areas and an increased frequency of extreme events causing drought, flooding or extremes of temperature, which will have an impact on rangeland productivity, and therefore food security and livelihoods (Herrero et al. 2016). However, climate change may also create opportunities for pastoralists, if areas become less suitable for crop farming and livestock production is the best alternative land use (Thornton *et a*l., 2014).

In general a suite of climate, biological and socio-economic and political drivers are changing the fundamental nature of pastoral systems. Climate change, intensification of pastoral production, privatization, sedentarization, land use change, livelihood diversification, resettlement, economic change and degradation are exerting tremendous pressure on rangeland ecosystems and pastoral communities (Galvin, 2009).

2.2.3 Pastoralism and resilience

In the past few years, building resilience has become a goal for international and national development programs in the Horn of Africa, especially in arid and semi-arid areas (Little and McPeak 2014, USAID 2014), and is a theme of the United Nations' Sustainable Development Goals (Zinsstag *et al.,* 2016). Resilience can be defined as the capacity of a system to absorb disturbance and reorganize, while undergoing change in a manner that allows for the persistence of system function, structure and feedbacks (Leslie and McCabe 2013) or, more simply, making people, communities and systems better prepared to withstand catastrophic events and able to bounce back more quickly and emerge stronger from these shocks and stresses. A resilient pastoralist system would support the health and well-being of the people, livestock and the rangeland. It is a public good to support pastoralist system resilience, not just for humanitarian reasons, but because of the contribution pastoralist systems can make to the Sustainable Development Goals, including food security, health and well-being, and sustainable ecosystems (Zinsstag *et al.* 2016). By 2050 the global population is projected to reach 9.7 billion people, from an estimated population of 7.3 billion in 2015, and most of the increase is expected to be in urban populations in Africa and Asia (UN 2015). With the increase in human population and increased income, there is an increasing demand for livestock products, but it is important that this demand be met by sustainable systems. Along with sustainable intensification, sustainable pastoralism can contribute to meeting this demand (Niamir-Fuller 2016). Low input pastoralism already contributes to meeting international demand, for example, the large-scale export of livestock from the Horn of Africa to the Middle East, and it can play an increasing role, if appropriate policies and support are provided (Little, 2013).

The recommendations for pastoralist development that were made by researchers in the 1980s are similar to those being made today (Little 2013). For pastoralism to be resilient, the knowledge and institutions of pastoralists need to be supported, and land tenure should be secure, to ensure

mobility, access to key resources, and allow pastoralists to manage their ecosystems (Niamir-Fuller 2016, Zinsstag *et al.* 2016). Over time, aspects of pastoralist systems have varied, such as the relative proportions of different species, the level of mobility, and the integration of other livelihood activities, such as cultivation, fishing, paid labour and trading. These variations can be seen as adaptations to changing conditions as well as drivers of change (Galvin 2009). Marketing systems should be equitable and accessible, and able to accommodate opportunistic selling of animals before drought and re-stocking afterwards (Niamir-Fuller 2016, Zinsstag *et al.* 2016). Services should be provided to pastoralist areas that are appropriate and use sustainable technologies; energy, health, education, communications and safe water (Niamir-Fuller 2016, Zinsstag *et al.* 2016).

2.2.4 Pastoralism in Ethiopia

Pastoralism in Ethiopia is mainly practiced in the arid and semi-arid lowland areas below 1,500 meters above sea level (masl) to the northeast, east, south and west of the Ethiopian highlands. The main pastoralist groups are the Somali, Boran, Afar, Hamar, Arbore, Kereyu, Nuer and Arsi (Hogg 1997). Twelve million pastoralists in Ethiopia occupy over 60% of the country's land which is arid and semi-arid areas and dominated by the livestock economy (United Nations Office for the Coordination of Humanitarian Affairs [UN OCHA], 2008).

As in other parts of Africa, the general attitude to pastoralism in Ethiopia has been that the system is inefficient, keeping too many animals, leading to over-grazing, soil degradation and erosion (Hogg 1997). This is partly because of a lack of understanding of the contribution that pastoralism makes to the national economy, due to incomplete data on human and livestock populations, the contribution of livestock production to household income, and domestic and export trade (Little *et al.*2013).

Although pastoralists have contributed significantly to the economy of the country, the decision makers are still not willing to address the challenges facing pastoral communities. Policymakers focused on crop farming in the highlands of the country. For example, Agricultural Development Led Industrialization strategy, which is the general development policy in the country, is unfair regarding pastoralism and does not sufficiently address the constraints and potentials of the pastoral communities. Likewise little consideration is given to pastoralists regarding their access to public services such as access to health services and schools (Hundie, 2008). However, it has also been

recognized that the recent five years growth and transformation plans (GTP I-2010-2014 and GTP II-2015-2019) have paid a particular attention to livestock development; water for people and livestock; forage development; irrigation; improving the livestock marketing system; and strengthening implementation capacity in the pastoral agro-pastoral areas (EFDRE, 2010).

2.2.5 Pastoralism in Afar Region

The Afar people are part of the Southeast Cushitic-speaking group together with the Somali, Oromo, Beja and Rendille (Homewood 2008b). They inhabit the eastern part of Eritrea, western Djibouti and the northeast of Ethiopia, bounded by the eastern edge of the Ethiopian highlands (Tigray and Amhara Regions), Oromia region to the south, and Somali region to the east. This is an arid and semi-arid area with highly variable rainfall, both temporally and spatially. The Afar people depend on the Awash River and its tributaries that flow from the highlands, causing seasonal flooding of riverine pastures and woodland, to support their mobile pastoralist system of camels, cattle, sheep, goats and donkeys (Said1997).

Like many other pastoralists in East Africa and elsewhere, it is also common for Afar pastoral communities to keep multiple species of livestock to cope with droughts and disease outbreaks and meet their subsistence needs (Getachew, 2001). The species composition of livestock kept by pastoralists varies with the vegetation covers of the region (Ellis, 2000). In parts of rangelands, where the grazing resources are relatively good, cattle and sheep are the dominant types of livestock. In the drier parts of the region, camels and goats make up the prominent parts of the herd composition with mainly camels in the extremely arid areas. According to Hogg (1997), dependence on milk enables many pastoral societies not to depend on the highlanders for grain foods, although many pastoral communities do not have adequate herds to be only pastoralists and have come to be progressively reliant on food grain as a part of their diet. Ellis (2000) noted that in spite of the fact that the interest in grain is generally profoundly occasional, the exchange of livestock to buy food grains has turned into an essential part of the livelihood of pastoralists.
(Hagmann, 2005) reported that an extensive livestock production system has been the predominant livelihood system which provides subsistence for the Afar pastoral households. It supplies goods for household consumption (milk, meat, butter, hides and skins). Due to the occurrence of droughts in wider areas of the region and conflicts among ethnic groups, mobility of livestock among alternative grazing areas has been harshly inhibited, causing poor body conditions of livestock and

a substantial increase in death of livestock. The aggregate influence of these drivers has led to the weakening of informal institutions, impoverishment of rangeland resources, and increasing vulnerability of pastoralists to shocks and stresses (Rettberg, 2006).

Overall, inappropriate policies and strategies, fragmentation of rangelands, and prolonged and recurrent droughts have led pastoral communities to pursue other non-pastoral livelihoods such as irrigation crop cultivation; wage labor, charcoal making, and firewood selling (Sanford & Habtu, 2000). Consequently, the hitherto economically undifferentiated pastoral groups have been disintegrated and some pastoral households pursued non-pastoral activities. Some have started practicing crop farming. Still, some are forced to take up wage labor and other non-pastoral activities. And some fortunate ones maintain their herds through a grazing alliance (namely, stock association with the neighboring farming population or with bond friends) and engaging in animal trading (Mesfin, 1999; Sanford & Habtu, 2000). Therefore, the economic change implies a growing pattern of wealth differentiation. For instance, in the Middle and Lower Awash Valley a few wealthy Afar households were transformed into commercial agro-pastoralists, while the poor Afar households were neither able to sustain themselves in the pastoral sector, nor were they able to cope with the new circumstances that followed the development, including increasing involvement in opportunistic farming on marginal lands, wage labor and the cash economy (Getachew, 2001).

2.3. Conceptual framework

2.3.1 Resilience Assessment conceptual framework

The resilience conceptual framework as developed and explained by Frankenberger *et al.* (2012), was designed to give a comprehensive understanding of the drivers and processes that affect resilience and vulnerability of the society. In an altering social, economic and natural environment, this framework should finally help stakeholders indicate, estimate and model different vulnerability and resilience pathways in a community. According to Frankenberger et *al.* (2012), the components of the resilience assessment conceptual framework include the following:

i. **Context**: Refers to social, demographic, environmental, economic, political, historical, conflict, policy conditions, and religions that disturb and are impacted by people resilience.
ii. **Disturbance**: Includes shocks (for example, droughts and floods), stresses (for example, political instability, price increases, environmental impoverishment, and climate change and

variability).

iii. **Adaptive capacity**: Involves the ability of households to deal with disturbances such as livelihood assets, structure and processes, and livelihood strategies employed by households.

iv. **Vulnerability and resilience pathways**: The term 'pathway' refers to the concept that both resilience and vulnerability are reasonably seen as a process rather than static states. Households who are capable of managing shocks or stresses that they are exposed to and decrease their vulnerability, are less susceptible and are on a resilience pathway. However, those that have low adaptive capacity to deal with shocks and stresses are susceptible and are likely to follow a vulnerable pathway.

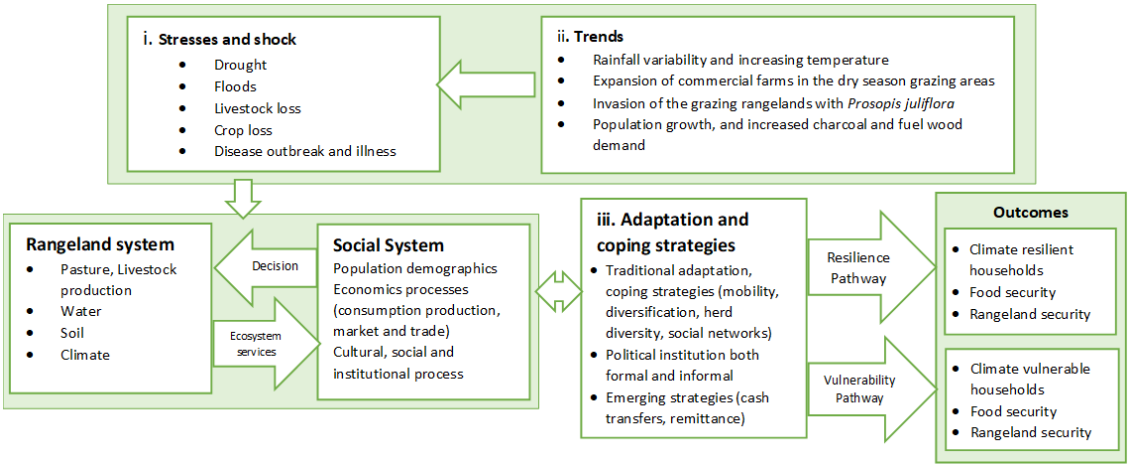
v. **Livelihood outcomes**: Refers to the household's interests and needs that they intend to achieve. Resilient households will be capable to achieve the food security of its family, will have access to sufficient nutrition, will ensure availability of a secured environment, will be able to meet secured health and income, and will be capable to send their children to school. Vulnerable households experience insufficiencies or high risk of insufficiencies in these characteristics.

The present study aimed at understanding the resilience status of pastoralists to climate- related shocks, such as droughts and floods, and climate stresses such as climate change and variability. Therefore, an attempt has been made to employ the conceptual framework developed by Frankenberger *et al.* (2012), with some modifications. The reformed conceptual framework and description of the elements of the framework for resilience that fitted to Afar pastoralists are described below.

The central focus of the conceptual framework was the social-ecological system connected by arrows (Figure 2.2). Decisions and actions emerging from the social system on how to use and manage the rangeland resources and services from the ecological system such as pastures and water, fuel wood, maintain a continuous and dynamic interplay between these tightly coupled systems. In the present study, this conceptual framework was designed to analyze the resilience of pastoral households, considering climatic and non-climatic drivers that are acting on the system. These drivers fall in to three categories: (i) shocks and stresses; (ii) trends, and (iii) Adaption and coping strategies.

The shocks and stresses (drought, floods, livestock and crop loss, and illness) on the upper part of the framework in Figure 2.2 can shape and transform the livelihood strategies of pastoral

communities in arid and semi-arid areas of the Afar region. Climatic extremes, particularly recurrent droughts, act on rangeland and result in depletion of water and pasture resources which are critical for pastoral production systems in arid areas of the Afar region



Source: Adopted from Frankenberger et al., (2012) in Muluken (2017)

Figure 1.1: Resilience conceptual framework

The incidences of severe and recurrent droughts can result in the deaths of large numbers of livestock, resource-based conflicts, livestock disease outbreaks and environmental degradation, which in turn affects the resilience and well-being of the society (Woldetsadik & Hailu, 2011).

On the other hand, trends on the upper part of the framework (Figure 2.2), such as rainfall variability and increasing temperature, expansion of commercial farms in the dry season grazing areas, invasion of an alien shrub, *Prosopis juliflora*, on rangelands, and population growth, can affect the rangeland ecosystem services which in turn threaten the sustainability of pastoralism. Rainfall variability causes shortage of pasture, which in turn affects livestock assets. It can also lead to changes in rangeland species diversity, water resources and forage quality. The increasing temperature trends can also reduce the surface water which can compound the increased demand for water by livestock and humans. The increased temperature beyond its normal range can cause lignification of forages which affects the palatability and digestibility of forages. Temperature increments from the normal range can impact animal production. Warmer and drier conditions increase animal thermal stress with resultant declines in meat, dairy production and measure of animal success, such as conception rates (Easterling *et al.*, 2006).

Furthermore, allocation of the dry season grazing areas along the Awash River for state farms can

affect the resilience of pastoralists to climate variability, and change as their main strategy, *mobility*, might be restricted during dry seasons. *P. juliflora* expansions in the Afar rangeland also suppress palatable grass and browse species which further aggravates the influences of climate-related shock on Afar pastoralists. Many pastoralists own few livestock today than they did in the past due to degradation of rangeland resources as a result of climate extremes such as droughts and floods and non-climate drivers, for example allocation of prime grazing areas for commercial farming and urbanization (Reid *et al*.,2008).

The other important trend, *population dynamics*, greatly alter the dynamics of the coupled social-ecological system. Population dynamics can include not only increasing human population pressures, but also reduced herder populations due to patterns of rural to urban migration. The economic opportunities and the social and other services that cities provide are attracting the younger generation of pastoralists who are leaving their traditional homes and livelihoods, with significant consequences for the resilience and running of the pastoral system.

On the other hand, the herder's decision and action in response to an environmental change is highly determined by the institutions and policies such as policy changes, public services and rules. For example, mobility is the main strategy of the pastoral society in response to climate shocks, such as droughts, as it offers access to key resources such as water and forage resources for livestock during the drought season. The movements of grazing animals across the landscape also provide an opportunity for the grazed landscape to rest and recover. However, local and national government encourages pastoralists to settle because they can control less mobile pastoral populations, tax them and provide social services to them. Settlement encourages privatization and fragmentation of rangelands which makes the social- ecological system more susceptible to climate-related shock. In contrast to this, government working towards in support of traditional practices of the pastoral community, such as mobility and common property regimes, co-management and capacity-building can reduce the vulnerability of a pastoral community. This can also improve coordination between the community and the government. Institutions and policy have a significant impact on access to assets, namely: They (i) generate assets, for example, if government works towards improving infrastructures, promoting human capital or the presence of local organizations that reinforces social capital; (ii) govern access, for example, tenure rights; (iii) impact rates of asset growth, for example, policies that impact earnings from various livelihood activities and taxation. Government commitments regarding early warning information (EWI),

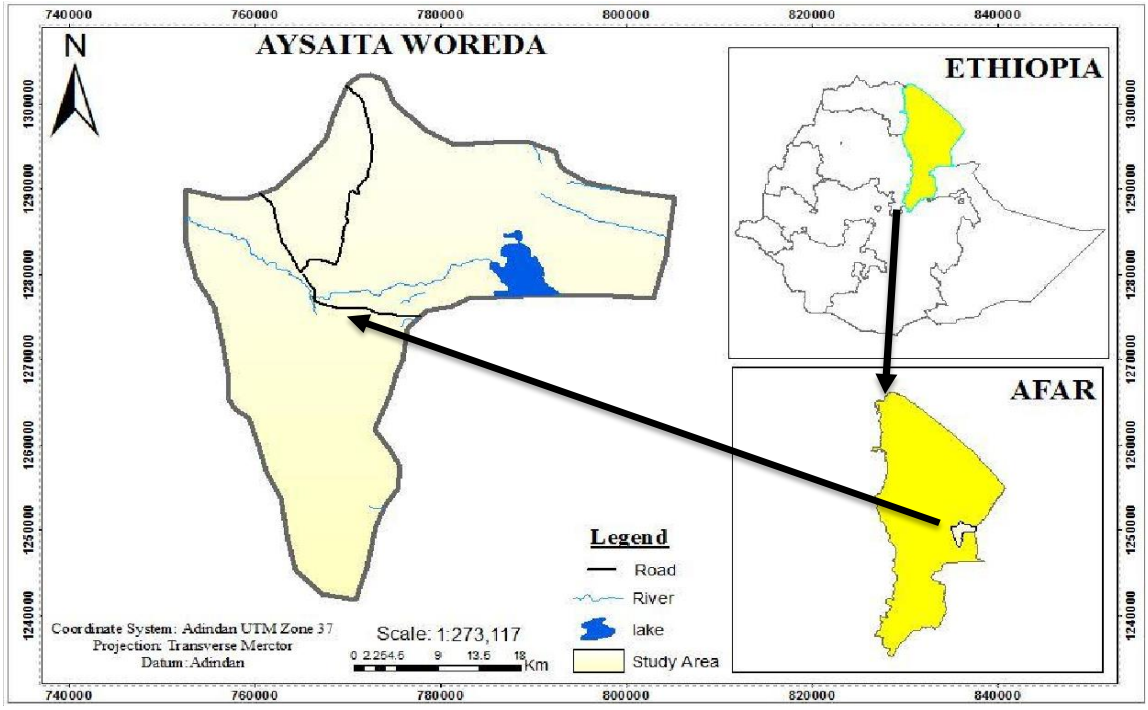
preparedness and supporting the community to respond and recover from climate-induced shock impacts can enhance the resilience of pastoralists. All these factors shape the way various assets (land, labor) are used in production strategies.

The resilience conceptual framework also depicts the coping/adaptation strategies of pastoralists, which may either lead to climate resilient households or climate vulnerable households, depending on the relationship and interactions among other components of the resilience framework. The coping/adaptation mechanisms include livestock mobility, livestock diversification and splitting, and traditional social security systems. Using this conceptual framework, this study identified which elements of the framework made the household resilient to climate change and variability in Asayita Wereda of Afar region.

CHAPTER THREE
3. METHODOLOGY

3.1. Description of the study area

The Afar National Regional State is one of the nine administrative regions of Ethiopia located in the north-eastern part of the country. The region is divided into five zones and 32 Woredas. Geographically, the region is located between 8°49' -- 14°30'north latitude and 39°34' -- 42°28' east longitude. The region shares national boundaries (with four national regional states i.e. in the northwest Tigray Region, in south west Amhara region, in south Oromia and in southeast Somalia region) and has two International boundaries in east Djibouti and northeast Eritrea (ANRS BoFED. 2010). The study was conducted in Assyita Woreda of zone one of the Region. Asayita town, the Woreda capital is located at 11°34′ North latitude and41°26′ East longitude average elevation of 300 meters. Whereas, the Woreda is relatively located in the south of Afambo, west of Dubti, north of Awash River, which separate it from Elidar, and east of Djibouti (CSA, 2007).



Source: Own Construct (2019)

Figure 3.1: Map of the study area

3.1.1. Socio-Economic Characteristics

Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), the Woreda has a total population of 50,803, of whom 27,284 are men and 23,519 women; with an area of 1,678.28 square kilometers, Aysaita has a population density of 30.27. Ecologically, the Afar region is one of the unfriendly regions in the Horn of Africa. The total area of the region is around 108 860 km², and the number of inhabitants is approximately 1.4 million people, of which approximately 87% are living in rural areas (Population Census Commission, 2008). Pastoralism and agro-pastoralism are the two dominant modes of livelihood systems in Afar region. Approximately, 78% of the people depend on a subsistence pastoral production system, while the remaining 22% pursue agro-pastoralism. The Woredas where agro-pastoralism is common are located along the Awash Valley and those Weredas located adjacent to Oromia, Amhara and Tigray regions including, but not limited to Assayita Woreda. (Sonneveld *et al*., 2009). Furthermore, most of the commercial farming in the Afar region and sustenance irrigation crop farming have been possible due to the Awash and other rivers in the region. The inhabitants are also involved in other off-farm activities for income, such as charcoal making.

According to the 2007 Census, Asayita Woreda has a total population of 50,803, of which 27,284 are men and 23,519 women. With an area of 1,678.28 square kilometers, Assayita has a population density of 30.27 persons per square kilometers. While 16,052 or 31.60% are urban inhabitants, a further 9,358 or 18.42% are pastoralists. The Woreda has a total household size of 11,096 with an average of 4.6 persons to a household (CSA, 2007). Agro-ecologically, Asayita Woreda is categorized under arid and semi-arid, where livestock production is the main occupation of the community.

Based on Assyita Woreda 2016 report, on average a household has 1.78 hectares of land. Of the 5.39km^2 of private land surveyed, 71.59% has been under cultivation, 1.22% pasture, 31.06% fallow, and 4.54% was devoted to other uses; the percentage in woodland was missing. Land tenure in this Woreda is distributed between 66.49% own their land, 14.09% rent, and the remaining 19.42% are held under other forms of tenure. For the land under cultivation in this Woreda, 66.21% is planted in cereals like maize. About, 9.95% of the farmers both raise crops and livestock, while 25.79% only grow crops and 64.26% only raise livestock. Lack of access to basic infrastructure (road, market etc) and social service facilities (education, health, veterinary etc.) as well as local

saving and credit institutions have been common in the study area.

3.1.2. The Bio-Physical Environment

The Afar Region is both the hottest and driest part of the country. The major part of the region falls within the arid agro-ecological zone below 500 masl. The mean annual temperature of the region as a whole is 35 ℃. Rainfall is rather sparse and erratic. The mean annual rainfall varies from 500 mm in the south-west with less than 200 mm in the north-eastern part of the region. The temperature very much varies among seasons, and the months of December and January are comparatively cold months while June, July and September are the hottest ones. Bereha is the dominant agro climatic zone covering 99.33% of the region (ANRS, 2010).

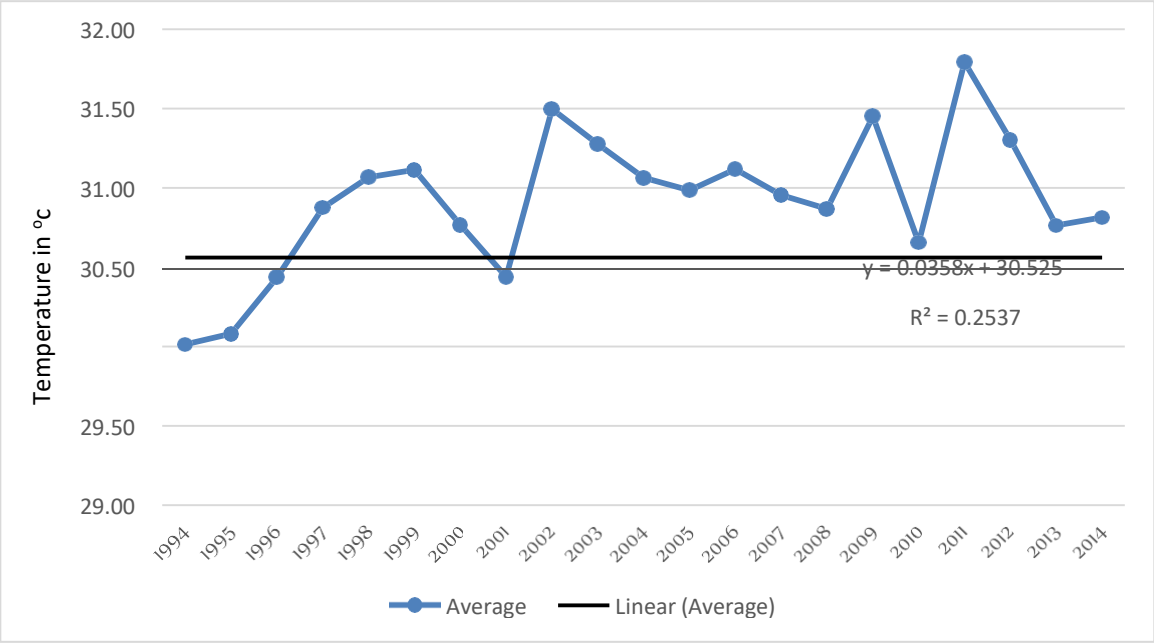
Natural resources such as water and forage vegetation play a key role in providing fodder and water points for livestock production in the region. The main vegetation covers are mostly associated with patterns of temperature and precipitation, with spatial variability due to soil and drainage factors. The southern and central parts of the western hills and plains have dense shrub and bushlands with a declining altitude and rainfall. According to Zerga (2015), grasses and browse species in a rangeland are the key sources of feed for livestock in the Southern Afar region. According to Simenew *et al*., (2013), out of the total area of the Afar region, shrub and bushland accounts 18.62%, forest 1.54%, marshy land 2.74, grassland 1.56%, cultivated land 5.24%, water bodies 0.63% and bare land 63.7%.

The study area, Aysaita is one of the Woredas in Afar region, which is located within the rift valley system. Its location connected with low altitude, makes it to have warm temperature. The average temperature of the area is about 31.1°C. The Woredas' location at low altitude and within the rift valley system makes it to have warm temperature with slight variations across seasons. Rainfall is bi-modal throughout the region with an average annual rainfall recorded to fall between 250 and 350mm. Rainfall is seasonal and the main rain, Karma accounts for most of annual rainfall occurring from mid-June to mid-September. Topographically, Aysaita and its surrounding area consist of basically flat landscape with some hills and small mountains. Besides, the Woreda is frequently hit by droughts causing a loss of livestock assets due to feed scarcity (Smith *et al.*, 2014).

3.1.3 Temperature and rainfall trend of Asayita woreda

Annual temperature trend:

Generally, the trend of temperature shows slight increment from year to year. The average temperature of the study area has increased by 0.72ºC in the past 20 years with an increment of 0.36ºC in every decades. On the other hand maximum and minimum temperature increased by 0.82ºC and 0.62ºC respectively in the past two decades.

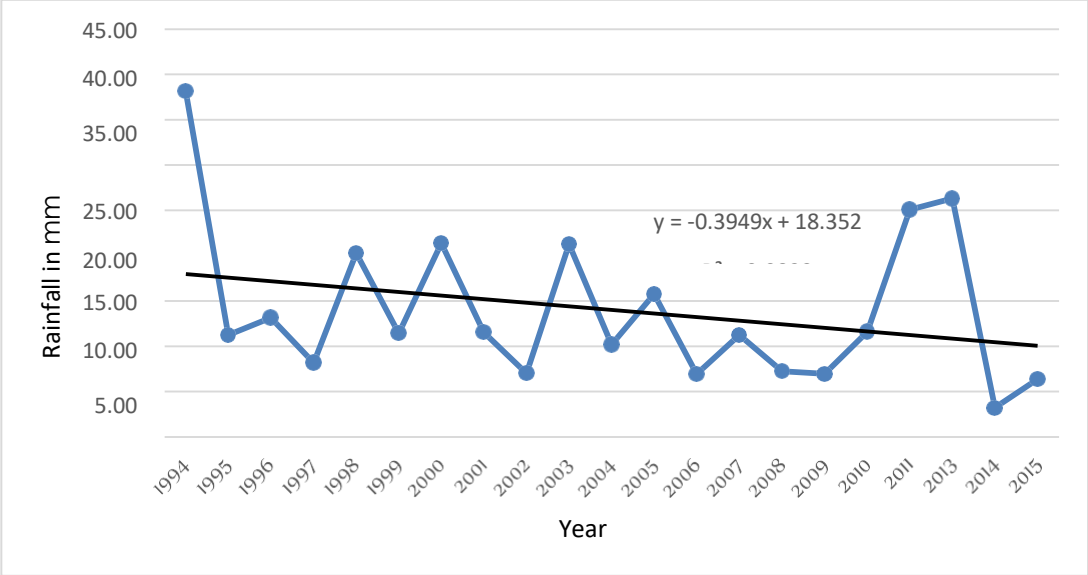


Source: NMSA 2017

Figure 2.2: Average temperature of Asayita woreda

Annual Rainfall Trend:

In Asayita woreda, for the period of 1994-2014, annual rainfall ranging from 0 mm to 38.1 mm with 1994 the moistest year and 1998 and 2015 the driest of all. The annual trend of rainfall in Aysaita woreda was 125.4 mm and the standard deviation was 61.6. When we compute the coefficient of variance account 49.1% which means this much amount of rainfall is deviated from the mean in the last 21 years. This has led pastoralist and agro pastoralist to be more vulnerable by decline of pastureland which was help them to get more fodder to their livestock from pasture land and crop productivity decrease due to inconsistency of rainfall (NMSA, 2017).



Source: NMSA 2017

Figure 3.3: Trends of mean Annual rainfall of Asayita woreda

3.2. Research Design

3.2.1. Sampling technique and Sample size determination

Purposive sampling was used to select the study woreda and simple random sampling approach was adopted to select sampling kebeles and households. Stratification was based on dominant livelihood activities practiced by households in the study area (Asayita Wereda). Firstly, Kebeles were identified and stratified into pastoralists and agro-pastoralists. Accordingly, from the study Wereda involving six pastoralist kebeles and five agro- pastoralist kebeles, two kebeles consisting of one pastoralist (Galifage) and one agro-pastoralist (Barga) kebele were randomly selected.

After random selection of the study kebeles, the total number of households was obtained from the wereda pastoral and agricultural development officer. The number of households currently living in these two Kebeles is 614, of which 492 are male-headed and 122 households are female-headed. In this study a simplified formula provided by Yamane (1967) was used to determine the required sample size at 95% confidence level, 0.5 degree of variability and 9% (0.09) level of precision. Hence, the required sample size (n) was determined as follows:

$$\mathbf{n} = \frac{\mathbf{614}}{\mathbf{1 + 614\ (0.09)^2}}$$

Where

- n is the sample size
- N is the population size (total household heads size), and
- e is the level of precision

Based the above formula, it is found out that the total sample size for this study was 102 households. Taking in to account the non-response rate, a 10% contingency was added on top of the determined sample size (102) and hence a total of 115 HHs were randomly selected from both livelihood groups based on their proportional size. A random start was used in selecting the first household to be interviewed. For the selected households whose heads were absent, next household was chosen and interviewed.

3.2.2. Data collection Methods and Tools

A structured questionnaire was administered through individual interviews with the heads of the households in the two kebeles of Asayita wereda. Data were collected regarding household characteristics, household's access to basic services, livelihood assets and their trends, the householders' annual income, and sources of income, climate change information, farm labor, social networks and remittances. The collected data were coded and thereafter analyzed using excel and STATA software (version 13.0). The PCA and regression analysis were also employed to achieve the objectives of this study. To complement the household questionnaire data, individuals from sampled kebeles and various organizations were interviewed as key informants. Two focus group discussions were piloted with gender equality from the sampled kebeles.

i. Reconnaissance visit

Initially, a reconnaissance survey of the study Woreda and sample Kebeles was conducted prior to commencement of the actual study. The objective was to meet participants like local administrators, extension officers and local elders, nongovernmental organizations and introduce the study objectives and collect preliminary information on the topic beforehand. The stakeholders involved in the informal introductory survey meeting was Woreda/kebele administration, pastoral and agriculture office, NGO staffs and experts including local elders. The reconnaissance survey was useful as it helped in providing more insights into areas that the stakeholders prioritized for the study assessment, which later enabled the researcher to better understand the peculiarities of the study area and identification of the local enumerator for the households' interview.

ii. Formal Survey

A semi structured questionnaire with open-ended, multiple-response and dichotomous questions were administered to household head during data collection. Information on various aspects was collected through interviewing of the selected household heads. The survey sought information about household characteristics, access to basic services, annual income, sources of income, farm labor, social networks and remittances including, but not limited to the information required to construct the household resilience index like adaptive capacity, social safety nets, assets, access to public service, income and food access, and stability. To avoid misunderstanding, household survey were undertaken in the local language by local field enumerators who are well versed with the local context and fluently speak the language.

Plate 1: Events during HH survey– 2019 Asayita

iii. Key informant interview and focus group discussions

To complement the household questionnaire data, individuals from the sampled Kebeles and various organizations were selected as per their roles and responsibilities and interviewed as key

informants. 15 respondents from local clan leaders, Woreda and regional level experts who had long experience about the local climate, resources, livelihoods, and policies were included in the key informant interviews. Four focus group discussions were conducted separately with each of the livelihood (two from pastoralists and two from agro-pastoralists) groups. The discussions were aimed at capturing the local knowledge on climate change and variability and its impacts on local communities' livelihood, resilience, adaptation and coping strategies.

Plate 2: Events during FGD, key informants interview and filed observation (P. Juliflora invading rangelands and farming area) – 2019 Asayita

iv. Field observation

Besides the researcher used field observation through transect walks in sample Kebeles to get some insights on the effect of climate-induced shocks and stresses on the biophysical and socio-economic environment including the status of rangelands and the livestock bases alongside with settlement patterns as well as traditional and government/donor-induced livelihood interventions implemented in the study area intending to build the resilience of pastoralist and agro-pastoralist communities or reduce their vulnerabilities to climate-induced shocks and stresses. The field observation helped to complement the information gathered through formal survey, key informant interview and focus group discussions.

v. Secondary Data

In addition to the above primary data, the study attempted to incorporate secondary data obtained from different sources such as project reports, Woreda and Kebele levels institutional or official documents and related supportive records on the climate trends of the area, the vulnerability context and the response strategies attempting to reduce vulnerability and/or improve resilience of pastoralists and agro-pastoralists.

3.3. Method of Data Analysis

3.3.1. Quantitative assessment of resilience of Households

In recent years, the quest to quantify individuals, households and society's resilience to disasters or extreme events beyond their control remains a challenge from a quantitative point of view. Given that the resilience of individuals, households and societies are not observed by the analyst, quantifying resilience demands a detailed modeling approach. Various authors have employed different modeling approaches (Alinovi *et al.,* 2008, 2010; Carter *et al.,* 2006; Demeke & Tefera, 2010). Alinovi *et al.* (2008, 2010) as well as Demeki and Tefera (2010) employed a latent variable approach to quantify resilience. These authors quantified resilience among households in Kenya and Palestine using a latent variable approach.

Carter *et al.* (2006) adopted a proxy variable approach by employing an observable variable to represent resilience. These authors assessed resilience and expressed it in six dimensions, which included social safety nets, public service accessibility, assets, income and food access, stability and adaptive capacity. They expressed these dimensions as latent variables. Following this, resilience was estimated in a two-stage procedure. The first estimation procedure involves the use of factor analysis to identify the set of latent variables explaining resilience. The identified latent variables in the first stage are then used to calculate an index for resilience for the sampled households.

The latent variable approach and PCA were employed by Demeke and Tefera (2010) to examine resilience to food insecurity in Ethiopia. These authors used panel data at a household level. They first identified four components that explained resilience to food security using PCA. These components included household access to food, liquid assets, level of education, and social network. Secondly, the authors employed panel fixed effect and dynamic panel modeling approaches to find factors that influence household resilience.

In Ethiopia, different coping strategies have been adopted by resilient households. Carter *et al.*

(2006) revealed that resilient households in Ethiopia relied on their assets and also depleted their stock in periods of drought, especially during the 1998–1999 drought periods. Similar strategies were employed in the Honduras in 1998 to minimize the impact of the Mitch hurricane. Households, who are not resilient, tend to cope by cutting down on their consumption level as a way of keeping their assets or properties.

Based on the discussion, it is clear that using a proxy variable approach is more appropriate method for calculating resilience. One limitation of this approach is the difficulty in identifying variables which will act as proxies for resilience. This is because resilience is a multifaceted concept. Additionally, there is difficulty in defining the levels or categorizing resilience and finding its determinants if the proxy variable approach is employed. For these reasons, it was decided to adopt the multi-stage modeling approach developed by Alinovi *et al.,* (2010), building on its flexibility to adapt to very different real cases. The use of this approach depended on the premise that the alternatives accessible to a household to make a living, would determine the household's resilience at a given point in time.

Empirically, the resilience index (RI) for a household (i) is described as:

$$\mathbf{R_i = f\ (IFA_i, A_i, APS_i, SSN_i, S_i, AC_i)}$$

Where:

R = resilience

S = stability

SSN = social safety nets

AP = access to public services

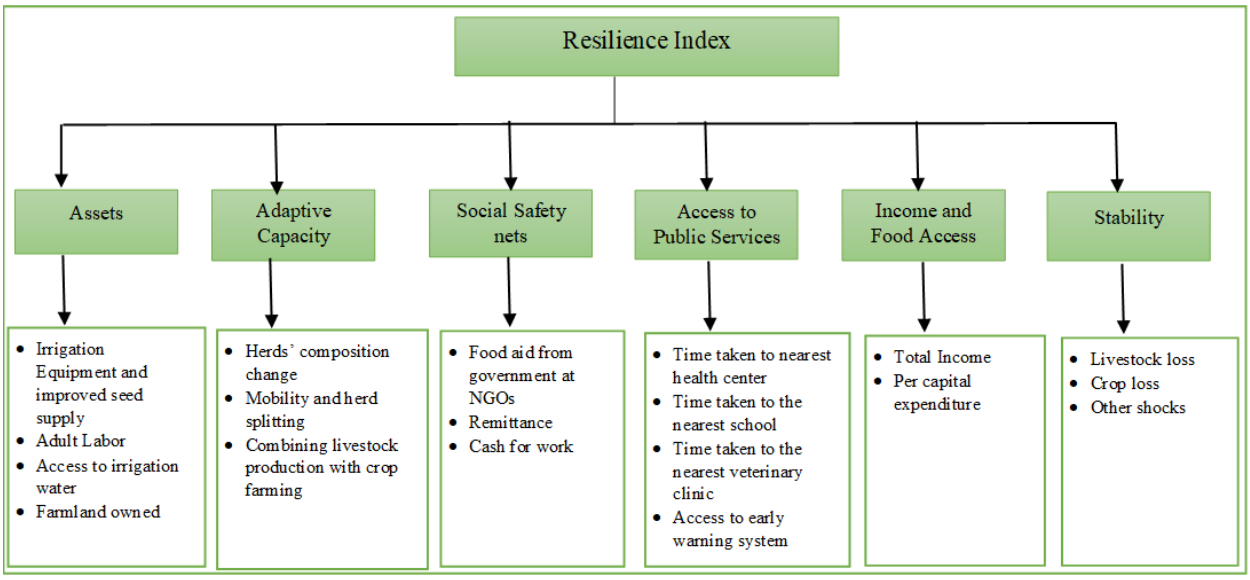
A = assets

IFA = income and food access

AC = adaptive capacity.

According to Alinovi *et al*. (2010), two options are adopted to estimate resilience of households. The first approach is structural equation models which are the utmost suitable models to determine resilience of households based on latent variables. This approach is based on regression and factor analysis. According to this model, observed variables are employed to estimate the latent variables using a factor analysis model, and concurrently a regression analysis is employed to determine relations amongst the latent variables (Bollen, 1989). A multi-stage strategy is the second alternative proposed by Alinovi *et al.* (2010) to estimate the latent variables

separately using observed variables.



Source: Adopted from Muluken (2017)

Figure 3.4*: The household resilience model diagram*

In this study, a two-step approach was employed to estimate the RI of households. The first procedure involved the identification and measurement of observed variables or indicators for the estimation of dimensions of the resilience. Secondly, the RI for each household was determined based on the estimated values of the latent variables (dimensions of resilience). PCA was used to examine the components of resilience and the percentage variance explained by each of the components, as well as their commonalities. According to the approach proposed by Alinovi *et al*. (2010), the factor variance obtained for each factor from the PCA was multiplied by the generated factor to develop the R of each household. The formula is described as follows:

$$\mathbf{R} = V_1 * F_1 + V_2 * F_2 + V_n * F_n$$

Where:

R = resilience

V_1 = variance of proportion explained by factor 1 (F_1)

V_2 = variance of proportion explained by factor 2 (F_2)

V_n = variance of proportion explained by factor n (F_n) with eigenvalues >1

3.3.2. Determinants of resilience of households to climate induced shocks

The determinants of resilience of households to climate-induced shocks and stress in the study

area were assessed based on the multiple linear regression (MLR) analysis. The MLR analysis tries to model the relationship between two or more independent variables and a dependent variable by applying a linear equation to observed data. In the present study, the response/dependent variable was the resilience of households. The MLR model has been used to determine the best linear combination of 115 heads of household for envisaging household resilience statuses. The MLR model is described as follows:

$$\mathbf{Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_n X_n + \varepsilon i}$$

Where:

Y= Resilience of households

$X_1 \ldots X_n$ = predictor variables

$\beta_o \ldots \beta n$ = Regression coefficients

ε_i = Random disturbance error

Table 3.1 Variables used in the econometric analysis to assess the determinates of resilience and their expected sign

Variable	Description	Measurement	Expected sign
Dependent variable (Resilience index)	Resilience status of a HH as calculated from the observed variables (latent)	Index	
Independent variables			
Irrigation	Household use Irrigation crop farming	Dummy: 1 if HH use irrigation and 0 otherwise	+
Livestock	Livestock ownership of HH in TLU	Continuous -	+
Veterinary	Access to veterinary	Continuous	+
Education	Education level of HH	Ordinal scale: 0 – illiterate, 1- read and write 2- primary, 3- secondary 4 – above secondary education	+

Health	HH Access to health facility	Continues	+
Income	Per capita income of HH in ETB	Continuous	+
CFW	Access to cash-for-work	Dummy: 1 if the HH receive cash and 0 otherwise	+
Mobility	Mobility and herd	Dummy: 1 if the household move from place to place and 0 otherwise	+
Herd	Herd composition	Dummy: 1 if the HH use different herd composition and 0 otherwise	+
Market	HH Access to livestock market	Continuous	+/-
Labor	Adult labor	Continuous	+
Remittance	Remittance	Dummy: 1 if HH receive remittance and 0 otherwise	+
EWI	Access to early warning	Dummy: 1 if the HH receive EW information and 0 otherwise	+
Extension	Access to extension	Ordinal scale:: 0 if the HH never received extension service 1 – rarely and 2 – regularly	+
Food Aid	Food aid	Dummy: 1 if the HH received food aid and 0 otherwise	+
Credit	Access to credit	Dummy: 1 if the HH received credit access and 0 otherwise	+

CHAPTER FOUR

4. RESULT AND DISCUSSION

This study determined the current status of resilience of pastoralists to climate-induced shocks based on cross-sectional data. As discussed in the methods section, household resilience to climate-induced shock was determined using a two-step approach developed by Alinovi *et al.* (2010). The first procedure involved the identification and measurement of observed variables or indicators for the estimation of RI. Secondly, the RI for each household was determined based on the estimated values of the latent variables using Thompson's regression method as proposed by Alinovi *et al.* (2010). In the first section, a general description of the surveyed households and the different dimensions used to estimate RI were provided. In the subsequent sections, comparison of resilience indices between pastoral and agro pastoral households, and the factors determining the resilience of households to climate induced shocks and stresses in the study area were discussed.

4.1 Descriptive statistics

The results indicated that the average household size in the study area was 6.8, which was higher than the national average rural household size (5.1) in Ethiopia (CSA, 2007). Such large family size in the region might be associated with the general perception on the socio-economic importance for parents and the cultural values associated with having large number of children, which is common to the whole Afar region. The average age of household heads was 48.2 years. Of the total sample households, 31.3% were female headed[1], while the rest perhaps the majority (68.7%) of the sample households were male headed households. Similarly, considerable proportion (60.9%) of the household heads were illiterate, which meant that only 39.1% of the respondents could read and write with formal primary education attainment ranging from 1 to 8 grade levels. Summary of the descriptive statistics is given in Table 4.1.

[1] *A female-headed household is defined as a woman who makes main economic decisions concerning the well-being of the household and who defines herself as head of the household*

Table 4.1: General characteristics of surveyed households

Characteristics	N	Minimum	Maximum	Mean	Standard deviation
Age	115	29	76	48.2	10.11
Household size	115	1	14	6.8	3.33
Dependency ratio	115	.00	4.0	2.4	1.01
Years of education	115	.00	10	.86	1.98

Source: Household survey (2019)

Access to basic services in the study area was generally poor. However, 82.2% of the households had access to livestock markets relatively near their villages since Asayita is one of the major livestock market in the region. Furthermore, 89.6% of households received informal market information about the price prior to selling through an informal local information exchange system (locally called *Dagu*). Only 10.4% of households received formal market information through Wereda extension officers and the radio. Therefore, there is a need to provide formal market information to enhance the resilience of pastoralists and agro-pastoralists towards climate related shocks and stresses.

Moreover, the results revealed that only 28.7% of households had access to extension services, indicating that access to extension services in the study area was poor. The results further indicated that households' access to credit (14.8%) was also poor in the study area. The results further showed that 30.4% of the sample households had access to veterinary services and 32.2% households had access to the health center and basic health services summary of the descriptive statistics is given in Table 4.2.

Table 4.2: Household access to basic services

Basic services	Percentage of households
Access to market	82.2%
Access to extension	28.7%
Access to credit	14.8%
Access to health center	32.2%
Access to veterinary services	30.4%

Source: Household survey (2019)

In addition, about 90% of all HH assessed a decline in livestock number, irrespective of the species. Therefore, the current average numbers of livestock per household are significantly lower than in the past so that many households depend on food aid. The average numbers of camel and cattle, the most important animals for milk production, were found to be about three to five head of camel as well as three to five heads of cattle per household. The total number of cattle, shoat (sheep and goat) and camels were computed in Tropical Livestock Unit (TLU), where 1 TLU is equivalent to 250 kg of livestock using factors 0.7, 0.1 and 1.25, respectively (ILCA, 1990).

Table 4.3: Average livestock holdings per household in TLU

Herd species	Mean	Standard deviation
Cattle	3.6	2. 1
Camel	4.5	4.8
Sheep	3.1	2.4
Goat	18	9.3

Source: Household survey (2019)

According to Sanford and Habtu (2000), a 5–15% decline of livestock assets happened in Afar due to the drought of 1999/2000. During a severe drought, the mortality of livestock was estimated to range between 15% and 45%. As reported by same authors, 42% of the respondents, pastoralists were also negatively affected by floods. As a result of the declined livestock numbers and productivity over time, some households started cropping using small-scale irrigation along the banks of the Awash River. Recently, the pastoralist and agricultural development office together with NGO support began organizing households into cooperatives and delivers agricultural inputs and improved crop varieties. The results indicated that out of 115 sample households, 45.2% practiced crop cultivation along the Awash River (Table 4.4).

Table 4.4: Household groups based on livelihood strategies

Livelihood Groups	Frequency	Percent
Pastoralists	63	54.8%
Agro-pastoralists	52	45.2%
Total	**115**	**100.0**

Source: Household survey (2019)

On average, the agro-pastoral households owned 1.45 hectares of farmland. In this regard, some key informants complained that total shifting to crop farming is risky as practicing irrigation farming along the river banks involves the risk of flash floods due to the overflow of Awash River resulted from occasional heavy storms. On the other hand, livestock production as the sole livelihood strategy is also becoming a risky enterprise associated with recurrent drought and high seasonal, annual and spatial variability of rainfall.

In this study, the annual income of households was calculated and the results revealed that the minimum annual income of pastoral households as Ethiopian Birr was 1,100 and the maximum was 12,250 while the minimum and maximum annual income for agro-pastoral households were 3,540 and 7, 740, respectively. The average annual income of the pastoral households was 4,242, while that of the agro-pastoral households was 5,425.6

Table 4.5: Average income (ETB*) of pastoral and agro-pastoral households

Livelihood Groups	Minimum	Maximum	Mean	Standard deviation
Pastoralist	1,100.00	12, 250.00	4,242.00	2417.38632
Agro-pastoralist	3,540.00	7,740.00	5,425.60	1224.22219

*Exchange rate for May 2019: Ethiopian Birr (1 US$= 28.54 ETB) **Source: Household survey (2019)**

Furthermore, the average livestock holding of pastoralist HHs and agro-pastoralist HHs was 14.6 TLU and 11.3 TLU, respectively, which showed a significant difference between the two livelihood groups in terms of livestock holdings. Perhaps, the low livestock holdings of agro-pastoralists might be attributed to the sharing of production inputs such as labor, land, between livestock and crop production. However, the total annual income of agro-pastoral households was significantly higher than pastoral households, indicating the positive effect of livelihood diversification on income level of households.

4.2 Observed variables and factor loadings used to measure resilience components

This section discusses the findings on how the observed variables contributed to measuring the value of the latent variables representing the resilience components. The PCA was used to estimate the components of resilience (the latent variables). The approach depended on the premise that the alternatives accessible to a household to make a living determined the household's resilience at a given point in time. The RI was determined based on six dimensions

(latent variables) including assets (A), adaptive capacity (AC), social safety nets (SSN), access to public service (APS), stability (S), and income and food access (IFA).

4.2.1. Asset (A)

Assets are one of the most important capitals households have as an adaptation/coping mechanism to hazards. Hence, assets should be taken as a key factor in measuring resilience. The indicators for this latent variable are discussed as follows:

i. ***Livestock owned in tropical livestock unit (TLU)*:** This is a materialized asset owned by a household. By having more assets a household's resilience to climate-induced shocks increases. Those households with more livestock will have more opportunities to recover after climate-related hazards.

ii. ***Farmland owned (ha)*:** Households practicing crop farming using irrigation agriculture and livestock production may have better resilience to climate shocks than households solely dependent on livestock production.

iii. ***Adult labor:*** Those households with a better working force can have better livelihood outcomes and more resilience.

iv. ***Access to irrigation water:*** This is also a crucial asset, especially for pastoralists who are vulnerable to frequent and prolonged drought and where there is increasing climate variability. Therefore, households having access to irrigation water can have the opportunity to diversify their livelihood strategies and easily adapt to climate-induced shocks. It is a dummy variable equal to 1 if the household has access to irrigation water in the previous year; 0 otherwise.

v. ***Access to irrigation equipment and improved seed varieties*:** This is critical for agro-pastoralist households. Water pumps for irrigation and improved seed varieties, which can resist droughts and diseases as well as early maturation for harvest, increases efficiency of households to adapt to prolonged and recurrent droughts. The value of this indicator was log of the monetary (Eth.Br.) value of farm implements (equipment) owned by households.

vi. ***Access to credit*:** The value of this indicator is 1 if the household had affordable credit access in the last five; 0 otherwise.

As shown in Table 4.6 below, all the values of the variables under agro-pastoralist are characterized by a fair degree of similarity. The results indicated that all variables had positive impacts on the assets of households. However, the impacts of irrigation equipment and improved seed supply, access to irrigation water, and farmland-owned had a negligible impact on the assets of pastoralists. This was explained by pastoralists exhibiting little or no participation in crop farming. On the other hand, labor availability, livestock ownership and access to credit were more relevant and have important influences on pastoralists' assets. Similarly, labor availability and livestock ownership were also significant for the assets of agro-pastoralists. Access to credit also influenced assets of both pastoralists and agro-pastoralists. Farmland ownership, access to irrigation water and inputs such as access to irrigation equipment, and improved seed supply were more important for agro-pastoralists.

Table 4.6: Contribution of observed variables to estimate asset (A) by livelihood groups

Variables	Livelihood groups	
	Agro-pastoralist	**Pastoralist**
Irrigation equipment and improved seed supply	0.701	0.189
Adult labor	0.690	0.788
Livestock owned (TLU)	0.801	0.963
Access to irrigation water	0.799	0.132
Access to credit	0.720	0.711
Farmland owned (ha)	0.887	0.250

Source: Household survey (2019)

4.2.2. Adaptive capacity (AC)

Adaptive capacity shows the ability of a household to adapt and cope with a hazard, in this case, climate-induced shocks and stresses such as drought, floods and climate variability. It enables households to continue performing their basic functions. The following observed variables were included to estimate adaptive capacity for this specific study area.

i. ***Diversity of income sources:*** Refers to the number of income sources for the household. The more income sources, the more resilience the pastoralists have to a given climate-induced disaster and risk.

ii. ***Changing herd composition:*** The value of this indicator was 1 if the household had changed his/her herd composition from keeping higher numbers of cattle and sheep, but lower numbers of camels and goats to higher numbers of camels and goats production but lower numbers of cattle and sheep in the previous year; 0 otherwise.

iii. ***Herd mobility:*** The value of this indicator was 1 if the household used mobility as coping strategy to climate shock; 0 otherwise.

iv. ***Irrigation farming:*** The value of this indicator was 1 if the household used irrigation farming as an adaptation strategy to climate shock; 0 otherwise.

v. ***Access to extension service:*** The value of this indicator was an ordinal scale ranging from 2 (regularly) to 0 (Never), and 1 if household heads responded that they have access to extension services, but sometimes.

vi. ***Education level:*** In this case, households were grouped based on their education level as illiterate (the value of this indicator was 0), only read and write (the value of this indicator was 1), those who completed primary education (the value of this indicator was 2).

Table 4.7 below indicates the results of the factorial analysis to estimate the adaptive capacity of pastoralists and agro-pastoralists. The results revealed that changes in herd composition, mobility and herd splitting were more important for pastoralists and households in Asayita Woreda. However, herd composition change was considered as low adaptation strategies by agro-pastoralists. The results further indicated that combining livestock production with crop farming and income diversification were more important for the resilience of agro-pastoral households. On the other hand, access to education, extension and credits influenced the latent variable, adaptive capacity in a similar degree across both livelihood groups.

Table 4.7: Factorial analysis to estimate adaptive capacity (AC) of households

Variables	**Livelihood groups**	
	Agro-pastoralist	**Pastoralist**
Herds composition/livestock species change	0.354	0.943
Mobility and herd splitting	0.635	0.894
Combining livestock production with crop farming	0.951	−0.183

Access to extension & credits	0.674	0.588
Level of education	0.641	0.509
Number of income sources	0.743	0.433

Source: Household survey (2019)

Elderly pastoralist comment on herd mobility during FGD at Galifage Kebele

> "Our place here used to be a Dry season grazing area, pastoralist used to come over here from Chifra, Ewa, Bidu.Teru and other areas to graze their animal during dry season, we also move to those places during wet season since Awash River overflow. However, since the plantation of sugarcane started we stopped going and they also stopped coming because we doesn't have as much grass as it used to have before the beginning of the sugar project". Therefore, the recent government lead development measure is also affecting our pastoral way of life negatively. (Elder from Galifage, 2019)

4.2.3. Social safety nets (SSN)

This is an important dimension of household resilience, particularly the poor, because social safety nets assist in reducing crises. Recently, because of mounting poverty, dependence of households on support from charities, non-governmental organizations and other international development partners have increased in Asayita Woreda in particular and Afar region in general. The mutual support among relatives, friends and neighbors was still significant according to the qualitative information obtained from key informants and focus group discussions. Thus, it is important to consider social safety nets to represent the system's ability to reduce climate shocks, and indicators for social safety nets should be involved in the measurement of household's resilience. The indicators or observed variables used to estimate the social safety nets were:

i. ***Free distribution of food/grain from government or NGOs***: The value of this indicator was 1 if the household received food/grain support; 0 otherwise.
ii. ***Remittance:*** The value of this indicator was 1 if the household received cash and in-kind assistance from friends, communities, and relatives; 0 otherwise.
iii. ***Cash-for-work:*** Included transfers received by households from international agencies, charities and NGOs. The value of this indicator was 1 if the household received cash from international agencies, charities and NGOs; 0 otherwise.

The factor loadings of the observed variables used to estimate social safety nets are indicated in *Table 4.8*. The latent variable was not influenced by the observed variables to a similar degree

across the pastoral and agro-pastoral livelihood groups. The observed variables were relatively more important to influence the social safety nets of pastoralists than agro-pastoralists. This implied that pastoralists were more dependent on social safety nets than agro-pastoralists.

Table 4.8: Factor loadings of the observed variables to measure social safety nets (SSN)

Variables	Livelihood groups	
	Agro-pastoralist	**Pastoralist**
Food aid from government or NGOs	0.531	0.829
Remittance	0.542	0.749
Cash-for-work	0.513	0.898

Source: Household survey (2019)

4.2.4. Access to public services (APS)

Access to public services provides pastoral households with numerous essential factors for improving their resilience by enhancing the efficiency of pastoral households' access to public services. The following indicators were considered to estimate access to public services:

i. ***Time taken to nearest health center:*** In this case, the value of the indicator is the time that it takes to walk to the nearest health center. Those households near to the health center can have better access to health, which is important in building resilience. Household members can accomplish their livelihood activities successfully if they are healthy.
ii. ***Time taken to nearest market center:*** The value of this indicator is the time that it takes to walk to the nearest market center. Distance to the market also influences resilience of households negatively or positively. Households who are near to the market center can easily buy and sell their agricultural inputs and outputs. This, in turn, increases their adaptation to shocks and stresses.
iii. ***Time taken to nearest veterinary clinic:*** The value of this indicator is the time that it takes to walk to the nearest veterinary clinic. Households with better access to a veterinary clinic can have a better livestock asset as they have a more opportunities to reduce livestock death associated with disease outbreaks, than households with low access to a veterinary clinic.
iv. ***Time taken to the nearest school:*** The value of this indicator is the time that it takes to walk to the nearest school. Access to schools increases the number of children obtaining an education, which in turn, increases the human capital of households. The higher the

human capital of households, the more they have the ability to diversify their livelihood activities and, hence, the higher the resilience of households.

v. ***Access to early warning information (EWI):*** This is an important element of disaster prevention and management, which provides information to pastoralists before the occurrence of a climate-related hazard. Households who are better informed about a coming drought may destock their livestock at a good price before its occurrence and can have a better recovery capacity after drought. The value of early warning information was 1 if the household received such a warning from the Woreda Disaster Prevention and management unit in the survey year; 0 otherwise.

Accesses to public services are beyond the household's control, but are important in building household resilience to climate-induced shocks by enhancing economic connectivity through market access. The economic connectivity of a household is its ability to be connected to several markets and income-generating opportunities. Access to public services also increases the household's access to assets by increasing human capital of households through increasing access to health and education. Table 4.9 reveals that all observed variables in both livelihood groups have similar patterns and influenced access to public services positively. However, the observed variables were more important relatively for enhancing resilience of agro-pastoralists than pastoralists. This implies that there were inequalities in accessing public services among the two livelihood groups. For example, the factor loading for the time taken to the nearest school was 0.45 for pastoralists implying access to school for pastoralists were poor as compared to agro-pastoralists. However, access to early warning information was almost equally important in enhancing the resilience of both livelihood groups.

Table 4.9: Access to public services (APS) and factor loadings across livelihood groups

Variables	Livelihood groups	
	Agro-pastoralist	Pastoralist
Time taken to nearest health center	0.623	0.514
Time taken to the nearest school	0.520	0.451
Time taken to nearest market center	0.636	0.576
Time taken to nearest veterinary clinic	0.755	0.623
Access to early warning systems (EWI)	0.653	0.512

4.2.5. Stability (S)

Stability is an important component for resilience of pastoral and agro-pastoralists, which shows how the livelihood options of the household differ over time. The asset losses experienced by a household were taken into account to measure the value of this variable.

i. ***Livestock loss*:** Refers to the number of livestock that a household lost as a result of a climate-induced hazard such as drought and floods over the past five years.

ii. ***Crop loss*:** Refers to crop loss due to climate-induced hazards such as drought and floods over the past five years.

iii. ***Other shocks*:** Refer to market shocks, illness and death of a household family member associated with climate-induced shocks in the past five years.

The observed variables used to measure stability were instability indicators. Then, each indicator was multiplied by -1 in order to make them consistent with the meaning of the latent variable stability. *Table 4.10* reveals that stability across pastoral and agro-pastoral households was highly influenced by livestock losses, crop losses except in primary pastoralists, and other shocks such as market instability. This implies that climate-induced livestock and crop loss as well as market failure were common in the study area.

Table 4.10: Factor of stability (S) and their relative loadings

Variables	Livelihood groups	
	Agro-pastoralist	**Pastoralist**
Livestock loss	0.741	0.952
Crop loss	0.754	0.213
Other shocks	0.613	0.667

4.2.6. Income and food access (IFA)

Income and food access is directly linked to the resilience of a household. Those households with better resilience to shocks have better access to food (Alinovi *et al*., 2010). Usually, food access is estimated by income; however, to better measure the general feature of access to food, per capita expenditure was included in estimating income and food access:

i. ***Total income:*** Refers to the total annual income (in Ethiopian birr) of a household from all income sources.

ii. ***Expenditure:*** Refers to the average portion of the income expended by households for foodstuffs and consumption (in Ethiopian birr).

The communalities of the observed variables to measure income and food access in Table 4.11 show that the share of per capita income to food access was relatively low for pastoralist groups. This indicated that the role of per capita income was too low to estimate the income and food access indicator in the case of pastoralists. Similarly, the values of per capita expenditure were characterized by a fair degree of homogeneity across pastoral and agro-pastoral livelihood groups, except for pastoralists, which meant that all values of per capita expenditure contributed in a similar degree to estimate the income and food access dimension.

Table 4.11: Observed variables and their factor loadings to estimate income and food access (IFA)

Variables	**Livelihood groups**	
	Agro-pastoralist	Pastoralist
Total income	0.501	0.443
Per capita expenditure	0.612	0.526

Source: Household survey (2019)

> "The poor ones survive with this small food aid they get from the government for some months and when their food is finished they depend on the support of those rich ones among us. Afars have the tradition of helping each other and that is how they survive. Another means of survival is the small agricultural produce despite the challenge of water shortage for agriculture activities. The little bit of rain makes the land to grow grass and waters our agriculture. After eating the grass our animals produce some milk and our agriculture give us some grain with which we survive for some time"
>
> (FGD Berga Kebele, 2019).

4.3 Measuring Resilience Index

Following the methodology used by Alinovi et al. (2010), the factors of the resilience components were used to compute the overall RI of households. The latent variables measured in the above sub topics came to be the explanatory variables to measure RI. Using the iterated principal factor method, factor analysis was run to re-estimate communalities iteratively.

Table 4.12 indicates the first factors that seem to represent the resilience of households fairly well, although social safety nets were not positively correlated to the first factors indicating its negative

correlation with other variables. As households become poorer, the availability of social safety nets from members of the society, government or NGOs increases. The social safety nets had a positive contribution to the household's resilience to climate-induced shocks and hence became positive in the second factor. Adaptation strategies followed by the households' assets were the most important components of the resilience of pastoral households.

Table 4.12: Factor loadings of the components of resilience

Variable	Factor 1	Factor 2	Factor 3
Asset	0.7350	−0.0053	0.1001
Adaptive capacity	0.8470	0.0330	0.0034
Access to public services	0.5630	0.1300	0.0234
Social safety net	−0.4570	0.6560	0.1230
Stability	0.6820	0.3340	0.0030
Income and food access	0.5500	0.0680	0.0340

Source: Household survey (2019)

Table 4.13 below reveals that factor 1 alone explains 57.1% of the variance, while factors 2, 3, 4 and 5 explains 17.4%, 12.2%, 11.1% and 2.1% of the variance, respectively. For resilience measurement, the first four factors that explained 97.85% of the variance were included.

Table 4.13: Eigen values and variances explained by the components of resilience

	Eigen values	% variance
Factor 1	2.805	57.101
Factor 2	1.901	17.413
Factor 3	0.905	12.221
Factor 4	0.704	11.124
Factor 5	0.1963	2.141

Source: Household survey (2019)

Factor 1 includes adaptive capacity (AC) and assets (A), while Factor 2, 3, 4 and 5 include social safety nets (SSN), access to public services (APS), stability (S) and income and food access (IFA), respectively. The Thompson's regression method developed by Alinovi *et al.* (2010) was employed to generate the four factors in order to estimate resilience of pastoral households. Once the four factors had been generated, each factor was multiplied by its own proportion of variance explained as:

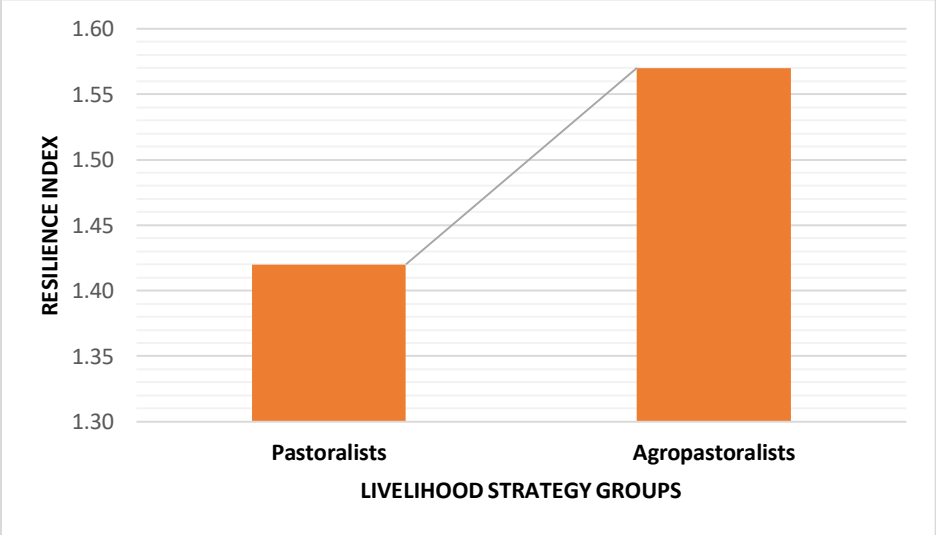
Resilience = 0.571 * Factor 1 + 0.174 * Factor 2 + 0.122 * Factor 3 + 0.111 * Factor 4

Households were clustered with livelihood groups and gender of the household head, in order to discuss the estimated RI.

3.4. Resilience Indices of Pastoral and Agro-pastoral Households: A comparative Analysis

Analyzing resilience by livelihood groups indicated that agro-pastoral households were more resilient than pastoral households (Figure 4.1 below). The higher resilience of agro-pastoral households can be explained by their small-scale irrigation crop farming activities in addition to livestock production. According to respondents, since livestock numbers and productivity declined over time due to the number of dry spells and recurrent droughts in the area, some households started cropping using small-scale irrigation to complement pastoralism. The results indicated that out of 115 households, 45.2% practiced crop cultivation along the banks of the Awash River.

Figure 4.5: Resilience index by livelihood strategy groups



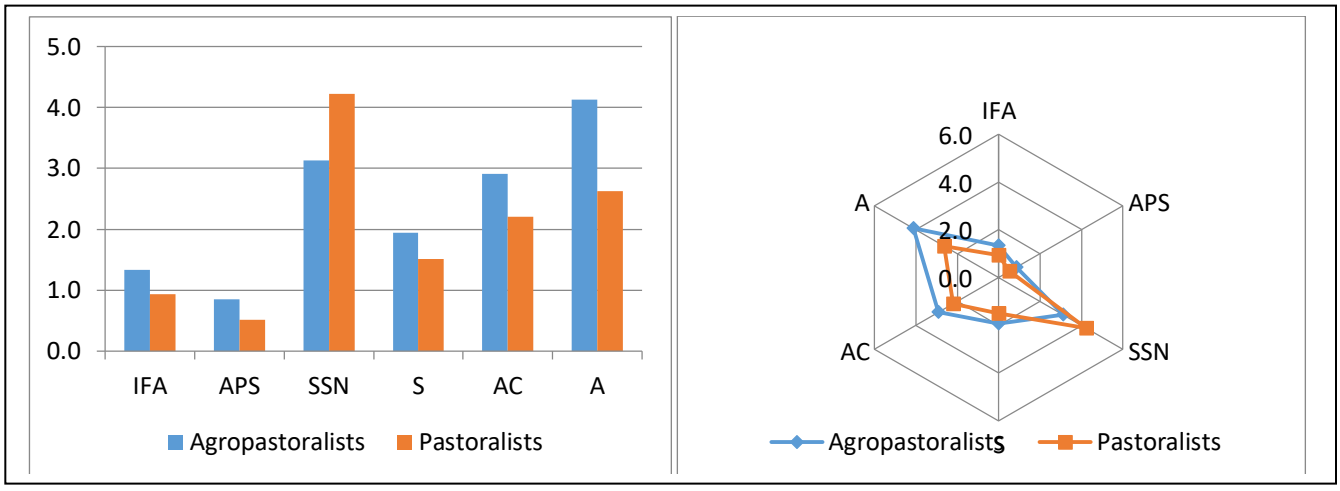
Source: Household Survey (2019)

In this study, the annual income of households was calculated and the results revealed that the minimum annual income of pastoral households as ETB was 1,100 and the maximum was 12,250 while the minimum annual income for agro-pastoral households was 3,540 and the maximum was 7,740. The average annual income of the pastoral households was 4,242, while that of the agro-pastoral households was 5,425.60. Significant differences were observed between the *per capita* income of agro-pastoral households and pastoral households, indicating that the *per capita* income level of agro-pastoral households was significantly higher than that of pastoral

households. Obviously, those households with a better income level could be more resilient to climate shocks and stress than households with a low level of income.

The findings further revealed that although variations among resilience strategies of pastoralists and agro-pastoralists were observed, limited access to food and income and poor access to public services (access to market, health, EWI) was observed across both livelihood groups. Pastoralists showed very low level of resilience, which can be explained by low levels of all resilience components, except social safety nets indicating the worst situation of pastoralists (Figure 4.3 below). Similar findings were reported by Alinovi *et al*. (2010) who revealed that pastoralists in Kenya were less resilient than agro-pastoralists, although the resilience difference was not significant. Agro-pastoral households showed relatively high levels of resilience, which was highly dependent on assets and adaptive capacity, it was also characterized by low stability and poor access to public services and limited access to food and income (Figure 4.3 below).

Figure 4.6: Resilience components by livelihood strategy groups



Source: Household Survey (2019)

2.3. Determinants of resilience of households to climate-induced shocks

The determinants of resilience of households to climate-induced shocks in the study area were assessed based on the multiple linear regression (MLR) analysis. The MLR analysis tries to model the relationship between two or more independent variables and a dependent variable by applying a linear equation to observed data. In the present study, the response/dependent variable was the resilience of households. The MLR model has been used to determine the best linear combination

of 115 heads of household for envisaging household resilience statuses. The MLR model is described as follows:

$$\mathbf{Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \cdots \beta n Xn + \varepsilon_i}$$

Where:

Y = Resilience of households $X_1 \ldots X_n$= predictor variables

$\beta_o \ldots \beta n$ = Regression coefficients

ε_i = Random disturbance error

The findings indicated that the coefficient of multiple determinations is R2 = 0.864 and the adjusted multiple determination is Adjusted R2 = 0.852. Therefore, about 85.2% of the variations in the level of household resilience were due to the explanatory variables included in the model. Based on the value of R2, the regression equation model could be used in making predictions of the factors affecting household's resilience to climate-related hazards. The linear regression's F-test has the null hypothesis that the linear correlation coefficient is zero. In this model it can be accepted that there is a linear relationship between the variables since the F-test is highly significant ($F = 126.25$; $p < 0.001$).

Furthermore, in this study the Durbin−Watson test ($d = 2.23$) indicated no autocorrelation. Since d is approximately equal to 2 (1 − r), where r is the sample autocorrelation of the residuals, $d = 2$ showed no autocorrelation (Durbin & Watson, 1971). Also, a formal detection-tolerance and the variance inflation factor (VIF) were carried out to test for multicollinearity among independent variables. The results indicated that multicollinearity among independent variables was not observed as the tolerance levels, on average, were 0.53 which is >0.2 and the VIF were 2.17 which is <5 (Table 4.14). According to O'Brien (2007), multicollinearity among independent variables can be reported if a tolerance of less than 0.20 or 0.10 and/or a VIF of 5 or 10 are detected during regression analysis. Hence, the model used is acceptable.

The results indicated that irrigation crop farming, livestock ownership, education level, per capital income, mobility and herd splitting, herd composition change, labor, remittance, food aid, access to credit, access to market and access to formal early warning information had a significant impact on the resilience of households to climate- induced shocks. The regression coefficient of 0.192 in Table 4.14 implies that the odds of those households who practiced irrigation crop farming were 0.192 times more resilient to climate-induced shock than those households who did not practice irrigation crop farming. The present findings are supported by Radeny *et al.* (2006) who

indicated that those people who pursued off-farm and farm livelihood activities were more resilient than their counterparts. Similarly, the results showed that livestock assets owned by a household had positive and significant impacts on household resilience, as expected. The analysis showed that the odds of a household to be resilient to climate shocks increase by 0.171 for a unit increase in the number of livestock. That is, those households having more livestock will have more opportunities to recover from climate-related hazards. This study is also supported by the findings reported by Feleke *et al.* (2003) who indicated that a livestock asset was positively related to the probability of a household being resilient to food insecurity.

The results further indicated that the odds of a household to be resilient to climate shocks increase by 0.249 for a unit increase in its income level. A similar study was reported by Omotesho *et al.* (2006) who indicated that the per capital income of households significantly affected the household's resilience to food insecurity.

Table 4.14: Estimated results for the determinants of household's resilience

Explanatory Variables	Under-standardized Coefficients		Standardized Coefficients	T	Collinearity statistics	
	B	Standard error			Tolerance	VIF
Constant	0.052	0.023	**	2.488		
Irrigation crop farming	1.240	0.231	0.192***	5.441	0.523	2.429
Livestock ownership	0.128	0.040	0.171**	3.134	0.721	3.869
Access to veterinary	0.073	0.289	0.006	0.253	0.631	2.310
Education level	0.801	0.230	0.128**	3.553	0.831	1.735
Access to health	0.246	0.162	0.073	1.518	0.413	1.346
Per capita income	1.769	0.217	0.249***	7.921	0.693	3.903
Access to cash for work	0.288	0.198	0.064	1.402	0.743	1.551
Mobility and herd	1.757	0.179	2.56***	8.784	0.632	2.801
Herd composition	1.334	0.384	0.242***	5.285	0.568	3.482
Access to market	1.342	0.234	0.243***	6.111	0.822	1.332
Adult labor	0.851	0.251	0.134**	3.401	0.448	1.668
Remittance	1.110	0.232	0.163***	5.201	0.571	1.317
Access to early warning	0.859	0.269	0.131**	3.112	0.635	2.349
Access to extension	0.068	0.139	0.011	0.498	0.750	1.279
Food aid	0.127	0.033	0.378**	4.242	0.679	1.311
Access to credit	0.631	0.162	0.132**	4.071	0.469	1.191

Source: Household survey (2019)

R-Square = 0.864; Adjusted R-Square = 0.852; F-statistic = 126.25, Prob (F-statistic) = P< 0.001; Number of observations = 115; Durbin−Watson =2.23, **** and ** indicates significance levels at 1% and 5% probability levels, respectively.*

The regression coefficients indicated in Table 4.14 also indicated that education level and *per capita* income were positively and significantly correlated to the odds that a household would be resilient. The odds of those households who can read and write and those who had primary education were 0.128 times more likely to be resilient than those households who were illiterate. This can be explained by the more years the head of the household spent at school, the more the skill and knowledge the household will have to manage climate-induced hazards.

Therefore, educated households have a great opportunity to pursue less climate sensitive livelihoods than uneducated households. Similar studies conducted by Haile *et al.* (2005) indicated that in the Oromia regions of Ethiopia, a change in level of education from illiterate to literate caused an increase in the likelihood of a household being food secure from 0.14 to 0.325. This study is also supported by the findings reported by Deressa and Hassan (2009), who indicated that education enhances the probability of household resilience to climate-induced shocks and stresses.

Herd mobility and herd species composition changes were crucial resilient strategies in pastoral communities of the study area, Asayita to utilize the seasonal, annual and spatial variability of rangeland resources and to cope and recover from the recurrent droughts. The results showed that changing species composition of herds and mobility had an affirmative and important influence on the resilience of the pastoralists. The odds of those households who use mobility and herd splitting, and change in herd species composition as a resilient strategy is respectively 2.56 and 0.242 times more resilient to climate-induced shocks than their counterparts (from table 4.14).

Moreover, households can use cash/livestock transfers from their family, relatives, community and friends outside the community or food aid from charities, NGOs and the government in times of need during climate-induced shocks such as weather-related loss of livestock, death or sickness of family members and during food crisis. Remittance and food aid also positively and significantly impact household resilience to climate-induced shock. The coefficient for remittance of 0.163 in Table 4.14 above suggests that those households who received remittance, for a unit increase in the amount of transfers, their probability to cope and recover from climate-induced shocks such as drought, increased by 0.163. Similarly, those households who received food aid are 0.378 times more likely to cope and recover from climate-induced shock, implying that food aid was significant for households to cope with the food crisis during drought periods.

However, it is better to assist households to produce more food than receiving food aid in order to enhance their long-term resilience to climate- induced shocks. Then they can absorb the food crisis by themselves using their own food stock during drought periods. This is in line with, Frankenberger *et al.* (2012) reported other strategies that could enhance the resilience of vulnerable populations which include increasing access to communal assets, consolidating the capacities of formal and informal institutions, assisting livelihood diversification, resolving disputes and rehabilitations of degraded ecosystems.

Furthermore, access to family labor enables households to pursue their livelihood activities successfully and use enhanced technologies which can lead to higher yields. The result indicated that labor availability positively and significantly impacted the resilience of households and, as indicated in Table 4.14 above, the coefficient 0.134 implies that a unit increase in access to labor for a household increases the probability of the household by 0.134 times to be more resilient. The findings reported by Asenso-Okyere *et al.* (2013) revealed that those households with better access to labor availability were more likely to be resilient to climate-induced shocks.

Moreover, the findings revealed that a household's access to credit has an affirmative and significant relationship with their resilience. The result in Table 4.14 above implies that the more the household is likely to get credit access, the higher is the probability of the household by 0.132 times to be resilient to climate-induced shocks. Access to affordable credit is crucial for pastoralists to pass through droughts. Access to credit enables households to have bargaining power to wait for better times and receiving good prices for selling of their livestock. Access to credit also enables households to pursue non-pastoral livelihood activities. Similar results were reported by Hassan and Nhemachena (2008) who indicated that access to credit enables households to shift their livelihood strategies in light of climate shocks and stresses.

The results also indicated that access to market and formal EWI were significant factors influencing of household resilience. The coefficient 0.243 in Table 4.14 for market access implies that a decrease in a one-hour travel from the household's residence to the market center increases the likelihood of household resilience to recover from the climate shock by 0.243. Similarly, the coefficient 0.131 for early warning information infers that the likelihood of being resilient to climate-induced shocks increases by 0.131 for those households who have access to formal early warning information. During FGD and KI interview it was found that Afar community is well known by its informal communication mechanism called "Dagu" to exchange information.

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. CONCLUSIONS

- The results indicate that pastoralists were less resilient than agro-pastoralists, which was largely attributed to low level of Adaptive capacity and Assets owned by pastoralists.
- The higher resilience of agro-pastoral households can be explained by their small-scale irrigation crop farming activities in addition to livestock production.
- Pastoralists showed very low level of resilience explained by all resilience components, except social safety nets which further indicating the worst situation of pastoralists
- The findings further revealed that although variations among resilience dimensions of pastoralists and agro-pastoralists were observed, limited access to food and income and poor access to public services was observed across both livelihood groups.
- The results indicated that out of the total 16 explanatory variables used in the regression model 6 were found to be most important in determining the resilience of households at a 99% significant level ($P<0.01$) which includes (Irrigation crop farming, Per capital income, mobility and herd splitting, herd composition change, access to market and remittance).
- The other 6 explanatory variables includes (livestock ownership, education level, labor, food aid, access to credit and access to formal early warning information) played important role in determining HH resilience at a 95% significant level ($P<0.05$).

5.2. RECOMMENDATIONS

- Future development interventions which also match local aspirations should relates to the need for livelihood diversification and income generation activities for long-term resilience building.
- Enhancing household's capacity in terms of finance through provision of affordable credit access, and provision of capacity building to enhance their technical skills on crop farming are of paramount for agro pastoral HHs.
- As part of pastoralist resilience building initiative it is also better to focus on livestock based intervention strategies such as improving production and productivity of livestock through better access to pasture, water, and improving veterinary services.

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Annexes

Annex A - Household survey questionnaires

ADDIS ABABA UNIVERSITY

COLLEGE OF DEVELOPMENT STUDIES, CENTER FOR RURAL DEVELOPMENT

Household Questionnaire for Resilience Assessment, Asayita Afar Region

The purpose of this interview questionnaire is to collect information for the fulfillment of ***Master of Arts thesis and the information is on analysis of resilience of pastoralists and agro-pastoralists to climate-induced shocks and stresses in Asayita Woreda of Afar regional state, Ethiopia.*** Please note that the answers you will provide for this survey are completely confidential. The results from the survey will be used only for research purpose, will not be shared with any other official agencies and will not in any way affect your residence. Moreover, your participation is completely voluntary.

Questionnaire Code: _____ **Interviewer:** _____ **Date**_____

Woreda: Asayita **Kebele:** _____ **Village:** _____

I. Social capital

A) Demographic characteristics

1. Name of Interviewee: _____

2. Sex ☐ M ☐ F

3. Age of the household head_____ (in years)

5. Interviewee's relation to household head: HH head ☐ Spouse ☐ Mother/Father ☐ (grand)-child ☐ sister/brother (in-law) ☐ other ☐_____

6. Marital Status: ☐ Married ☐ Widowed ☐ Not married ☐ Divorced/Separated

7. For Males: **How many wives do you have**? _____

8. How many people belong to this household (Bura)? Total number: _____

9. Please tell us the age and sex of people living in this HH.

Age	Male No.	Female No.
Below 16		

	16-64			
	Above 64			

B) Network and Relationship

10. Did you receive any kind of support and help from neighbors in the last 12 months? **Yes** ☐ **No** ☐
11. If yes, what was it? Livestock ☐ Cash ☐ Gun ☐ Others (Specify) _____
12. In the most recent 12 months has your family unit gotten any of the accompanying types of help from anybody outside the family unit?

Item			From whom	Why
Lending Milking animal	Yes 1	No2	1 2 3 4 5	1 2 3 4 5 6
Livestock	1	2	1 2 3 4 5	1 2 3 4 5 6
Cash loan	1	2	1 2 3 4 5	1 2 3 4 5 6
Free labor	1	2	1 2 3 4 5	1 2 3 4 5 6
Free use of oxen	1	2	1 2 3 4 5	1 2 3 4 5 6
Free use of camel	1	2	1 2 3 4 5	1 2 3 4 5 6
Other	1	2	1 2 3 4 5	1 2 3 4 5 6
			Code:	**Code:**
			1=relatives/kin	1= food shortage
			2= own clan Members	2= to buy consumer goods
			3=other clan Members	3=for marriage ceremony
			4= non-Afar friends	4= funeral ceremony
			5= other specify	5= loss of stock
				6= other(specify)

13. Did you receive any kind of assistance from local government or aid? Yes ☐ No ☐
14. If yes, what was it? Livestock ☐ Cash ☐ food or grain ☐ Others (Specify)_____
15. Do you think the assistant from the government or aid is important? Yes ☐ No ☐
16. If yes, what are their importances? _____
17. What is the reason that your household was the beneficiary of above assistance?
    a. Severe food shortage
    b. Loss of livestock
    c. It is a free distribution?
    d. Other (specify) ___

II. Human capital

A. Knowledge and skills

18. Level of education of the household head: Illiterate ☐ Read and write ☐ Formal Education (Grade level_____): TVET (Level_____): College/University: Diploma ☐ Degree ☐
19. Do you send your children to school? Yes ☐ No ☐

20. If no, why? (Provide the most relevant reason to your household)
    a. They have to keep cattle
    b. Inaccessibility of schools
    c. Other (specify) _____

21. Did you attend training in the last five years? Yes ☐ No ☐

22. If yes, what kind of training did you attend?
    a. In relation to livestock and rangeland management
    b. In relation to marketing and income generation activity
    c. In relation to water harvesting and irrigation
    d. Other (specify) _____

B) Food security and consumption

23. Did your household endure any deficiency of food? Yes ☐ No ☐

24. If yes, in which months was food shortage most acute for your household?

_

25. During that worst month, how frequently a day did the adults and children in your family unit eat?

	Mealtimes every day
A. Adults	0 1 2 3
B. School-age and working children	0 1 2 3 4
	Code: 0=Occasionally passed an entire day without eating anything

C) Health

26. What is the average time needed to reach the healthcare from your resident? <1 hr ☐ 1-2hr ☐ >2 hr ☐

27. Is your household able to afford health care prices?
    a. No
    b. Yes
    c. Partially
    d. Others (specify) _____

28. Have you observed diseases that have impacted your household during climatic extremes (low rainfall, high rainfall and high temperature from the normal range)?

_____

29. If yes, list the type of diseases that occurred during climatic extremes

_____

30. What is the impact of the aforementioned diseases in production?

_____

31. How do you rate interventions done to prevent the above diseases by the government or other agencies?
    a. Bad
    b. Worse
    c. Worst
    d. Good
    e. Better
    f. Best

III. Natural Capital

A) Land

32. Does your household own farming plot? Yes ☐ No ☐

33. If yes, how large is your farm land (ha) ----------

lot type	When did you start having your plot? (Year)	Plot size (Owned)	Types of crop planted: 1=maize 2=pepper 3=vegetables 4 =onion or potato 5 = fruits 6=other	How the land is cultivated: 1 = own force 2= renting out 3= share cropping 4= support from friend 5= hiring labor 6 = other
Irrigated land			1 2 3 4 5 6	1 2 3 4 5 6
Rain fed located near the homestead			1 2 3 4 5 6	1 2 3 4 5 6
Bush field far from home			1 2 3 4 5 6	1 2 3 4 5 6
Other			1 2 3 4 5 6	1 2 3 4 5 6

34. Why have you started cultivation? Multiple response is possible, but give priority
    a. For additional sources of food or income
    b. Since animal rearing alone has been less viable
    c. Since I saw my village fellows
    d. Since I saw neighboring wereda farmers
    e. Other (specify) _____

35. If you use sharecropping to cultivate your farm land, how do you share the produce?
    a. Sharing the produce equally
    b. I give 25% of the produce to sharecropper
    c. Other arrangement (specify) _____

36. If you use hired labor, how much money did you pay?_____Birr per day

37. What is the source of money for hiring labor?
    a. Sale of livestock
    b. Sale of crop
    c. Sale of milk
    d. Other (specify) _____

38. Why did you use sharecropping arrangement or hiring labor to carry out cultivation? Multiple response is possible
    a. Lack of skill to carry out cultivation
    b. Shortage of labor

c. Lack of tool
d. Lack of traction power
e. Other (specify) _____

39. Do you have your own land which is registered or certified? Yes ☐ No ☐

40. If no, what is the land tenure system in your area?

_____

41. Does your household have access to the following irrigation equipments?

No	T Type of assets	Yes/No	Number	Purchase price	Service year
1	Watering can				
2	Sprayer				
3	Water storage tank				
4	Motorized pump				
5	Generator				
6	Other, Specify_____				

42. Do you apply improved seed varieties in the current production year? Yes ☐ No ☐

43. If you did not apply them (#42 above), why (multiple answer possible)?

- No water resources for irrigation purpose in our village ☐
- We do not have technical and financial capacity to irrigate ☐
- We do not want to make use of irrigation water for crop production ☐
- Lack of money to buy improved seed varieties ☐
- Lack of money to buy the associated agricultural inputs (fertilizer, chemicals) ☐
- Other reason, (specify)_____ ☐

B) Grazing land and herd movement

44. Have you lost your traditional grazing land/dry season grazing area? Yes ☐ No ☐

45. If yes, why? Multiple response is possible, but give priority
    a. Grazing land is taken by investors or government for commercial farms
    b. Conflict with neighboring groups
    c. Agricultural expansion from highland areas
    d. Rangeland is invaded by invasive species
    e. Mining
    f. Other (specify) _____

46. What happened to your household when you lost grazing land in your area?
    a. I lost my livestock
    b. I started crop cultivation

c. I had to move my livestock to distant places
d. I had to confine livestock close to my village
e. Other (specify)……

47. Did you move livestock from place to place as you did it before 20 to 30 years? Yes ☐ No ☐

48. If no, list the factors that have led to further reduction of livestock mobility?

_____

_____

49. Which of the following factors are causes of decline for pasture availability (multiple response is possible)? Give priority for each factor from 1-5, 1 being the main factor, 5 being the least factor.

Perceived factors for decline of pasture availability	Yes	Priority
a. Recurring drought		
b. Invasive species		
c. Encroachment of agricultural frontiers		
d. Expansion of large-scale irrigated farms in the dry season grazing area		
e. Change in land tenure from communal to privatization		
f. Others (specify)		

50. What extension services did you get to improve livestock productivity for the last five 5 years?
_____

51. What extension services did you get to improve rangeland productivity for the last five 5 years?
_____

52. Who is responsible for the management of the grazing land?
a. Government
b. NGOs
c. User communities
d. Traditional rangeland management committee (if any)
e. Others Specify) _____

B) Livestock holdings and access

53. Describe the type and number of livestock currently owned by your household?

No.	Type of livestock	Number	No.	Type of livestock	Number
1	Oxen		9	Sheep (Adult)	
2	Cows		10	Sheep (Young)	
3	Bull		11	Goats (adult)	
4	Heifer		12	Goats (young)	
5	Shoats		13	Donkey (adult)	
6	Calves		14	Donkey (young)	
7	Camel (Adult)		15	Other, specify____	
8	Camel (Young)				

54. Currently, if you don't have any livestock, from where do you get livestock to start the previous activity?

_____

55. If you will not go to the previous livelihood activity (livestock production), what will be your

option as livelihood strategy?

56. What are the sources of fodder in the wet season?
    a. Grazing
    b. Trees and leaves
    c. Crop residues
    d. Other (specify)

    _____

57. What are the sources of fodder in dry season?
    a. Grazing
    b. Trees and leaves
    c. Cut and carry
    d. Hay
    e. Other (specify)

    _____

58. Did you have extension contact in relation to livestock marketing? Yes ☐ No ☐
59. Do you get a marketing information preceding sale? Yes ☐ No ☐

60. If yes, what is /are your source(s) of marketing information?
    a. Radio/TV
    b. VEWs
    c. Cooperatives
    d. Broker
    e. Means of local information exchange (*Dagu*)
    f. Others (specify) _____

61. Do you have access to livestock market? Yes ☐ No ☐

62. What is the average time needed to reach the most frequently livestock market (one way)?

    <1 hr ☐ 1-2hr ☐ >2 hr ☐

63. What do you think about the current livestock numbers and species composition as compared to the last 10/15 years? What are the reasons for these changes?

Livestock numbers and species composition status	**Yes**	**Reasons for changes in livestock numbers and composition**	
a. Livestock asset holding has been declining in recent years		Reasons for changes in number of livestock	Reasons for changes in spp. Composition
b. In recent years there is a shift from cattle and sheep to goats and camels			

64. Which factors do affect your animal husbandry? (Multiple responses are possible). Give priority from 1-6, 1 being the main factor and 6 being the least

Factors	Priority
Loss of grazing due to bush encroachment	
Recurrent severe drought	
Livestock diseases	
Scarcity of water	
Loss of dry season grazing areas for commercial farms	
Other (specify)	

65. Was the livestock production adequate to provide food for your family before 10 years? Yes ☐ No ☐
66. Is current livestock production less viable? Yes ☐ No ☐

67. If yes, why is the traditional livelihood strategy (livestock production) less viable now?
    a. Degradation of pasture
    b. Prolonged drought or severe recurrent drought
    c. Population increase
    d. Animal diseases epidemics
    e. Other (specify) _____

C) Water

68. What are the primary sources of water for human and livestock utilization?
    a. Ponds
    b. Traditional well
    c. Protected spring
    d. Unprotected spring
    e. Awash River
    f. Deep well
    g. Others (Specify) _____

69. If No, why?
    a. No water resources for irrigation purpose in our village
    b. There are irrigable water resources, but we do not have technical and financial capacity to irrigate
    c. There are irrigated water resources, but as a HH, we do not want to make use of irrigation water for crops/vegetables/fruit production
    d. Other reasons (if any) _____
70. What is the average time needed to reach the most frequently used water source at this site (one way)?
    <1 hr ☐ 1-2hr ☐ >2 hr ☐

D) Finance

71. What are the sources of income for your household?
    a. Livestock and livestock products sale
    b. Crops sale
    c. Cash for work program
    d. Rent (house, land, livestock)
    e. Vegetable sales

f. Natural resources (gum, incense, salt)
g. Remittance
h. Firewood/charcoal sells
i. Employment
j. Others(specify) _____

72. Contribution of each income source to the total annual income of the household

Source of income	Average Annual income (in Birr)	Rank	Portion of the income spent on foodstuffs
Livestock			
Crops			
Employment			
Rent (house, land, livestock)			
Charcoal or firewood sale			
Remittance			
Cash for work program			
Natural resources (gum, incense, salt			
Others (specify)			

73. Which kind of stock do you sell in times of financial need?
    a. Sheep and goat
    b. Cattle
    c. Camel
    d. Others (specify) _____
74. When (season of the year) did you like to sell livestock? Why?_____
75. What do you say about the price you receive for your livestock in the market?
    a. Reasonable/fair
    b. Not fair
76. Does your household received credit or loan from government or NGOs in the last three years?
    Yes ☐ No ☐
77. If your answer is Yes (#75 above), what is the total amount_____
78. If your answer is No (#75 above), why not? _____

_____

IV. Physical capital

79. How long (hours) it takes from your resident to the nearest market? 5 km ☐ 10-15km ☐ >15 km ☐ other
80. What is the average time taken to the nearest school (walking) (one way)? <10 min ☐ 15-25 min ☐ >25 min ☐ Other (specify) _____
81. What is the average distance to the nearest vet clinic (walking) (one way)?
    <5 km ☐ 10-15km ☐ >15 km ☐
82. How reliable is the road network where you live? Please explain and describe the type of road infrastructure
    _____
83. Average distance to the nearest all weather road from your residence (in KM or hours)? _____

V. Early warning system and formal extension services

84. How often you get formal advices from local DAs or experts, which are intended to improve your productivity (livestock or crop production)? Regularly ☐ Rarely ☐ Never ☐

86. Do you have access to early warning information regarding climate change and variability? Yes ☐ No ☐

87. How often you receive early warning about climate disasters pending around? Regularly ☐ Rarely ☐ ever ☐

88. If yes, from where do you get?

_____

89. Description of Early Warning information availability

_____

VI. Exposure to extreme climate and non-climate shocks and the effects on their livelihood

90. Did your household encountered death of livestock or loss of livestock quality due to climate-induced hazards such as drought and floods in the last five years? Yes ☐ No ☐

91. If your answer for question #1 above is 'Yes', specify the total estimated value of the loss/damage in birr: _____.

92. Did your household encountered crop loss/damage due to climate-induced hazards such as drought and floods in the current production year? Yes ☐ No ☐

93. If your answer for question #3 above is 'Yes', specify the total estimated value of the loss/damage in birr:

94. Have you observed diseases that have impacted your household during climatic extremes (low rainfall, high rainfall and high temperature from the normal range)?

Yes ☐ No ☐

94. Did your household encountered with any market shocks, illness and death of the household member associated with climate-induced shocks during the surveyed period? Yes ☐ No ☐

Annex B–FGD and key informant interview checklist

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✓ Check List for Focus Group Discussions

1. Did your community loose traditional grazing land/dry season grazing area? If yes, why? **Probing:**
    - Grazing land is taken by investors or government for commercial farms
    - Conflict with neighboring groups
    - Agricultural expansion from high land areas
    - Rangeland is invaded by invasive species
    - Mining, Others (if any)
2. Do you move livestock as you did it before 10/20 years? If no, what are the factors that have led to further reduction of livestock mobility?
3. What do you think about the current livestock numbers and species composition compared to the last 10/20 years? What are the reasons for these changes?
4. What do you think are the major causes for the decline in pasture availability? **Probing:**
    - Recurring drought
    - Invasive species
    - Encroachment of agricultural frontiers
    - Expansion of large-scale irrigated farms in dry season grazing area
    - Change in land tenure from communal to privatization, Others (if any)
5. What do you think are the major factors that affect your animal husbandry? **Probing:**
    - Loss of grazing due to bush encroachment
    - Recurrent severe drought
    - Livestock diseases
    - Scarcity of water
    - Loss of dry season grazing areas for commercial farms, Other (if any)
6. So, is current livestock production less viable? If yes, why is the traditional livelihood strategy (livestock production) less viable now? **Probing:**
    - Prolonged drought or severe recurrent drought
    - Degradation of pasture
    - Population increase
    - Animal epidemics, other (if any)

7. What do you think are the adaptive strategies to cope with the ecological/environmental stress and livelihood resilience? **Probing:**
    - Combining herding with non-pastoral activities (trading, cultivation)
    - Changing the composition of herds
    - Herd splitting and mobility to areas where fodder can be available
    - Leaving livestock under the care of bond-friend/kin
    - Gotten food aid
    - Sold charcoal and firewood
    - Movement/looked for business somewhere else
    - Lent from relatives and others
    - Sold our cattle, camel, sheep and goat, other (if any)
8. What are the perceived hindrances to adaptation and coping of climate variability and change? **Probing:**
    - Lack of access to dry grazing season area
    - Absence of access to water for irrigation agriculture
    - Absence of access to irrigation materials
    - Absence of current knowledge on adaptation strategies
    - Absence of information on weather occurrence
    - Absence of cash to gain modern techniques
    - Absence of assistance from government for indigenous rangeland, other (if any)
9. What problems do you have in relation to range/pasture/browse land **Probing:**
    - Management problem
    - Too many livestock
    - Distance from homestead
    - Grazing/pasture land shortage
    - Bush encroachment and un-palatable and toxic plants
    - Low forage and browse yield, Others
10. Who do you think is responsible for the management of the grazing land?
    - Government
    - NGOs
    - User communities
    - Traditional rangeland management committee, Others (if any)
11. What do you think the mitigation strategies to the problems with range/pasture/browse land? **Probing:**
        - Bush clearing
        - Improved fodder production

- Encouraging communal land management
- Providing trainings for community at large and committees in particular
- Strengthen and train/ capacitate traditional rangeland management system
- Promote/increased area enclosure for rangeland
- Promoting environmental protection, other (if any)

✓ **Check List for Key Informant Interviews**

12. How do you assess the present amount of precipitation during a rainy season compared to the last 10/20 years?
    - Does precipitation happen routinely during rainy season or occur late from the normal season?
13. Can you harvest your crops utilizing precipitation water? Does rainfall occur early from the normal season? Since how many years have you noticed this change and variability? What do you think about the impacts of change in rainfall on livestock?
14. What is the present amount of temperature in contrast to the last 10/20years? What problems do you observe due to changes in the intensity of temperature? What kind of affects you observed in livestock? **Probing:**
    - Thermal stress on livestock & caused production loss
    - Growth and yield of crops have decreased and caused production loss
    - Can't go outside of the house because of extreme heat and caused working loss
    - Need to work hard for irrigation and caused extra work
    - Burning sensation
    - Feel tired
    - Can't rest around evening time because of extreme heat and sweating
    - Tin top of house turns out to be excessively hot, Others (if any)
15. How many times your area has passed from drought condition since last 10/20 years? When was the last time there was a severe drought in your area? Does flooding happen during the rainy season? How do you assess the frequency of drought, floods and other climate extremes in your area? How do you assess the intensity of these climate extremes in contrast to the last 10/20years?
16. How do you assess the effects of the above climate extremes on the livelihood of your household (livestock, crop production, non-farm/pastoral livelihood activities?
17. Do you think that there are invasive species spread in your area? What do you think is the reason for its spread? What are the impacts of these invasive species in your livelihood? What should be done to avoid these invasive species?
18. What extension services did you get to improve your resilience (grazing land and natural resource management, livestock productivity, crop production, marketing etc) for the last five years?
19. What are the informal support systems in your community recognized to assist poor households or households affected by natural hazards or socio-economic shocks?

20. Are there any social safety nets or related programs in your community run by government and NGOs? What is the reason that?
21. **Probing:**
    - Severe food shortage
    - Loss of livestock
    - It is a free distribution, Other (if any)
22. Do you think the assistant from the government or NGOs is important to address the specific problem?
23. Do you think your community have adequate access to different infrastructure (e.g. road and social service facilities (schools, water supply and, human/livestock health facilities? In this regard, how do you assess the adequacy/quality of the interventions?
24. Do you have access to early warning information regarding climate shocks and stresses? If yes, what are these services? Where do you get them from? How do you assess the adequacy/quality of services provided in this regard