HOUSEHOLD RESILIENCE TO FOOD INSECURITY

SHOCK EXPOSURE, LIVELIHOOD STRATEGIES & RISK RESPONSE OPTIONS: THE CASE OF TACH-GAYINT DISTRICT, AMHARA REGION, ETHIOPIA

Doctoral Thesis

Prepared by: Tesfahun Asmamaw Kasie

Supervisors: Antonio Agrandio (PhD), Enyew Adgo (PhD) & Isabel Garcia (PhD)

Institute of International Development Cooperation

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ABSTRACT

The purpose of this study is to contribute to efforts to measuring and assessing resilience properties of household livelihoods, constructed in the risky environments, explaining why some households are more resilient than others. Based on resilience theory as applied to social-ecological systems with an application of Modern Portfolio Theory, this study adapted and measure the four properties of resilient livelihood systems and tested the expected relationships between system properties. It also examines risk coping behaviors of households and its role in shaping resilience trajectories of livelihoods towards a positive food security outcome. Acknowledging household resilience as a stochastic phenomenon, this study has also made an effort to investigate determinants of resilience to food security shocks as a function of the nature of adaptive system properties, shock exposure and risk coping behavior of households as system participants. At system level, household livelihoods exhibited the expected pattern of increasing connectivity with increasing wealth (food income). Similarly, household resilience to food insecurity increases with increasing diversity of livelihood options and diversity declines with increasing connectivity of the system. This study confirms the key role of livelihood diversification for improving household resilience to food insecurity at both higher and lower wealth groups. In terms of household risk coping behavior, the magnitudes of past shock experiences found to be significantly and positively correlated with perceived future risk levels and the latter is also found to be positively and significantly correlated with the decision of households to apply ex-ante risk management choices. Location characteristics and nature of livelihood strategy group also affects household choices of ex-ante risk management strategies indicating the need for considering the local livelihood context in the design and promotion of adaptation technologies. Household's decisions to adopt ex-ante risk management strategies have found to have strong correlation with resilience outcomes. For example, precautionary saving and income diversification are positively and significantly correlated with the probability of a household to be resilient. In terms of shock reaction capacity, households tend to expand food income per unit of expected loss primarily in response to weather shock. High wealth groups tend to keep livestock as a buffer against shock. Enhancing market-based coping options would improve household resilience against food security shocks since a fraction of expected loss covered by extra food income is majorly obtained from labor and livestock sales. Overall, this study suggests that the major source of poor household resilience is both structurally constrained adaptive capacity and high shock exposure. Therefore, resilience programs, in the study area and in similar areas that are designated as risk prone and chronically food insecure districts of the country, should promote risk reduction measures while implementing programs designed to address structural causes of food insecurity.

Keywords: Household Resilience, Livelihoods, Risk Response, Food Insecurity

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ACRONYMS

ABB LZ	Abay Beshilo Basin Livelihood Zone
ANRS	Amhara National Regional State
ATW LZ	Abay Tekeze Watershed Livelihood Zone
Birr	Ethiopian Currency
BoFED	Bureau of Finance and Economic Development
DFID	UK-Department for International Development
DRMFSS	Disaster Risk Management and Food Security Sector
FAO	Food and Agriculture Organization (United Nations)
HEA	Household Economy Approach
HRD	Humanitarian Requirement Document
Kcal	Kilocalorie
MoFED	Ministry of Finance and Economic Development
MPT	Modern Portfolio Theory
PSNP	Productive Safety Net Program
RIMA	Resilience Index Measurement Analysis Model
SES	Social-Ecological Systems
SLF	Sustainable Livelihoods Framework
TLU	Tropical Livestock Unit

1. INTRODUCTION

Ethiopia with a population of more than 100 million (USAID, 2017) is often characterized by structurally food insecure, drought prone country in the Horn of Africa. For many generations, Ethiopian rural population have experienced significant episodes of food emergencies and the most dramatic food crisis come from the mid-1980s when an estimated one million people died of hunger. More than one-third of its rural districts are characterized by risky environments exposed to protracted food crisis (MoARD, 2004). Over 30 million of its population classified as either transitory or chronically food insecure and fall underneath the national poverty line, and remain highly vulnerable to shocks such as drought (Rahmato, 2013). For example, in Amhara Region, where the study area is located, more than 2 million people requested assistance every year between 1995 and 2014 including chronically food insecure population targeted for Productive Safety Net Program (PSNP) (Figure 1).

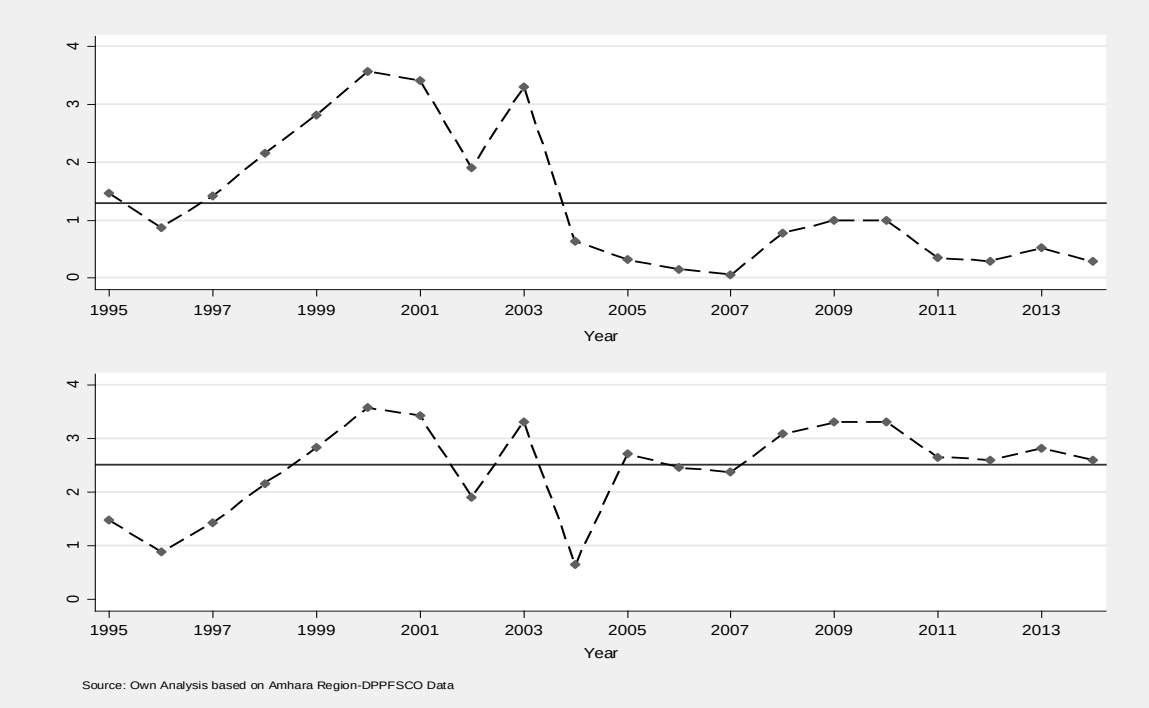

Figure 1 Emergency Food Aid and PSNP Beneficiary Population (1995-2014)

Coupled with chronic poverty, recent climate-related crises have directly threatened the lives of

millions of people and further aggravate vulnerability to recurrent shocks (Deressa, 2007; Deressa and Hassan, 2009; Devereux et al., 2006; Ruth H. & Catherine P., 2013). In particular, vulnerability to drought has historically been very high among Ethiopian rural households. Almost half of rural households in Ethiopia were affected by drought in a five year period from 1999 to 2004 (Dercon et al., 2005), and recently drought affected significant proportion of population in risk prone areas of the country (GOV, 2016).

While the negative GHI trends have declined in the 1990s (Wiesmann, 2006), food emergencies in 2000s affected most of the rural population of Ethiopia up to an estimated 15 million people in 2003(GOV, 2004) and recently drought affected 8.5 million people in 2011 (GOV, 2012) and 10.1 million people in 2015 (GOV, 2016) respectively.

A complex set of factors cause Ethiopia's food insecurity. On one hand, the risky environment with highly variable rainfall and an underlying threat of drought often characterized the country's fragile ecological context (ACF, 2006; Devereux and Sussex, 2000a). Climatic factors and natural resource availability are critical factors of food security in Ethiopia, where more than 80% of the population makes a living from agriculture. The econometric evidence on poverty determinants (Bigsten et al., 2003; Dercon and Krishnan, 1996) establishes that households residing in poorly endowed agricultural areas face significant uncertainty with regards to future consumption. These areas are mainly located in the north and central highlands and in the Eastern and southern pastoral lowlands of the country. Most of these areas share common biophysical characteristics of highly variable rainfall, recurrent drought and high rates of land degradation. On the other hand, dynamic pressures emanated from underlying socio-political context such as increasing population with associated diminishing landholdings, constrained agricultural innovations and market integration including limited opportunities for off-farm employment have also contributed to the persistence of food insecurity and often

translates drought episodes into food crisis (ACF, 2006; Devereux and Sussex, 2000b; Frankburger et al., 2007; Gabre-Madhin, 2001). Combined with these complex set of factors, recurrent drought substantially erodes the productive assets of communities and households and in turn has led to environmental degradation and increased pressure on existing agricultural land causing many rural populations to remain under poverty trap.

Faced with such ecological fragility and underlying socio-political vulnerability conditions, many households find it extremely difficult to accumulate cash savings, livestock or food stores sufficient to weather the bad seasons. In times of drought, agricultural production declines by 25% in most risk prone areas with more than 75% in some ecologically fragile areas (GOV, 2016) including livestock losses as high as 70% in drought prone pastoral areas of the country. Since most households depend on agriculture, with few off- farm income opportunities, crop and pasture failures can be devastating for rural livelihoods. Repeated droughts have caused high rates of malnutrition as households seek to survive in the short-term by decreasing their consumption to protect assets (Gilligan and Hoddinott, 2007). Furthermore, repeated and severe shocks cause some households to resort to distress sells of assets, such as livestock compromising future livelihoods. A growing body of evidence documented since early 1990s by studies in Ethiopia, (Alderman et al., 2006; Carter et al., 2007; Dercon, 2004; Dercon and Christiaensen, 2007; Dercon and Krishnan, 1996; Hoddinott and Kinsey, 2001) points to the role that risks/shocks, and vulnerability in perpetuating poverty with not only negative expected livelihood outcome in terms of low future consumption but also negative risk management outcome i.e. deteriorating coping ability to deal with future risks.

For over three decades, the main responses to this situation in Ethiopia were dominated by emergency food aid (Clay et al., 1999, 1998; Gilligan et al., 2008; Sharp, 1998), making the country the largest emergency recipient among Sub-Saharan African nation. Despite high levels

of food aid, food aid studies of the 1990s in Ethiopia documented the fact that rural households further depleted their assets and become increasingly vulnerable to even the most marginal livelihood shocks. Even during times of good rainfall, a significant part of the population remained food insecure and the overall number of predictably food insecure households continued to rise (Raisin J, 2002; WB, 2011). Studies focus on food aid (Devereux et al., 2006) established evidences that much of the annual emergency food aid was being distributed to the same people in the same geographic areas characterized as chronically food insecure risky environments. Following repeated food crisis in the late 1990s and 2000s primarily caused by successive drought episodes of 1999–2000 and 2002–03, 2005–06 and 2011–12, government, donors and NGOs all agreed that decades of interventions have not resulted in sustainable assets at household or community level (MoARD, 2004; Raisin J, 2003).

The critique on this relief oriented emergency system resulted in improvements in the design of aid programs towards resilience building among humanitarian and development communities in the last 15 years (Vaitla et al., 2012). Among the major initiatives with resilience building as an objective include the introduction of Ethiopia's Productive Safety Net (PSNP) program; the use of improved guidelines for livelihoods response and the development of improved pastoral early warning systems (Sabates-Wheeler and Devereux, 2010; Vaitla et al., 2012). The growing consensus for 'resilience building' therefore stems at large from widespread acknowledgement that previous humanitarian responses and development initiatives have failed to adequately address the needs of chronically vulnerable populations and the need to respond to the inherent complexity of factors contributing to protracted crisis (Timothy Frankenberger et al., 2012).

Building resilience to food security shocks is the major development agenda in Ethiopia to help vulnerable households to maintain a certain level of well-being in the face of risks, which depends on the options available to vulnerable households to augment its ability to handle risks

(Frankenberger et al., 2007). Hence, understanding and measuring characteristics and dimensions of household resilience in the context of protracted crisis has become a critical issue in designing and evaluating programs to resilience building.

The major debating themes among empirical studies in understanding such dynamic and emerging construct, the concept of resilience, include how to measure and model resilience to explaining why some households are resilient than others with evidences pointing to identifying appropriate interventions to strengthen resilience.

Several overarching lessons have been learned and knowledge gaps identified from previous empirical studies related to vulnerability and resilience. These lessons and knowledge gaps could be seen in two broad aspects as reviewed by Franken Berger. First, resilience measures must be done based on comprehensive baseline assessments and closely tied to the local context and the occurrence of an actual shock with a specified type and nature including vulnerable people's response mechanisms. One of the shortcomings of much of the existing empirical research on vulnerability and food insecurity include assessment of vulnerability or resilience to all types of shocks rather than assessments with respect to specific types of shocks (Timothy Frankenberger et al., 2012). These researches do not help to identify appropriate interventions that would strengthen household resilience which is shock and context specific by its very nature. This is mainly because these line of research focus on estimating the proportion of households with the characteristics of vulnerable groups rather than explaining why some are vulnerable or resilient than others. This is partly because of lack of well-established baseline and follow-up data in most developing countries (Christiaensen and Subbarao, 2004). However, in response to unavailability of such data, poverty and vulnerability studies developed a methodology to estimate consumption vulnerability based on a single cross-sectional data (Chaudhuri et al., 2001) and helps to identify potential new caseload that needs to be targeted for vulnerability reduction programs. Most studies

that define vulnerability as expected poverty (Capaldo et al., 2010; Christiaensen and Subbarao, 2004; Demeke et al., 2011; Morduch and Kamanou, 2002; Novignon, 2010; Scaramozzino and others, 2006) assesses vulnerability in reference to an outcome variable i.e. food insecurity without attributing vulnerability to specific shocks. As a result such studies do not help to identify the type and impact of shocks nor explicitly incorporate shock coping strategies in the model in order to understand persistent effects of some coping behaviors on resilience outcomes (Timothy Frankenberger et al., 2012). Furthermore, these studies were not designed to explicitly explore the particular risk management strategies adopted by different kinds of households in response to specific types of shocks, or to understand how the adoption of different risk management strategies affected household outcomes or measure of well-being (2012).

Second, measurement of resilience must follow system wide approach involving complementary mix of quantitative and qualitative indicators that have the power to explain the multi-dimensional aspect of resilience. A qualitative analysis of the context for specific types of shocks is necessary to identify the key variables that should be included in the quantitative analysis, as well as indicate how the variables should be appropriately measured. For example a study in Ethiopia employed a qualitative approach based on qualitative information obtained through rapid rural appraisal techniques, (Frankenberger et al., 2007) demonstrated key qualitative attributes of resilient households such as pro-active behavior and an entrepreneurial spirit. Although the study is based on the perception of few individuals and generally lack objectivity required for operational purposes, it uses livelihood systems as a classification unit and helps to identify key attributes of resilient households that would rather be difficult to identify with other approaches.

Though a different empirical approach, studies that recognize the multi-dimensional nature of resilience (Alinovi et al., 2010, 2008) employed structural equation modeling and factor analysis to identify unobserved (latent) variables and to estimate the overall resilience as a higher-level

latent variable that is a function of the component latent variables. For example, in the Kenya study (Alinovi et al., 2010), the overall resilience measure, along with the components, are compared across different household livelihood categories. In the model, the resilience index is measured in relation to aggregate shocks as a composite of both the determinants and the results of resilience. While this line of research helps to better understand the differences in resilience across categories of livelihood strategy, it does not shed light on how households adjust to specific shocks (Tim Frankenberger et al., 2012).

Recent empirical studies of social-ecological systems have also contributed to advance the measurement and understanding of resilience from systems perspective. These studies have applied ecosystem resilience theory in explaining properties of social systems such as food systems (E. D. G. Fraser et al., 2005), institutions and social network systems (Anderies et al., 2006). Such new and emerging line of research brought new insights of systemic properties of resilience which could complement most of the previous empirical studies, designed to identify the characteristics of vulnerable households including to estimating the proportion of such households in a particular context.

The major gap of existing empirical works on vulnerability and/or resilience is therefore the development of a comprehensive framework for measuring and assessing resilience. It has become critical to building on existing knowledge and understanding of resilience from the perspectives of various fields of study. Particularly an approach to addressing key empirical questions posed by (Timothy Frankenberger et al., 2012) which are directing towards understanding of 1) why some households are resilient than others, 2) the factors that affect households' choice of risk management strategies to prepare for and respond to particular shocks, and 3) how specific interventions may strengthen households' adaptive capacities to utilize strategies (either coping or adaptive) that better maintain their resilience to future shocks. The aim of this research is therefore to apply systems approach to understanding the underlying factors determining household's

resilience to food security shocks in order to contribute to the debate on the discourses of measuring and modeling resilience in explaining why some households are more resilient than others among households constructed their livelihoods in the risky environments, taking one of the chronically food insecure areas of Ethiopia as a case study.

To meet the main aim of the research, three research questions were to be answered. First, how are households construct resilience properties of livelihoods? Examining the livelihood system as adaptive system at household level represented by a portfolio of livelihood strategies were used as an entry point for understanding resilience properties of household livelihood systems. In this regard, the various portfolio configurations in terms of diversity of options and portfolio covariance structure including stochastic distribution of portfolio returns were to be the focus of the study. Second, how households are managing livelihood risks? The different risk management strategies households possibly adopt to reduce the risk of food insecurity were to be examined along with the factors that determine household decisions and choices of strategies. Third, what determine household resilience to food insecurity? The characteristics of resilient and vulnerable households were determined including the reasons that are important to answer why some households are more resilient than others with a focus on identifying appropriate interventions to strengthen resilience to food insecurity. The reasons that explain differential resilience levels assumed to be established following answering the first and the second research questions related to determinant factors representing inherent livelihood system properties and shock coping behaviors of households as system participants.

2. LITERATURE REVIEW

2.1. Introduction

This chapter discusses the concepts and theories that are relevant to the issues raised in this study. a holistic and multi-dimensional understanding of the concepts of food security and related issues is crucial for analyzing and explaining a household ‘s resilience to food insecurity. Several key concepts underpin this study. It includes the concept of resilience and vulnerability, household livelihoods and food security, including insights from various discourses such as Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) for understanding household’s risk coping behaviors as system participants. It also reviews approaches for understanding household livelihoods as complex adaptive systems and its functions and services in terms of ensuring food security in the face of risks and shocks at both conceptual and empirical levels. These approaches include the sustainable livelihoods and vulnerability approaches, social-ecological approach, household economy and portfolio theory approaches which provide the theoretical and empirical basis for the study.

The reasons for reviewing these discourses from various fields of study is because of the concept of household food security, of the many livelihood outcomes of concern to rural households, is closely intertwined in the notions of poverty, and lack of resilience or vulnerability to shock. Hence, the literature on household food security has developed to take account of parallel developments in other fields due to the fact that households experience different shocks and risks, and often follow different food security strategies and people ‘s own perceptions of vulnerability and risk predominate in food security strategies. In addition, the sensitivity, resilience and sustainability of livelihood systems are crucial to understand levels of food insecurity and it is misleading to treat food security as a fundamental need, independent of a wider livelihood consideration (Maxwell et al., 1992a). The novelty of this

thesis lies in combining the approaches taken by different disciplines in order to design and test a systems-oriented approach that will be applied to investigate resilience properties of household livelihoods and food security outcomes.

This part of the thesis is organized into the following sections. First, the existing literature on livelihood and food security is discussed with a focus on evolution of food security concerns and its definition. Second, the concept of resilience and its application to household livelihoods and food systems as complex systems is discussed. Third the potential contributions, which the fields of sustainable livelihoods, ecological resilience, risk management and portfolio theory could make to livelihoods analysis at a systems level, are assessed.

2.2. Evolution of Food Security Concerns & Definitions

International attention to the concept of food security can be traced back to the 1943 Hot Springs Conference on Food and Agriculture resulted in the establishment of the United Nations Food and Agriculture Organization in 1945. This has led to the Universal Declaration of Human Rights in 1948, which recognized the right to food as a core element of an adequate standard of living in its article 25 (UN, 1948). However, a renewed interest in food security followed the world food crisis of 1972-74, resulted in the 1974 First World Food Conference with a focus on enabling every country to become self-sufficient in food to adequately feed their population. As a result, the 1974 World Food Summit defined food security as: "availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices"(Maxwell and Watkins, 2003).

Since then, the meaning of food security has undergone significant changes and its definition has been modified many times for instance, (Maxwell et al., 1992a) documented more than 200

definitions of food security. However, the most commonly accepted definition of food security recognized as a multi-dimensional concept is the one suggested by the 1996 World Food Summit where food security was defined as access by all people at all times to enough food for an active and healthy life (Von Braun et al., 1999). This definition points to four important dimensions of food security: food availability; food access; utilization, and; stability.

With varied focus on these dimensions, various fields of study such as nutrition and economics contribute to parallel developments of the concept. The development of the concept of food security since the 1970s, therefore, can best be characterized as vigorous developments towards substantial understanding of the concept from the broader livelihood systems perspective involving issues of sustainability, sensitivity and resilience with a multi-dimensional and multi-objective phenomenon (Maxwell et al., 1992a). Maxwell and others identified three important and overlapping paradigm shifts to explain developments in the thinking of the food security concept (1992a). The first shift in understanding food security is the shift from the global/national to the household/individual focus. Following the First World Food Conference in 1974 researches focused on understanding why agricultural productivity is slow and how to increase food productivity. This, leads to the emergence of the Food Availability Decline (FAD) approach. According to the FAD approach, food insecurity and famine are caused by declines of aggregate food availability at either the local, regional or national level. It is based on the assumption that food availability is primarily a factor of productivity which in turn is attributed to a number of factors like rapid population growth and the resultant land fragmentation as well as natural hazards (Devereux, 2001a). Though the FAD approach provides a starting point to the emergence of the food security approach, it has been criticized for many reasons. One of these criticism is from the fact that widespread hunger could co-exist with adequate food supply at the national and international levels. It has been also criticized for being incomplete and failed to address vulnerability difference of different

groups of people. These criticisms contributed significantly to the shift of focus from the 'national' to 'household' and 'individual' levels of food security.

Following the criticisms on FAD, Sen came up with a concept of 'entitlement' and the question of poverty and access began to feature more prominently in the food security discussion based on the assumption that a household may suffer from food shortage in a region where adequate food is available (Sen, 1981). These understanding, therefore, led to the emergence of the Food Entitlement Decline (FED) approach. The FED approach was originally designed by Amartya Sen to analyse the causes of food shortage and famine in developing countries. This approach is proposed as an alternative method to FAD. Despite the improvement of supply after 1975, the incidence of hunger and under nutrition remained high especially in the developing countries. This situation led to the understanding that food insecurity is not a transitory lack of enough food supply at national or international level but rather as a chronic lack of access to enough food among vulnerable groups of people (Sen, 2001, 1992).

The FED approach assumes that, adequate food availability at global or national levels does not automatically imply food security for all. It stressed the importance of the incidence of poverty in explaining why certain groups of people are under nourished. This approach thus brought a shift in famine analysis from the national to individual or household level.

A central concept in Sen's approach is the 'food entitlement failure', which refers to a situation in which the entitlements set of a person does not contain enough food to enable this person to avoid hunger and starvation. A famine occurs when a large number of people with in a community suffer from such entitlement failures at the same time. FED approach is thus strong in its potential to identify which groups of people will be affected by declining availability or lack of access to food based on their degree of vulnerability.

However, like the FAD approach, FED approach has been also criticized for a number of points, for instance it failed to take intra-household food distribution into account including ccriticisms for exclusion of relief entitlement as part of the sources of entitlement (Devereux, 2001a). Several critics (Edkins, 2000; Keen and others, 1994; Rangasami, 1985; Waal, 1990) have also argued that Sen's overemphasis on economic market forces neglecting the underlying socio-political and historical processes in creating conditions of vulnerability and famine.

This has led to the shift from a 'food-first' perspective to a livelihood perspective representing the second paradigm shift in the thinking of the food security concept. Many empirical findings (Corbett, 1988; Rahmato, 1991; Waal and others, 1989; Webb et al., 1992) on famine and food insecurity, confirmed that the response of the food insecure people to food shortage focuses on the long-term objectives of livelihoods rather than focusing on satisfying the short-term food needs. The conventional view of food security was mainly on food as a primary need. However, this assumption has been challenged and food security has been recognized as constituting part of the system of a wider people's livelihoods. Davies (1993) has pointed out that in the 'livelihood approach', as opposed to the 'food first' approach the objective is the management of risk and vulnerability, as people try to achieve secure and sustainable livelihoods. The result of this paradigm shift from a 'food-first' approach to a 'livelihood' approach is, therefore, a view of food security which identifies livelihood security as a necessary and often sufficient condition for food security. Parallel to these conceptual developments, food security measurement approaches began to include qualitative aspects of food security, such as issues related to consistency with local food habits including cultural acceptability, in addition to the quantitative measurements (Devereux et al., 2001a).

As a result of these paradigm shifts, the complexities of livelihood strategies in uncertain environments and the understanding of how people themselves respond to perceived risks and

uncertainties gained much more emphasis in the food security agenda (Maxwell et al., 2001). In this study, resilience properties of household livelihood systems are understood as complex systems including the various risk management strategies employed by households as system participants with food security as one objective of the system of concern.

2.3. The Concept of Resilience

The term resilience as a concept distinct to other stability concepts was first introduced by C.S. Holling in his influential paper *'Resilience and stability of ecological systems'* referring to the capacity of a system, or amount of disturbance a system can absorb (C.S. Holling, 1973) without shifting into an alternate state (Walker et al., 2006) or a regime shift (Carpenter et al., 2005), and to regenerate after disturbance (Resilience Alliance, n.d.). Recently the concept of resilience has been proposed to exploring the relative persistence of different states in complex dynamic systems, including food and livelihood systems (Alinovi et al., 2010, 2008; Ericksen, 2008; Folke et al., 2005; Timothy Frankenberger et al., 2012; E. D. Fraser et al., 2005; Manyena, 2006; Pingali et al., 2005). Multiple disciplines have contributed to the core principles governing the concept of resilience including engineering and psychology. For instance, Ecological resilience is the magnitude of disturbance that a system can absorb before it redefines its structure by changing the variables and processes that control behavior (C. S. Holling, 1973). This definition emphasizes conditions far from any equilibrium steady state, where instabilities can shift a system to another basin of attraction which is controlled by a different set of variables and characterized by a different structure (Gunderson, 2000; C. S. Holling, 1973; Walker et al., 2004; Walker1a et al., 2002). Resilience, understood in this way, is the "magnitude of disturbance that can be absorbed before the system changes its structure by changing the variables and processes that control behavior.

Building on engineering resilience that is conceptualized as a system's ability to return to the steady state after a perturbation, ecological resilience (Holling, 1996) further expanded resilience

theory by acknowledging various adaptive behaviors of complex systems. The recently expanded definition and integration of more drivers of the concept of resilience has brought within its scope the role of institutions, social capital, leadership, and learning (Olsson et al., 2004). The application of resilience construct in social systems is being recognized as a way of viewing the evolution of social systems as resilience shifts attention away from long-run equilibria, towards a system's capacity to respond to short-run shocks and stresses constructively and creatively (Adger, 2000a; Berkes, 2007; Carpenter et al., 2001a; Marshall and Marshall, 2007). Such human capacity for deliberate action and foresight, reflexivity and technological development distinguishes social from ecological systems and makes adaptive capacity relevant (Walker et al., 2006; Young et al., 2006).

Despite a wealth of literature on resilience theory as well as practical application from several disciplines, consensus supporting a set definition and prescribed metrics has not been established. This is mainly because, though each discipline shares a similar lexicon, concepts are often imbued with different meanings. For example (Miller et al., 2010) reviewed convergence and divergence of resilience concepts among disciplines and they indicated that while researches in the field of ecology tend to focus on the physical vulnerability and/or resilience of ecosystems and their services, social scientists in the field of developmental sciences, tended to stress social aspects such as access to assets, social support systems and institutions rather than interconnections between social and ecological systems (Miller et al., 2010). However, there is currently growing engagement between scholars of various disciplines working towards a common lexicon, allowing easier interdisciplinary collaboration and better engagement with communities outside academia. Particularly obvious synergies are apparent following the introduction of the concept of social-ecological system resilience with its central tenets of adaptation and transformation, acknowledging the necessity and certainty of constant change as a requisite to persist (Folke, 2006). Generally, resilience is best measured

both in terms of outcome and as a process. As an outcome, resilience could be measured in relation to food and nutritional outcomes (Tim Frankenberger et al., 2012; Hoddinott and others, 2014a). As a process, resilience is considered in terms of stress resistance and changes in resilience capacity over time (Norris et al., 2008; Vaitla et al., 2012).

2.4. Understanding HH-Livelihoods & Food Security Outcome as Complex Systems

The concept of resilience makes sense particularly when applied to a system. A system is a group of interacting components, operating together for a common purpose, capable of reacting as a whole to external stimuli (Spedding, 1988). A system behaves as a whole in response to stimuli to any of its components beyond just a collection of unrelated items.

A very general definition of a food system is that it is made up of all the interacting social and ecological components that affect the food security of a given group of people (Ericksen, 2008). A sustainable food system fosters equitable food production, distribution, consumption, and opportunities for economic development (Allouche, 2011). A food system therefore involves all the phases from production to consumption of food, through distribution and processing. Such a definition is general and conceptually very broad because it entails the complexity of many dimensions and scales (Morin, 1992).

According to social-ecological system studies, a food system comprises both the resource base that ensures the food supply, and the socio-economic component that depends on this resource base. One of the more significant recent discoveries in the study of social-ecological systems is the fact that they are jointly determined (Carpenter et al., 2001b; Walker et al., 2006). The consequences of this are important in terms of both the contents of the analysis and the methodology adopted, as they imply that food systems should be thought of as complex adaptive systems to be analyzed using a non-reductionist, systemic approach (Alinovi et al., 2009a). The stability of a jointly determined system depends less on the stability of its individual components

than on its ability to maintain self-organization in the face of stress and shocks, that is, on its resilience (2009b). This requires moving from a static, deterministic analysis towards a dynamic, stochastic analysis (Berkes et al., 2002). These conclusions have profound implications for the analysis of food systems and food security (Alinovi et al., 2009a; Le Vallĕ et al., 2007).

Households are components of food systems and can themselves be conceived as sub-systems. The household definition is consistent with the definition of a system (Alinovi et al., 2009a) as "a group or set of connected components that make up a unified object and operate together for a common purpose. Moreover, as the decision-making unit, the household is where the most important decisions are made regarding how to manage uncertain events, what income-generating activities to engage in, how to allocate food and non-food consumption among household members (Alinovi et al., 2010; Hoddinott and others, 2014b).

Households can therefore be viewed as the most suitable entry point for the analysis of food security. This implies that a household should be considered as a complex adaptive system. In this regard, resilience is often defined as the capacity of a system to experience change while retaining essentially the same function, structure, feedbacks, and therefore identity (Walker et al. 2006), maintaining food system properties and services. It is a concept that has been highlighted in recent research aimed at understanding abrupt change in ecological systems (Berkes et al., 2002; Holling, 2001; Walker et al., 2004) and is increasingly being applied to food systems from a theoretical perspective (E. D. G. Fraser et al., 2005; Løvendal and Knowles, 2005; Pingali et al., 2005). In this study the concept of resilience applied to household livelihood systems with the aim of measuring households' capability to absorb the negative effects of unpredictable food security shocks. The following sections outlined system-wide approaches including social-ecological resilience theory relevant to characterizing and understanding household livelihood and food systems.

2.4.1. Livelihoods Approach

Over the past 30 years, the original approach to analyzing household livelihood systems has evolved markedly. Essentially, the scope of the analysis has gradually expanded, placing increasing emphasis on multiple sources of household livelihoods, and on the role of the community, the environment and support services (Carney, 2003). The use of the livelihoods approach as an analytical framework became common in the 1980s, and it has contributed to a paradigm change in rural development thinking from a predominantly top-down, reductionist view of agricultural development to a more holistic perspective (Chambers and Thrupp, 1994). Livelihood approaches defined a livelihood as the means by which households obtain and maintain access to essential resources to ensure their immediate and long-term survival. It comprises the capabilities, assets (including both material and social resources) and activities required for a means of living (Chambers and Conway, 1992). Such approaches situate food needs within a wider set of needs driving people 's actions, and within a set of influences, possibilities and constraints which go beyond the food first mentality of much of the food security literature.

Although food security remains a distinctive concern which may need to be differentiated from other concerns and a focus on poor people's access to food should remain central to the analysis, a wider livelihoods approach can offer a framework within which to understand food security outcomes and behavior more comprehensively (Devereux, 2001b). in this regard, livelihoods approaches provide a more robust framework for the analysis of poverty and food insecurity beyond just income and consumption levels (Carney, 2003). Therefore, the potential for a livelihoods based analytical framework to generate improved approaches to poverty and food security measurement is viewed as very promising (Devereux et al., 2004).

One such approach is Sustainable Livelihoods Framework (SLF) developed in the early 1980s to guide development programming in poverty ridden developing countries. A working definition of sustainable livelihoods is: A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets, while not undermining its natural resource base (Scoones, 1998).

SLF is people-centered, designed to be participatory and has an emphasis on sustainability. The approach is positive in that it first identifies what people have rather than focusing on what people do not have (Moser, 1998). As an analytical framework, it seeks to improve our understanding of how people use the resources at their disposal to construct a livelihood. It was initially developed in rural development context and the rural household is taken as the main social unit to which the framework is applied (Ashley et al., 1999; Carney, 1998). This is implied by using the use of the term 'livelihood strategies' in which the household as a social unit is observed to alter its mix of activities according to its evolving asset position, and changing circumstance it confronts (Ellis, 2000a). It recognizes diverse livelihood strategies and sustainability as a key quality of successful livelihoods towards a positive household food security outcome (Devereux et al., 2004; Maxwell et al., 2001). that both diversity and sustainability are important aspects of resilience. The framework points to both the ability of the livelihood system to deal with and recover from shocks and stresses, by means of coping (short-term reversible, responses) or by adaptation (a longer-term change in livelihood strategy), and also the ability of the livelihood system and the natural resources on which it depends to maintain or enhance productivity over time. This aspect of the livelihoods approach reflects the dynamics and temporal dimension of food security.

The key question to be asked in any analysis of sustainable livelihoods for food and nutrition security (Hoddinott and others, 2014a) is that given a particular context (of policy settings, politics, history, agro-ecology and socio-economic conditions), what combination of livelihood resources (different types of capital) result in the ability to follow what combination of livelihood strategies with what outcomes? Of particular interest in this framework are the institutional processes (embedded in a matrix of formal and informal institutions and organizations) that mediate the ability to carry out such strategies and achieve (or not) such outcomes (Scoones, 1998). Furthermore, SLF shows that food security is not just an issue of productivity, or even the sustainability of production, or of entitlements, but depends on how people, especially poor people, gain access to production and exchange capabilities to meet at least minimum food needs (Devereux et al., 2001b).

While having the above conceptual relevance of the approach, the following section outlines the various elements of the framework together explains key properties of livelihood systems and its services including food security as one of the livelihood outcomes. It has five separate but interlinked components, which determine people ‘s livelihood outcomes and choices. Figure 2 shows the main components of a Sustainable livelihoods framework. First, the external dimension of vulnerability which is often known as the ‘vulnerability context’. It refers to a collection of external processes that are a key factor in many of the hardships faced by poor people. The vulnerability context forms the external environment in which people exist and gain importance through direct impacts upon people‘s asset status (DfID, 1999). Therefore, the context in which poor households pursue their livelihood strategies is a key determinant of the types of assets available to them and the types of livelihood strategies that they are likely to pursue. It comprises trends (i.e. demographic trends; resource trends; trends in governance), shocks (i.e. human, livestock or crop health shocks; natural hazards, like floods or earthquakes; economic shocks; conflicts in form of national or international wars) and seasonality (i.e.

seasonality of prices, products or employment opportunities) and represents the part of the framework that lies furthest outside the stakeholder ‘s control (DfID, 1999). Not all trends and seasonality must be regarded as negative; they can move in favorable directions, too. Trends in new technologies or seasonality of prices could be used as opportunities to secure livelihoods.

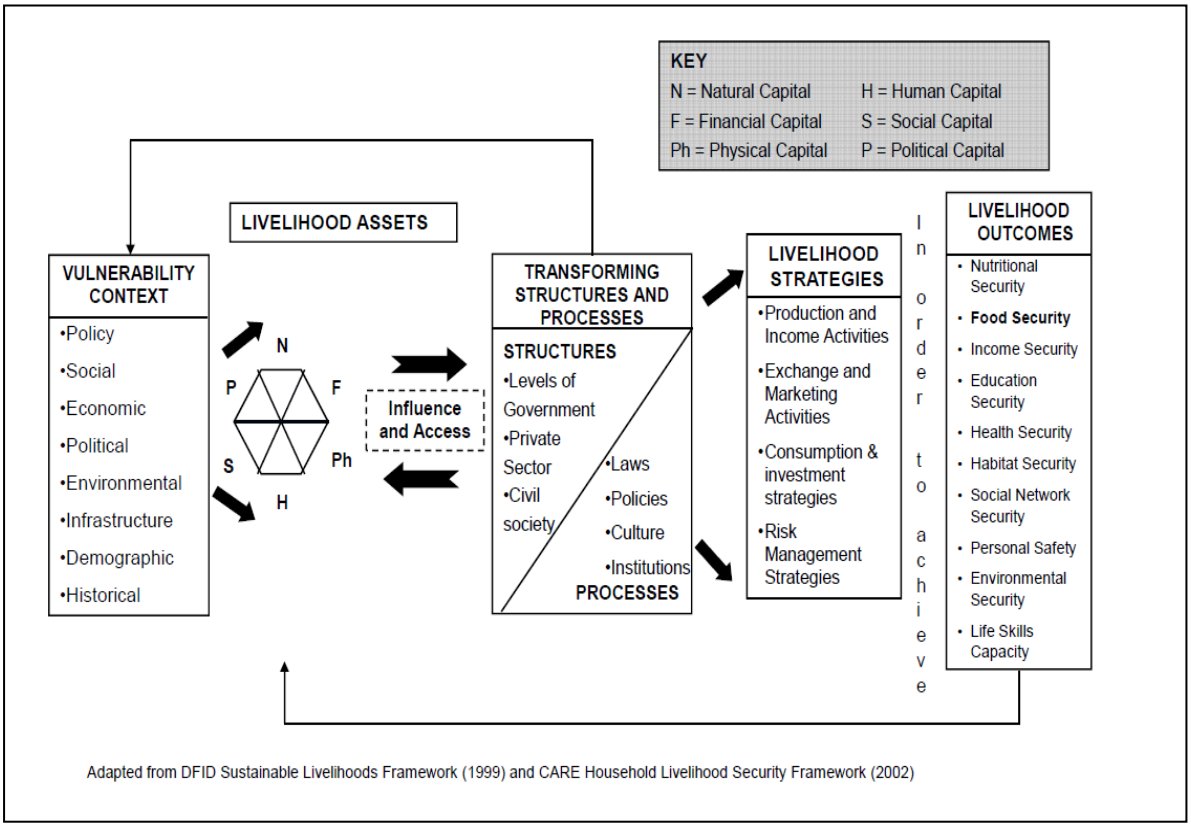

Figure 2 Sustainable Livelihoods Framework

Such contexts in which livelihoods are constructed are a crucial part of the analysis since these contexts and settings inevitably shape people‘s livelihood choices (Scoones, 1998). For example, in their study in South Africa (Ziervogel and Calder, 2003), shows how the nature and seasonality of climate shocks affect agriculture including indirect impacts on household assets and strategies. Similarly, long term trends such as policy shifts-primarily those related to structural adjustment (Bird and Shepherd, 2003) and land degradation (Yesuf et al., 2005) have considerable influence in shaping both livelihood trajectories and outcomes.

Second, Livelihood Assets: the livelihood approach is concerned primarily with people. Central to the approach is the need to recognize that those who are poor may not have cash or other savings, but they do have other material or non-material assets such as their labor and the natural resources around them. Livelihoods approaches, therefore, require a realistic understanding of these assets in order to identify opportunities and constraints for promoting a viable livelihood. For example, for rural Ethiopians livestock, labor and land play deeply interlocking roles in viable livelihood strategies, and misfortune in one of them causes spirally downward effects in others (Ellis and Woldehanna 2005). Despite no single capital endowment is sufficient to yield the desired outcomes on its own, these capitals can be stored, accumulated, exchanged or depleted and put to work to generate a flow of income or other benefits (Ellis, 2000b). DFID (1999) categorize livelihood assets into the following asset classes: ***Natural capital*** or natural resources such as the stocks and flows and environmental services available in particular agro-ecological settings; ***Financial capital*** such as savings and access to credit; ***Physical capital*** such as infrastructure and transport; ***Human capital*** related to demographic and gender structures, a body of education, the skills, knowledge and good health needed to produce effectively; ***Social capital*** which includes social networks, claims, associations and social relationships, including consensual norms and relationships of legitimate authority. It is based on these forms of capital that people 's livelihoods can be constructed. Therefore, the ability to pursue different livelihood strategies is dependent on the basic material and social, tangible and intangible assets that people have in their possession (Scoones, 1998)

Third Policies, Institutions and Processes: This are policies structures and processes that mediate the complex and differentiated process of achieving a sustainable livelihood that explain why different people have different access to different livelihood resources. Institutions, organizations, policies and legislation transform the structures and processes that shape livelihoods. They are of central importance as they operate at all levels and effectively determine

access to and terms of exchange between different types of capital, and returns to any given livelihood strategy. Institutions social cast systems and institutionalized norms often determine the options available to men and women in formulating viable livelihoods as well as the ability to cope with disasters (Cannon et al., 2003). Furthermore, the transforming structures and processes occupy a central position in the framework. They directly feed back to the vulnerability context, while influencing and determining ecological or economic trends through political structures, while mitigating or enforcing effects of shocks or keeping seasonality under control through working market structures (DFID, 1999; Scoones, 1998).

Finally, Livelihood Strategies and Outcomes: Livelihood strategies comprise the range and combination of activities and choices that people undertake in order to achieve their livelihood goals such as food security. They have to be understood as a dynamic process in which people combine activities to meet their various needs at different times and on different geographical or economical levels, and they may even differ within a household. The combination of activities that are pursued can be seen as a 'livelihood portfolio', for example in a rural context (Scoones, 1998) identified four main categories of livelihood strategy. These include, ***Livelihood intensification***, where the value of output per hectare of land or animal is increased by the application of more labor, capital or technology; ***Livelihood extensification***, where more land or animals are brought in to production at the same levels of labor, capital or technology; ***Livelihood diversification***, where households diversify their economic activities away from reliance on the primary enterprise (livestock or cropping), typically seeking a wider range of on- and off-farm sources of income; and ***Migration***, where people move away from their initial source of livelihood, and seek a living in another livelihood system

However, SLF assessments tend to focus more on understanding the factors underlying those strategies and outcomes and it requires analytical tools to measure the returns obtained from

pursuing certain strategies for entitlement mapping and analysis to predict food security outcomes. One such livelihoods-based approach with analytical functions is the Household Economy Approach (HEA) originally developed in the early 1990s by Save the Children-UK in response to a demand for an approach that could quantify the problem and allow for comparisons as well as provide reliable results for large populations and point to appropriate responses (Seaman et al., 2000).

HEA was developed in order to improve the ability to predict short-term changes in access to food. It helps to determine people 's food and non-food needs and identify appropriate means of assistance, whether it is short-term emergency assistance or longer-term development programs or policy changes. Following the works of Amartya Sen, which suggested that famine occurs not from an absolute lack of food, but from systematic inequalities that keep some people from obtaining access to that food, the HEA remains a key analytical framework relevant to food and livelihood security analysis. The HEA is not a data collection research method but is rather an analytical framework that helps to define the information that needs to be gathered and specifies the way in which it should be analyzed.

The HEA starts with an understanding of how households normally live and then incorporates the impact of a shock and how people might be able to cope. In general, the HEA includes two major components: HEA Baseline Analysis and HEA Outcome Analysis. The former includes the first three steps of the process of HEA (livelihood zoning, wealth breakdown, livelihood strategies) and the later includes another three steps of HEA process (problem specification, analysis of coping capacity, projected outcome) (Boudreau et al., 2008).

Furthermore, while the HEA was developed prior to and independently of the sustainable livelihoods framework (SLF), both share many common elements (Boudreau et al., 2008). The HEA explicitly describes livelihood strategies and livelihood outcomes through the presentation

of sources of food and income and expenditure patterns. The wealth breakdown in the HEA incorporates a particular formulation of the assets available to the households, which can be expressed in terms of the five types of assets or capitals in the SLF. However, given their respective roots, with the HEA originally designed as a tool for emergency needs assessment, and the SLF conceived for more development-oriented planning, the HEA has focused more on livelihood strategies and outcomes, while SLF assessments tend to focus more on understanding the factors underlying those strategies and outcomes. Both approaches views household livelihoods as complex systems illustrating the structural complexity and interrelationships between various components of a household livelihoods. Both also shows the variety of tangible and intangible resources available to households including the diversity of livelihood portfolio activities and the many ways portfolio configuration could be constructed characterizing the livelihoods of most rural households and communities.

2.4.2. Modern Portfolio Theory

The finance literature in its emphasis on resource allocation and multiple investment options offers valuable insights into household livelihood strategy as a portfolio of activities. Its concepts are applicable to the livelihoods analysis because resources (labor, time, money) are invested into multiple activities. Modern portfolio theory (MPT), developed in the 1950s, provides a set of metrics with a systems-based analysis approach (Markowitz, 1952) to examining the whole portfolio of activities (E. D. G. Fraser et al., 2005). MPT with its underlying principle of risk minimization, can therefore provide an analytical framework for examining a livelihood system as a whole.

Rural household livelihood portfolios with multiple ways of asset combinations could represent a social-ecological system of concern for resilience assessment (E. D. Fraser et al., 2005). While a portfolio return is determined by weighted sum of individual asset returns, portfolio volatility

is a function of the correlations of all portfolio components. MPT predicts which combinations should be chosen to reduce the total variance of the portfolio return. In this regard, MPT stresses the role of diversification of investments to reducing the total variance of the portfolio return.

MPT assumes that investors are rational, risk-averse and utility-maximizing. Optimal portfolio configuration with minimal total variance of the whole portfolio return could be constructed. Diversification of investments could be done if all investments are subject to risk, and the value of the investments do not co-vary in a way that the same economic conditions does not affect all investments equally (Markowitz, 1952). It has been widely criticized by behavioral economists for its incompleteness to consider implications of psychological decisions made by individuals that both help explain many anomalies and the existence of several biases. The basic MPT assumption of efficient market has been strongly challenged by behavioral economists such as Richard thaler who argue that markets are imperfect because people often abandoned rational decisions and this behavior creates market breakdowns (Barberis and Thaler, 2003; Bondt and Thaler, 1985). Similarly, it has been criticized for its assumption of fixed correlations between assets as well as normal distribution of asset returns which may not always reflect the real market situations(Ball, 1995; Campbell and Ammer, 1993).

Despite these drawbacks, the general concepts underlying Modern Portfolio Theory have been applied in agriculture and diversification of agricultural production units has been widely suggested as a risk management tool to reduce the impact of fluctuating farm incomes. However, agricultural producers primarily consider diversification approaches only within the farm itself, despite the considerable benefits from diversifying beyond the farm enterprise (Libbin et al., 2004). By holding a portfolio of farm and non-farm assets, rural households can diversify and reduce risk (Dercon and Krishnan, 1996). However, diversification into a new livelihood strategy reduces the risk of livelihood failure, if that new strategy is less susceptible to the shock

in question (Tincani, 2012) and if the underlying assets remain accessible (Maxwell et al., 1992b).

Though conceptually useful, it is difficult to quantitatively apply MPT to livelihood analysis, due to a lack of reliable panel data from which to calculate co-variances. There are few studies where portfolio theory has been explicitly applied to rural livelihoods such as (Abson et al., 2013; Barkley et al., 2010; Collins and Barry, 1986; Paydar and Qureshi, 2012; Witt et al., 2009). These researches applied MPT with a focus on crop variety selection, irrigation water allocation and management of other resources within the farming enterprise. While portfolio theory, with its underlying principle of minimizing risk for a given level of returns, can provide an analytical framework for examining a livelihood system as a whole (E. D. Fraser et al., 2005), the applications of some of the principles underlying MPT were employed in this paper to measuring resilience properties of household livelihoods.

2.4.3. Social-Ecological Resilience Approach

Following the paradigm shift initiated by Holling (1973) in understanding ecosystem stability by using the concept of resilience to explain non-linear dynamics and threshold effects, the term Social-Ecological System (SES) is often used in recent times to representing the complexity and interlinkage between nature and society (Berkes et al., 2002). In a SES, resilience is characterized by (a) the amount of disturbance that a system can absorb and remain within a given state, (b) the degree to which the system is capable of self-organization, and (c) the degree to which the system can build capacity for learning and adaptation(Carpenter et al., 2001a; Folke et al., 2002). In this regard, resilient SES constantly self-organize, evolve and adapt to change while undergoing through the four phases of development along the adaptive cycles described as periods of exploitation, conservation, release and reorganization (Holling and Gunderson, 2016).

As a measurable unit, there are well established evidences at least the four key resilience properties of systems. First, resilience comes from accumulated capital (wealth), which provides sources for renewal and represents the inherent potential of a system that is available for change. In the case of ecosystems, this stored wealth refers to the biomass stored within an ecosystem (Carpenter et al., 2001b). As an ecosystem accumulates biomass and is aggregated among fewer units, and in turn species diversity declines (Gunderson et al., 2006). This progression makes the system more susceptible to shock. However, in social systems, (E. D. Fraser et al., 2005) wealth has a very different meaning that social or financial wealth help communities adapt to changes.

The second key source of resilience that lies within a system captures the connectivity of the system, describing the interdependence of different elements within an ecosystem (Holling, 2001). For socio-ecological systems, it has also been termed as the degree to which the system is capable of self-organization, rather than being shaped by external factors or being disorganized (Carpenter et al., 2001b). (E. D. Fraser et al., 2005) suggested that MPT could help to capture the interdependence of different elements of the livelihood system measured by the variance and covariance structure between livelihood activities. MPT is uniquely suitable to measure this property of the livelihood system as its measure of portfolio variation accounts both the variation of individual livelihood activities as well as the covariance between any two activities within the whole household livelihood portfolio. Increasingly positive covariance between portfolio activities as well as increasing variation in portfolio return as a whole would indicate a higher degrees of connectivity of the system (E. D. Fraser et al., 2005).

The third key property of a resilient system is the diversity and variety that exists within functional groups, such as biodiversity in critical ecosystem functions, and cultural and political diversity in social groups (E. D. Fraser et al., 2005). Both vulnerability and resilience research communities (Adger, 2000b; Berkes and Seixas, 2005; Braun et al., 2005; Perz, 2005) agreed

that diversity is the key property of resilient social-ecological systems. Diversity provides a way of assessing the capacity of the system to adapt to external forces as diverse systems are better able to tolerate a wide range of environmental conditions than simple systems (Holling, 2001). In social systems as applied to livelihood system many suggested several diversity indices such as Shannon's diversity index (Timothy Frankenberger et al., 2012; E. D. Fraser et al., 2005; Niehof, 2010; Tincani, 2012), to measure diversity of entitlements to better reflect the process described for ecosystems.

The fourth resilience property captures the adaptive capacity of the system, describing how vulnerable the system is, based on its capacity to reorganize its elements into a new form which is less exposed to a given shock (Holling, 2001). In ecosystems, adaptive capacity is characterized by the opportunities for innovation which arise after a disturbance. For socio-ecological systems, it refers to the capacity for learning and adaptation occurring within the system (Carpenter et al., 2001b). In the case of livelihood systems, this can be understood as the opportunities to undertake new or different livelihood strategies (E. D. Fraser et al., 2005; Tincani, 2012). In some studies of global change, the concept of adaptive capacity (Bohensky and Lynam, 2005; Luers et al., 2003) is differentiated from the concept of adaptation. The latter is considered as inherent property of the system to deal with shock while the former often defined as the extent to which the expected vulnerability of the system could be reduced due to coping and adaptation interventions.

2.5. Risk Coping Behavior of Households as System Participants

Shocks particularly related to climate change have impacts on all dimensions of food security, namely availability, access, utilization and stability, and have impacts over the whole food system (Campbell et al., 2016). A growing body of evidence in Ethiopia and other African countries (Bryan et al., 2009; Campbell et al., 2016; Seaman et al., 2014; Ziervogel et al., 2006)

points to the need for a food systems approach to understanding climatic shock impacts and adaptation options for food security.

Recent studies of food systems vulnerability, taking a social-ecological systems perspective, points to consider the broder determinants of food security and drivers of system change including the deliberate choices and actions of system participants (i.e. households and other external stakeholders) to understanding resilience trajectories towards a positive food security outcome. This looks at particularly the capacity of households to manage resilience which may include coping and ex-ante risk management behaviour of households to deal with shocks.

In the risky environments, the poor and vulnerable population has always dealt with a highly fluctuating natural environment. The study of coping and adaptive resource management strategies in such environments recognized that coping and adaptation choices and decisions of households have an influence on both vulnerability and resilience properties of the food system and resultant food security outcomes. The risk coping behavior of the households is very much related to the persistent effects of risks and shocks. A growing body of evidence,(Dercon, 2004; Dercon et al., 2005; Gilligan and Hoddinott, 2007; Morduch, 1990) points to the role that risks/shocks and peoples choices of response strategies such as distress sales of assets contribute to perpetuating poverty. This resulted in not only negative expected livelihood outcome in terms of low future consumption but also negative risk management outcome i.e. deteriorating coping ability to deal with future risks.

These persistent effects run through three mechanisms (Morduch, 1995) First, in a risky environment, households may sacrifice their expected profit to cope with risk by choosing risk coping strategies such as crop diversification and activity diversification. In this mechanism, rural households choose to be poor as they choose crops and activities with low profit to achieve greater protection against risk. Second, in hard times households are forced to protect their

consumption today by depleting their productive assets or withdrawing their children from school. This mechanism is often termed as negative coping strategies that may undermine future livelihoods with low expected income (Devereux et al., 2008; Roncoli et al., 2001). Third, some household may also choose to reduce consumption today to protect their future livelihoods (Waal and others, 1989). This has also negative effect on health and nutritional status which have persistent effects on labor capacity and health expenses subject to high vulnerability to future poverty (Roncoli et al., 2001; Webb and Harinarayan, 1999).

Risk coping strategies are usually grouped into two categories: ex ante strategies and ex post strategies. The strategies adopted before shocks happen are referred to as ex ante strategies and the ones conducted after shocks happen are referred to as the ex post strategies. Crop diversification and activity diversification are the most important ex ante risk coping strategies. Whereas, the ex post strategies include depleting assets, getting transfers from public or private sources, borrowing from credit markets, shifting labor to off-farm activities and reallocating resources (switching expenditure and shifting to less preferred foods). Some of the ex post strategies need ex ante planning for example, (Deaton, 1992) discusses the precautionary motive in asset accumulating like livestock, jewelry and grains is primarily for consumption smoothing during periods of shock. For example in Ethiopia (Ali, 2015) confirmed that households keep livestock as a buffer stock against shock to smooth consumption primarily in response to weather shocks. There is however a cost to store such buffer assets to deal with risk (Roncoli et al., 2001) for example the prices of livestock tend to decrease due to oversupply in the market during periods of shock.

2.6. Research Framework

As an emerging complex concept, resilience has been defined and conceptualized differently by various scholars and institutions resulted in a plethora of conceptual frameworks. These

frameworks/models could be broadly categorized into two categories: models that attempt to capture complex resilience properties of systems i.e. a system-wide approach to resilience, and models that attempt to define and measure the characteristics of resilience at household and community level with frameworks consist of a set of resilience domains. The former includes models such as TANGO/DFID Food Security Resilience Framework (Tim Frankenberger et al., 2012); and Livelihoods Cycle Framework-Livelihoods Change Over Time (LCOT) (Vaitla et al., 2012) while the later may include FAO-RIMA model (Alinovi et al., 2008) and USAID-Resilience Domain Framework (2013).

However, all share a number of common components (Hoddinott and others, 2014b) that include highlighting the broader environment in which a household resides; the resources available to that household; how that household allocate those resources to multiple livelihood activities; and how portfolio returns on those activities are affected by shocks and leads to livelihood outcomes for instance food security.

The conceptual framework for resilience which guides this research is based on the comprehensive framework developed by Tango International and DFID (Timothy Frankenberger et al., 2012) which integrates the concepts and principles of three approaches to address the underlying causes that contribute to resilience. These are sustainable livelihoods framework, Disaster Risk Reduction and Climate Change Adaptation approaches. The framework seeks to understand and address how long-term trends such as climate change, socio-political and environment factors affect livelihoods security and exposure to risk, which results either in increased vulnerability or increased adaptive capacity over time. In order to capture this dynamics, Tango International and DFID uses the term ‘pathways’ as indicated in the framework (see figure 3) to underscore the idea that both vulnerability and resilience are properly viewed as processes rather than static states. Households or communities those are able to use their adaptive capacity to manage the shocks or stresses they are exposed to be less sensitive and are

on a resilience pathway. Households that are not able to use their adaptive capacity to manage shocks or stresses are sensitive to shocks and are likely to go down a vulnerability pathway.

The vulnerability pathway could result in permanent and negative changes to coping capacity, ultimately leading to a state of chronic vulnerability and destitution (Timothy Frankenberger et al., 2012).

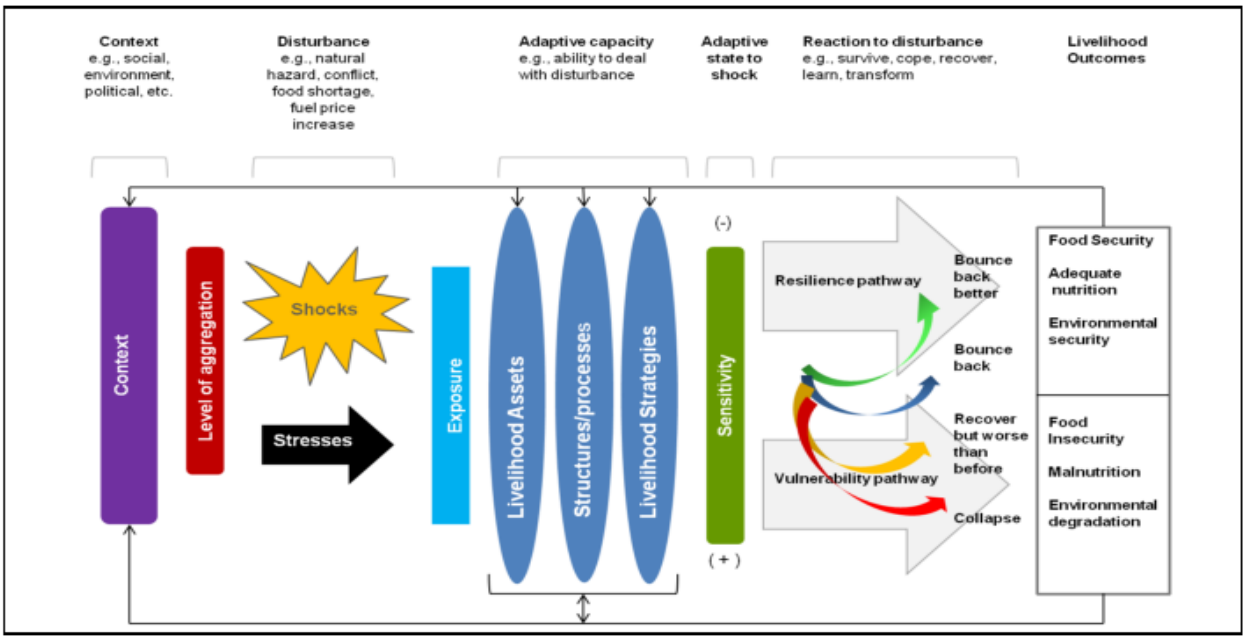

Figure 3 Resilience Framework developed by Tango International and DFID (2012)

The resilience pathway, on the other hand, is an iterative process, involving innovation and application of lessons learned from past experience that increases adaptive capacity and leads to resilience. In the framework above, a resilience pathway leads to positive livelihood and risk management outcomes. These are resilience outcomes that lead to the ability to cope with shocks, to learn from past and prepare for future shocks while remaining food secure, and ultimately, moving beyond poverty and food insecurity (Timothy Frankenberger et al., 2012). In the context of food security, resilient households are those who achieve a positive livelihood and risk management outcome in the face of shocks. This framework is not uni-directional, but includes several feedback loops. Improved livelihood outcomes (resilience pathway) increase

adaptive capacity and reduce exposure and sensitivity to shocks/stresses. Conversely, worsening livelihood outcomes (vulnerability pathway) negatively impact adaptive capacity and increase exposure and sensitivity. Thus, resilience is not just about dealing with today's shocks and stresses but also planning for and being able to adapt to unpredictable shocks and changing conditions in the future (2012).

Generally, the framework comprises four important components of resilience with associated characteristics of the livelihood system at household level. Based on the conceptual framework depicted in figure 3, the four components of resilience in the context of food security at household level include:

External environments that influence household livelihoods (Context): These external environments which are beyond the capacity of individual households. This includes broader contexts related to environmental, political, social, economic, historical, demographic and policy conditions that affect households and communities, and determine to some degree the extent to which they are able to cope with risks. The context is dynamic, rather than static, and changes according to the adaptive capacity of a unit in response to risks and disasters (Alinovi et al., 2009a). Thus, changes in contextual factors impacts, either positively or negatively, the ability of a unit to cope with future risks and disasters. Incorporation of new contextual factors is critical to a resilience approach and underscores the importance of disaster planning and "future thinking".

Policies, Institutions and processes within the livelihood framework also include factors beyond individual households and usually determine people's access to resources and livelihood options. Structures and processes are embodied in the formal and informal institutions that enable or inhibit the resilience of individuals, households and communities. High adaptive capacity results when there is a flexible governance structures and planning

frameworks reflecting the dynamics of the system (Folke et al., 2005). Important interactions exist between structures and processes within the context of rules and social norms in which they exist. Various structures and patterns of collaboration among institutions, and among individuals or communities, can have positive or negative effects on local livelihood systems.

Shock Exposure (Disturbance): Disturbance may come in the form of rapid onset shocks such as earthquakes, floods, drought, human disease epidemics, plant pest outbreaks, and conflict, or longer-term stresses such as environmental degradation, political instability, conflict, price inflation. In assessing resilience, it is important to acknowledge that some disturbances are idiosyncratic (i.e., affecting only certain individuals or households) whereas others are covariate (i.e., affecting an entire population or geographic area). The underlying causes of vulnerability to shock or stress differ and therefore require different analysis and response based on the type of shock/stress (Günther and Harttgen, 2009; Mitchell and Harris, 2012; Twigg, 2001). Resilience to one type of shock does not necessarily ensure resilience to others. In this regard capturing both temporal and permanent nature of shocks is very important to understand the effects of shocks on resilience outcomes. Exposure, in the resilience framework above, is defined as a function of the magnitude, frequency, and duration of a shock or stress. Some shocks are sudden onset with little or no advance warning (e.g., earthquakes and flash floods) while some others are slow onset with their duration can be marked in years (e.g., drought and land degradation). Many stresses or shocks are seasonal and the inability to cope with seasonal shocks or stresses can make already vulnerable households even more vulnerable to disaster by increasing their risk of exposure to future hazards (Pasteur, 2011). Similarly, in the context of food insecurity, the inability to cope with seasonal hunger may lead to long-term vulnerability to famine (Devereux et al., 2008)

Adaptive capacity: This includes access to assets and diversity of livelihood & risk management options/strategies. It represents the strengths and capacities internal to the household and can be understood as the nature and extent of access to and use of resources in order to deal not only with shocks but also with stresses and longer-term trends. It results not only in the ability to 'bounce back' from shocks but to successfully adapt to long-term trends or changing conditions in the future. These resources can generally be classified as tangible and intangible assets that allow individuals and households to meet their basic needs. Livelihood security depends on a sustainable combination of these resources often grouped into six assets or capitals as described in the sustainable livelihoods framework. Greater diversity of assets reduces vulnerability to shocks, and high adaptive capacity results from the ability of households and communities to access and utilize these key assets in a way that allows them to respond to changing circumstances. Thus, it is not only critical to have access to livelihoods assets but also to have the skills and knowledge base required to utilize them in ways that improve the capacity of households and communities to deal with future shocks and long-term trends. Households form livelihood strategies based on the combination of assets they have, the shocks and trends they are exposed to, and the overall context regarding formal and informal structures and social and legal systems. Household livelihood strategies involves a diverse and evolving combination of multiple income-generating activities. The fact that achieving positive risk management outcome is also the main objectives of household livelihood; this component of the framework includes risk management strategies. These strategies can be categorized into ex-ante and ex-post strategies. Ex-ante risk management strategies are preventive in nature and are therefore implemented before a shock or stress occurs (e.g., crop diversification, use of drought-tolerant crops/livestock, obtaining insurance, protecting health). Vulnerable populations also use Ex-post risk management strategies when they are incapable of meeting basic household needs because of the impact a shock has had on their normal livelihood options. Household coping strategies

are implemented ex post, in response to a shock or stress. Some coping strategies are unsustainable often termed as distress strategies which are more detrimental over the long term to household livelihood systems and tend to reduce household adaptive capacity and resilience.

Sensitivity and reaction to shock/response capacity: Sensitivity to shocks refers to the degree to which an individual, household or community will be affected by a given shock or stress (Timothy Frankenberger et al., 2012). Whereas reaction to shock refers to response capacity of household livelihoods represented by those actions and behaviors that help people to respond to shocks, thereby reducing their vulnerability to the shock, and increasing adaptive capacity. For practical purposes, response capacity is defined in this paper in two ways. The first one is the extent to which a system can modify its circumstances to move to a less vulnerable condition (Luers et al., 2003). This definition of response capacity does not include the capacity of a system to absorb the impact of shock, rather the capacity to mobilize resources and respond to shock, emphasizing the role of coping strategies in influencing resilience outcomes. Hence the second definition that includes both capacities is defined in this paper as the ability of households to expand extra food income beyond the minimum survival threshold to cover expected losses due to shock.

Some of the indicators representing the above components of resilience are process indicators primarily consists of household and community characteristics as well as the characteristics of shocks and the external environment in which households reside. Some are outcome indicators such as response capacity and sensitivity of livelihood systems at household level. As shown by figure 4, the conceptual framework is modified to operationalize state variables. The principles of Modern Portfolio Theory (MPT) were employed to measure and characterize the system's adaptive state to shock at t+0 and at t+1. Of the many livelihood outcomes of concern to rural households, this study focus on the food income obtained from different sources as a measure of

well-being and the system of concern is represented by a portfolio of household food and income sources.

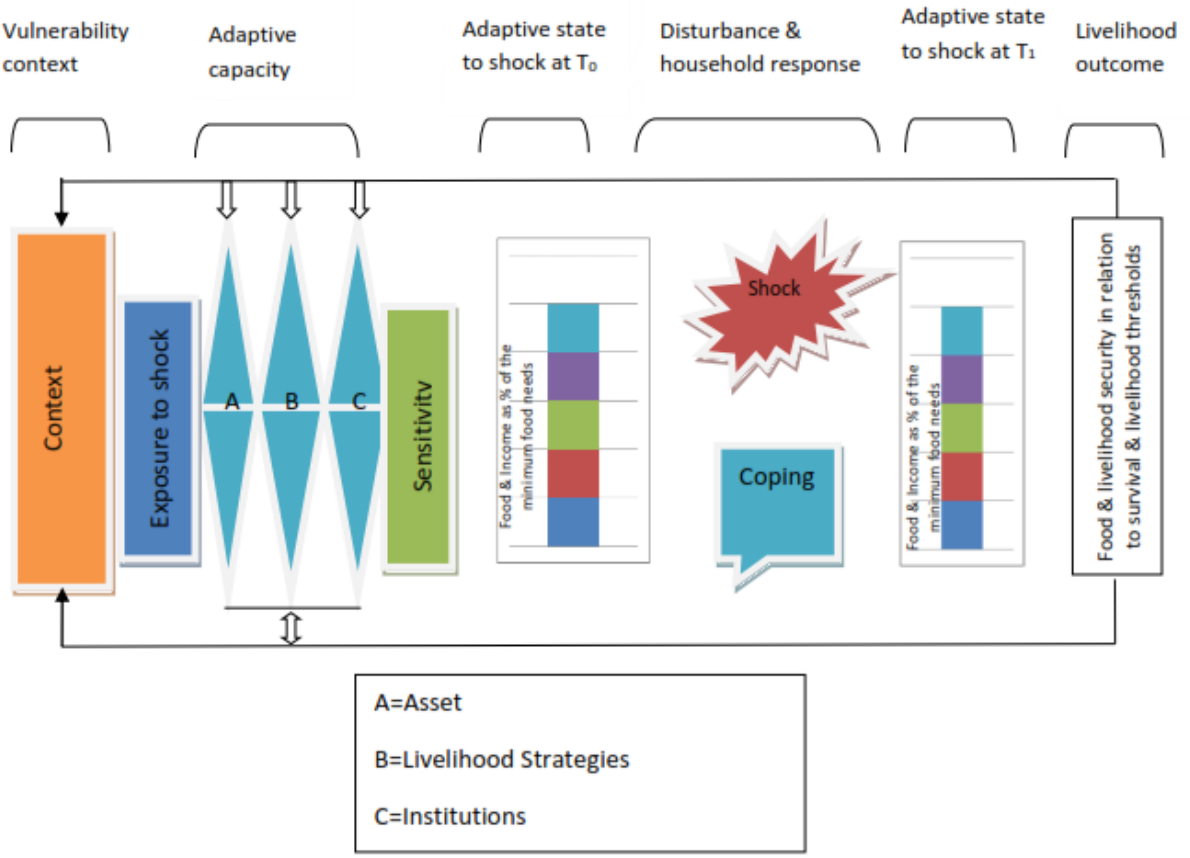

Figure 4 Modified Resilience Framework of the Study

Modern portfolio theory (MPT), developed in the 1950s, takes a systems-based approach examining the whole 'portfolio' of investments (Markowitz, 1952). Portfolio volatility is a function of the correlations of all portfolio components. Its concepts are also applicable to household livelihoods because resources (labor, time, money) are invested into multiple activities.

As a result, portfolio theory, with its underlying principle of risk minimization, can provide an analytical framework for examining a livelihood system as a whole (E. D. Fraser et al., 2005). In this regard MPT provides methodological approach to measure adaptive state to shock at t+0 (which is the expected state of household food security) defined by expected average household

portfolio return and its variability. Hence at its normal state, sensitivity of the livelihood system could be measured by percentage variation of expected household food income relative to its mean return. Therefore, adaptive state to shock at t+1 could be measured as follows:

$$\mathrm{E}(\mathrm{FI}_{\mathrm{port}})(1 + CC_{hi}) \boldsymbol{X} \begin{pmatrix} 1 \quad if\ there\ is\ no\ shock\ at\ t+1 \\ 1 - CV_{hi}\ if\ there\ is\ shock\ at\ t+1 \end{pmatrix} \qquad \textbf{\textit{Eq.2.1}}$$

Where $\mathrm{E}(\mathrm{FI}_{\mathrm{port}})$ is expected average household portfolio food income; CC_{t+1} is household coping capacity measured by the ratio of the amount of food income that a household could expand (during periods of shock) to the expected average portfolio food income; CV is the coefficient of variation of portfolio return and 1-CV is the recovery potential of a household. For the details of data and MPT metrics, see chapter 5, section 5.2.1)

3. STUDY AREA

3.1. Introduction

This chapter presents the bio-physical and socio-economic context within which the thesis is situated. Ethiopia is a land-locked country located in the Horn of Africa ranked as the second most populous country in Africa, engulfed with a huge number of foods insecure populations over the years. The country, with more than 29% of its population still living under poverty line (MoFED, 2012), is the home of almost half of the food insecure population of the Sub Saharan Africa and this makes it the world's most food aid dependent country. This chapter focuses on the North central region of Ethiopia known as the Amhara Region, where the study area is located (see Figure 5). Geographically, chronic food insecurity plagues many areas of Ethiopia, and 82 out of the total 168 districts of Amhara region are drought prone and food insecure (GOV, 2016).

Among such districts, given the primary goal of the study which is to investigate resilience properties of livelihood systems at household level, this case study focused on Tach Gayint district where half of its population is chronically food insecure and vulnerable to climatic risks such as drought, flood, hailstorm, and associated crop and livestock diseases.

Of the many livelihood outcomes of concern to rural households, this study focus on the food income obtained from different sources as the study measure of well-being with a focus on climate related risks. However, it is important to bear in mind that the conclusions drawn from the study sites cannot necessarily be generalized for the rest of the risky environments in the country, as different districts vary greatly both in the social structure and in the ecological characteristics of their area.

The context within which livelihood systems constructed in the study area is presented as follows. The first section outlines the bio-physical context of the study area involving overview of geographic, meteorological and key environmental aspects that influence livelihoods and food security outcomes. The second section presents the overall socio-economic context that characterize the study with emphasis on agriculture as a primary livelihood sector, contributing more than half of the Ethiopia's GDP and employing 80% of the workforce. Finally, the last section of the chapter presents shock history and food security profile of the study area.

3.2. Location and Bio-physical Context

Located in Amhara region, northwestern Ethiopia, South Gondar administrative zone is one of the ten administrative zones found in Amhara regional state where the study area, Tach Gayint district is located. The administrative zone encompasses seven major livelihood zones and ten administrative districts. Five of the districts in South Gondar zone are characterized as drought prone and food insecure areas.

Tach Gayint district is located 200 km north east of Bahir Dar Regional capital that lies between 11^0 22' –11^0 4'N latitude and 28^0 19' – 28^0 43' E longitudes with the total area of 994.84 Sq. km. Two livelihood zones, namely Abay Beshilo Basin (ABB) and Abay Tekeze Watershed (ATW) hereafter referred to as Abay and Guna cluster respectively, both with a very long history of relief assistance predominantly characterize these risk prone district (TGWA, 2014). Guna cluster characterized by mid-land and highland agro ecologies, and Abay cluster, predominantly characterized by lowland agro ecology but also include some midlands. Both livelihood zones suffer from chronic food insecurity due to a combination of various factors including erratic rains, small landholdings, highly degraded farmlands, infertile soil, pest infestation, livestock disease and malaria.

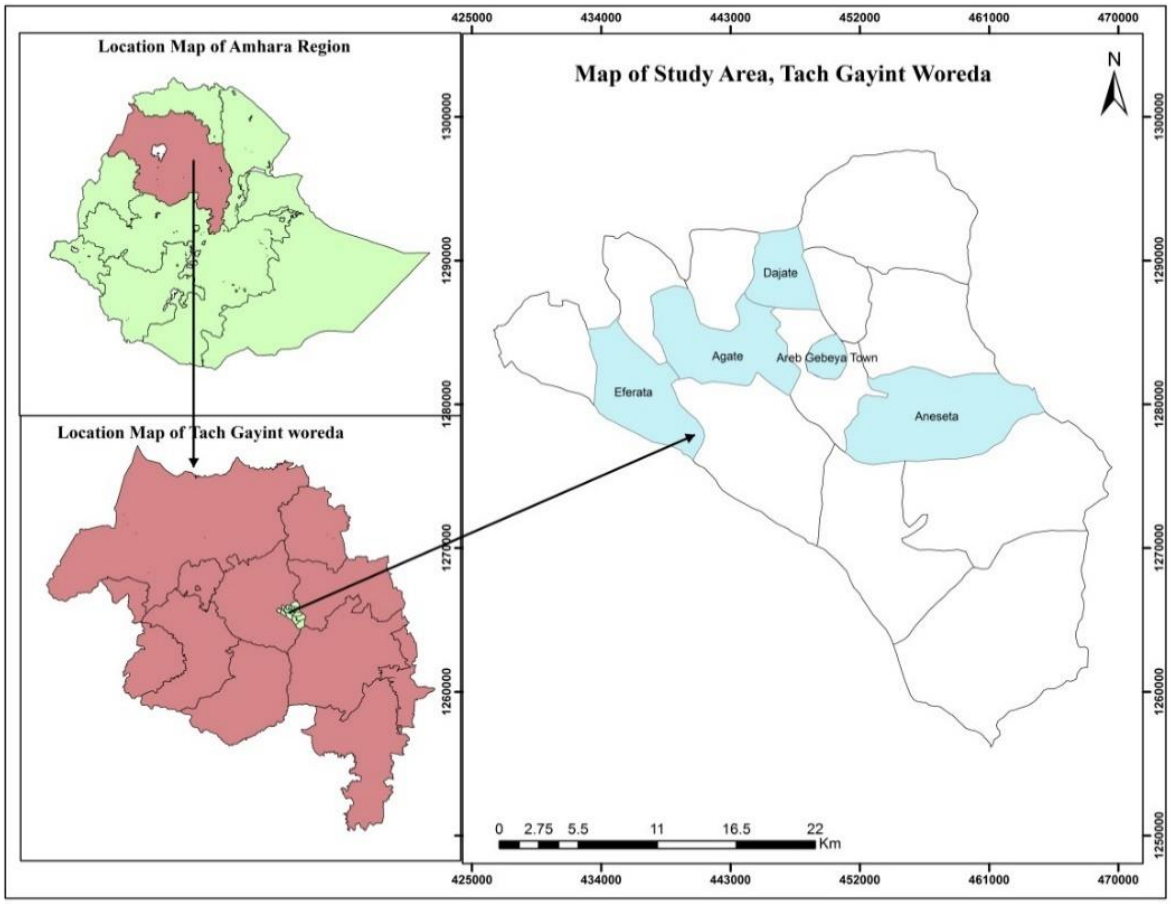

Figure 5 Map of the Study Area

The district shares borders with districts of Este (in the west), Simada (in the south and southwest), Lay Gayint (in the north), North Wollo zone (in the east) and South Wollo zone (in the southeast). It is divided into 16 kebeles (the lowest administrative units in Ethiopia). These are: Bethelihem, Gomenge, Shengo, Efrata, Agat, Dejat, Zemfel (Aketo), Eskindrawit, Jaji, Enjit, Aduka, Anseta, Adunsa, Arib Gebeya, Endewa and Gedoda.

Most of the areas of the district are more than 2000 meters above sea level, and altitude decreases as one move from the northern part to all directions. The northern parts of Tach Gayint are in the Debre Tabore massif that rises more than 2500 meters. The north eastern, north western and central parts have medium elevation while the south and south western are lower areas of the district (Figure 6). The topography of the district comprises of mountainous areas (23 percent),

plains (22 percent), gorges and valleys (27 percent) and rugged terrain (28 percent) (TGWA, 2014).

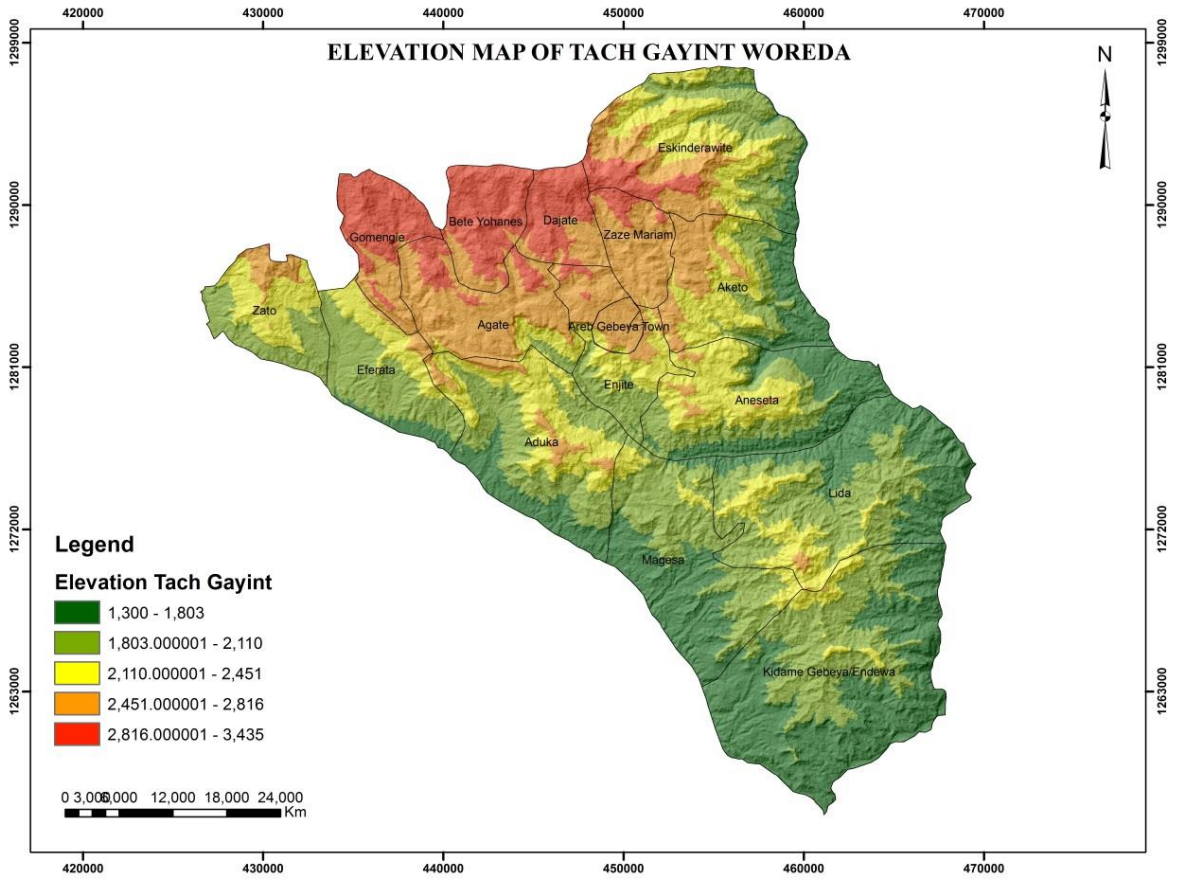

Figure 6 Elevation map of study area

There are three agro-ecological zones in the district, namely warm low land "(*kola)"* that covers 23.5%, warm and humid mid-highland "(*Woina Dega*)" which covers 63.5% and wet highland "(*Dega*)", which covers 13%. Thus, the climatic zones of the district are classified into Dega (above 2500m.a.s.sl) that refers to highlands, Woyna Dega (1500-2500m.a.s.l.) that refers to the intermediate and Kolla (below 1500m.a.s.l.) that refers to the lowlands. The mean minimum and maximum annual temperature ranges from 13^0c to 27^0c while the mean minimum and maximum annual rainfall ranges from 900 to 1000mm per annum. The district is characterized by erratic rainfall pattern. With the mean annual temperature of 22°C, the main rainy season is between early June and the end of September, when agriculture is predominantly depending

on. There is a high concentration of rainfall in July and August. The amount of rainfall generally varies with altitude, and the highland portion of the area receives the highest rainfall. Small rains occur between early February and the end of April. The main rainfall seasons shows a decreasing trend with less than 700 mm, the threshold total precipitation required for most crops in the area, for most of the years between 1997 and 2015 (Figure 7).

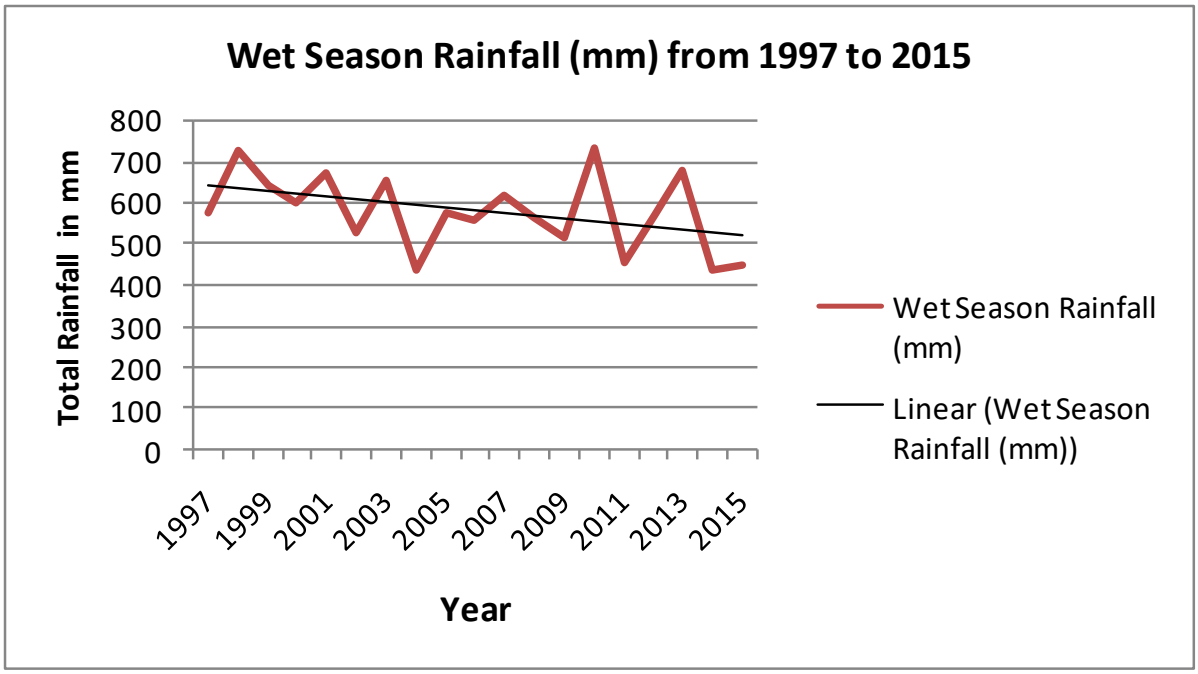

Figure 7 Trends of Wet Season Rainfall (1997-2015)

Recently the worst global El Niño season affects the 2015 wet season resulted in up to a 30% reduction of crop production in the district. The Standard Precipitation Index (SPI) calculated using historical record of precipitation of data available for the district between 1997 and 2015 is shown by Figure 8. The SPI values were calculated for the cropping season (JJA) in order to account episodes of agricultural drought in the district. The district experiences at least four drought episodes over the last 20 years with the severe drought in 2015. Drought induced food emergencies are recurrent problems causing half of the population trapped in a state of chronic poverty subject to beneficiaries of the biggest social protection program in Ethiopia.

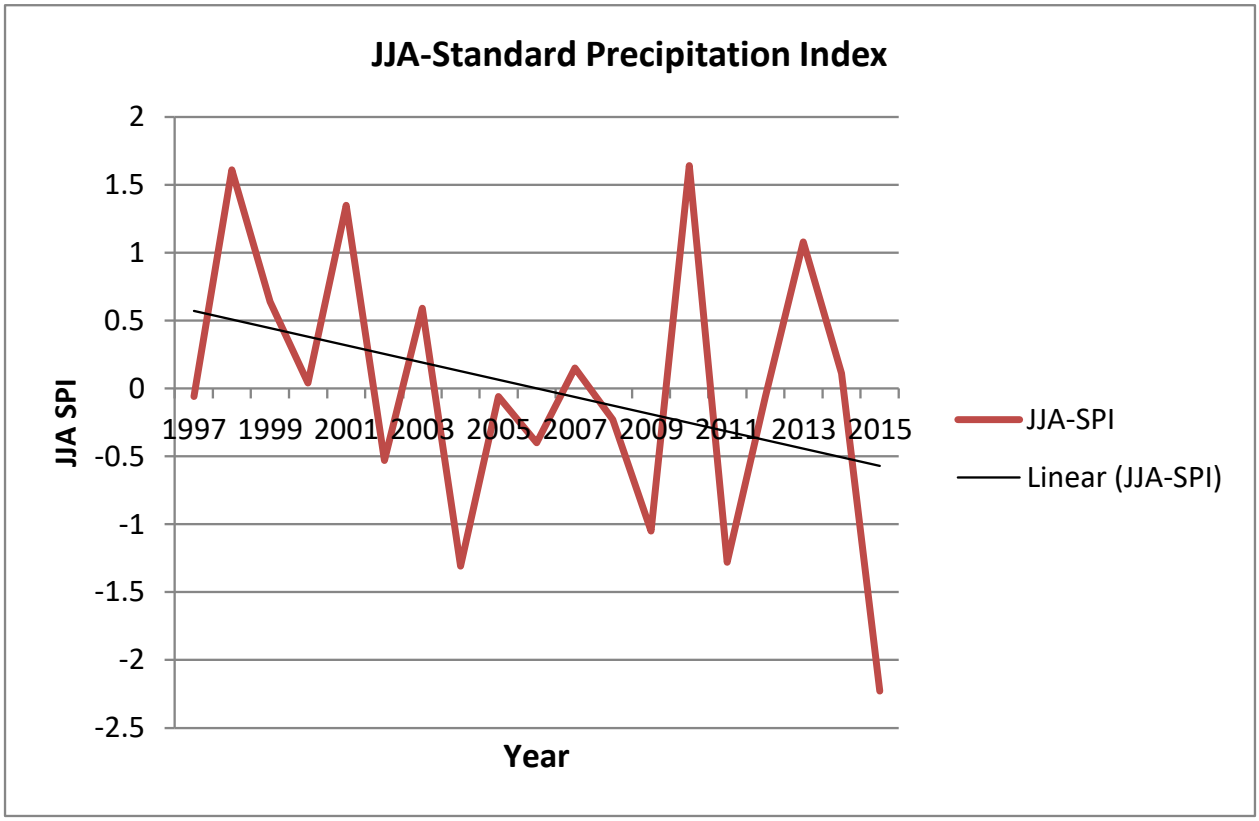

Figure 8 Standard Precipitation Index for Wet Season (Tach Gayint District)

Annual rainfall and its seasonal distribution highly affected crop production in the region in general and in the district in particular. Cereal crops exhibit the largest year-to-year variability in terms of area cultivated, total production and yield compared to other crop types. This high inter-annual variability is caused mainly by inter-annual variability in rainfall. Though seasonal variation of rainfall distribution is very important than the intensity and amount of annual average rainfall, figure 9 shows the positive correlation between summer rainfall amount and cereal production indicating farmers' vulnerability to food-insecurity related to rainfall variability. Thus there is a critical need in the area for water resources development including household level rainwater harvesting for crop production as an adaptation strategy to current rainfall variability and supplement rain fed crop production.

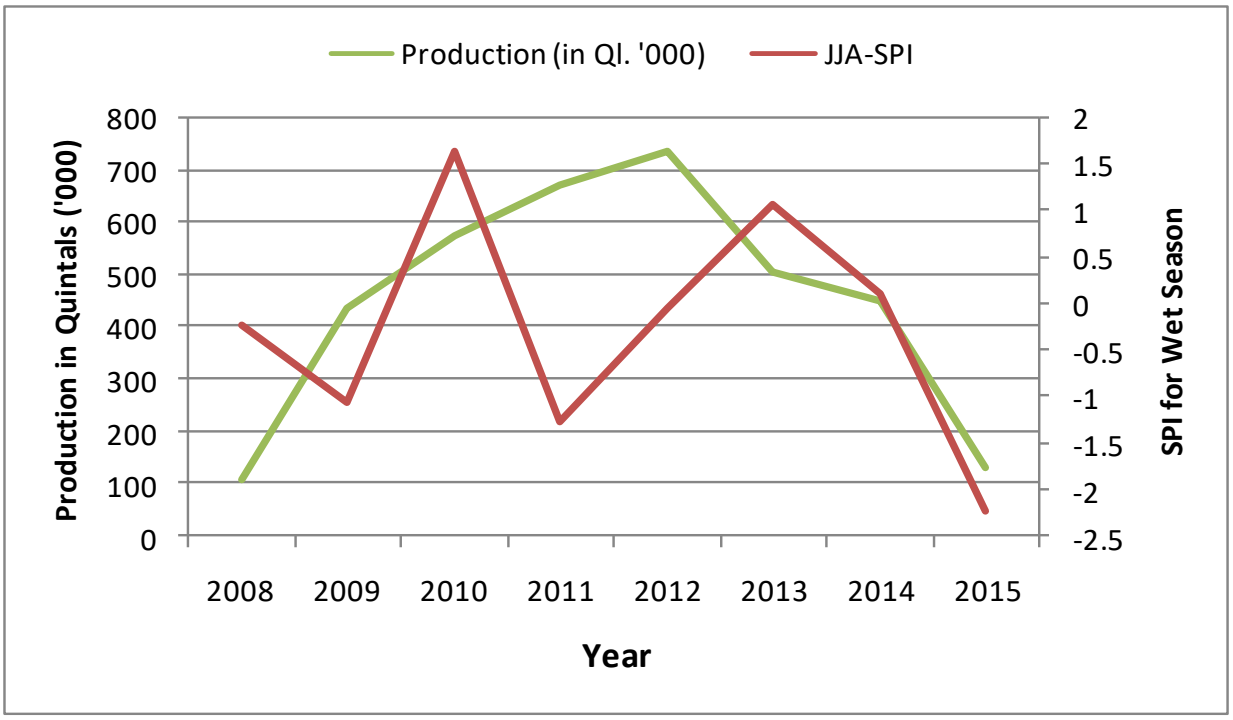

Figure 9 Relationship between Crop Production and Wet Season Rainfall (2008-2015)

With only less than 10% of vegetation coverage, environmental problems of long term stresses such as climate change and land degradation are critical challenges of development in the area (TGWA, 2014). Coupled with a rapid population growth rate and centuries of cultivation, these environmental problems are manifested in the area in the form of higher levels of deforestation, soil erosion, and the depletion of biodiversity. At regional level, a significant portion is affected by soil erosion, and about 29% of the total area is categorized as being under a high erosion hazard. About 58% of the soil eroded in the country is from the Amhara region (BoFED, 2004). In this regard, soil erosion in the region in general and Tach Gayint district in particular, is a critical problem characterizing the area's ecological fragility that underlines the problem of poor productivity and pervasive problem of food insecurity.

The wide diversity in climate and topography in the area has given rise to at least three distinct soil types where lithic leptosols predominantly characterize most of the area's soil type. The Eutric leptosols common on the highland parts of the district (Figure 10). However, many years

of continuous cultivation, the limited application of nutrients and the removal of all crop residues have depleted the soil of nutrients.

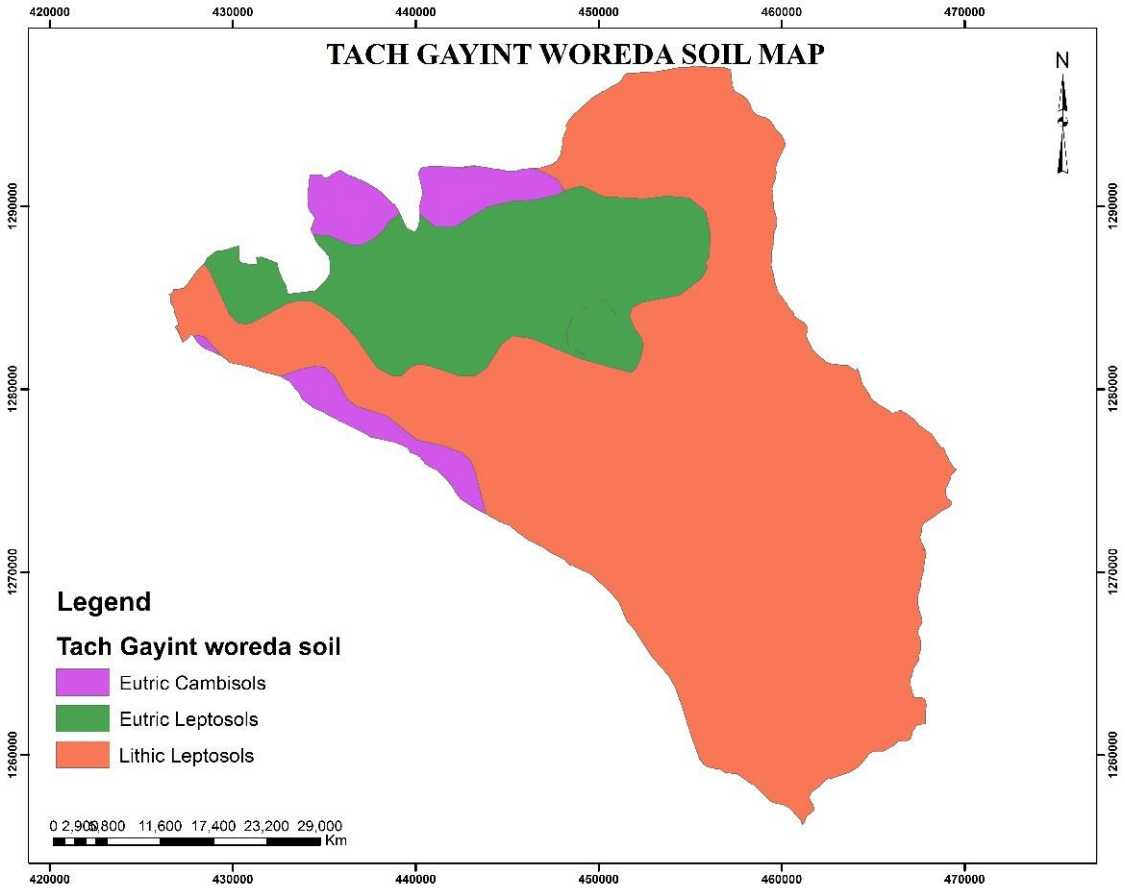

Figure 10 Soil Map of the Study Area

Farmers in the area have their own way of describing and characterizing soils in their fields, and this is based on levels of fertility and physical properties such as color, depth, workability, and susceptibility to erosion. The management of soil fertility and other agronomic practices vary according to each soil type.

The district is endowed with many perennial springs and seasonal streams which are the main source of drinking water, for both human and livestock, from which 65% of the household obtained drinking water while the remaining 35% of the households have access to piped water. According to the District Rural Development and Agricultural Office, there are 1,549 spring

water and two pond water sources, which are available for water supply in the district. All streams in the highland and lowland catchments drain into the Blue Nile River. The Blue Nile River is a natural border separating this district from South Wollo Administrative Zone. Most lowland *kebeles* are found within the Blue Nile River Valley.

3.3. Socio-economic Context

According to the 2007 Population and Housing Census, the total population of Tach Gayint District was 109,812, with more males (51%) than females (49%). The region's Commission of Plan projected the population of the district for the 2015 which is 112, 762 (BoFED, 2015). Out of the total population, 92% were rural and the remaining 8% urban. Most of the population (63.2%) is aged between 15 and 60 years, while the young population (less than 15 years of age) constitutes 28.2%. However, the old age people constitute less than 9%. The overall dependency ratio is about 1.73 i.e. there are 173 dependents for every 100 working-age people. The household sizes in the district range from between three and seven people.

About 98% of the population lives in rural areas where mixed farming is the main activity. The population growth rate is about 2%. In addition, the Census showed that the crude population density of the district is 113 persons per/km^2. Furthermore, almost all residents in the district belong to the Amhara ethnic group and 98% of the population follow the Orthodox religion. A small percentage (2%) of the population is Muslim.

Size of arable agricultural lands in the district is about thirty-six thousands of hectare with average land holding size of 0.75 hectare/household which is less than from both the national and regional averages. Production and productivity of the district is very low due to erratic rain fall, low soil fertility, occurrence of disease and pest, flood, poor agronomic practice, low input utilization. Farming system in the district is mixed farming involving both crop and livestock with free grazing characterizing the area's grazing system.

In addition to the dominant rain fed agricultural system very poor irrigation systems are practiced for cropping with furrow irrigation is a common type of irrigation system used. Basin irrigation is also practiced in very limited areas primarily for fruit crops. In general, agriculture is the single most dominant means of livelihood in the district, and 78% of the population depend on it while about 22% of the population are engaged in casual labor as well as business activities.

The main crops grown in the area are wheat, barley, teff, maize, beans, chickpeas, potato, sorghum, safflower and lentils. The type and pattern of crop cultivation is affected by altitude. Barley, wheat, beans and peas are the major crops in the highlands while sorghum, maize and haricot beans are widely cultivated in the lowland *kebeles*. Rearing livestock types such as cattle, shoats and equines are also the other important economic activity performed in combination with crop production.

In terms of access to basic infrastructures, there are 62 schools and 28 health centers and 15 Farmer's training Centers in the district (TGWA, 2014). The literacy level of the population above 7 years old is 13.1% out of which 55% of them completed only below first grade level while 28% and 15% of the population attended primary and secondary school respectively. There is only one hospital for the entire district where the health service is relatively inadequate compared to other districts in South Gondar Zone. Furthermore, transport is very limited. There are 3 main roads which connect to other districts while more than 70% of the households did not have any type of road that leading to their home. Average time taken to reach the nearest paved road is 2hrs and 23 minutes. On the other hand, average time taken to reach the nearest urban center is 3hrs and 33minutes. There is no banking service in the district and people have to go to Lay Gayint district about 30 km away.

3.4. Food Security & Shock Context

This section presents the food security situation and common shock types affecting the study area. Before presenting the specific shock and food security situation of the area of concern, it is important first to provide overview of the broader situation at regional and zonal levels within which the study area is situated. The Amhara region where the research is located, primarily suffers from recurrent droughts and more than half of its 106 districts are classified as drought prone and chronically food insecure by the region's Disaster Risk Management institution. For example, on average more than 2 million people in the region, including the chronically food insecure who are under regular safety net program, required food emergency assistance between 1995 and 2014 (Figure 11).

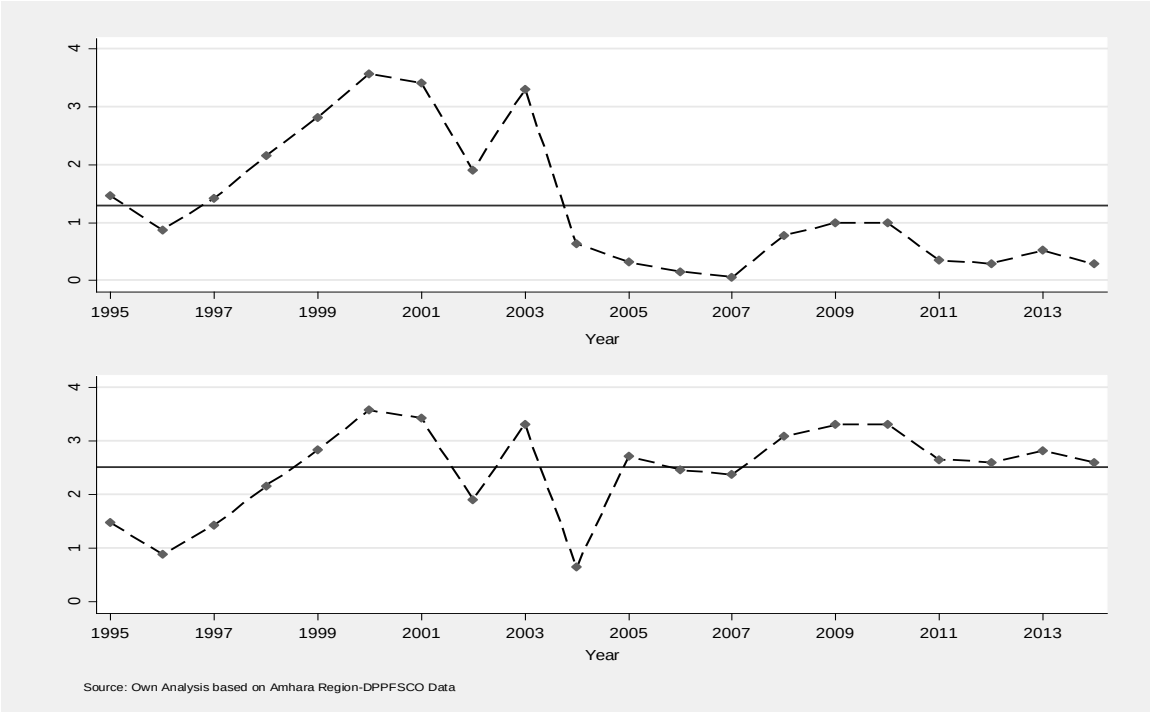

Figure 11 Food Emergency Affected Population between 1995 and 2014 in Amhara Region

The problem of food insecurity is more pronounced among poor farmers and farmers in marginal areas and nearly three million people have faced chronic food insecurity problems, making the situation more critical than ever before. Similarly, South Gondar Zone where five out of its ten districts are chronically food insecure areas where the study area, Tach Gayint

district is one of them. The following graph shows both the chronically food insecure (who benefit from the national safety net program-PSNP) and transitory food insecure population of South Gondar Zone between the periods of 2009 and 2015.

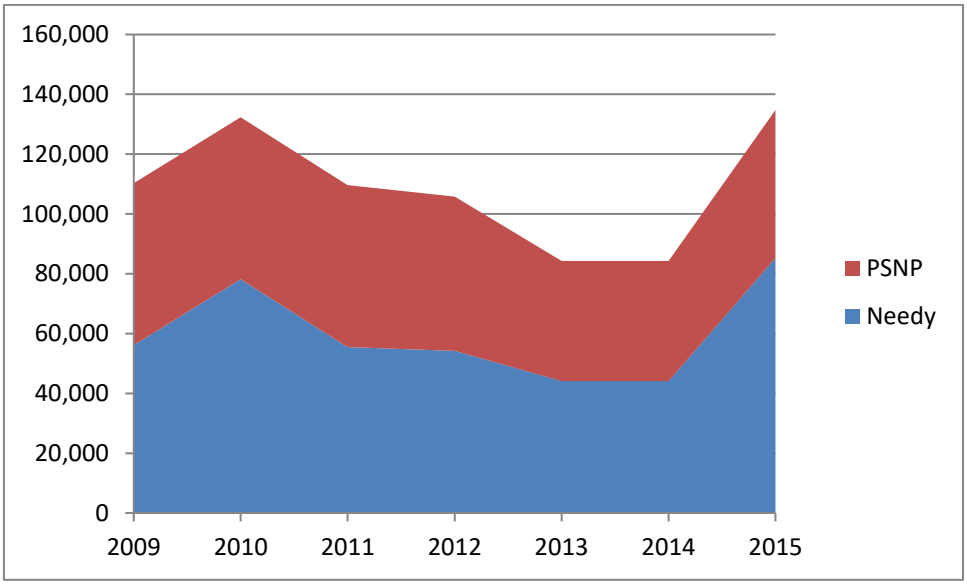

Figure 12 Food emergency affected population between 2009 and 2014 in South Gondar Zone

While considerable proportion of population are exposed to shock induced periodic food emergencies, about half of Tach Gayint population are chronically food insecure and currently benefiting from the social protection program.

The major disaster risk occurring in the woreda are more of hydro-meteorological nature such as flooding, drought and hail storms which have huge impacts on the livelihood of the community. Crop pest, livestock disease, and human disease are also prevalent. Furthermore, soil erosion and deforestation are among the environmental problems challenging the overall development of the district (DRMFSS, 2012). Common disaster types in order of importance is presented in the table below by specific administrative units. It was also evident during community group discussion of this study that climatic shocks are the major events affecting communities (Table 1).

Table 1 Common Disaster Occurrences in Order of Importance by Kebele

Kebele	Disaster 1	Disaster 2	Disaster 3
Enzhet/02	Drought	Soil erosion	Hail storm
Dajat/03	Drought	Crop pest	Land slid
Beteyohanese/04	Hail storm	Drought	Flood
Eskenderawit/06	Drought	Flood	pest
Anseta/05	Drought	Crop disease& pest	Flood
Zhazh/08	Drought	Crop disease& pest	Flood
Gedoda/09	Pest	Drought	Flood
Endwa/10	Drought	Pest	flood
Adansa/11	Drought	Pest	Animal disease
Aduka/12	Drought	Flood	Crop pest
Agat/13	Flood	Ice damage	Drought
Gomengie/14	Flood	Ice	Crop disease& pest
Efrata/15	Drought	Crop pest	Flood
Betelehem/16	Drought	Pest	Flood
Aketo/07	Drought	Crop disease& pest	Hail storm

Source: National District Disaster Risk Profiling Program (DRMFSS, 2012)

The following sections presents details of the common shocks affecting the district organized by shock categories of weather, biological as well as market related shocks. Please note that the main data sources for this sub-sections are both from the national district disaster risk profiling program as well as qualitative information collected and documented during the study primarily from five community group discussions and key informants involving officers and experts of the district food security and emergency response coordination office.

3.4.1. Weather Shock

Weather shocks such as drought, flood, hail-storm, and frost are the common climate related problems affecting the district household livelihoods. Agricultural drought is characterized by unusually dry conditions during the growing season with poor rainfall distribution is the most common form of drought affecting agricultural production in the district. Table 2 shows the specific nature of drought related to the start and end of rain including irregular and unusual rainfall patterns affecting crop production as well as availability of pasture for livestock.

Communities reported that such drought features are a recurring feature of the district causing production shortfalls in almost every year. Recently in 2015, a severe drought affected most kebeles of the district causing a significant production shortfall of up to 50% due to late on set and inadequate kiremet (summer) rain during critical times of agriculture.

Table 2 Type of Weather Shock Affecting the Study Area & Its Temporal Aspects

Type of Weather Shock	**Period of occurrence**	**Frequency of occurrence**
Drought (late onset)	After June 30	Once in every two years
Drought (Early secession)	Before August 30	
Drought (Unusual rainfall)	October & November	
Drought (Erratic rainfall-Rains in May-stops in June)	May to June	
Frost (Wurch) combined with strong wind	September to October	Once in every three years
Flood	July to August	Once in every four years
Hail storm (Beredo)	June to August	Once in every three years

The community group discussion participants in both Guna and Abay clusters perceived that drought hazard is a recurrent problem and they believe that it will occur in the near future with increasing severity as the frequency is increasing in recent years. Communities recalled that in the past droughts had shorter durations, with smaller periods of irregular rainfall during cropping season but they noted that in recent years, they have experienced more frequent droughts with longer periods of either little or no rain occurring during crop growing seasons with inadequate amount of rain. They reported that though there is rain for instance during the planting seasons in March and April, the amount of rain might be very little or no rain at all during subsequent crop-growing seasons. Moreover, reportedly even the amount of rain in the main rainy seasons - July and August - is not satisfactory in recent years and most of the time there is no rain at all

for the month of September when short maturing crops such as chickpea commonly grown using available soil moisture following the harvest of long cycle crops.

Other climatic shocks such as frost, hail-storm and flooding also affects communities in the district. For example, during September and October, communities in the highland areas of the district (Guna cluster) are also affected by frost combined with strong wind often damages standing crops and causing health problems for both people and livestock. While in the lowland parts of the district hail-storm occurring once in three years with severe intensity damaging standing crops and other physical structures particularly during periods of June-August. Sometimes, this is associated with intense rainfall causing flooding of farmlands and drowning of small livestock.

Reportedly, in response to these climatic shocks and stresses, communities primarily adopted coping mechanisms such as use of drought tolerant and short maturing crops; diversifying crop & income sources as well as natural resource conservation through tree planting, terracing & water harvesting. Similarly, key informants of the study such as the district food security and emergency response coordination officer, very recently the overall land management is improving in the district following some land management practices such as: introduction of soil and water conservation structures, area exclusive and rehabilitation of degraded hillsides, abandoning of free-grazing in the crop dependent highland areas of the district.

3.4.2. Crop & Livestock Shocks

The district risk profile document shows that crop pest is the most common problem in both highland and lowland parts of the district. It was also evident during the community group discussion that a wide range of crop pests affecting pulses and cereal crops. Table 3 presents common crop problems by crop type and seasonality of occurrences.

Table 3 Type of Crop Shock Affecting the Study Area & its Temporal Aspect

Type of crop problem	Period of occurrence	Type of crop affected
Gelmit	July	Beans/Peas
Bilh	August	Teff
Degeza	September-October	Millet
Mitikugn	July	Boleke
Wag	August-October	Wheat
Ageda Korkur	June-August	Sorghum
tikotiba	July	Teff
Yeshimbra til	Sep-Oct	Cowpeas
Magid (Mich)	September-October	Teff, Wheat
Kemkem	July	Beans/Peas

Most crop problems occur in the critical growing periods between June to August affecting most of the main cereal crops with severe impact on pulses such as beans and peas. Communities particularly emphasized the impact of crop problems such as *Gelmit* and *Kemkem* on the production of beans and peas as there is no solutions for such problems so far and no prospect for growing such important crops traditionally used for stew making. Similarly, one of the main staple food crops such as Sorghum and one of the few cash crops such as *Boleke* are also at risk of production failure due to crop pest and diseases occurring during growing periods of crops. For example, pests such as *"Ageda-Korkur"* (stalk borer), which attack sorghum and *"Til"* (shoot fly), which mainly affect teff are the major problems to crop production in the district.

Pest infestation according to communities is an annual problem. Reportedly, pest and diseases affecting pulses (locally called Gelmit & Kemkem) are very serious problems because pesticides are not available either in the market or from the district Agriculture and Rural Development office.

In terms of livestock shocks affecting both small and large livestock types, the district risk profile document shows that livestock shocks such as yedalga-ebitet and *ligag* are the most common problems in the district, particularly in the lowland areas. Livestock shocks are one of the major

challenges of communities and their livelihoods as mixed-farming is the dominant production system involving both crop and livestock. Communities also reported that *yedalga-ebitet* particularly affecting cattle and *getir* and *kortem* primarily affecting shoats are critical problems of their livelihoods as livestock are buffer assets used against other shocks.

3.4.3. Market Shock

Input and output price volatility are also critical shocks related to market affecting household livelihoods in the district. The fact that the district is located in the inaccessible livelihood zones with rugged topography of the Abay-Beshilo Basin and Abay Tekeze Watershed prevents the district market integration with other important markets in other districts and zones.

The rising trends of price inflation of basic food commodities in Ethiopia affects chronically food insecure districts including the study area with very severe impact in the periods of 2008 and 2011. Despite inflation had previously been a less significant problem, the recent volatility compounded already-existing high levels of indebtedness often with negative effect on poor smallholders with cheaper prices for their outputs immediately following harvest season and a rise in crop prices in the input market later in the subsequent months until September, just before the next harvest.

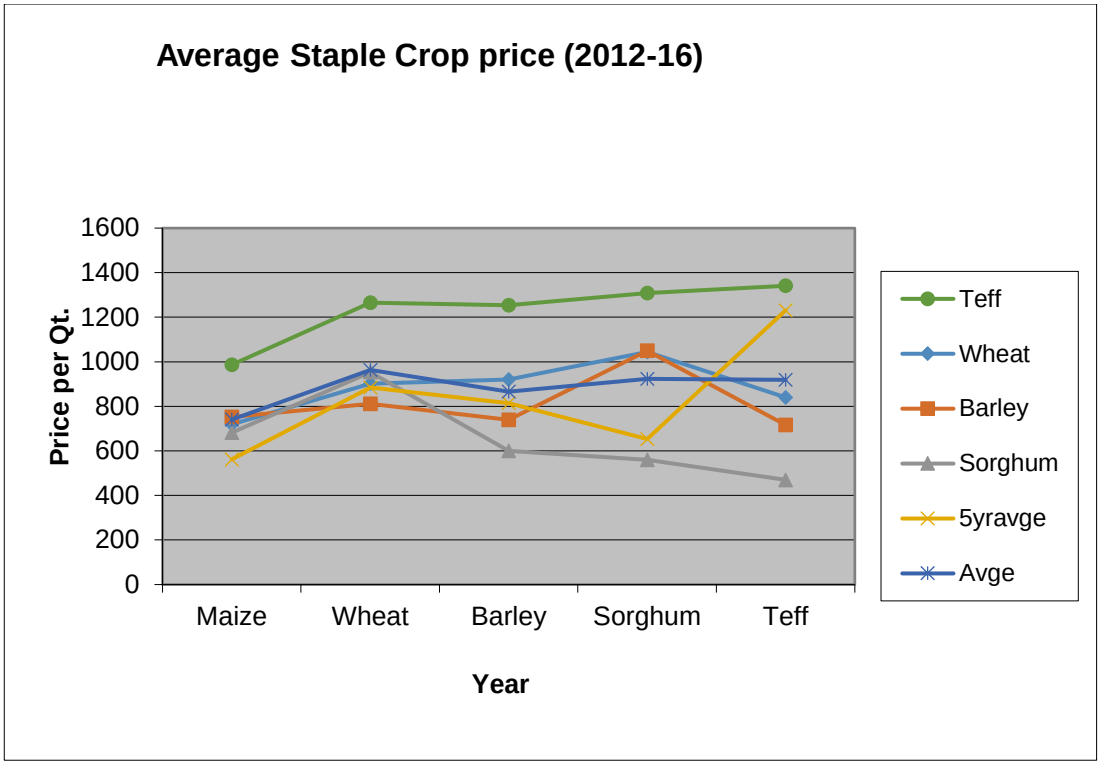

Figure 13 Average Staple Crop Price in Arib Gebeya Local Market (2012-2016)

For example, the input market for staple crops in the district main market is shown by figure 13 indicating that prices of food crops are above the long term average and affecting most of the poor whose food security depends on food purchase as they could not produce enough even for household consumption. Furthermore, the fact that selling of wood lots and livestock are a key coping strategy as a buffer against weather shock related crop failure, communities emphasized access to road and a well-functioning market for such critical buffer assets including for casual and migratory labor markets.

In conclusion a wide range of shocks (weather shocks, biological shocks and market related shocks) affected the lives and livelihoods of households in the study area. In response to these shocks and related food security impacts, many programs intended to enhance livelihood security are being implemented in the district including the largest national social protection program i.e. PSNP and the Household Asset Building program, promoted by both government and non-governmental organizations. This also includes disaster risk reduction and climate change

adaptation programs primarily implemented by the local Disaster Risk Management/Food Security Coordination Office with the support of NGOs working in the district to improving community-based preparedness and early warning systems.

4. METHODOLOGY

4.1. Introduction

This case study was conducted in Tach Gayint district, one of the risky environments of Ethiopia, located in food insecure parts of Amhara region. A total of 300 households were sampled to investigate resilience properties of livelihood systems including how households in such risky environments dealt with shocks and maintain positive livelihood outcome i.e. food security. This chapter explains how these households and study sites were chosen and studied using a combination of qualitative and quantitative methods. Field work was carried out between the 15th of November and the 29th of December, 2015 with financial and logistical support of USAID funded program called "African University Network-PERIPERI U", which has been supporting resilience building efforts in Africa since 2007. Their mandate is to promote risk reduction and disaster resilience research and capacity building efforts in Africa.

4.2. The Research Design

A mixed design approach was followed involving both qualitative and quantitative methods to allow triangulation of results as well as generating new insights to the assessment of household resilience. Before explaining the data and specific methodological procedures, the overall stracture of the research design which link the literature review with the research questions and choice of analitical model of the research is reiterated first, as these determined the design of the study and the choice of methodology. The following table outlines the elements that link the research questions with methodological components. The overall research design followed three interelated stages. As a first step, key resilience properties of livelihood systems at household level were identified, following review of a wide rage of literature focus on livelihood diversification, food security, disaster risk and climate change adaptation discourses explaining the ability that a household will be meeting or exceeding the normative well-being threshold.

More specifically, essential elements of the livelihood system which consists of the assets, capabilities, and activities including risk management strategies, which determine the ability of households to meet minimum food requirement for each members of the household and continue to maintaining food security in the risky environment.

Table 4 Research Design-Methodological Approach Employed by Research Question

Research questions	Quantitative	Qualitative
How is resilience properties of household livelihood systems manifested in the risky environment of the local context?	portfolio configuration structure of food income sources for households classified by livelihood strategy groups	Community discussion on seasonality of shocks and livelihood sensitivity matrix Community development challenges and opportunities
	Survey of food income sources and expenditure flows	
	Secondary data on existing shock exposure	
	Constructing household livelihood diversity index	
	Quantifying expected average household portfolio food income, covariance between individual portfolio activities and expected average portfolio food income variation based on MPT	
How do households deal with shocks?	Quantification of the food income that households commonly expand from a set of temporary coping mechanisms which are only activated during periods of food income shortages	Challenges and opportunities of households to access community resources including social capital to deal with shocks The role of external support including public transfers to the management of shock impacts
	Survey of shock experience, risk perception as well as coping and ex-ante risk management choices	
	identification of determinant factors that influence household risk management choices based on multi-variate probit model estimation procedures	
Why are some households more resilient than others?	Modeling household resilience status as a function of livelihood system properties, household and community characteristics including characteristics of shocks	Community criteria to describe the characteristics of resilient households
	Household self-assessment of wellbeing transition in the last 10 years which is used to understand the relative movement of households between different wellbeing states	

Hence insights from these discourses were used to characterise household livelihood systems with a primary focus on the combination and stracture of household portfolio of livelihood activities including a set of strategies and options available to households to deal with risks and shocks. This defines the unit (system) of analysis-the household livelihood with food security as the primary livelihood outcome of concern that focuses on the food income obtained from different sources as a measure of well-being. In this regard, principles of social-ecological resilience were adapted to the system of concern, to propose an analytical set of metrices with which to assess the resilience properties of the livelihood system.

However examining properties of household livelihoods at system level is not enough to understand resilience trajectories towards a positive livelihood outcome, it also requires understanding the deliberate choices and actions of system participants (i.e. households and other external stakeholders) introduced to the system in response to shocks. This looks at the capacity of households to manage resilience which may include coping and ex-ante risk management behaviour of households to deal with shocks. Hence, as a second step, the research design include analysis of household risk management choices including both ex-ante and ex-post strategies as well as external support targeted to the management of shocks.

As a third step the first and the second stages are brought together to form a coherent research framework for assessing household resilience to food insecurity with the aim of addressing the central research question of the study. In this regard the role of system properties as well as household and community characteristics including the nature of shocks the system is exposed to could be determined to explain why some households are more resilient than others, which is a central research question of the study.

With this overall stracture of the research design, this study should be understood with the following spatial and tempral contexts as well as with principles and assuptions of sustainable

household livelihoods framework and resilience theory as applied to explain social-ecological systems. First, the study area is located in one of the drought-prone and chronically food insecure areas of the country. The area experienced one drought episode in every three years (DRMFSS, 2012). Almost half of the district population has a food gap of more than 6 months every year regardless of normality of seasonal climate and the same proportion of population subject to benefiting regular food transfer programs of the country in collaboration with international donor agencies (TGWA, 2014). Deep rooted poverty trap predominantly characterize the study area and household resilience should be understood in the context of recurrent drought and protracted food crisis.

Second, intra-annual and inter-annual variation in availability of food is an important temporal aspect of food security to understand household resilience. Seasonal cyclic food insecurity often occurs during September to December i.e. between end of consumption year from the previous harvest (September) and the beginning of the next harvest (December) with October, the severe and typical hungry season. In this study, only the inter-annual food security dynamics was considered to understand household resilience using methodological approach of MPT as the former require repeated surveys during harvets and hungry seasons in order to capture the dynamics of seasonal food insecurity. Hence household resilience should be understood in the context of inter-annual foos security dynamics rather than in the context of seasonal hunger.

Third, in terms of theoretical frameworks in explaining household resilience, a multi-disciplinary perspective should be considered as the study design brought principles and assumptions of various fields of study together. This include sustainable livelihoods, social-ecological systems, household economy and modern portfolio analysis approaches. According to sustainable household livelihood framework, food security is only considered as one of the multi-objectives of households to be achieved through their livelihood strategies. Household livelihood portfolios

often consists of more than just one activity and the portfolio structure and configuration may vary from household to household. This portfolio structure along with its functions and services represent the system of the study concern i.e. livelihood system at household levels. Resilience properties of the system are adapted from ecosystem resilience from the field of ecology, hence this properties should be understood as applied to the social-ecological systems (in this case livelihood systems). Finally this study was designed to understand resilience properties of household livelihoods constructed in areas of recurrent food crisis with a purpose of gaining new insights for exploring determinants of household resilience to food insecurity rather than generalising the results to all livelihood and shock contexts.

Considering the above study design considerations and the research questions described above, the following sections outline details of sampling choices, data requirements and suitable research methods. The research questions primairly approached by econometric analysis while concurrently triangulating the econometric result with the qualitative data analysis.

4.3. Choice of the Sample Size & Study Sites

Given the primary goal of the study which is to investigate resilience properties of livelihood systems, at household level, constructed in the risky environments of South Gondar zone where half of the districts found in the zone are chronically food insecure. Among the five districts in South Gondar zone characterized as such risky environments, Tach Gayint District was selected purposively to conduct the study. The primary reason to select the district is due to the fact that the district is the top priority risky environment for the region where more than half of its population are chronically food insecure with high exposure to recurrent climatic shocks. This makes the district appropriate for the study designed to investigating why some households are resilient than others despite high exposure to recurrent shocks.

Tach Gayint district consists of 16 kebeles that all fall into two broad livelihood systems namely Guna and Abay livelihood zones. Proportional to the size of livelihood zones, primary sampling units of 3 kebeles were selected randomly from Guna and two sample kebeles from Abay livelihood zones. In each sample kebeles, 3 villages were randomly selected as secondary sampling units and finally to reach desired samples of 300 households, 20 samples of HHs from each village were randomly selected from the household listing prepared to serve as sampling frame.

Table 5 Structure and Sampling Procedure

Sampling units	**Sampling procedure**	**Number of sampling units per strata**		**All samples**
		Guna LZ (Strata 1)	**Abay LZ (Strata 2)**	
Primary sampling unit (kebele)	Stratified random sampling, PPS	3	2	5
2ndary sampling unit (village)	Simple random sampling	3 per kebele= 9	3 per kebele= 6	15
Tertiary or final sampling unit (Household)	Simple random sampling	20 per village= 180	20 per village= 120	300

4.4. Definition of the Sampling Unit

In this study, the unit (system) of analysis is the "household unit" - that is the household head and its members who together contributes to the household economy. This household definition is consistent with the definition of a system (Alinovi et al., 2009a) as a set of connected components that make up a unified group and operate together for a common purpose. Moreover, as the decision-making unit, the household is where the most important decisions are made regarding how to allocate labor, land and capital on various portfolio of livelihood activities including what strategies to implement to manage and cope with risks (Alinovi et al., 2010; Hoddinott and others, 2014b). Households can therefore be viewed as the most suitable entry point for the analysis of livelihood systems. Of the many livelihood outcomes of concern to rural

households, this study focus on the food income obtained from different sources as a measure of well-being. Household food income is affected by factors both internal and external to the system. However, this study primarily focusses on climate related risks /shocks to calculate relative sensitivity of household livelihood portfolio returns and to understand resilience properties of the livelihood system at household level.

4.5. Survey Design & Data Collection

The survey design for both household questionnaire and checklists and templates for community group discussion and key informant interviews were guided by the framework that maps research objectives with abstract concepts and required information to measure the key concepts to item formats. The following table shows the framework used for the design of survey questions.

Table 6 Survey Design Framework-Outline of Required Information & Level of Measurement

Objective	Concept	Required information	Level
Understanding structure of household economy for measuring resilience properties of livelihood systems using Modern Portfolio Theory	Structure of household economy	Portfolio activities and yield amounts and income flows from each activity	HH
		Labor hours devoted to each activity	HH
	Risky environment	Subjective probabilities for states of climate conditions (bad, normal & good years) over the last ten years; Risk history of the study area	HH Community, secondary
Determinant factors that influence household risk management strategy (RMS) choices	RMS	Ex-ante and ex-post risk management strategies	HH
	Determinant factors	Household characteristics, community characteristics, past shock experience, future risk perception,	HH, Community
Determinant factors that influence household resilience to food insecurity	resilience to food insecurity	Household food income from various sources, calculated as % of the minimum food needs	HH
	Determinant factors	HH assets, livelihood and risk management strategies, access to institutions, shock exposure,	HH, Community

Based on this framework, three existing documents involving standard survey modules pertinent to food security and resilience were reviewed and adapted for the study. These were the Amhara National Regional State District Vulnerability Profiling survey, Ethiopia 's Livelihood Integration Unit survey instrument documents, and TANGO Self Resilience Pathways survey. See details of content and structures of survey instruments for both quantitative and qualitative data collections on section 4.6 and 4.7, respectively.

Regarding planning and implementation of the survey field work for data collection, several stages were followed. First, as part of the preparation stage, desktop study to understand the overall setting of the study area (geography demography, socio-economic as well as risk profile of the target district) was done. This background information was obtained from Amhara Region Bureau of Finance & Economic Development (BoFED) at regional and zonal levels and specific district profile from South Gondar Zone and Tach Gayint district administration bureaus. Based on the 2007 census projected by BoFED for 2015 population size of the district, the desired sampling size were determined. Current list of kebeles arranged by livelihood zones were also obtained from the same sources. A total of 5 kebeles were randomly selected as primary sampling units from both strata (Guna & Abay Livelihood zones of the district)

Second, initial visit to the study area were made to contact and introduce my study to the local officials of the district who are often considered as gatekeepers. During the initial visit, research assistances were identified. These include 5 supervisors and 15 enumerators who have good knowledge of the 5 sample kebeles. Full lists of villages in each kebeles were also obtained and 3 villages per kebele were randomly selected, as secondary sampling units, making up a total of 15 villages. One enumerator for each village was assigned to administer survey questionnaires. Due to absence of full list of households in each village, it was decided to conduct household listing in the 15 villages for the purpose of constructing appropriate sampling frame. Hence as a third step, the lists of all households found in 15 sample villages were done by 15 enumerators

for about 3 days where a minimum of 149 and maximum of 255 households were registered per village. 20 households per village were randomly selected from the list, as final sampling units, to come up with the required sample size (300 HHs) for the study.

Fourth, training was given to the 5 supervisors and 15 enumerators about details of the questionnaire including practical procedures to be followed during household interview. As part of the training enumerators were distributed to the rural villages for practical learning by administering at least two questionnaires. The completed questionnaires were reviewed and discussed practical challenges particularly related to the questionnaire itself. This was considered as pilot testing and few phrase/word editing were made with pen in only two modules of questionnaires that were finally administered to 300 households.

Fifth, in order to conduct household questionnaire interview, 15 enumerators assigned for 15 sample villages, which is one enumerator per village to administer the questionnaire for 20 households. Each enumerator managed to complete five household interviews per day with supervision of five supervisors assigned for the five kebeles in addition to the researcher. While conducting household interviews, focus group discussion in each sample kebeles were made to collect qualitative data at community level which includes disaster history, seasonal calendar of livelihood activities & hazards, as well as opportunities and constraints that determine shock coping and livelihood options at community level.

4.6. Structured Household Questionnaire Survey

Household questionnaire were developed based on the design framework described above. The main modules of the questionnaire and details of the required information sought is outlined in the table below. These include demographic characteristics (structure of household, age, gender); institutional variables (market, gender, land tenure, fertilizer and other agricultural input providers); labor market (education, health, employment status, on/off farm labor income);

production variables (livestock and crop production); economic variables (assets, land, investment, credit); expenditure variables (food consumption, non -food consumption, durables); as well as past shock experience and household‘s perception of hazards/risks, the types and frequency of the coping strategies used.

Table 7 Structure and contents of the Household questionnaire

SECTION	SUB SECTION	TYPE OF INFORMATION
HH roster	List of HH members	Gender, R/n to Head, Age, Education, health status, labor capacity
Shocks	Shocks in the past five years	Type of major shocks; Frequency & Estimated loss due to shock; Coping activities; Value of coping activities;
Risks	Risks or future shocks in the next five years	Subjective risk determination as perceived by the HH terms of frequency & expected loss in the next five years.
Assets	Housing	quality and estimated value
	Productive assets	inventory taking (number and value of items)
	Convertible/consumption assets	changes in the last year (sale / purchase)
	Debts/Receivables	inventory taking (liabilities and receivables)
	Savings	changes (repayment / indebtedness)
Livelihood Portfolio Activities (in both bad and good years)	Crop	Quantity produced; inputs used
	Livestock	Livestock sales; liv. products obtained; inputs used
	Off-farm employment	Income earned; work days;
	Non-farm self-employment/trade	Income earned; volume of sales, prices, input costs
	PSNP-public works	Food/income obtained; work days
Expenditures	Non-food	Education, hygiene, clothing etc.
	Food expenditures	Food items (frequency of consumption
		Monthly expenditures
		Number of proper meals per day
		Days of hunger
		Coping options during hunger seasons

Questions were structured, pre-coded and administered to the heads of the household or any available member of the household who had knowledge of household ‘s food security, shock experience as well as vulnerability situations in all enumeration areas of the study area. The household interviews were undertaken with the assistance of experienced local development

agents and supervisors. The purpose of the questionnaire and how best to approach potential interviewees and conduct the interviews were discussed with selected enumerators.

For the collection of data on yields and income flows from household livelihood portfolio activities (such as crop, livestock, off-farm and non-farm employment activities) and subjective probabilities for stochastic outcomes, a visual impact method was applied. First, households were asked to report how often out of the past ten years (covering the period 2005-2014) they had encountered a bad, normal or good year. The criteria for defining each state were clearly presented to respondents. The criteria were set based on how good production year was in terms of availability of rains, harvest and pasture conditions. For instance, a bad year was defined as a production year with poor or no rains, poor or no harvest and poor or no pasture, while a good year was represented by good rains, good harvest and good pasture. A production year that does not reflect either of the two descriptions but a typical year with usual production conditions, was considered as a normal year. The study reference year, the 2014 production year was considered as a normal year. The fact that the reference year was the last 12 months' prior the survey, it was possible for households to recognize the deviations in production conditions from what is considered to be a normal year.

Having a clear understanding about the above criteria, households were given 10 bean grains and asked to allocate them among the three rectangles, representing each state. The relative number of stones in each state of the world represents the subjective probability of facing a certain climatic event. Referring to this probability distribution, several questions followed concerning the average yield and income levels for the livelihood activities carried out by the household in each state of the world. The data that was generated through this exercise was used to derive probability density functions for each activity as well as the whole livelihood portfolio. In addition, referring to the study reference year (2014) which is considered as part of the normal

state, households were asked to report the amount of labor hours devoted for each livelihood activity. The reported labor hours were used as a weighting factor for calculating expected average returns and standard deviation of returns for the whole household portfolio of livelihood activities.

4.7. Qualitative Data

Both key informant and community group discussions were used as qualitative data collection instruments. Key informant interviews were made at regional, district and village levels. At each level, the researcher conducted a key informant interview with two or three people. Key informant interviewees include regional disaster risk management and food security coordinators as well as district early warning and emergency response business process owners. These interviews were done with the objective of establishing background information for community group discussions and household questionnaire interviews. The information collected include conditions of food and livelihood insecurity at regional and district levels; demographic and socio-economic aspects; conditions of access to markets and services; and other specific and relevant information (such as average land holding sizes, crops grown and farm production levels). As a qualitative approach, community group discussions were also conducted with a maximum of nine local residents involving both men and women in each of the enumeration areas of the study. Discussion issues include the temporal aspects of major agricultural activities, the risks associated with food security, and common coping and survival strategies during periods of food crisis.

4.8. Contextual & Secondary Data Used

Secondary materials include both published and unpublished documents such as government reports, policy documents and program manuals including books, journal articles, maps and bulletins about the research topic were collected from relevant organizations and institutions.

Recent government policy documents, reviewed and used to establish institutional context within which household economy operate, include agricultural development and food security as well as relevant district-level development program documents related to education, health, agriculture, and rural development. Publications related to food security were also obtained from Food Policy and Development Journals as well as from the websites of the Food and Agriculture Organization of the United Nations (FAO).

4.9. Data Analysis

The study central research question to be addressed also determines choice of data analysis methods and techniques as much as it determines the data requirements and choices of data collection instruments as discussed above. Hence, both qualitative and quantitative data analysis techniques were used in a way that results from the latter cross-checked with the findings obtained through the former, in effect improving the understanding of overlooked areas, and providing additional details to substantiate evidences for answering the central research question. Both quantitative and qualitative processes involve analysis of existing information such as secondary data and literature reviews, as well as information generated through primary data collection instruments. In order to make these data ready for analysis, all quantitative data sets coded and entered into SPSS-version 16 (due to its quality for data management) and exported into STATA-version 12 (due to its quality for executing and using statistical models). Similarly, qualitative data generated through community discussion and key informants were summarized and documented immediately following data collection. The following sections outline firstly details of quantitative analysis methods, followed by the qualitative part. In terms of quantitative analysis methods, the first section presents the context and data aggregation levels within which analysis is made and subsequently method of determining and quantifying food income sources as well as method of measuring and modelling household resilience properties will be presented.

4.9.1. Level of Data Aggregation: Classifying Livelihood Systems

By choosing the livelihood system as a classifying tool, it is possible to cluster individuals with similar characteristics into groups that are subject to similar factors and processes affecting resilience properties of their livelihoods as well as its services to meet household food security. The principles and methodological procedures of HEA were used in order to classify households into meaningful groups where data could be aggregated and analyzed. In HEA there are two meaningful levels of aggregations, these are livelihood zoning and wealth ranking. The former is defined based on broader contexts of geography, production systems and market access which shape distinct livelihood patterns across regions even districts. This livelihood zones are already established in Ethiopia and the study area fall within two broad livelihood zones. According to the livelihood zone information, the district consists of 16 kebeles (the lowest administrative units in Ethiopia) that all fall into two broad livelihood systems. These livelihood systems are referred to as *Abay Tekeze Watershed (ATW)* and *Abay Beshilo Basin (ABB)* predominantly characterized by highland and lowland agro ecologies, respectively. However, the later also include some midland areas of the district.

The researcher considered this spatial variation during sample selection to meaningfully represent the whole study area. However, within the same livelihood zone, households may pursue distinct livelihood strategies and faces different challenges resulted in vulnerability differentials. Hence, households were classified into livelihood strategy groups based on the proportion of food income they obtain from various sources. Classifying households into distinct livelihood strategy groups is a necessary step for resilience analysis as it allows better understanding the structure of the household economy. Particularly within both livelihood zones, mixed farming involving both crop and livestock is the dominant livelihood strategy. There are also labor-based and self-employment livelihood strategies pursued by some households in both livelihood systems of the district.

In this study, each household is classified according to livelihood strategies they pursue using cluster analysis, which is a multivariate statistical technique that encompasses algorithms and methods for grouping different observations into categories. Among alternative cluster analysis methods varied based on the techniques for measuring the similarities or differences between clusters, the Euclidean distance was chosen as it is the most reliable and commonly used distance definition. In terms of the choice of the aggregation algorithm, non-hierarchical technique with k-mean as linkage method were chosen, by which the observation is assigned to the cluster with the nearest mean. This clustering procedure leads to a unique partition of the $\boldsymbol{n}$ observations in the predefined $\boldsymbol{g}$ groups. This method was chosen for its simplicity and availability of prior information regarding livelihood groups in the study area. This method also maintains the required variability between clusters and homogeneity within clusters.

4.9.2. Quantifying Food Income Sources Using Household Economy Approach

Household Economy Approach (HEA) is a livelihoods-based framework for analyzing the ways people obtains access to the things they need to survive and prosper. It was developed in the early 1990s by Save the Children UK in order to improve the ability to predict short-term changes in access to food. It becomes important analytic tool particularly following the works of Amartya Sen's entitlement approach that describes how endowments are 'mapped' into entitlements or commodity bundles which aim to fulfill the demands of the individual. This provides a calculation of the overall entitlement balance in a household over a given period of time (Seaman et al., 2000). This in turn determines consumption as well as the ability of the household to accumulate and, thus, the resilience of the livelihood system in general as it is an emergent property of complex systems, which arises from the combination of several elements.

Therefore, examining household livelihood strategies involving the various sources of food and income were used as a basis for understanding livelihood construction and its resilience properties. A livelihood strategy is, in this study, defined as a strategy to obtain food and income that is necessary to ensure the food security of the household. Based on the existing livelihood zone information for the study area, the ways in which the household acquires the food it consumes includes food gained through own crop and livestock production, labor, purchase, collection (e.g. wild foods), gifts and relief. The income by which a household can purchase its food and non-food needs that can be earned through a variety of sources, including the sale of own production, self-employment, and labor.

The proportional contributions of each source were calculated as percent of the minimum energy requirement. For production activities such as crop and milk production, households reported the amount of production in kilograms for the three states of climate defined below in section 4.9.3. Based on standard calorie table, representing caloric value per 1kg (1000 g) edible portion for each food production items, the required energy requirements for each item were first calculated. To calculate the amount of each production items an average person needs to eat per day, the following equation were used.

$$Required\ Amount\ (kg/ppd)_{item\ i} = \frac{2100\ \text{kcal}}{RCV_{item,i}} \qquad \textbf{Eq.4.1}$$

Where, 2100 kcal is daily minimum food energy requirement; and ***RCV*** is representative caloric value of item *i* per 1kg (1000 g) edible portion. Hence, to calculate the amount of each item a household needs to eat per year, the individual kg figure obtained from equation 4.1 above were multiplied by the number of individuals belonging to the household.

In order to calculate the percentage contribution of production items to household annual food requirements, the following equation were used.

$$\boldsymbol{C}_{item\ i} = \frac{AP_{item\ i}}{AR_{item\ i}}\ X\ 100 \qquad \textbf{\textit{Eq.4.2}}$$

Where $\boldsymbol{C}_{item\ i}$ percentage contribution of production of *item i* to household annual food needs*;* $AP_{item\ i}$is amount produced in kg for item *i* and $AR_{item\ i}$ is amount required in kg for item *i* to cover the minimum household food needs if item *i* is only eaten.

For exchange activities such as labor and livestock sales as well as self-employment and business activities, the amount of income obtained from each source were converted into equivalent kilocalorie based on the amount of staple cereal crop the income received from each source would buy. Hence the contribution of income sources as percent of the minimum food needs were calculated in a similar way with equation 4.2 including for exchange activities received in kind (for instance, food crop amount received).

Finally, the food and income sources along with their contribution to household annual food needs were aggregated into four distinct livelihood portfolio activities representing the household economy. These are crop, livestock, off-farm and non-farm activities. MPT analysis approach was used for the whole household portfolio of activities as a way of understanding and measuring resilience properties of household livelihoods.

4.9.3. Applying Modern Portfolio Analysis Approach

The finance literature in its emphasis on resource allocation and multiple investment options offers valuable insights into household livelihood strategy as a portfolio of activities. Rural household livelihood portfolios with multiple ways of portfolio configuration and objectives could represent a social-ecological system of concern for resilience assessment. Modern portfolio theory (MPT), developed in the 1950s, provides a set of metrics with a systems-based analysis approach (Markowitz, 1952) to examining the whole portfolio of activities. Its concepts are also applicable to household livelihoods because resources are invested into multiple

activities. As a result, portfolio theory, with its underlying principle of minimizing risk for a given level of returns, can provide an analytical framework for examining a livelihood system as a whole (E. D. Fraser et al., 2005). Therefore, household's expected livelihood portfolio returns is used as a measure of wealth and its variance as the standard deviation of expected returns, which includes not only the variation in return of individual livelihood activity but also the covariance between portfolio activities, is used in this paper as a measure of connectivity of the livelihood system (a measure of the degree of interdependence between components of the livelihood system).

For the analysis of livelihood activity portfolios the following assumptions are made following the works of (Witt and Waibel, 2009) who applied MPT to farming systems in Cameroon with the objective of understanding the system's sensitivity to climate risk. First, households behave in a rational way, i.e. productive assets are allocated among the different activities in order to maximize returns for a given level of risk or minimize risk for a given level of returns. Second, the relative weight of each activity in the portfolio is represented by the share of labor allocated to the activity a household is engaged in, as livelihood activities in the study area are characterized by high labor intensity. Third, labor is completely distributed among the different activities in the portfolio of a given household. The returns to labor for each activity are computed as the maximum possible income if all labor would be assigned to the respective activity. Households in the study area are often vulnerable to climate related risks where the portfolio analysis can be done subject to probabilities of identifiable climatic states of the world based on subjective perception of households in the last ten years. Based on resilience properties described in section 2.4.3 at conceptual level following resilience characterization in the field of ecology, hereafter referred to as resilience theory, a set of metrics developed in various fields of study were applied to measure resilience properties of household livelihood systems. Primarily, these include portfolio analysis approach from financial literature and household economy

analysis (HEA) approach from food and livelihood security literature. Details of measurements for the four key resilience properties including resilience itself are described in section 5.2.

4.9.4. Modeling Risk Response Choices and Shock Reaction Capacity of Households

Examining existing properties of household livelihoods at system level is not enough to understand resilience trajectories towards a positive livelihood outcome, it also requires understanding the deliberate choices and actions of system participants (i.e. households and other external stakeholders) introduced to the system in response to shocks. In order to examine the factors that determine risk response choices of households, it is important to understand first how households experience shocks, particularly related to climate as well as their perceptions to future risks. Past shock experience affects risk perception and in turn influences adoption of risk management strategies.

The methodology used for empirically testing the relationship between climate shock experience, risk perception, and the adoption of risk management strategies, takes a two-step regression approach. In the first step households' risk perception is estimated while controlling for the short-term effect of climate-related shocks on households' risk perception as well as for other socio-demographic factors that construct and maintain risk expectations. The first model estimates household's risk perception using ordinary least squares (OLS) regression based on the following simplified relationship:

$\boldsymbol{R_i} = f$ *(Past shock experience (S), Household characteristics (H) and Community & location characteristics (C))*

Where $\boldsymbol{R_i}$ is subjective risk levels perceived by each household indexed by *i*, measured by an ordinal risk score which indicates the magnitude of climate risk which a household expects to happen in the future. In the household questionnaire respondents were asked to quantify both the frequency of each shock type as they perceive they will occur in the next 5-years and severity of

impacts on income and asset using an ordinal scale from 0 (=no impact) to 3 (=high severity). The risk score for each shock type was computed by multiplying the levels of shock severity by its respective frequency. The sum of the risk scores of all shock types is then computed for each household to represent household risk perception. ***S*** is a vector of climate shock incidents that a household experienced during 2011 and 2015 and ***H*** is a vector of household characteristics and ***C*** is a vector of community and location specific characteristics in which households reside.

In the second step the likelihoods of household decision to adopt the most frequently applied ex-ante risk management strategies are estimated by applying a multivariate probit model. It is assumed that the decisions of households to engage in the different strategies are interdependent. Therefore, a standard probit model is not suitable for making predictions about the joint probabilities of the relevant strategy choices. The model is estimated using maximum likelihoods method.

Furthermore, this study also examined ex-post shock coping strategies with the aim of identifying determinants of shock reaction capacity of sample households of the study area. Shock reaction capacity defined as the capacity of a household to expand extra food income per unit of expected loss based on the distribution of portfolio food income obtained from MPT. Household shock reaction capacity (SRC_i) was then modelled as a function of household and community characteristics as well as the nature of shock experienced by sample households in order to identify its determinants. Those households whose expected average portfolio food income less than the minimum survival threshold are considered to be struggling for survival in both normal and bad years. Hence their capacity to expand extra food income beyond the minimum survival threshold per unit of expected loss is zero. This threshold assumption allows us to adopt a left censored data-modelling criterion, which is a tobit model. For details of the multivariate probit and tobit regression models, see section 6.2.

4.9.5. Modeling Household Resilience to Food Insecurity

In order to address the third objective of the research to explaining why some households are more resilient to food insecurity than others, this section outlines estimation procedures for modeling household resilience to food insecurity as a function of properties of household livelihoods and their risk management choices as well as household specific and community characteristics. The conceptual framework of the study outlined in chapter two, section 2.6 suggests the following simplified relationship:

Household resilience status (RS) = f (C, SE, AC, S, RS)

Where household resilience status (RS_i), a binary dependent variable indexed by household *i*, is a function of the wider geographical and institutional context (*C*), household shock exposure (*SE*), adaptive capacity (*AC*) & sensitivity (*S*) of their livelihoods, as well as household reaction to shock (*RS*). *Context (C)* variables capture the broader physical and institutional environment in which households are situated. The physical setting encompasses climate, geography, and infrastructure, and is captured in the livelihood zone dummy. *Sock Exposure (SE)* is measured by the aggregate shock index constructed from frequency and severity levels of climatic, biological and socio-economic shock categories as experienced by sample households in the last five years' prior the survey. *Adaptive Capacity (AC)* is measured by a vector of variables related to household *Asset as well as risk and livelihood* strategy variables. Unlike the adaptive capacity which is existing potential capacity inherent to household livelihood systems, *household reaction to shock (RS)* defined in this paper as the capacity of households to shift itself to a less sensitive position indicating the extent to which households could expand the total food income through coping options including public transfers during periods of shocks. Based on the loss distribution of portfolio food income with the contribution of coping strategies, household shock reaction capacity could be determined by equation 2.1 (see the modified research framework in section 2.6). hence,

this variable was measured by a fraction of extra food income beyond the survival threshold that is available to cover a unit expected loss due to shock. Finally, *Sensitivity (S)* to shocks which refers to the degree to which the system of concern will be affected by a given shock or stress. In this paper it is measured by the coefficient of variation in household portfolio food income obtained from MPT, i.e. dividing expected average household portfolio food income by its standard deviation. See section 7.2 for the details of the resilience measurement and estimation procedures of the basic probit regression model.

4.9.6. Checking Robustness of the Study Measure of Resilience

For the purpose of checking robustness of the study measure of resilience, FAO's Resilience Index Measurement Analysis model (FAO-RIMA) was estimated to construct a multi-dimensional Resilience Capacity Index (RCI). A measure of MPT-based resilience, as applied in this study, defined as the probability of the household to maintain food security beyond the minimum wellbeing threshold, was then tested for how well it correlates with FAO-RIMA measure of resilience (RCI). In order to construct the latter (RCI), a two stage procedures were applied. In the first step, factor analysis (FA) was done to construct each of the resilience components from observed variables. In the second step, Structural Equation Model (SEM), which includes correlation between residual errors and a number of formal statistical tests and fit indices were performed to construct resilience index. This method requires a greater computational effort than factor analysis, it allows for model calibration until the satisfactory level of goodness-of-fitting is achieved. Overall, applying SEM has the advantage of identifying the direct and indirect effects, the possibility to have multiple indicators explaining the latent variable and the measurement error inclusion in the model. Based on the newly updated FAO-RIMA model i.e. RIMA-II (FAO, 2016), access to basic services, assets, adaptive capacity,

social safety nets and sensitivity were used to construct resilience as a latent variable. The combined scores in this index can be expressed in the equation as follows:

$$RCI_i = f(ABS_i\ AST_i\ SSN_i\ AC_i\ SEN) + \varepsilon_{i,t} \qquad \textbf{\textit{Eq.4.3}}$$

Where, RCI = resilience capacity index; SSN = social safety nets; ABS = access to basic services; AST = assets; and AC = adaptive capacity; and SEN= sensitivity, indexed by household *i*, for all components. Resilience index of i^{th} household depends on the level of ABS, ASS, SSN, AC and SEN at time t, plus the error term. These components are combined to arrive at the composite resilience index.

4.9.7. Qualitative Data Analysis

Data collected through community group discussion involving the application of participatory tools and templates such as seasonal calendar and livelihood sensitivity matrix were analyzed and documented both during and following data collection. Following the seasonal calendar and matrixes developed based on HEA outlining key seasonality of livelihood activities and risks for the district, community members were analyzing vulnerable livelihoods and common risk coping strategies prevalent in the community. These key issues were then written down on the flip chart with the help of research assistants and digitally compiled and documented. This information was used for triangulation purposes with the results obtained from analysis of quantitative survey data.

In addition, following (Downing et al., 2005), for building a livelihoods-based assessment of sensitivity to climatic risks, livelihood sensitivity matrix was developed for the study area. The approach requires an initial analysis of the dominant livelihood typologies in the case study area. The threats to these livelihood typologies are then identified. A matrix was developed (with rows and columns represented by climatic risks and livelihood activities, respectively) with which to assess how sensitive each typology is to each risk identified. This serves to reveal which

livelihood activity is vulnerable to different risks and was then used for triangulation purposes. The process involves at least three steps: first, the process begins with an understanding of the main livelihoods with identification of the livelihoods at-risk using existing typologies. Second, identification of the climatic risks based on historical events. Third, for each livelihood group, rating their exposure to the range of climatic risks into a five level ordinal scale (representing from a scale of 1-no impact to 5-very high impact) with the objective of determining the extent of livelihoods exposed to risks. Additional notes were also captured to understand differential impacts within livelihood groups including to enable qualitative analyses based on recent trends explaining how might livelihood vulnerability and risks change in the future.

Two output variables were generated for analysis of livelihood climate risk exposure. These were the *Exposure score* (sum of the columns for each row divided by the total possible score); and *Weighted exposure index (*the product-sum of rows by the frequency for the climatic risk, the sum of these weighted values is then divided by the sum of the frequencies). This was done using the sum-product function in Excel. The analysis was primarily depending on the later index as it allows to compare the degree of exposure to climatic risks among livelihood activities. However, these scores should be used with caution as they have no explicit meaning in and of themselves.

4.10. Data Quality

Efforts were made to improve data quality in all the stages of the research process from design of data collection instruments and training of enumerators to the use of statistical analysis and econometric model specification and estimation. The design of survey instruments consults existing tested standard surveys related to food security and vulnerability profiling. Combined with improved design of the instruments, training of enumerators involving practical exercises in the field before the main data collection contributes a lot for maintaining data quality. Efforts were

also made to improve data quality by verifying the portfolio data carefully against asset data and income and expenditure flows through discussion with enumerator's every day following the collection of 5 questionnaires per enumerator. Data for all modules were entered into SPSS and performed preliminary descriptive analysis to check for the consistency across households. It revealed few inconsistencies between responses within the same household, as well as exaggerated figures for some variables. Inconsistencies for income flows were checked by comparing income and expenditure data. Data and methodological triangulation was achieved by using both quantitative and qualitative methods of data collection and analysis. Observer triangulation was assured through discussions with my research assistants. To ensure representative data in a variable environment, appropriate sampling design were followed to consider various livelihood patterns and agro-ecologies characterizing the study district. Furthermore, based on the statistical models chosen for the study completeness of the data were evaluated using statistical techniques to maintain data quality for improved model estimation. For example, outlier and missing data analysis were performed and about eight observations were dropped from the analysis due to exaggerated and incomplete data for one or more variables to be included in the models.

4.11. Ethical Considerations

Due to the pervasive nature of poverty in the study area and repeated shock impact experience of many households, significant ethical considerations had to be kept in mind during the study. When each family was approached at the beginning of fieldwork, the aim of the task ahead was clearly stated, clarifying that the work was not part of a development project. Participation was voluntary and anonymity was respected where requested. In-kind compensation in the form of small gifts (iodized salt and soap) was provided to respondents for the time they spent answering questionnaires. Effort to maintain an open dialogue with my assistants were made regarding the progress of the study, accommodating their logistical suggestions as far as possible.

5. MEASURING RESILIENCE PROPERTIES OF HOUSEHOLD LIVELIHOODS

5.1. Introduction

The term resilience as a concept distinct to other stability concepts was first introduced by C.S. Holling in his influential paper 'Resilience and stability of ecological systems' referring to the capacity of a system, or amount of disturbance a system can absorb (C.S. Holling, 1973) without shifting into an alternate state (Walker et al., 2006) or a regime shift (Carpenter et al., 2005). Recently the concept of resilience has been proposed to exploring the relative persistence of different states in complex dynamic systems, including food and livelihood systems (Timothy Frankenberger et al., 2012; E. D. Fraser et al., 2005; Manyena, 2006; Pingali et al., 2005). This study was designed to explore resilience properties of livelihood systems, at household level, constructed in the risky environments of Ethiopia where recurring climate shocks undermines household's livelihoods and food security. Based on the concept of ecosystem resilience, commonly defined as the capacity of a system to experience change while retaining essentially the same function, structure, feedbacks, and therefore identity (Walker et al., 2006), a similar resilience characterization was followed as applied to the study system of concern. Hence, a livelihood system can be thought to be resilient if it can meet food security and other non-food security objectives and still maintain its essential functions following a disturbance (E. D. Fraser et al., 2005; Le Vallĕ et al., 2007; Tincani, 2012).

This new emphasis on resilience marks a shift away from conventional vulnerability assessments, which limit analysis to predicting probabilities of an individual to fall below a certain wellbeing threshold which serves for early warning and response purposes (Alinovi et al., 2009a; Pingali et al., 2005). By focusing on the mechanisms that facilitate or constrain a system's ability to cope, adapt or recover from various disturbing forces, resilience assessments

aim to not only identify which systems are most at risk but also to understand why (Timothy Frankenberger et al., 2012). Although the term resilience has become an important operational concept in chronically vulnerable or food insecure areas of the world, (Timothy Frankenberger et al., 2012; E. D. Fraser et al., 2005; Pingali et al., 2005), the application of the concept in policy-driven assessments has been limited by a lack of robust metrics to measure resilience.

In this paper, Modern Portfolio Theory (MPT) analysis approach is applied to understanding resilience properties of household livelihood systems including to measure household resilience to food insecurity in the context of rural livelihoods constructed in one of the risky environments of Ethiopia, Amhara regional state, Tach Gayint district.

5.2. Methodology

5.2.1. Measuring Resilience Properties

Based on resilience properties described in chapter 2, section 2.4.3 at conceptual level following resilience characterization in the field of ecology, hereafter referred to as resilience theory and a set of metrics offered by MPT at operational levels were applied to measure resilience properties of household livelihood systems. Measurements for the four key resilience properties including resilience itself are described below.

5.2.1.1. Measuring Wealth of the system

Wealth of the livelihood system in this paper is measured by the expected average food income that a household obtains from various entitlement channels. Household economy approach (HEA)[1] was employed to accounting the food and income obtained from different sources

[1]*Household Economy Approach (HEA) was developed in the early 1990s by Save the Children-UK in order to improve the ability to predict short-term changes in access to food. It is a livelihoods-based framework for categorization and quantification of people's sources of food and income, and their expenditure patterns, using a common currency. In other words, all food and income sources have to be converted into their calorific equivalencies, i.e. the calories in food consumed, plus the calories that could hypothetically be purchased if all cash income was used to buy grain, and then compared to the internationally accepted standard of 2100 kilocalories per person per day.*

(Seaman et al., 2014) as percent of the minimum food needs (See section 4.9.2). The ways in which the household acquires the food income includes own crop and livestock production, self-employment and labor exchange activities as well as participation in food-for-work programs. In order to capture the expected average livelihood portfolio income and its variability, modern portfolio theory (MPT) was applied. The stochastic distribution of returns for each activity results from the food income variations between years with different climatic states of nature as the set of $\boldsymbol{S}$ = *(1, 2…s)*. However, despite the many possible states of the climatic condition in the last ten years' prior the survey; it was decided to limit the possible states of the climate into three states: s= (1, 2, 3) representing "Bad year", "Normal year" and "Good year", respectively. Hence, it was possible to establish a subjective probability distribution for the stochastic outcomes based on household's shock experience in the last ten years. The expected mean food income was then estimated using MPT for both individual livelihood activity and the whole household livelihood portfolio. Expected mean food income as percent of the minimum food needs for individual livelihood activity is estimated using equation 5.1.

$$\boldsymbol{E[FI_i] = \sum_{s=1}^{s} P_s . R_{i,s}} \qquad \textbf{Eq.5.1}$$

Where $\boldsymbol{E(FI_i)}$ is the expected food income from activity *i;* $\boldsymbol{P_s}$ is the probability of state $\boldsymbol{S}$ occurring for $\boldsymbol{s}$= *(" Bad Year", "Normal Year", or "Good Year")*; $\boldsymbol{R_{i,s}}$ is the returns (in food income as percent of the minimum food needs) to labor for activity *i*, computed as the maximum possible food income if all labor would be assigned to the respective activity. The expected mean food income for the whole household livelihood portfolio was the estimated using equation 5.2, representing wealth of the livelihood system at household level.

$$\mathbf{E(FI_{port})} = \sum_{i=1}^{n} \boldsymbol{W_i} . \mathbf{E(FI_i)} \qquad \textbf{Eq.5.2}$$

where $E(FI_{port})$ is the expected average portfolio food income; W_i *is* the relative weight of each activity in the portfolio, represented by the share of labor allocated to activity *i*.

5.2.1.2. Measuring Connectivity

Connectivity was observed by examining the variation in return among individual livelihood activities as well as covariance between livelihood activities within the whole household livelihood portfolio. This captured the interdependence present between the four different entitlement channels, and thus the connectedness of whole system. Higher variation in return among individual livelihood activities and increasingly positive covariance between activities signals high interdependence and thus higher connectivity, whereas lower variation and negative covariance signals low interdependence and thus lower connectivity (Tincani, 2012). Variation in returns for individual activities and covariance between each pair of sources was calculated using equation 5.3 and 5.4. Considering both parameters the variation for the whole portfolio was calculated to represent connectivity using equation 5.5.

Hence, the expected average variability of the food income for individual livelihood activity was calculated using equation 3, where $SD(FI_i)$ is expected average variability of the food income from activity *i*

$$SD(FI_i) = \sqrt{\sum_{s=1}^{s} P_s . (R_{i,s} - E[FI_i])^2} \qquad \textit{Eq.5.3}$$

In addition, the covariance between any two individual activities (*i* and *j)* within a household livelihood portfolio was calculated using the equation below.

$$COV[FI_i, FI_j] = \sum_{s=1}^{s} P_s . (R_{i,s} - E[FI_i]) . (R_{j,s} - E[FI_j]) \; for\ all\ i \neq j \in n \qquad \textit{Eq.5.4}$$

The expected average variation of food income for the whole household livelihood portfolio, representing connectivity, was therefore calculated using equation 5.5 below.

$$SD(FI_{port}) = \sqrt{\sum_{i=1}^{n} w_i^2 SD_i^2 + \sum_{i=1}^{n}\sum_{i=1}^{n} w_i\, w_j \mathrm{cov}(FI_i, FI_j)} \qquad \textit{Eq.5.5}$$

Where $SD(FI_{port})$ is standard deviation of household portfolio food income; SD_i is expected average variability of the food income from individual activity *i* and $COV(FI_i, FI_j)$ is the covariance between any two individual activities (***i*** and ***j)*** within a household livelihood portfolio.

5.2.1.3. Measuring Diversity

Diversity as a property of resilient livelihoods captures the degree of concentration of portfolio of food entitlements through which the household achieved its food security. Resilience theory predicts the diversity of these entitlements to decline, as wealth is accumulated. This idea is based on the premise that wealth (food income) can be successfully accumulated through few entitlement channels, i.e. those which 'work best' (Tincani, 2012). The diversity of food entitlements was measured via the weighted proportion of food income obtained through each of the household's entitlement channels during the study period. Diversity was calculated using Shannon's diversity index (Equation 5.6),

$$SHI = \sum_{i=1}^{N} p_i * \ln p_i \qquad \textit{Eq.5.6}$$

Where ***SHI*** is Shannon's diversity Index; ***N*** is the number of food entitlement channels; ***P*** is the proportion of each food income that a household obtains from each food entitlement channels indexed by ***i***; and lnp_i is natural logarithms of each proportions of food income indexed by ***i***.

5.2.1.4. Measuring Response Capacity

In response to shocks, households tend to expand the food income through various temporary coping mechanisms which includes private and public transfers as well as through increasing sales of livestock and labor. Response capacity ***(RC)*** was defined in this paper as the extent to which a system can modify its circumstances to move to a less vulnerable condition (Luers et

al., 2003). It was therefore quantified as percentage improved in the food security position relative to the minimum survival threshold, at t+1 when there is shock impact, due to household coping mechanism compared to the relative position without including the contribution of coping. Food income expandability potential of household's during shock were captured in the survey questionnaire outlining how much of food income could a household often expand from various coping mechanisms based on their experience in the previous shocks they encounter. Households were asked during the survey to estimate the number of days that they could cover its food and non-food needs from coping options which are only employed during shock periods. The primary coping options include migratory labor, increasing livestock sales, borrowing money or food, switching to less preferred food items, and reducing non-essential expenditure items. The number of days reported from each coping options were then divided by 365 and multiplied by 100 in order to calculate the contribution of each potential coping options to the household needs as percent of the minimum food needs. The sum of all percentage contributions represents the maximum food income that the household could expand during shock periods.

Assuming that households could expand the food income through such positive coping options independent of the shock i.e. the extra food income expanded by a certain household represents mean zero shock portfolio return which should be accounted as part of response capacity to move the system to a less vulnerable position. Levels of food income at t+1 were calculated when there is shock and when there is no shock using equation 5.7.

$$\mathrm{E}\left(\mathrm{FI}_{\mathrm{port}}\right)(1+\ CC_{hi})\boldsymbol{X}\begin{pmatrix}1 & if\ there\ is\ no\ shock\\ 1-CV_{hi} & if\ there\ is\ shock\end{pmatrix} \qquad \textbf{Eq.5.7}$$

where $\boldsymbol{E(FI_{port})}$ is the expected average portfolio food income obtained from equation 5.2; CC_{hi} is the coping capacity defined as the proportion of food income that a household could expand

during periods of shock from various coping mechanisms relative to the expected average portfolio food income; and CV_{hi} is coefficient of variation calculated using equation 5.2 & 5.5.

Since coping mechanisms are only used when there is shock, response capacity (*RC*) as the percentage points improved in food security position due to coping relative to the minimum survival threshold (***z1***)[2] as compared to the relative position without including coping, at t+1 when there is shock. Given *a* and *b* represents the food income at t+1 where there is shock with coping included and excluding coping, respectively (derived from equation 5.7). Response capacity of household *i* ($\boldsymbol{RC_{hi}}$) is therefore given by equation 5.8.

$$\boldsymbol{RC_{hi}} = (\frac{\boldsymbol{a-b}}{\boldsymbol{z1}}) \qquad \textbf{\textit{Eq.5.8}}$$

Unlike household response capacity which is activated in response to shock, adaptive capacity is inherent to the system. The latter is already captured in the wellbeing function used to measure household resilience to food insecurity (see section 5.2.1.5). However, in order to check the robustness of MPT-based measure of resilience, FAO-RIMA[3], Resilience capacity index (RCI) based on the factors which includes access to basic services, social safety net, assets, adaptive capacity and sensitivity (See section 4.9.6). This is index measures resilience as a multidimensional construct.

5.2.1.5. Measuring Resilience

Following conventional vulnerability studies, resilience is defined as the probability that a household will be meeting or exceeding the normative well-being threshold representing the total income required to meet the minimum food & non-food needs. As a threshold-based

[2] *Survival threshold represents the total food income required to cover 100% of minimum food energy needs (i.e. 2100 kilocalories per person per day, which is the internationally accepted standard).*

[3] *Food and Agriculture Organization (FAO) of the United Nations developed a model for Resilience Index Measurement and Analysis (RIMA), hereafter referred to as FAO-RIMA model. The model adopted two-stage Factor Analysis with Bartlett's prediction technique. In the first step resilience pillars were estimated through Factor Analysis of observable variables and Resilience Capacity Index (RCI) was then estimated through Factor Analysis of the pillars ((the document information is available on* www.fao.org/publications*).*

approach, the latest livelihood protection threshold (***z2)***[4] value was considered. This threshold value for the study district is 140% as percent of the minimum food needs as set by Ethiopian Government Early Warning System. The probabilities were computed based on the distribution of the household average portfolio food income ***E(FIi)*** and its variance ***SD(FIi)*** obtained from MPT, using equation 5.2 and 5.5. Assuming natural logarithms of the expected average household portfolio food income, standard deviation of portfolio food income as well as the normative well-being threshold values as normally distributed in equation 5.9 denoted by $\boldsymbol{lnE(FIport)}$, $\boldsymbol{lnSD(FIport)}$ and ln_{z2} respectively and letting Φ (.) denote the cumulative density function of the standard normal distribution, the estimated probability ***(Pr)*** that a household will be meeting or exceeding the normative well-being threshold representing resilience denoted by $R_{i,t+1}$ is given by:

$$\boldsymbol{R_{i,t+1} = \Pr(ln_{E(FIport)} \geq ln_{z2}) = \Phi\left(\frac{ln_{E(FIport)} - ln_z}{ln_{SD(FIport)}}\right)} \qquad \textbf{Eq.5.9}$$

In order to profile household resilience along with the key resilience properties of their livelihood system defined above, the continuous measure of resilience $\boldsymbol{R_{i,t+1,}}$ was used to categorize a household as resilient or not resilient with reference to the normative minimal threshold probability, (P=0.5), under which a household's probability of meeting or exceeding the normative well-being threshold intolerably low. Hence households were classified as resilient to food security shocks if the measure of resilience, $\boldsymbol{R_{i,t+1,}} > 0.5$, and non-resilient otherwise.

5.2.2. Determining Thresholds and Pathological States

The long-term study of ecosystems confirmed that the changes in systems' structures and functions subject to internal dynamics and external shocks results in four characteristic phases

[4]*Livelihood protection threshold represents the total food income required to cover both the minimum food needs and non food needs such as regular purchases of seeds, fertilizers, veterinary drugs, etc. which can sustain livelihoods*

which constitute the adaptive cycle (Holling, 2001). The first two phases, growth (r) and conservation (K) phases, called the fore-loop. As applied to social-ecological systems, these two phases constitute a development mode in societies. The growth phase, characterized by readily available resources, the accumulation of structure, and high resilience to maintain system properties whereas the conservation phase, characterized as the stage where net growth slows and the system becomes increasingly interconnected and interdependent, and more vulnerable to external change. Sufficiently enough shock at this phase causing the crossing of tipping points lead to the next two phases release (Ω) and reorganization (α), called the back-loop. As applied to social-ecological systems, these phases constitute a period of change and transformation in societies. The release phase is a period of collapsing structures and release of accumulated wealth of the system. Subsequently the fourth phase, a period of reorganization followed to complete the cycle in which novelty can take hold, and leading to another growth phase in a new cycle.

Many systems appear to move through these four phases, including social systems (Holling, 2001). The properties of systems at a particular stage of the four systemic phases (r, K, Ω, α) is determined by wealth of the system and the degree of connectivity between system components and the resulting resilience of the system to change. Assuming that each of the three properties in the adaptive cycle is given two nominal levels, either low or high (Allison and Hobbs, 2004), shows possible combinations of the three properties that characterize the adaptive cycle. The first four combinations of the three adaptive cycle properties represent normal flow of conditions (Table 8) and the other four combinations represent a deviation from normal flows which are often known as pathological states (Table 9).

Table 8 Level of Key Properties & Normal Characteristics of the Four Phases of the Cycle

	The Four Adaptive Cycle Phases			
Key Properties	Reorganization	Conservation	Growth	Release
Wealth	High	High	Low	Low
Connectivity	Low	High	Low	High
Resilience	High	Low	High	Low

Source: (Allison and Hobbs, 2004)

Resilience is high in the first phase of the fore-loop and in the second phase of the back-loop. The description for the four phases above involving the characteristics of wealth and connectivity is based on the normal flow of conditions and relationships between the three key properties as shown by Table 8.

Table 9 Level of the Three Adaptive cycle Properties and Pathological States

	Adaptive Cycle Properties		
Pathological State	Wealth	Connectivity	Resilience
Poverty Trap	Low	Low	Low
Rigidity Trap	High	High	High
Lock-in Trap	Low	High	High
Structural Trap	High	Low	Low

Source: (Allison and Hobbs, 2004)

Following (Allison and Hobbs, 2004) the description of the four pathological states as applied to the study system of concern is outlined as follows. The first pathological state, poverty trap is the predominant state expected to characterize household livelihoods constructed in the study area predominantly characterized as chronically poor district. This pathological state is characterized by all three properties having low values, creating impoverished systems that exist

in a recurring state of crisis. The second pathological state, the rigidity trap, may apply to the study system of concern characterizing less diversified, highly connected and inflexible structure of household livelihoods. The third pathological state, the lock-in trap refers to the situation where technology effectively redefines the system and prevents the whole system from crossing critical thresholds. This pathological state is may be the least expected state to characterize the study system of concern. Finally, structural trap characterized by various forms of entitlement constraints that prevents access to available wealth sources, rendering the system caught in a back-loop of recurrent reorganization.

In this paper the method for classifying household livelihoods for each of the three variables (Wealth, Connectivity and Resilience) into levels of high and low is based on the following. First, wealth of the system represented by household livelihood portfolio food income is classified into high and low levels based on livelihood protection threshold (140% as percent of the minimum food needs). It is also possible to use minimum survival threshold which is 100% as percent of the minimum food needs but it was decided to use the former as it reflects both the food and non-food needs. Hence Households whose expected portfolio food income greater than this threshold are classified at high wealth level and low wealth level if otherwise. Second, in terms of connectivity, the average expected standard deviation associated with the level of portfolio food income equivalent to the livelihood protection threshold is used to classify household livelihoods into similar categories. Finally, for the third variable, resilience which is defined, in this paper, as the probability that a household will be meeting or exceeding the normative well-being threshold, were categorized into high and low resilience levels based on the normative probability threshold value of 0.5 or 50%.

For simplicity those households with a characteristic of the four combinations of the three variables representing any of the normal states of the adaptive cycle were classified as a state of

no-trap and the remaining households were classified into the four pathological states based on the relationship they exhibit between the three variables as described in Table 9.

5.3. Result and Discussion

5.3.1. Summary of Resilience Properties

In order to summarize measures of resilience properties, households were clustered into three distinct livelihood strategy groups who have similar livelihood patterns. Non-hierarchical cluster analysis technique (k-means) were used, based on the proportion of income each livelihood activities contributes to the total household food income as percent of the minimum food needs. Accordingly, sample households were categorized into crop farming groups (who obtains most of the food and income from crop farming); mixed farming groups (those who depend on both crop and livestock), and non-agricultural livelihood groups primarily dependent on off-farm and non-farm employment opportunities. The proportion of sample households who were classified as crop farming, mixed farming and non-agricultural groups accounts 57%, 34%, and 9% respectively. Figure 14 depicts the proportion of food income each entitlement channels contribute to the household. More than three-fourth of the food income for crop farming groups comes from crops where as both of the remaining livelihood groups have relatively more diversified sources of food income.

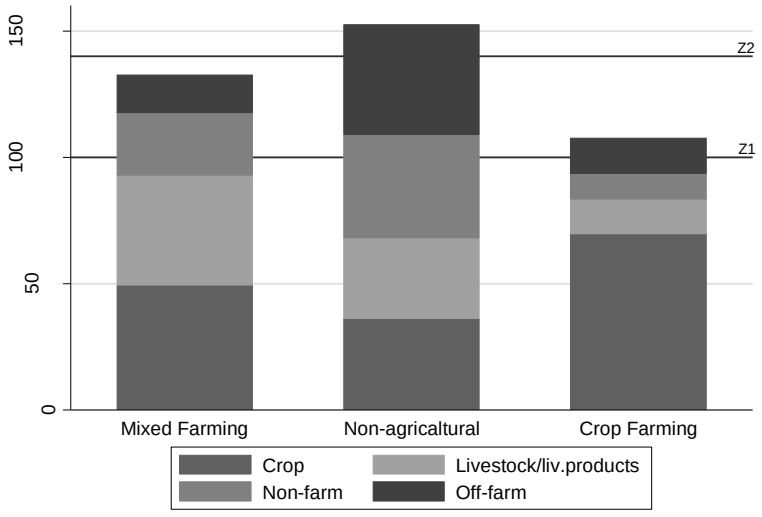

Figure 14 Average Contribution of Food Income Entitlement Channels by Livelihood Groups

The two reference lines ***z1*** and ***z2*** are survival and livelihood protection thresholds defined above. In this paper, resilience is defined as the probability that a household will be meeting or exceeding the normative well-being threshold representing the total income required sustaining local livelihoods. Based on the distribution of expected average household food income and its variability obtained from the MPT analysis, the probability of households to maintain food income beyond the threshold were computed. The probability that an average household will have to maintain food income beyond the threshold is 0.40 (Table 10) which is on average below the minimum probability (0.5) threshold that marks resilience status of households. Crop-based livelihood groups have relatively lower resilience level as compared to other livelihood groups. The average expected portfolio food income per household (a measure of wealth) and associated average standard deviation (a measure of connectivity), computed as percent of the minimum food needs, ranges between a minimum of (Mean=85%, SD=24%) and a maximum of (Mean=117%, SD=31%) for crop farming and non-agricultural livelihood strategy groups, respectively.

Table 10 Mean Values for Key Resilience Properties by Livelihood Strategy Group

		Livelihood-Strategy-Group		
Resilience Attributes	**All**	**Mixed-Farming**	**Non-Agricultural**	**Crop-Farming**
Wealth	94.85	105.79	117.02	85.12
Connectivity	25.61	26.37	30.68	24.43
Household Resilience to Food Insecurity	0.40	0.42	0.43	0.38
Diversity (Shannon's Diversity Index)	0.60	0.81	0.91	0.42
Response Capacity	0.29	0.28	0.33	0.28
Adaptive-Capacity Index	-0.0009	0.10	0.12	-0.08

Similarly, higher diversity as well as shock response and adaptive capacity were exhibited among non-agricultural livelihood groups. With higher diversity, mixed-farming and non-

agricultural groups could be able to maintain minimum covariance between individual livelihood activities. Households with higher wealth & connectivity as well as higher diversity and response capacity tend to have the highest resilience.

5.3.2. Testing Relations between Resilience Properties

This section focuses on testing relation among resilience properties of the livelihood system based on resilience theory described above. A two-way scatter plot was used to explore relationships between resilience properties including levels of household resilience plotted against each component. Relation between resilience properties tend to vary by levels of wealth. Hence, household's food security levels were classified into higher and lower levels using the threshold value defined above based on the distribution of expected average portfolio food income obtained from MPT. Firstly, resilience theory would predict that wealth of the system increases with increasing connectivity. In this study as applied to social system, household livelihood systems in the study area shows the same pattern as predicted at both lower and higher levels of food security. Similarly, with increasing wealth and connectivity household resilience to food insecurity increases (top-left and top-right side of figure 15). However, at higher level of wealth resilience theory would predict that with increasing connectivity of the system diversity declines and intern these relationship causes resilience to decline. As applied to livelihood systems, although livelihood diversity declines with increasing connectivity (bottom-right side of Figure 15) which is significant at 5%, household resilience to food insecurity does not decline as predicted (bottom-left side of Figure 15). This may be because of at least two reasons. First the study area is predominantly characterized as chronically poor district and households categorized as high wealth level are only relatively wealthy. Hence these households may tend to diversify their livelihoods sufficiently enough to maintain their resilience to food insecurity. In fact, most households exhibited the expected pattern of increasing diversity with increasing

levels of resilience at both lower and higher levels of food security. This confirms the critical role of diversity of entitlement channels to maintain household resilience.

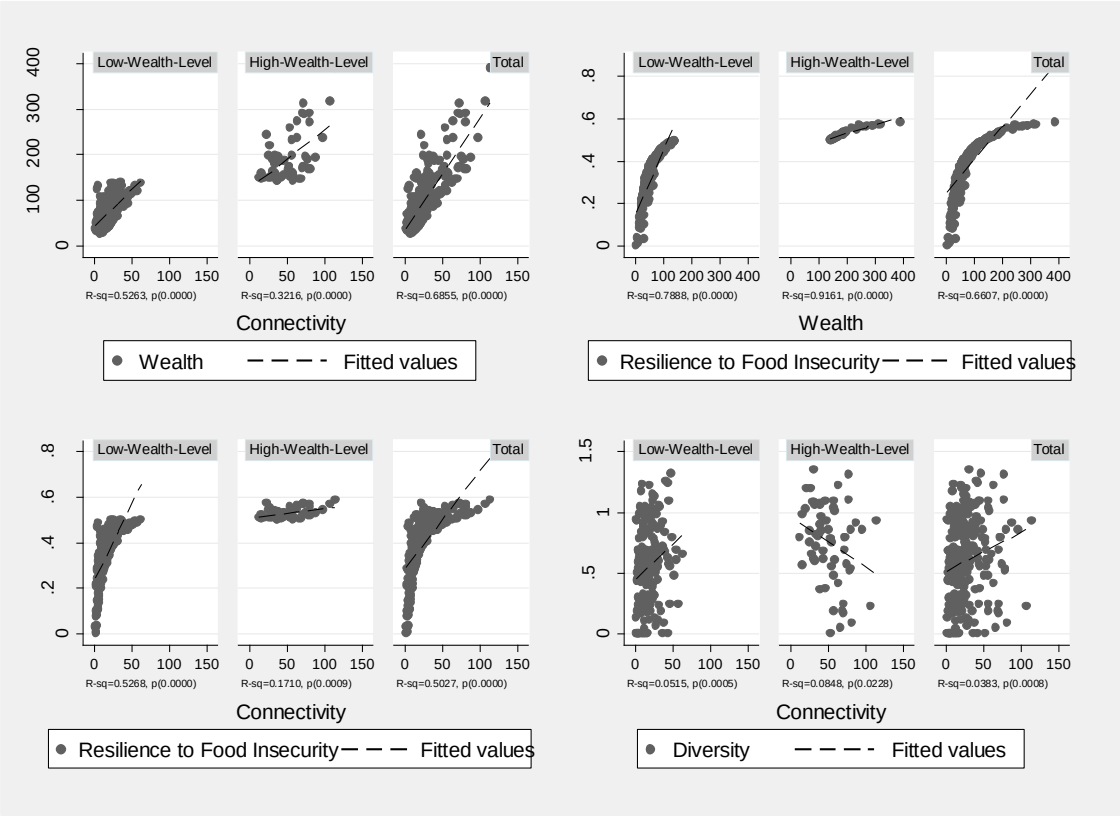

Figure 15 Scatter Plots for Wealth, Connectivity, Diversity and Resilience to Food Insecurity

Many studies in Ethiopia (Berhanu et al., 2007; Block and Webb, 2001; Canali and Slaviero, 2010; Carter et al., 2004; Dercon, 2002a; Dercon and Hoddinott, 2005a; Holden et al., 2004; Lemi, 2005; Vaitla et al., 2012), in the context of food insecurity confirms the critical role of livelihood diversification to deal with shocks and household resilience. This is not surprising as these studies focus on risky environments characterized by recurrent food crisis due to climate shocks as well as structural poverty. Second, the stage at which the system is at within an adaptive cycle also determines the relationship between resilience properties. For example, resilience theory predicts increasing resilience at growth stage while declining resilience at conservation stage with increasing wealth and connectivity. Hence none of sample household

livelihoods exhibited the characteristics of conservation stage (see section 5.2.2 for normal and pathological states of household livelihoods along the adaptive cycle).

In terms of adaptive capacity, this study distinguished the concept of response capacity, the ability of system participants to manage resilience trajectories of the system particularly in times of crisis, from existing inherent capacity of the system. In characterizing vulnerability (Luers et al., 2003) define the concept of adaptive capacity as the capacity of the system to move to a less vulnerable condition in the face of risk, the term response capacity is used in this paper to refer such capacity. Whereas the term adaptive capacity is used to represent the existing inherent capacity of the system of concern. In the resilience characterization, the latter is already captured by the measure of wellbeing function based on the distribution of expected average portfolio food income and its variation obtained from MPT. In order to check the robustness of the MPT-based measure of resilience, Resilience Capacity Index (RCI) was constructed as a multidimensional construct based on FAO-RIMA model. The relationship between both measures is depicted in Figure 16 below.

Hence, as independent property of resilience, response capacity was defined as the extent to which a system can modify its circumstances to move to a less vulnerable condition due to household coping. Households of the study area employed various coping mechanisms to meet the food and non-food gaps in response to shocks. Sample households were asked during the survey the number of days' they could cover their food and non-food expenditure from a list of common positive coping mechanisms during times of shortage. The number of days were converted into kilocalories as percent of the minimum food needs based on household economy approach. If for example a household reported a total of three months that they could cover from a list of coping mechanisms, the average contribution of coping to the household food needs as

percent of the minimum food needs could be computed by dividing 3 months by 12 months multiplied by 100.

Since this capacity is only used during periods of shock, response capacity was measured as the percentage points improved in food security positions of households due to coping relative to the minimum survival threshold as compared to the relative position excluding coping. Resilience theory would predict that household resilience to food insecurity declines with declining response capacity at both lower and higher levels of wealth. Figure 16 confirms this hypothesis as predicted by resilience theory despite the relationship is found to be not significant. This relationship is not surprising as only what is often considered to be positive coping mechanisms are considered unlike those coping mechanisms such as selling of productive assets which undermines the resilience of household livelihoods as a whole. This is very interesting if future studies explore further the relationship between negative coping behavior of households and resilience properties of their livelihoods.

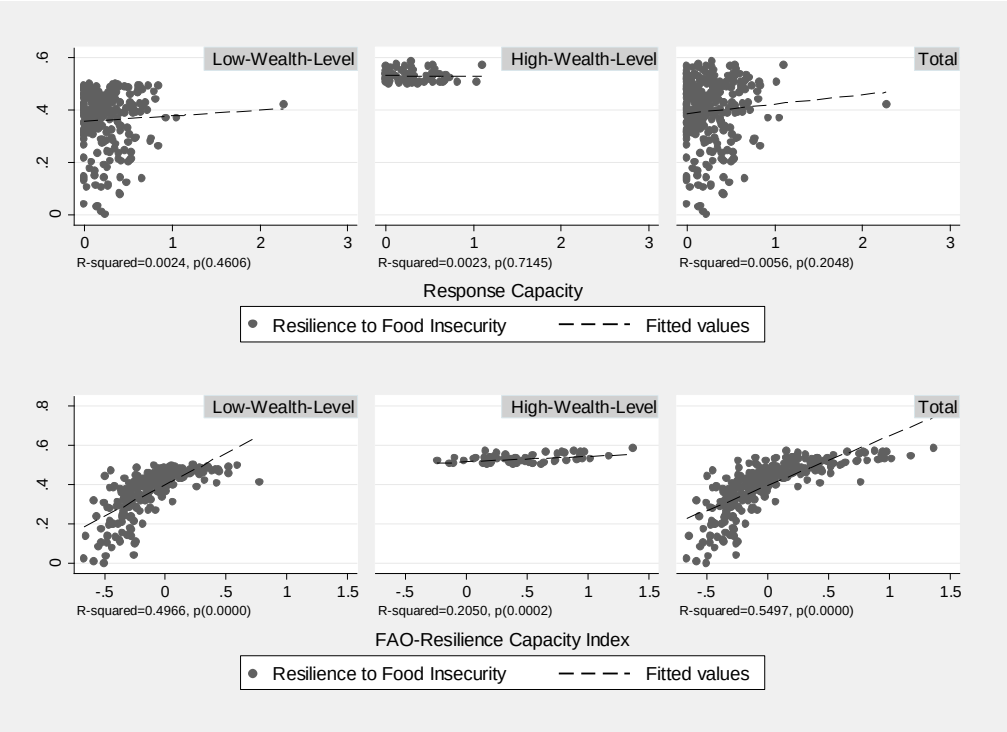

Figure 16 Scatter Plots for Response Capacity, Adaptive Capacity & Resilience to Food Insecurity

Similarly, the other aspect of inherent part of system's capacity which is adaptive capacity also shows a positive correlation with household resilience to food insecurity. Adaptive capacity index was constructed following a similar statistical techniques used by FAO-RIMA model in constructing resilience capacity index. This aspect of capacity is already part of the wellbeing function which is used to construct household resilience to food insecurity and it is not surprising to have a significant relation with the measure of resilience at 1% level of significance. However, FAO's measure of resilience capacity index as a multidimensional concept could confirm the robustness of MPT-based measure of household resilience to food insecurity.

5.3.3. Household Resilience Profile and Pathological States

From the four pathological states defined in section 5.2.2 based on resilience theory, only two undesirable pathological states of poverty trap and rigidity trap found to be characterizing household livelihoods in the study area. In livelihood systems, poverty trap can be observed if households achieve lower food security levels at lower connectivity with lower resilience i.e., lower probability to maintain food security beyond the minimum livelihood protection threshold. In contrast, rigidity trap can be observed if households achieve higher levels of food security at higher connectivity with higher resilience. Small proportion of households (14%) exhibited the pattern of rigidity trap.

Table 11 Household Resilience Profile by Livelihood Strategy Group

		Livelihood-Strategy-Group		
Resilience Attributes	**All**	**Mixed-Farming**	**Non-Agricultural**	**Crop-Farming**
Pathological-State				
Poverty-Trap	72.85	70.00	50.00	77.84
Rigidity-Trap	14.43	17.00	20.83	11.98
No-Trap	12.71	13.00	29.17	10.18
Food-Security-Status				
Chronic	63.23	53.00	41.67	72.46
Transitory	15.81	21.00	25.00	11.38
Food Secure	20.96	26.00	33.33	16.17
Connectivity-Status				
Low	79.38	79.00	62.50	82.04
High	20.62	21.00	37.50	17.96
Resilience-Status				
Non-Resilient	79.04	74.00	66.67	83.83
Resilient	20.96	26.00	33.33	16.17
Portfolio-Diversification				
Low Diversity	34.02	3.00	16.67	55.09
Moderate Diversity	34.02	42.00	12.50	32.34
High Diversity	31.96	55.00	70.83	12.57
Response-Capacity				
Low	33.33	34.00	29.17	33.53
Moderate	33.33	34.00	25.00	34.13
High	33.33	32.00	45.83	32.34
Resilience-Capacity Index				
Low	33.33	18.00	20.83	44.31
Moderate	33.33	37.00	29.17	31.74
High	33.33	45.00	50.00	23.95

As the study area is one of the risky environments in Ethiopia, more than 70% of sample households exhibited the characteristics of undesirable pathological state of poverty trap and only 21% of all sample households found to be food secure and resilient. However, this proportions varied by livelihood strategy groups. More of the households under Non-agricultural livelihood strategy groups are found to be outside of undesirable pathological state and more than one-third of them found to be food secure and resilient. This is mainly because these livelihood groups tend to diversify their livelihoods outside of agriculture. For example, 70% of these livelihood groups are categorized as higher levels of portfolio diversification (Table 11).

Similarly, these households also have relatively higher levels of response capacity as well as the capacity to manage resilience. Hence this confirms that livelihood diversification is a key strategy to building household resilience to food insecurity in the risky environments of Ethiopia characterized by chronically food insecure and other similar characteristics with study area.

5.4. Concluding Remarks

This study proposed a set of metrics for measuring the properties of resilience of livelihood systems at household level. Based on resilience theory (Holling, 2001) as applied to social-ecological systems, adapting the four properties of resilience to livelihood systems, the methodological approaches of Modern Portfolio Theory were used to measure wealth, connectivity, diversity, and adaptive capacity. The study also tested the expected relationships between resilience properties as predicted by resilience theory. Most of the sample households exhibited the expected patterns of increasing wealth, connectivity and diversity with increasing resilience of the system, particularly among sample households at lower level of wealth. At higher levels of wealth, sample households also exhibited the expected pattern of declining diversity with increasing connectivity as these households tend specialize on those few activities with higher return. As typical part of resilience, adaptive/response capacity plays a critical role to maintain household resilience towards a positive food security outcome.

The fact that the study area is one of the priority risky areas characterized by drought prone chronically food insecure districts in Ethiopia, only 21% of the sample households could be considered as resilient. Considerable proportion of sample households (73%) shows properties of poverty trap-where unviable livelihood system may persist at higher diversity and remain in the trap and continue to achieve negative livelihood outcome (food insecurity). Based on the portfolio analysis result designed to explore the relationship among resilience properties, interventions designed to expand opportunities of diversification are critical to improve household resilience to maintain food security beyond the minimum wellbeing threshold. In

addition, interventions designed to expand coping options of households in response to shock including safety net programs could have a positive role towards household resilience to food insecurity.

Finally, further research is recommended to explore the potential of modern portfolio theory to measure household resilience trajectories combined with household economy approach. The latter is livelihood based early warning instrument employed in most African and Asian countries to predict food emergency needs. This is particularly important to advance food security and early warning systems in determining not only emergency needs but also development needs which facilitates targeting and the design of resilience building programs in Africa.

6. SHOCK EXPOSURE, EX-ANTE RISK MANAGEMENT STRATEGIES & HOUSEHOLD SHOCK REACTION CAPACITY

6.1. Introduction

For many generations, Ethiopian rural population have experienced significant episodes of food emergencies and the most dramatic food crisis come from the mid-1980s when an estimated one million people died of hunger. More than one-third of its rural districts are now characterized by risky environments exposed to protracted food crisis (GOV, 2005). Over 30 million of its population classified as either transitory or chronically food insecure and remain highly vulnerable to shocks such as drought (Rahmato, 2013). For example, in Amhara region where the research is located, on average more than 2 million people, including the chronically food insecure who are under regular safety net program, required food emergency assistance between 1995 and 2014 (Figure 1 in Chapter one).

Coupled with chronic poverty, recent climate-related crises have directly threatened the lives of millions of people and further aggravate vulnerability to recurrent shocks (Deressa, 2007; Deressa and Hassan, 2009; Devereux et al., 2006; Ruth H. & Catherine P., 2013). In particular, vulnerability to drought has historically been very high among Ethiopian rural households. Almost half of rural households in Ethiopia were affected by drought in a five year period from 1999 to 2004 (Dercon et al., 2005), and recently drought has been found to have a significant impact on the welfare of these households.

While the negative Global Hunger Index trends have declined in the 1990s (Wiesmann, 2006), food emergencies in 2000s affected most of the rural population of Ethiopia up to an estimated 15 million people in 2003 (GOV, 2004) and recently drought affected 8.5 million people in 2011 (GOV, 2012) and 10.1 million people in 2015 (GOV, 2016) respectively.

The risk coping behavior of the households is very much related to the persistent effects of risks and shocks. A growing body of evidence, (Dercon, 2004; Dercon et al., 2005; Gilligan and Hoddinott, 2007) points to the role that risks/shocks and peoples choices of response strategies such as distress sales of assets contribute to perpetuating poverty. This resulted in not only negative expected livelihood outcome in terms of low future consumption but also negative risk management outcome i.e. deteriorating coping ability to deal with future risks.

The negative impact of shocks on wellbeing, particularly food security, depends on the coping options available for households as well as the ability to apply effective ex-ante risk management strategies such as income diversification and adoption of new agricultural technologies (Frankburger et al., 2007). Adoption of such strategies is a function of risk perceptions, community and location characteristics including knowledge, market and government incentives (Ashraf et al., 2014; Cavatassi et al., 2011; Dercon, 2002b; Deressa et al., 2010). The recent IFPRI study on climate risk perception adaptation choices in Ethiopia identified age of the household head, wealth, and information on climate change, social capital, and agro ecological settings have significant effects on farmers' perceptions of climate change in Ethiopia (Deressa et al., 2010). Past shock experience affects risk perception and in turn influences adoption of ex ante risk management strategies. Many studies emphasized the role of risk perception of various factors involved in the management of climate risk. One advantage of considering risk perception is taking into account individual perceptions and preferences of the decision makers and hence is more suitable for deriving policy recommendations (Otway and Thomas, 1982; Renn, 1998).

It is important to understand how households experience environmental change as well as their perceptions to future risks. Hence this study set to identify determinant factors that shape climate and related hazard risk perception and risk management choices as well as factors that determine

household shock reaction capacity. The part of the paper is organized into four sections including the introduction section presented above. The second section presents the methodology outlining empirical model estimation procedures and descriptions of model variables that are expected to determine risk perception, ex-ante risk management choices as well as shock reaction capacity of households. The third section presents the empirical model results regarding the relationship between climate shock experience, risk perception, and the adoption of ex-ante risk management strategies as well as the factors that determine ex-post shock reaction capacity. The last section presents concluding remarks including implications of the study to policy and resilience building programs and practices.

6.2. Empirical Model

6.2.1. Modelling ex-ante risk management choices

The methodology used for empirically testing the relationship between climate shock experience, risk perception, and the adoption of ex-ante risk management strategies, takes a two-step regression approach. In the first step households' risk perception is estimated while controlling for the short-term effect of climate-related shocks on households' risk perception as well as for other socio-demographic factors that construct and maintain risk expectations. The first model estimates household's risk perception using ordinary least squares (OLS) regression based on the following simplified relationship:

$\boldsymbol{R_i}$ *= f(Past shock experience (S), Household characteristics (H) and Community & location characteristics (C))*

Where $\boldsymbol{R_i}$ is subjective risk levels perceived by each household indexed by *i*, measured by an ordinal risk score which indicates the magnitude of climate risk which a household expects to happen in the future. In the household questionnaire respondents were asked to quantify both the frequency of each shock type as they perceive they will occur in the next 5-years and severity of

impacts on income and asset using an ordinal scale from 0 (=no impact) to 3 (=high severity). The risk score is then computed by summing the severity of each shock event and then multiplying it with the frequency of the event. Based on the nature of shock types, the risk scores were normalized (using min-max linear standardization technique) and aggregated in to indices of weather risk, crop risk, livestock risk, market risk and labor risk categories. The sum of the risk index of all shock categories is then computed for each household to represent household risk perception. $\boldsymbol{S}$ is a vector of climate shock incidents that a household experienced during 2011 and 2015 and $\boldsymbol{H}$ is a vector of household characteristics and $\boldsymbol{C}$ is a vector of community and location specific characteristics in which households reside. The basic estimation model can be expressed in general form as follows:

$$\mathbf{R_i} = \boldsymbol{\alpha S_i} + \boldsymbol{\beta H_i} + \Omega \boldsymbol{C_p} + \boldsymbol{\varepsilon_i} \qquad \textbf{\textit{Eq.6.1}}$$

Where R_i subjective risk levels perceived by each household indexed by i; H_i is a vector of household specific socio-demographic characteristics and C_p is a vector of community and location characteristics, ε_i is the error term which is assumed to be normally distributed with mean zero and constant variance and α, β, Ω are the parameters to be estimated. The model is estimated using ordinary least squares.

In the second step the likelihoods of households taking up the most frequently applied ex-ante risk management strategies are estimated by applying a multivariate probit model. It is assumed that the decisions of households to engage in the different strategies are inter-correlated. Therefore, a standard probit model is not suitable for making predictions about the joint probabilities of the relevant risk management strategy choices. The model is estimated using maximum likelihoods method. Consider the following stochastic functions, one for each risk management strategy choice from 1 to *J*.

$$\mathbf{Z_{1i}} = \alpha_1 R_{1i} + \beta_1 H_{1i} + \Omega_1 C_{1p} + \varepsilon_{1i} \quad \textbf{Eq.6.2}$$

$$Y_{1i} = 1 \; if \; Z_{1i} > 0$$

$$Y_{1i} = 0 \; if \; Z_{1i} \leq 0$$

$$\mathbf{Z_{2i}} = \alpha_2 R_{2i} + \beta_2 H_{2i} + \Omega_2 C_{2p} + \varepsilon_{2i} \quad \textbf{Eq.6.3}$$

$$Y_{2i} = 1 \; if \; Z_{2i} > 0$$

$$Y_{2i} = 0 \; if \; Z_{2i} \leq 0$$

$$\mathbf{Z_{ji}} = \alpha_j R_{ji} + \beta_j H_{ji} + \Omega_j C_{jp} + \varepsilon_{ji} \quad \textbf{Eq.6.4}$$

$$Y_{ji} = 1 \; if \; Z_{ji} > 0$$

$$Y_{ji} = 0 \; if \; Z_{ji} \leq 0$$

where $\mathbf{Z_i}$ is a latent decision variable indexed by household i, R_i is the ordinal risk score which was used as dependent variable in the first-step regression, H_i is a vector of household specific socio-demographic characteristics and C_p is a vector of community and location characteristics, and α, β, Ω are the parameters to be estimated.

6.2.2. Modelling ex-post household shock reaction capacity

This study also looked at the issue of ex-post shock coping strategies of households with the aim of identifying determinants of shock reaction capacity of sample households of the study area. Shock reaction capacity was defined as the capacity of a household to expand extra food income per unit of expected loss based on the distribution of portfolio food income obtained through the various entitlement channels.

In addition to the main household portfolio of livelihood activities, in response to shocks during bad year, households tend to expand the food income through various temporary coping mechanisms which includes private and public transfers as well as through increasing sales of

livestock and labor. Food income expandability potential of household's during shock were captured in the survey questionnaire outlining how much of food income could a household often expand from the above potential sources based on their experience in the previous shocks they encounter. Assuming that households could expand the food income through such positive coping options independent of the shock i.e. the extra food income expanded by a certain household represents mean zero shock portfolio return. Levels of food income were calculated at t+1 when there is shock and when there is no shock using equation 5.7 where $\boldsymbol{E(FI_{port})}$ is the expected average portfolio food income obtained from equation 5.2; CC_{hi} is the coping capacity defined as the proportion of food income that a household could expand during periods of shock from various coping mechanisms relative to the expected average portfolio food income; and CV_{hi} is coefficient of variation calculated using equation 5.2 & 5.5.

Given ***a*** and ***b*** represents the food income at t+1 where there is shock and no shock respectively (derived from equation 5.7). For household *i*, the extra food income available for shock reaction ($FI_{sr,i}$) was measured by subtracting the minimum survival threshold from ***a***, and the expected loss due to shock ($FI_{loss,i}$) by subtracting ***b*** from ***a***. Hence, Shock Reaction Capacity (SRC_i) representing the capacity of a household to expand extra food income, beyond the minimum survival threshold, per unit of expected loss for household i could be determined by equation 6.5.

$$\mathrm{SRC_i} = \frac{FI_{sr,i}}{FI_{loss,i}} \qquad \textbf{\textit{Eq.6.5}}$$

Household shock reaction capacity (SRC_i) was then modelled as a function of household and community characteristics as well as the nature of shock experienced by sample households in order to identify its determinants. Those households whose expected average portfolio food income less than the minimum survival threshold are considered to be struggling for survival

in both normal and bad years. Hence their capacity to expand extra food income beyond the minimum survival threshold per unit of expected loss is zero. This threshold assumption allows us to adopt a left censored data-modelling criterion, which is a Tobit model that can be mathematically represented as follows:

$$Y_i^* = \alpha_1 S_i + \beta_1 H_i + \Omega_1 C_p + \varepsilon_i \qquad \textbf{Eq.6.6}$$

Where $\varepsilon_i \sim N(0, \sigma^2)$ Y^* is a latent variable that is observed for values greater than the censoring point at $\tau = 0$ and censored otherwise; S_i is a vector of shock variables; H_i is a vector of household specific socio-demographic characteristics and C_p is a vector of community and location characteristics, and α, β, Ω are the parameters to be estimated.

The observed y is defined by the following measurement equation

$$y_i = \begin{cases} y^* \; if \; y^* > \tau \\ \tau_y \; if \; y^* \leq \tau \end{cases} \qquad \textbf{Eq.6.7}$$

The overall likelihood function will have two parts. The first part corresponds to the classical regression for the uncensored observations, while the second part corresponds to the relevant probabilities that an observation is censored.

6.3. Results and Discussion

6.3.1. Summary of Shock/Perceived Risk Levels and Risk Management Strategies

Respondents were asked about shock incidents that the household experienced during the past 5 years from 2010 to 2014, reporting a subjective assessment of their severity in terms of the magnitude of impact on their livelihood and their shock response mechanisms. In addition, respondents were asked to express their subjective assessment of the probability in terms of the frequency and the severity of future risks to occur in the next 5 years and their ex-ante coping strategies to be applied in response to perceived risks.

Table 12 presents levels of existing shock exposure levels as well as perceived risk levels in the future. Rural households in the study area were affected by different types of unexpected adversities including climatic, biological, socio-economic shocks. Adverse climatic shocks were the most prevalent type of calamity experienced by households, with drought (79%) and flooding (70%) having affected about more than three quarters of sample households. Volatility of crop and livestock prices was also the third most prevalent type of shock experienced by households. In addition to climatic shocks crop and livestock specific shocks affected more than half of sample households in the past five years' prior the survey.

An average household in the study area was affected by at least one climate shock in the last five years' prior the survey. Referring to standard deviations of reported climatic shock frequency and severity (Table 12), some households suffered a higher number or severity of shocks than others. A similar variation in shock frequency and severity can be observed for other shock types.

Biological shocks were reported with the highest severity experienced by households with crop pest ranked highest in terms of both frequency and severity, while in terms of frequency, socio-economic shocks were reportedly the highest category of shocks where an average household experienced about two episodes of price inflation in the last five years' prior the survey. Shocks such as strong wind and human disease generally played a minor role in the study area with less than 10% of households affected.

Table 12 Mean and Standard Deviation of Shock & Perceived Risk Levels by Shock Category

	Past shock experience				Future Risk Perception			
	Frequency		Severity		Frequency		Severity	
Shock type	mean	sd	mean	sd	mean	sd	mean	sd
Climatic	**0.81**	**0.63**	**1.07**	**0.59**	**1.56**	**1.11**	**2.11**	**1.00**
Drought	1.37	1.14	1.85	1.13	1.32	1.15	1.95	1.23
Flood	1.15	1.09	1.59	1.13	1.14	1.20	1.51	1.21
Strong wind	0.08	0.33	0.11	0.49	0.12	0.43	0.24	0.75
Frost	0.52	1.08	0.52	0.96	0.67	1.31	0.73	1.19
Hail storm	0.92	1.13	1.26	1.20	0.87	1.12	1.28	1.27
Biological	**1.36**	**1.28**	**1.49**	**1.05**	**1.35**	**1.34**	**1.73**	**1.22**
Livestock disease	0.77	1.12	0.94	1.10	0.87	1.20	1.21	1.29
Human disease	0.69	1.21	0.75	1.06	0.66	1.13	0.94	1.24
Crop pest	1.19	1.43	1.20	1.17	1.29	1.62	1.38	1.32
Socio-economic	**1.52**	**1.63**	**1.44**	**1.12**	**1.63**	**1.58**	**1.63**	**1.20**
price inflation	1.64	1.89	1.41	1.18	1.76	1.79	1.58	1.24
Conflict	0.12	0.45	0.18	0.58	0.18	0.54	0.28	0.73
Indebtedness	0.51	1.20	0.48	0.90	0.69	1.27	0.77	1.18

Table 12 also shows household's perception of risk levels referring to the five years' period to come following the survey period. Differences exist between the households' experience of shocks in the past and their perception of risk levels to the future. Households appear to be quite pessimistic about the incidence of shocks in a future reference period of 5 years from 2016 to 2020. Climatic shock types which have been experienced by large shares of the population are expected to happen in the future with almost doubling levels of frequency and severity. For socio-economic and biological shocks more severe impact on household income and assets are expected to happen in the future but with almost similar frequency as they used to be in the last five years' prior the survey.

Similarly, the community group discussion participants in both Guna and Abay clusters perceived that climatic hazards such as drought are a recurrent problem and they believe that it

will occur in the near future with increasing severity as the frequency is increasing in recent years. In terms of identifying which particular livelihood typology is most vulnerable to the impact of climatic shocks, livelihood sensitivity matrix (Downing et al., 2005) was developed for the study area. Table 13 and 14 shows how sensitive each livelihood typology is to risk identified by Communities in Guna and Abay Livelihood zones. Rows and columns of the tables below represented by climatic risks and livelihood activities, respectively. During community group discussion in both livelihood zones, the degree of livelihood exposure to climatic related shocks was subjectively rated into a five level ordinal scale (representing from a scale of 1-no impact to 5-very high impact)

Table 13 Community Livelihoods Climate Exposure Exercise (Guna Cluster)

Resources and Livelihoods	**Climatic risks**						**Exposure indices**	
	Drought	Hail storm	Flood	Frost	Crop pest	Livestock disease	*Exposure index*	*Weighted exposure index*
Frequency	*25*	*10*	*10*	*20*	*30*	*5*	100	
Ecosystem services								
Soil water balance	5	1	3	1	1	1	40	*2.20*
Water supply	5	1	2	1	1	1	37	*2.10*
Non-farm wood fuels	4	1	1	3	1	1	37	*2.15*
Grazing and fodder	5	2	2	1	1	1	40	*2.20*
Livelihood activities								
Sorghum	3	4	1	5	5	1	63	*3.80*
Teff	4	5	3	5	1	1	63	*3.15*
Wheat	5	5	4	5	1	1	70	*3.50*
Milk	5	1	2	1	1	5	50	*2.30*
Livestock sales	5	1	1	1	1	5	47	*2.20*
Fire wood	4	1	1	1	1	1	30	*1.75*
labor	4	1	1	1	1	1	30	*1.75*

From a maximum of weighted exposure index of 5 for a particular livelihood activity, production of cereals, in Guna, such as sorghum *teff* and wheat were rated with a higher exposure to the impact of climate and related shocks. While in Abay livelihood zone, predominantly characterized by lowland agro-ecology, most production items and livelihood activities were rated with above average weighted exposure index to climatic related risks with Sorghum and Boleke have the highest exposure index. The latter is a cash crop primarily contributing to household income.

Table 14 Community Livelihoods Climate Exposure Exercise (Abay Cluster)

Resources and Livelihoods	**Climatic risks**					**Exposure indices**	
	Drought	Hail storm	Flood	Crop pest	Livestock disease	*Exposure index*	*Weighted exposure index*
Frequency	*55*	*10*	*5*	*20*	*10*	100	
Ecosystem services							
Soil water balance	5	1	2	1	1	33	*3.25*
Water supply	5	1	2	1	1	33	*3.25*
Non-farm wood fuels	4	1	1	1	1	27	*2.65*
Grazing and fodder	5	4	2	1	1	43	*3.55*
Livelihood activities							
Sorghum	5	3	1	5	1	50	*4.20*
Teff	3	3	1	3	1	37	*2.70*
Wheat	3	2	1	3	1	33	*2.60*
Boleke	5	5	1	3	1	50	*4.00*
Beans/peas	4	5	1	5	1	53	*3.85*
Milk	5	1	1	1	5	43	*3.60*
Livestock sales	4	1	1	1	5	40	*3.05*

Reportedly, in response to these climatic shocks and stresses, communities primarily adopted coping mechanisms such as use of drought tolerant and short maturing crops; diversifying crop & income sources as well as natural resource conservation through tree planting, terracing &

water harvesting. The household survey also confirmed that considerable proportion of households (84.2%) reported to apply at least one ex-ante risk management strategies in order to prevent the adverse effects of future climate shocks (Figure 17).

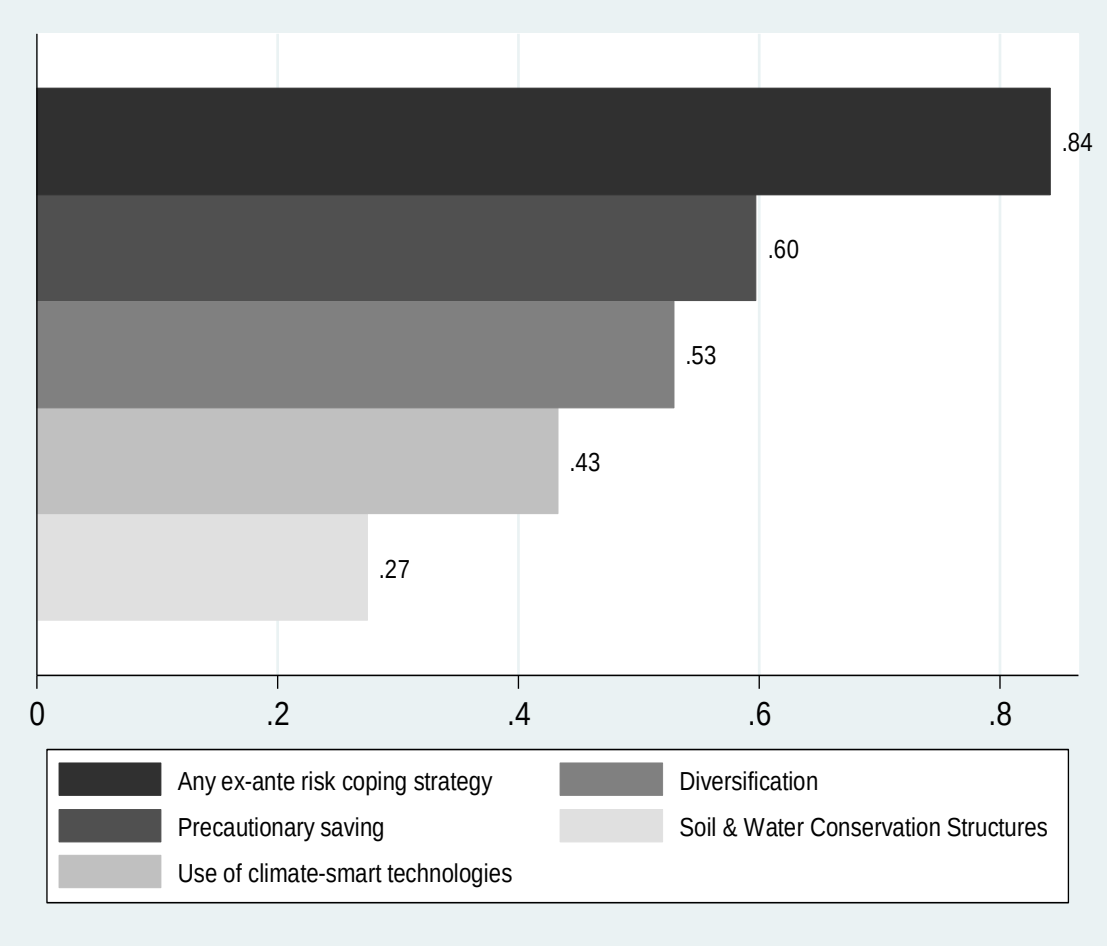

Figure 17 Proportion of Sample Households by Ex-ante Risk Management Strategies

The most common ex-ante coping strategies applied by at least half of sample households include precautionary saving and livelihood diversification. More than 40% of sample households believed to apply climate smart technologies such as drought tolerant crop and livestock varieties, while less than a third of sample households participated in community actions involving the construction of soil and water conservation structures.

6.3.2. Determinant Factors of Future Risk Perception

This section presents the econometric results obtained from OLS regression with risk score a dependent variable representing risk perception as subjective assessment of future shock frequency and severity. The model has been tested for the problem of endogenous and heteroscedasticity as well as multicollinearity between explanatory variables and no such problems could be detected.

Table 15 Regression Results of the Determinants of Risk Perception

	(Risk score)	
VARIABLES	Coefficients	Standard error
Household head gender (Male=1)	0.0547	(0.0802)
Household head Age	0.0356***	(0.0115)
Household head Age Squared	-0.000347***	(0.000114)
Education status (Literate=1)	0.0914*	(0.0552)
Maximum education (years)	-0.0104	(0.00991)
Household size	-0.0193	(0.0198)
Wealth per capita (Ethiopian birr)	2.72e-05	(2.58e-05)
Social network score	-0.00372	(0.00689)
Distance to road (Minutes)	-0.000941*	(0.000525)
Distance to market (Minutes)	-0.000191	(0.000734)
Distance to District town (Minutes)	-0.182*	(0.0939)
Livelihood zone dummy (Guna=1)	0.116**	(0.0555)
Livelihood group (Non-farm=1)	0.000705	(0.0856)
Aggregate shock index	0.512***	(0.0475)
Constant	-0.577**	(0.268)
Observations	286	
R-squared	0.406	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Results of the OLS regression of risk perception are presented in Table 15. The reported F-test and R^2 indicate that the independent variables are jointly significant and that the model has a reasonable goodness of fit.

Among the household specific characteristics hypothesized to affect risk perception, age and literacy status of respondents were found to be significant. The result indicates that older and literate respondents are more likely to evaluate a higher level of future risk levels than their counter parts. This is mainly because older respondents have longer-term shock experience and literate respondents may have better awareness about risk trends than illiterate respondents.

Distance from the main road and district town center were also found to be negatively correlated with the level of future risk as perceived by respondents. Households located far from the main road and town center are more likely to evaluate lower levels of future risk indicating remote villages may have limited access to information regarding future risk scenarios. With the same token, households located within Guna livelihood zone, where the district town is located, are more likely to evaluate a higher level of future risk than their counterparts in remotely located villages in lowland dominated Abay livelihood zone.

Furthermore, magnitudes of past shock experiences found to be significantly and positively correlated with perceived future risk levels. Households with higher degrees of shock exposure in the past are more likely to be pessimistic with evaluation of higher levels of future risk.

6.3.3. Determinants of Ex-Ante Risk Management Choices of Households

This section presents the econometric results obtained from multivariate regression of choices of ex-ante risk management strategies. Some households have been excluded from the analysis due to missing values for some variables included in the model. The model has been tested for its suitability in terms of whether various strategies could be jointly estimated. Results of the multivariate Probit regression are presented in Table 16. The reported F-test and R^2 indicate that the independent variables are jointly significant and that the model has a reasonable goodness of fit.

The negative impact of shocks on wellbeing, particularly food security, partly depends on the ability to apply effective ex-ante risk management strategies such as income diversification and adoption of new agricultural technologies (Frankburger et al., 2007). Adoption of such strategies is a function of risk perceptions, community and location characteristics including knowledge, market and government incentives(Ashraf et al., 2014; Cavatassi et al., 2011; Dercon, 2002b; Deressa et al., 2010). In this study the household specific characteristics such as age and literacy status of respondents, community characteristics such as distance from the main road and district town center as well as past shock experiences were found to be significantly correlated with the level of future risk as perceived by respondents.

Risk perception in turn influences adoption of ex ante risk management strategies. In this regard risk perception related to future climate risk is found to be positively and significantly correlated with the decision of households to apply diversification and use of climate smart technologies as ex-ante risk management choices. A unit increase in the respondent's evaluation of future climate risk levels, the likelihood that a household would apply these two ex-ante strategies increases by at least 20%.

Table 16 Multivariate Probit Regression Result for Determinants of Ex-ante Strategy Choices

VARIABLES	(1) Income Diversification	(2) Improved Varieties	(3) Saving/Buffer Stock
Respondent's sex (Male=1)	0.298	-0.176	-0.125
	(0.287)	(0.287)	(0.284)
Respondents Age (Years)	-0.0611	-0.0124	0.0180
	(0.0445)	(0.0461)	(0.0468)
Age squared	0.000663	5.70e-05	-0.000121
	(0.000445)	(0.000460)	(0.000466)
Education status (Literate=1)	-0.168	-0.240	0.213
	(0.174)	(0.181)	(0.181)
Maximum education (Years)	0.0203	0.0174	0.0255
	(0.0268)	(0.0283)	(0.0283)
Household size	-0.0330	0.0642	0.0142
	(0.0597)	(0.0613)	(0.0605)
Wealth per capita	-0.000136	6.78e-05	-6.37e-05
	(8.97e-05)	(9.26e-05)	(9.23e-05)
Social network score	-0.0112	0.0123	-0.0288*
	(0.0159)	(0.0162)	(0.0162)
Distance to road (Minutes)	-0.000106	-0.00135	-0.00315
	(0.00260)	(0.00321)	(0.00343)
Distance to Market (Minutes)	0.00205	-0.00442	-0.000400
	(0.00271)	(0.00282)	(0.00272)
Distance to Town (Minutes)	0.721	-0.360	-1.110
	(0.577)	(0.654)	(0.900)
Livelihood Zone (Guna=1)	-0.0358	-0.552***	0.0566
	(0.182)	(0.191)	(0.188)
Livelihood group (Farming=1)	-0.374**	0.0260	-0.0443
	(0.182)	(0.184)	(0.186)
Livelihood group (Non-farm=1)	0.425	-0.767**	0.739**
	(0.329)	(0.362)	(0.306)
Climate risk score	1.676***	1.804***	0.712
	(0.516)	(0.489)	(0.482)
Livestock risk score	2.253**	-1.504*	0.670
	(0.903)	(0.847)	(0.735)
Labor risk score	-1.735**	0.972	-1.227
	(0.766)	(0.708)	(0.818)
Crop risk score	0.388	0.443	0.155
	(0.403)	(0.382)	(0.386)
Constant	1.072	-0.187	-1.084
	(1.097)	(1.148)	(1.139)
Observations	286	286	286

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

An increase in perceived risk levels related to livestock shock would also increase the likelihood of a household to apply income diversification as ex-ante strategy but decreases the likelihood that a household would use climate smart technologies indicating that a higher evaluation of

future livestock risk would discourage pessimistic households to adopt technologies such as improved varieties of livestock breeds. Similarly, households with higher evaluation of future risk levels related to labor shock tend to have a higher likelihood to apply income diversification as a primary choice of ex-ante risk management strategy indicating labor is an important asset for engaging in various income generating activities.

Furthermore, location characteristics and nature of livelihood strategy group also affects household choices of ex-ante risk management strategies. Households residing in highland dominated Guna livelihood zone are less likely to adopt climate smart technologies as a risk management strategy than their counterparts in lowland dominated Abay livelihood zone. This may be because the highly variable climate in the lowland areas of Abay livelihood zone necessitates a higher demand for climate smart technologies. Similarly, households of different livelihood strategy group have also varied choices of ex-ante risk management strategies. For example, non-agricultural livelihood groups tend to prefer savings/buffer stock as a risk management strategy rather than adopting climate smart technology which may be due to unavailability of technologies for such strategy groups. This is also confirmed during community group discussion that technologies are only available for crop and livestock varieties. In fact studies such as (Bryan et al., 2009; Conway and Schipper, 2011; Deressa et al., 2009; Kato et al., 2011) underscore the importance of careful geographical targeting and understanding of local livelihood systems when promoting and scaling up climate smart technologies for adaptation to climate change. On the other hand, crop farming livelihood strategy groups are less likely to diversify out of agriculture than other strategy groups. This may be related to structural factors such as land tenure system which promotes farmers to stay in agriculture.

A contrasting result is obtained related to the expected role of social network score in influencing risk management decisions. The result indicated that an increase in participation of respondents in social networks decreases the likelihood of a household to saving or accumulate assets as a

buffer against anticipated shocks. This may be due to aggregate measure of social network score without distinguishing participation in formal and local networks. Some studies such as (Mogues and others, 2006) indicate that the later tend to depend on social claims and reciprocities involving sharing of food stocks primarily used as a coping strategy during periods of shock rather than encouraging precautionary saving as part of ex-ante planning.

6.3.4. Determinants of Household Reaction Capacity to Shock

This section presents the econometric results obtained from left censored Tobit regression with reaction capacity to shock a dependent variable representing the capacity of households to expand extra food income per unit of expected loss during shock. The Tobit model specification has been tested against the alternative of a model that is non-linear in the regressors and contains an error term that can be heteroskedastic and non-normally distributed. The model specification is found to be suitable and no alternative value for lambda would be required to return the linearity, homoscedasticity and normality assumptions that are necessary for consistent estimation. Results of the Tobit regression are presented in Table 17. With the likelihood ratio chi-square of 116.43 (df=27) and a p-value of (0.0000), the model as a whole fit significantly.

Among the household specific characteristics hypothesized to affect reaction capacity to shock, gender, household size and level of livelihood diversification were found to be significant. The result indicated that female headed households are less likely to have higher reaction capacity to shock than male headed households confirming with evidences documented in many vulnerability studies in Ethiopia (Dercon and Krishnan, 2000; Gray and Mueller, 2012; Hadley et al., 2008; Kumar and Quisumbing, 2013; Quisumbing, 2003) that female-headed households are the most vulnerable groups during shock with limited adaptive and response capacity.

Household size is also found to be significantly and negatively correlated with reaction capacity to shock. A unit increase in household size is associated with a 23% decrease in the predicted

value of household shock reaction capacity to expand extra food income per unit of loss. This is mainly because households with large size require more food income to meet consumption needs during shock than households with small size.

Table 17 Tobit Regression Result for Determinants of Household Shock Reaction Capacity

VARIABLES	Coefficient	Standard error
Household Characteristics		
Respondent's sex (Male=1)	1.244**	(0.613)
Respondents age (Years)	0.0624	(0.0833)
Age squared	-0.000769	(0.000837)
Educational status (Literate=1)	-0.0397	(0.350)
Maximum education (Years)	0.0700	(0.0534)
Household size	-0.234**	(0.117)
PSNP Beneficiary (Yes=1)	0.448	(0.326)
Informal transfer (Kcal-PPPD)	0.0244	(0.0148)
Per capita TLU	0.282	(0.868)
Land size (*Timad*)	-0.0366	(0.119)
Net debt (*Eth. Birr*)	-4.32e-06	(6.40e-05)
Livelihood Diversity (Shannon's Index)	1.902***	(0.557)
Crop Diversity (Shannon's Index	-0.860	(0.887)
Proportion of Productive investment	0.201	(0.430)
Community Characteristics		
Social network score	0.0110	(0.0304)
Distance to road (Minutes)	0.00321	(0.00534)
Distance to Market (Minutes)	-0.0190***	(0.00620)
Distance to Town (Minutes)	0.652	(0.927)
Livelihood zone (Guna=1)	0.803**	(0.371)
Interaction terms: Shock Index and Low Wealth Group		
Livestock Shock Index	-4.640**	(2.322)
Crop shock index	-0.717	(0.950)
Health shock index	0.0706	(1.496)
Weather shock index	0.419	(1.329)
Interaction terms: Shock Index and High Wealth Group		
Livestock Shock Index	4.226*	(2.304)
Crop shock index	-0.774	(1.525)
Health shock index	-1.415	(3.985)
Weather shock index	6.159**	(2.433)
Constant	-1.989	(2.047)
sigma	1.980***	(0.139)
Observations	281	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

However, interpretation of this relationship require more caution as labor capacity unlike household size would increase the ability to expand the food income from migratory labor during bad year. This could be understood the fact that labor demanding livelihood diversity index is positively correlated with the predicted reaction capacity to shock which is significant at 1%.

Access to market is also found to have a significant effect on the predicted household reaction capacity to shock. For a unit increase in distance from market, there is a 2% decrease in the predicted household reaction capacity to shock. Access to market (Dercon et al., 2009; Dercon and Hoddinott, 2005b; Gabre-Madhin, 2001) has been a critical factor for food security and growth of the rural economy as well as an instrument in response to food emergencies during periods of shock. Similarly, those households in Guna livelihood zone, where the district town center is located, are more likely to expand the predicted extra food income per unit of expected loss than those of households located in Abay livelihood zone.

In terms of the nature of shock, differential reaction capacity is expected among households at high and low wealth groups. Though only significant at higher wealth groups, weather shock is found to be positively correlated with the predicted value of household shock reaction capacity to shock indicating households tend to expand food income per unit of expected loss primarily in response to weather shock. With poor insurance market for weather related shocks and failure of informal support networks due to the covariate nature of weather shock affecting the whole community at the same time (Ali, 2015; Hill et al., 2013; Tadesse and Brans, 2012), households often tend to react by drawing down assets and buffer stocks in response to adverse effects of weather shocks on household wellbeing.

However, livestock shock shows contrasting relationship with reaction capacity among the two wealth groups. At higher wealth group increasing livestock shock index is associated with an increase in the predicted value of household shock reaction capacity by at least five percent,

while at lower wealth group, an increase in livestock shock index is associated with a decreasing predicted value of household shock reaction capacity. This is mainly because unlike low wealth groups, high wealth groups tend to keep livestock as a buffer against shock which may increase their capacity to expand extra food income per unit of expected loss. A similar evidence is also documented by several studies in Ethiopia (Ali, 2015; Carter et al., 2004; Mogues, 2011; Mogues and others, 2006).

6.4. Concluding Remarks

Rural households in the study area were affected by different types of unexpected adversities including climatic, biological, socio-economic shocks. The magnitudes of past shock experiences found to be significantly and positively correlated with perceived future risk levels and the latter is also found to be positively and significantly correlated with the decision of households to apply ex-ante risk management choices. Understanding this relationship is an important ground for effective process of risk communication between disaster management institutions and rural households. For example, an increase in perceived weather risk levels increases the likelihood that a household would use climate smart technologies such as improved varieties of crop and livestock breeds. Location characteristics and nature of livelihood strategy group also affects household choices of ex-ante risk management strategies indicating the need for considering the local livelihood context in the design and promotion of hazard mitigation and climate change adaptation technologies. For example, non-agricultural livelihood groups tend to prefer savings/buffer stock as a risk management strategy rather than adopting climate smart technology which may be due to unavailability of technologies for such strategy groups.

In terms of shock reaction capacity, households tend to expand food income per unit of expected loss primarily in response to weather shock and high wealth groups primarily tend to keep livestock as a buffer against shock which may increase their capacity to expand extra food

income per unit of expected loss. Since shock reaction capacity of sample households depends on the extra income obtained from migratory labor and livestock trade, monitoring people's access to labor and livestock market as part of early warning systems and promoting efforts targeted to reduce transaction costs for marketing such important buffer assets should be critical elements of emergency management systems at the local and regional levels.

7. DETERMINANTS OF HOUSEHOLD RESILIENCE TO FOOD SECURITY SHOCKS

7.1. Introduction

For many generations, Ethiopian rural population have experienced significant episodes of food emergencies and the most dramatic food crisis come from the mid-1980s when an estimated one million people died of hunger. More than one-third of its rural districts are now characterized by risky environments exposed to protracted food crisis (GOV, 2005). In the 1980s and 1990s, the major response system was dominated by food aid with lifesaving as a primary purpose. Recently, however, in such risky environments, promoting household resilience against shock has become a primary development agenda for both governments and humanitarian organizations. This is essentially because the recognition among GOs and NGOs that the problem of food insecurity is deep rooted and pervasive caused by multiple complex factors. It is also partly because decades of ad hock emergency response system failed to address the problem of recurrent food emergencies. Recently efforts are made towards resilience building, for instance the introduction of Ethiopia's Productive Safety Net Program, the use of improved guidelines for livelihoods response and the development of improved pastoral early warning systems (Sabates-Wheeler and Devereux, 2010; Vaitla et al., 2012). However, one of the challenges facing the design, implementation, monitoring and evaluation of resilience building programs is the lack of well-established set of metrics to modelling household resilience and to explaining why some households are more resilient than others. Hence, as a compliment to past food security and vulnerability studies, this part of the paper presents determinant factors of household resilience to explaining why some households are more resilient than others despite their exposure to shock. This is done so by drawing evidences from the findings of the proceeding chapters, particularly resilience properties of livelihood systems as well as risk

coping behaviors of households as system participants presented in chapter five and Six, respectively.

Hence, at conceptual level, the study adopts the resilience framework proposed by Franken burger and DFID (2012) (See section 2.6) with some modification for the purposes of operationalizing the concept of resilience particularly state and outcome variables included in the framework. Based on this framework, household resilience was modeled as a function of context & shock variables, adaptive capacity variables that include household assets, livelihood and risk management strategies, as well as institutions that influence household livelihoods) in order to investigate determinant factors of household resilience to food security shocks.

The paper is organized into four sections including the introduction part presented above. The second part presents data and modelling strategies outlining the measurement of household resilience as a dependent variable as well as estimation procedures of the chosen model. The third part presents result and discussion of the key findings and finally the last section concludes by pointing out key remarks and recommendations.

7.2. Methodology

7.2.1. Measuring Household Resilience

In the context of food security, resilience is both an outcome variable and an emergent property of a complex adaptive social-ecological system. Measurement of the later is presented in chapter five along with its relationship with state and driving variables. In line with the modified conceptual framework presented in section 2.6 (Figure 4), MPT offers not only a systems-based approach examining the whole 'portfolio' of livelihood activities (as presented in chapter 5) but also it enables to measure resilience to food insecurity as an outcome variable based on MPT measures of expected average portfolio return and volatility as a function of the correlations of all portfolio components. Therefore, following conventional vulnerability studies, resilience as

an outcome variable, is defined as the probability that a household will be meeting or exceeding the normative well-being threshold representing the total income required to meet the minimum food & non-food needs. As a resilience threshold, the latest livelihood protection threshold (***z2)***[5] value (140%) as percent of the minimum food needs were considered, which is set by Ethiopian Government Early Warning System for the study district. The probabilities were computed based on the distribution of the household average portfolio food income ***E(FIi)*** and its variance ***SD(FIi)*** obtained from MPT, using equation 5.2 and 5.5 (see section 5.2.1.1 & 5.2.1.2). Assuming natural logarithms of the expected average household portfolio food income, standard deviation of portfolio food income as well as the normative well-being threshold values as normally distributed in equation 7.1 denoted by $\boldsymbol{lnE(FIport)}$, $\boldsymbol{lnSD(FIport)}$ and $\boldsymbol{ln_{z2}}$ respectively and letting Φ (.) denote the cumulative density function of the standard normal distribution, the estimated probability ***(Pr)*** that a household will be meeting or exceeding the normative well-being threshold representing resilience denoted by $R_{i,t+1}$ is given by:

$$\boldsymbol{R_{i,t+1} = \Pr(ln_{E(FIport)} \geq ln_{z2}) = \Phi\left(\frac{ln_{E(FIport)} - ln_z}{ln_{SD(FIport)}}\right)} \qquad \textbf{Eq.7.1}$$

In order to profile household resilience, the continuous measure of resilience $\boldsymbol{R_{i,t+1,}}$ were used to categorize a household as resilient or not resilient with reference to the normative minimal threshold probability, (P=0.5), under which a household's probability of meeting or exceeding the normative well-being threshold intolerably low. Hence households were classified as resilient to food security shocks if the measure of resilience, $\boldsymbol{R_{i,t+1,}}$> 0.5, and non-resilient otherwise.

[5] *Livelihood protection threshold represents the total food income required to cover both the minimum food needs and non food needs such as regular purchases of seeds, fertilizers, veterinary drugs, etc. which can sustain livelihoods*

7.2.2. Modelling Household Resilience to Food Insecurity

In order to address the objective of the research to explaining why some households are more resilient to food insecurity than others, this section outlines estimation procedures for modeling household resilience as a function of properties of household livelihoods and their risk management choices as well as household specific and community characteristics. The conceptual framework of the study outlined in chapter two, section 2.6 suggests the following simplified relationship:

$$\textit{Household resilience status (RS)} = f(C, SE, AC, S, RS)$$

Where household resilience status (R_i), a binary dependent variable indexed by household *i*, is a function of the wider geographical and institutional context (*C*), household shock exposure (*SE*), adaptive capacity (*AC*) & sensitivity (*S*) of their livelihoods, as well as household reaction to shock (*RS*). Each of these factors of resilience is measured by the following variables:

Context (C): This includes the broader physical and institutional environment in which households are situated. The physical setting encompasses climate, geography, and infrastructure, and is captured in the livelihood zone dummy (x1). This also include institutional settings represented by access to road (X2), and access to market (X3) measured by average time taken by the household to reach the nearest road and market centers.

Sock Exposure (SE): SE_i *is* measured in both a covariate and household-specific sense represented by aggregate climatic shock impact (x4) experienced by a household in the last five years' prior the survey.

Adaptive Capacity Variables: the variables used for measuring the potential adaptive capacity include the following: first, Asset (A): Human capital is measured by the variables household head education (X5), maximum educational attainment of household members (X6), proportions

of healthy household members (X7), and fraction of dependents in the household (X8). Natural assets are measured by whether a household has access to community resources (X9). Physical assets are measured by the variable, total value of livestock, productive assets, and land (X10), Financial capital is measured by net debt (savings minus outstanding loan) in US Dollar (X11). Social capital is measured by the sum of community organizations that a household is a member of weighted by degree of participation (X12). Second, livelihood strategies (Ls): this includes household production and consumption decisions represented by the proportion of expenditure devoted to productive investments (agricultural and livestock inputs) (X13), crop diversity (X14), livelihoods diversity index (measured by Shannon's index based on the proportion of each sources of food income) (X15).

Third, Risk management strategies (Rs): these include ex-ante and ex-post risk management strategies. Binary variables with a value of 1 if risk management strategy k (indexed over all possible strategies K) is adopted by a particular household. The former include using saving/buffer stock (X16), diversifying income sources (X17), investing in structural mitigation measures (X18), and adopting climate smart technologies (X19) and the latter, ex-post strategies, is related with ***household reaction to shock (***a variable measured by a fraction of extra food income beyond the survival threshold that is available to cover a unit expected loss due to shock (See chapter 6). However, this variable is also a measure of resilience and perhaps it is already captured in the resilience measure, the dependent variable. Therefore, it was decided not to include in the model estimate. Instead it was decided to include individual coping strategy choices of households measured by the contribution of a strategy to household food needs as reported by households in terms of the number of days the household managed to cover its food needs from a strategy during periods of food shortage. This include increasing livestock sale (X20), increasing labor sales (X21), switching expenditure (X22), public transfer (X23), private transfer (X24)

The basic probit regression estimation model utilizing the measurement variables described above can be expressed in general form as follows:

$$\mathbf{Z_i} = \boldsymbol{\alpha C_p} + \boldsymbol{\beta SE_i} + \Omega \boldsymbol{AC_i} + \boldsymbol{\Psi RS_i} + \boldsymbol{\varepsilon_i} \qquad \textbf{Eq.7.2}$$

$$\boldsymbol{Y_i = 1\ if\ Z_i} > 0$$

$$\boldsymbol{Y_i = 0\ if\ Z_i} \leq \mathbf{0}$$

Where $\mathbf{Z_i}$ is latent variable representing household resilience status; C_p is a vector of the wider geographical and institutional context variables; SE_i is household shock exposure; AC_i is a vector of household adaptive capacity variables; RS_i is a vector of ex-post coping strategies measured by the contribution the strategy to household food needs during periods of food shortage; and ε_i is the error term, which is assumed to be distributed by the standard normal, and $\alpha, \beta, \Omega, \Psi$ are the parameters to be estimated.

The model is estimated using Maximum Likelihood Estimation (MLE). The estimated coefficient relates explanatory variables to the latent variable Z and the effect of the latter on Prob (Y = 1) varies depending on Z. therefore, marginal effects were calculated for a meaningful interpretation of the magnitude of estimated coefficients indicating the differential role of each explanatory variables in determining the likelihood of a household to be resilient i.e. Prob (Y = 1).

Similarly, the effect of factors that determine the state of poverty trap were also estimated using the same procedure above. Poverty trap is one of the undesirable resilience properties systems, termed as pathological traps, representing deviations from the normal flow of conditions along the adaptive cycle. This pathological state is characterized by all three properties of an adaptive system (wealth, connectivity, and resilience) having low values, creating impoverished systems that exist in a recurring state of crisis. Poverty trap was found to be the predominant state characterizing household livelihoods in the study area (See section 5.2.2). Hence household *i* is

classified as under a state of poverty (Y=1) if its livelihood exhibited the state of poverty trap, and otherwise (Y=0).

7.4. Results and Discussions

7.4.1. Household Characteristics by Livelihood Strategy Group

Several household characteristics expected to correlate with resilience and influence the probability of being resilient. Table 18 outlines typical characteristics of an average household by livelihood zone. There are two dominant livelihood zones characterizing livelihood patterns of the district. More than half of sample households reside in Guna livelihood zone where predominantly characterized by highland agro-ecology where population density is the highest in the district. Unlike the lowland dominated Abay livelihood zone where mixed farming involving both crop and livestock production are equally practiced, the majority of the population in Guna livelihood zone depends on crop farming as a central livelihood strategy. It was hypothesized that the broader context that shape patterns of household livelihoods influence household resilience to food security shocks. For the entire sample, there are only 21% resilient households and more than 70% are under poverty trap. Shock reaction capacity, measured by the amount of extra food income available for shock reaction beyond the minimum survival threshold per unit of expected loss of food income due to shock, is very low for an average household in the study area. Compared to Abay livelihood zone, households in Guna livelihood zone have a better shock reaction capacity where an average household could absorb at least 55% of the expected loss without going hungry below the minimum survival threshold.

In terms of household specific demographic characteristics, age, gender and educational status of the household head including family size were hypothesized to affect household resilience. The average age of household heads was 48 years and around 11% was female-headed households. On average, there are 5.2 household members and around 0.75 dependents in each sample household.

Table 18 Summary of Average Values for Variables by Livelihood Zone

Variables	Abay	Guna	Total
Proportion of resilient households	11%	27%	21%
Proportion of households under poverty trap	84%	66%	73%
Average age of household heads	47.08	48.96	48.21
Proportion male headed households	86%	91%	89%
Average household size	5.07	5.23	5.17
Proportion of literate household heads	40%	46%	44%
Average distance from road (Minute)	20.87	15.22	17.47
Average distance from market (Minute)	65.33	52.81	57.80
Average climatic shock index	0.16	0.19	0.18
Average maximum education (Years)	7.35	9.03	8.36
Average Dependency ratio	0.87	0.67	0.75
Proportion of HHs with access to community resources	69%	56%	61%
Average value of productive assets $PPP)	59.79	60.58	60.27
Average net debt (in Birr)	933.70	235.50	513.80
Social participation score	8.03	11.37	10.04
Average proportion of income spent on food purchase	51%	65%	59%
Average Input intensity	0.28	0.24	0.26
Average Crop diversity index	0.56	0.61	0.59
Average Livelihood diversity index	0.53	0.64	0.61
Proportion of households using climate smart technologies	38%	29%	32%
Proportion of households with precautionary saving	30%	31%	31%
Livestock sale (as percent of the minimum food needs)	12.18	18.04	15.70
Labor exchange (as percent of the minimum food needs)	11.04	9.93	10.38
Switching expenditure (as percent of the minimum food needs)	4.80	4.52	4.63
Private transfer (as percent of the minimum food needs)	0.41	3.36	2.19
Public transfer (as percent of the minimum food needs)	8.34	12.79	11.02

Source: Own survey 2015; computed by the author

In terms of education, it was assumed that if farmers are provided with the opportunity to get a basic education, they can adopt agricultural technologies, and manage their household income properly and have the capability of better management of shocks towards positive resilience outcome. The educational status of household heads and/or maximum educational level within the household is therefore expected to influence household's resilience to food security shocks.

Of the household heads questioned, more than half could neither read nor write and the maximum grade completed within an average household is a school grade of 8, which is the minimum grade Ethiopian government envisioned to achieve in its development policy.

Among adaptive capacity variables involving assets, livelihood and risk management strategies, were also hypothesized to influence household resilience. Household wealth per capita is one of the key factors expected to influence household resilience. These include access to productive assets such as land, livestock and other key agricultural equipment. The estimated value of these key assets were summed and divided by household size to represent the total wealth per capita for each sample household. The average per capita value of household productive assets equaled 60.27 US dollar, in purchasing power parity (PPP) adjusted terms. In addition, access to financial capital represented by net debt, an average household in the study area could not cover all the outstanding loans with saving in the reference period with a maximum of net debt 41 US dollar for an average household in Abay livelihood zone.

The social participation score which is an aggregate figure looking at degree of household engagement with a wide range of community groups, measured on a scale of 0 to 30, with larger values indicating greater participation. This include local/informal and formal social networks. The former includes local social support groups and social work groups while the later include more of formal social institutions such as Women's association, Farmer's association including political groups. Aggregate social participation scores for an average household is 10 (from the maximum score possible of 30 points). A social participation score of 8 and 11 were observed for an average household in Abay and Guna clusters, respectively.

Hypothesized resilience factors related to livelihood strategies i.e. production and investment decisions include diversity of income sources and crops grown as well as the intensity of inputs applied such as fertilizers. Shannon's Income diversity index measures diversity of income

sources with a score of 1 indicates highly diversified income sources. The mean score for the sample population is 0.61 which suggests moderately to highly diversified income sources. Similarly, in risky environments, diversifying the types of crops grown is expected to have positive contribution to resilience. With a crop diversity index of 0 indicates monoculture, the mean score for an average household is 0.59 which suggests more than average degree of crop diversification. Regarding input intensity, for each crop grown, households were asked if the crop was planted with improved varieties, and/or whether organic and non-organic fertilizers was applied. Hence, the number of inputs applied per crop representing input intensity is a measure of the ability of a household willing to invest on such agricultural inputs. An average household was able to apply only fewer inputs in their cropping system.

In terms of access to basic services such as road and market accessibility, an average household in the study area is located within less than an hour walking distance from market center and less than half hour walking distance from main road. Access to market (Dercon et al., 2009; Dercon and Hoddinott, 2005b; Gabre-Madhin, 2001) has been a critical factor for food security and growth of the rural economy as well as an instrument in response to food emergencies during periods of shock. Hence, access to such basic services were hypothesized to influence household resilience to food insecurity.

Regarding Shock related variables, an index was constructed based on the frequency and severity of impacts on household livelihoods as they experienced in the last five years' prior the survey. Based on the nature of shock types, individual shock indexes were aggregated into five categories i.e. weather shocks, crop shocks, livestock shocks, labor shocks and market shocks. Weather shock and crop shock, and market shock are the primary concerns of sample households as sample households experienced these categories of shocks in the last five years' prior the

survey. Past aggregate shock exposure index is therefore expected to influence household resilience to food insecurity.

7.4.2. Determinants of Household Resilience to Food Insecurity

This section presents the determinants of household resilience to food security shocks as well as the state of poverty trap based on the econometric results obtained from binary probit regression. Some households have been excluded from the analysis due to missing values for some variables included in the model. The model has been tested for the problem of normality and the computed goodness-of-fit score test of normality for the probit model shows that no problem of normality could be detected with chi2 (2) =1.69, p-value (0.4304). Results of the Probit regression are presented in Table 19. The reported Wald-chi2-test and R^2 indicate that the independent variables are jointly significant and that the model has a reasonable goodness of fit.

Among household specific demographic characteristics expected to influence resilience to food insecurity, household size and gender of household heads found to be significant. Household size is negatively and significantly correlated with the probability of a household to be resilient. Similarly, the probability of a household exhibiting a characteristics of poverty trap increases with increasing family size. The fact that an average household in the study area owns less than one hectare which is equivalent to what is often called a starvation plot, an increase in family size tends to exert more pressure on consumption than the labor it contributes to production. Thus, the probability of a household to be resilient declines with increasing numbers of its members with higher risk of falling under poverty tap. This can be also confirmed with the fact that dependency ratio is negatively and significantly correlated with household resilience. In terms of gender, male headed households have a higher likelihood to be resilient compared to female headed households. Similarly, the likelihood to be trapped with poverty is also higher among female headed households.

Table 19 Probit Regression Result for the Determinants of Resilience to Food security shock as well as determinants of poverty trap

VARIABLES	Resilient (Yes=1)		Poverty trap (Yes=1)	
	Coefficient	Standard error	Coefficient	Standard error
Household Demographic characteristics				
Respondent's age (Years)	-0.00872	(0.00814)	0.0161	(0.0152)
Age squared	6.74e-05	(7.94e-05)	-0.000139	(0.000149)
Respondent's sex (Male=1)	0.0459*	(0.0261)	-0.142***	(0.0531)
Household size	-0.0281**	(0.0138)	0.0407*	(0.0220)
Respondent's education (Literate=1)	0.0284	(0.0348)	-0.0413	(0.0605)
Context and shock variables				
Livelihood zone (Guna=1)	0.134***	(0.0345)	-0.208***	(0.0532)
Distance to road (Minute)	-0.00101	(0.000800)	0.00195	(0.00121)
Distance to market (Minute)	-3.05e-05	(0.000687)	0.000546	(0.00108)
Aggregate Climatic shock index	-0.393***	(0.135)	0.607***	(0.193)
Adaptive capacity (Asset variables)				
Maximum education (Years)	-0.00175	(0.00518)	0.00883	(0.0108)
Dependency ratio	-0.0465*	(0.0263)	0.0630	(0.0446)
Access to community resources	0.0581**	(0.0288)	-0.0810	(0.0518)
Value of productive assets ($PPP)	0.00215***	(0.000552)	-0.00375***	(0.000756)
Net debt	-2.33e-06	(6.17e-06)	1.51e-05	(1.40e-05)
Social participation score	-0.00742**	(0.00298)	0.0137***	(0.00518)
Adaptive capacity (Livelihood and Risk management Strategies)				
Proportion of expenditure on food	-0.0660*	(0.0354)	0.000620	(0.0645)
Input intensity	0.137***	(0.0514)	-0.203***	(0.0694)
Crop diversity index	0.0949	(0.0856)	-0.197	(0.151)
Shannon's diversity index	0.161***	(0.0598)	-0.247**	(0.102)
Climate smart technology (Yes=1)	0.0257	(0.0337)	-0.0463	(0.0598)
Precautionary saving (Yes=1)	0.145***	(0.0543)	-0.147**	(0.0619)
Livestock sale (Kcal)	0.000932	(0.000610)	-0.000647	(0.00117)
Labor sale (Kcal)	0.00120*	(0.000681)	-0.000187	(0.00130)
Switching expenditure (Kcal)	0.00358**	(0.00167)	-0.00376	(0.00276)
Private transfer (Kcal)	0.00161	(0.00132)	-0.00202	(0.00240)
Public transfer (Kcal)	-0.00182*	(0.00108)	0.000902	(0.00201)
Observations	283		283	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Although female heads of household experience more autonomy in decision making compared to some decades ago, their social and economic activity remains circumscribed by culture and custom (Ellis F. and Wlodehanna T., 2005). Devereux and others also found gendered differences in household income are significant in all of the largest four regions of Ethiopia.

Female-headed households are more prone to food shortage and seasonal food insecurity than male-headed households (Devereux et al., 2006)

In terms of context variables, households in Guna livelihood zone have a higher likelihood to be resilient with lower risk of poverty trap than lowland dominated Abay livelihood zone where most of its villages located far from the district town. This is mainly because households in Guna livelihood zone have better access to basic services such as the district market town, where rural households undertake a significant proportion of their economic transactions.

In this regard, self-resilience assessment study in Ethiopia indicated that remotely located villages and households from district towns are less likely to purchase inputs or sell a variety of products (Frankburger et al., 2007). Improved access to market towns also has positive effects on welfare (Dercon and Hoddinott, 2005a). Though not significant in the estimation model result (Table 19) as effects might be captured by the livelihood dummy variable, increasing distance from road and market centers is also negatively associated with household resilience.

In terms of climatic shock exposure, an increase in the severity of past weather shock experience decreases the probability of a household to be resilient with causing a higher risk of poverty trap. A unit increase in the severity index of climatic shock, increases the likelihood of a household to be trapped with poverty by a considerable magnitude (60%). Similar studies in Ethiopia (Carter et al., 2004; Dercon, 2004; Dercon and Krishnan, 2000; Mogues, 2011; Sharp et al., 2003) established evidences that vulnerability to shocks has persistent effects on growth and pushes poor Ethiopians toward destitution

Value of productive assets, such as land, livestock and agricultural implements, is also found to be positively and significantly associated with the probability of a household to be resilient. A 100 US$ increase in the per capita value of productive assets would increase the probability of a household to be resilient by at least 20% with a reduction of the risk of poverty trap by 37%.

That is why productive assets are the key targeting criteria for safety net programs in Ethiopia designed to lift chronically food insecure households out of poverty (MoARD, 2004). Similarly, households with better access to community resources such as communal grazing lands and rivers are more likely to be resilient than their counterparts. However, among asset variables, social participation score shows a different relationship with household resilience which deviates from what is originally hypothesized in this study. Though with lower magnitude, an increase in household participation in social networks, decreases the probability of a household to be resilient. One of the reasons might be the nature of the variable measurement may not capture the complex nature of social capital as different social network types works differently with various objectives. For instance, in drought-prone risky environments like the study area, social networks such as funeral groups and Senbete groups come with higher social costs due to the fact that frequent calling in claims on social networks (due to recurrent shock) might exhaust such key resources so that their ability to survive appears suddenly to collapse (Swift, 1989). Despite agreement about the theoretical importance of social capital, empirical evidences from Ethiopia show mixed results regarding the effect of social capital on household resilience to shock (Mogues and others, 2006).

In terms of household's production and investment decisions, input intensity, income and crop diversification decisions are found to be positively correlated with the probability of being resilient to food security shocks. A unit increase in input intensity increases the probability of a household to be resilient by at least 14% with a reduction of the risk of poverty trap by 20%, indicating crop intensification using fertilizers and improved seeds would increase resilience to food insecurity through improved productivity. Similarly, Households with diversified income sources as well as crop varieties have significant positive contribution to resilience. A unit increase in Shannon's income diversification index increases probability of households being resilient by at least 16% with a reduction of the risk of poverty trap by 25%. A similar resilience

study in Tigray region (Vaitla et al., 2012) also found a strong and positive association between such household production and investment decision variables and household resilience.

In terms of risk management behavior of households, those households who adopted precautionary saving as ex-ante risk management strategies are more likely to be resilient and less likely to be trapped with poverty than those who don't adopt the strategy. The other alternative risk management choice, use of climate smart technologies such as drought tolerant crop and livestock varieties also positively correlated with resilience although appear to be not significant. Furthermore, the ability of households to expand food income from various coping strategies such as switching expenditure and migratory labor are also positively and significantly correlated with the probability of a household to be resilient against food insecurity. However, public transfer is found to be negatively and significantly correlated with household resilience. This may be because public transfer programs primarily targeted less resilient and chronically food insecure groups.

In general, household and community characteristics representing adaptive capacity variables as well as context and shock exposure variables determine both the risk of poverty trap and household resilience to food insecurity. Hence, it is important to note and conclude that lower resilience is a function of both lower adaptive capacity and higher shock exposure among households in the study area.

7.4.3. Checking Robustness of the Model

This subsection presents the robustness of the study measure of resilience (the probability of a household to maintain beyond the minimum wellbeing threshold), derived from MPT measures (See 5.2.1.5) by comparing with resilience measure of FAO's Resilience Index Measurement Analysis model (FAO-RIMA model). This provides a test of whether the model based on MPT measures household resilience to food insecurity well.

FAO-RIMA model assumes resilience as a multi-faceted concept that is not directly observable suggesting that it has to be measured through a proxy. For the purpose of testing the correlation with the study measure, this paper followed a two-stage procedure as suggested by FAO-RIMA model. In the first step, factor analysis (FA) is used to identify Resilience components based on observed variables representing each component. These components include (1) Access to basic services (ABS), (2) Assets (AST), (3) social safety net (SSN) and (4) Adaptive capacity (AC) and recently the model is updated to include (5) Sensitivity (SEN). In the second step, Structural Equation Model (SEM) model was estimated and the predicted value from the model is then generated to represent household resilience capacity score. The distribution of household resilience score by livelihood strategy group is shown by Figure 18.

The graph shows that crop farming groups exhibited the most inequality with low average level of resilience capacity score. Mixed farming and non-agricultural livelihood groups show more or less similar resilience capacity score distribution with less inequality among households in both groups. If a considerable change in resilience is to be achieved in the study area, resilience building programs should focus primarily on crop farming livelihood groups as well as to the lowest quintiles of the remaining livelihood strategy groups.

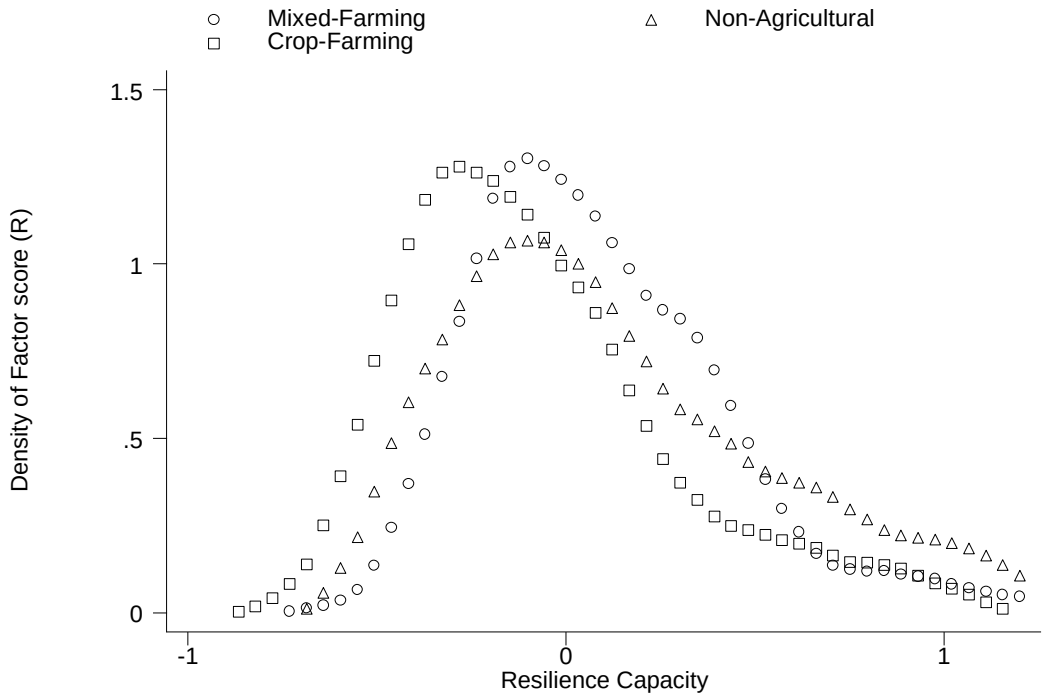

Figure 18 The Distribution of FAO-Resilience Capacity Index by Livelihood Strategy Group

In terms of the relationship between the latent variable, resilience capacity score (RCI) and its components Table 20 shows that asset and adaptive capacity as well as sensitivity variable are positively and significantly correlated with the latent variable (RCI).

Table 20 Structural Equation Model (SEM) Result for Determinants of Resilience Capacity Index

VARIABLES	(1) ABS	(2) AST	(3) SSN	(4) AC	(5) SEN
RCI	1	1.391*	-0.0227	1.232*	42.67*
	(Constrained)	(0.789)	(0.120)	(0.723)	(25.36)
Constant	0.0282	-0.0112	0.000724	-0.0109	25.93***
	(0.140)	(0.0456)	(0.0254)	(0.0528)	(1.270)
Observations	264	264	264	264	264

```
Likelihood ratio     |
          chi2_ms (5) |     15.842   model vs. saturated
----------------------+-----------------------------------------------------
Population error     |
               RMSEA |      0.091   Root mean squared error of approximation
----------------------+-----------------------------------------------------
Baseline comparison  |
                 CFI |      0.874   Comparative fit index
                 TLI |      0.748   Tucker-Lewis index
       ----------------------+-----------------------------------------------
```

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note that sensitivity is measured by the amount of variation in portfolio return relative to households expected average return. Given considerable proportions of households whose livelihood portfolio configuration exhibited a state of poverty trap (See 5.3.3), a relatively higher degree of sensitivity to shock is a desired property of resilient livelihood systems unlike to those exhibiting a state of poverty trap which is not responsive to shock. In the probit model above, both asset and adaptive capacity variables significantly determines whether a household is resilient or not resilient against food security shocks. Hence, the study measure of resilience correlates well with FAO-RIMA model that the later explained more than 50% of the variation in the study measure of resilience (Figure 19).

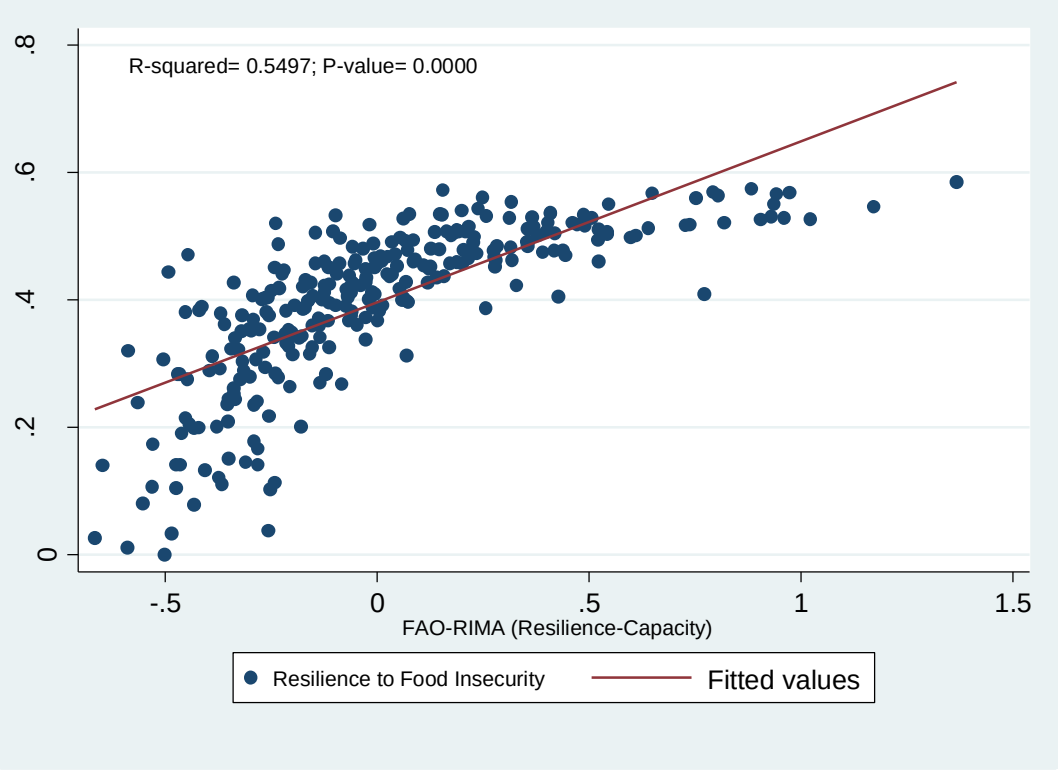

Figure 19 Relationship between the Study MPT-Based Resilience Measure and FAO-Resilience Capacity Index

7.4.4. Self-Resilience Assessment

The study results were also checked against household's self-resilience assessments. Households were asked to provide their evaluation regarding their wellbeing status over the last ten years' prior the survey i.e. since the introduction of PSNP in the district back in 2005. Based on the self-assessment question in the household questionnaire, households evaluated their status in four categories of the specified time (i.e. ten years ago; five years ago; last year prior the survey; and in the current period during the survey). The four possible mutually exclusive states that define their wellbeing status were: (1) "Sustainable" (Doing well); (2) "Viable" (Doing Just Okay); (3) "Vulnerable" (Struggling) or; (4) "Destitute" (Unable to meet household needs).

Table 21 Self-Resilience Assessment (Transition Probabilities between ten years ago and current period)

		HH-Self Assessment Situation (Currently)				
	Non-PSNP	Doing well	Doing just fine	Struggling	Unable to meet needs	total
HH-Self Assessment Situation (Ten Years Ago)	Doing well	**10.00%**	**24.00%**	**42.00%**	**24.00%**	**100.00%**
		3.33%	8.00%	14.00%	8.00%	33.33%
	Doing just fine	**4.76%**	**35.71%**	**38.10%**	**21.43%**	**100.00%**
		1.33%	10.00%	10.67%	6.00%	28.00%
	Struggling	**10.81%**	**13.51%**	**48.65%**	**27.03%**	**100.00%**
		2.67%	3.33%	12.00%	6.67%	24.67%
	Unable to meet needs	**14.29%**	**9.52%**	**42.86%**	**33.33%**	**100.00%**
		2.00%	1.33%	6.00%	4.67%	14.00%
	total	**9.33%**	**22.67%**	**42.67%**	**25.33%**	**100.00%**
		9.33%	22.67%	42.67%	25.33%	100.00%
	PSNP					
	Doing well	**4.55%**	**22.73%**	**47.73%**	**25.00%**	**100.00%**
		1.42%	7.09%	14.89%	7.80%	31.21%
	just fine	**8.57%**	**17.14%**	**51.43%**	**22.86%**	**100.00%**
		2.13%	4.26%	12.77%	5.67%	24.82%
	struggling	**14.29%**	**16.67%**	**50.00%**	**19.05%**	**100.00%**
		4.26%	4.96%	14.89%	5.67%	29.79%
	destitute	**5.00%**	**20.00%**	**30.00%**	**45.00%**	**100.00%**
		0.71%	2.84%	4.26%	6.38%	14.18%
	total	**8.51%**	**19.15%**	**46.81%**	**25.53%**	**100.00%**

	8.51%	19.15%	46.81%	25.53%	100.00%

Markov Chain Transition Matrix Analysis were followed to understand the movements of household from one well-being status to another. Table 21 shows state transition probabilities and the probability of each of the four states in the current period for both PSNP beneficiaries and non-beneficiaries. The probabilities of the four states *ten years ago* (given that these households had been formed then) are shown in row totals (bold font) of the table above and the probabilities of the four states at the *current period (in 2015)* are shown in the column totals of the table for both PSNP beneficiary and non-beneficiary households.

The one-step movement by households from one state ten years ago to another state in the current period was governed by a probabilistic/stochastic law given by a ***State Transition Probability Matrix*** and is said to follow the ***Markov Chain Process***. The State Transition Probabilities (shown in the row totals of Table 21-bold font) can be represented in a form of **Matrix A** below for both beneficiary and non-beneficiary households.

$$A_{Non-PSNP} = \begin{bmatrix} 0.100 & 0.240 & 0.420 & 0.240 \\ 0.048 & 0.357 & 0.381 & 0.214 \\ 0.108 & 0.135 & 0.486 & 0.270 \\ 0.143 & 0.095 & 0.429 & 0.333 \end{bmatrix} \quad A_{PSNP} = \begin{bmatrix} 0.045 & 0.227 & 0.477 & 0.250 \\ 0.086 & 0.171 & 0.514 & 0.229 \\ 0.143 & 0.167 & 0.500 & 0.190 \\ 0.050 & 0.200 & 0.300 & 0.450 \end{bmatrix}$$

The transition probability matrix represents the probabilities of "switching" from one state to another. For example, for non-PSNP beneficiary households that were "Doing well" ten years ago, the probability of maintaining that status is 0.100[10%] and the probability of "switching" from "Doing well" to "Doing just okay" is 0.240 [24%]. The probability of switching from "Doing well" to "Struggling" is 0.420 (42%) while the probability of switching from "Doing well" to "Destitute" (unable to meet basic household needs) is 0.240(24%).

Similarly, the probability of each of the four states in the current period (shown in the column totals of Table 21) are shown as **Matrix B** (below) for both beneficiary and non-beneficiary households:

$$B_{Non-PSNP} = \begin{bmatrix} 0.093 \\ 0.227 \\ 0.427 \\ 0.253 \end{bmatrix} \qquad B_{PSNP} = \begin{bmatrix} 0.085 \\ 0.191 \\ 0.468 \\ 0.255 \end{bmatrix}$$

The Markov Process suggests the following transition equation:

$$\boldsymbol{P_{10} = (A'B)} \qquad \textit{Eq.7.3}$$

Where, P_{10} is the vector of future probabilities of the four states (ten years from now), **A'** is the transpose of the State Transition Probability Matrix **A;** and **B** is the state probabilities in the current period.

Thus based on the Markov Chain Process, future state of households was predicted as in the matrix below.

$$P10_{Non-PSNP} = \begin{bmatrix} 0.102 \\ 0.185 \\ 0.442 \\ 0.271 \end{bmatrix} \qquad P10_{PSNP} = \begin{bmatrix} 0.100 \\ 0.181 \\ 0.450 \\ 0.269 \end{bmatrix}$$

The result shows that, ten years from now, we expect 10.2% of non-beneficiary households to be "Doing well"; 18.5% to be "Doing just okay", 44.2% to be "Struggling" and 27.1% to be "destitute" (unable to meet basic household needs). While proportion of "viable" non-beneficiary households are expected to fall from 22.7% in the current period to 18.5%, the proportion of non-beneficiary "Vulnerable" households is expected to increase from 42.7% to 44.2%. similarly, the proportion of that of non-beneficiary "Destitute" households is expected to increase from 25.3% now to 27.1%. However, for beneficiary households, the proportion of "sustainable" beneficiary households are expected to slightly increase from 8.5% now to 10%

while the proportion of “Vulnerable” beneficiary households is expected to fall from 46.8% to 45%. Though PSNP beneficiary households shows more improvements in their transition to a relatively desirable state of well-being than non-beneficiary households. However, the above Markov chain processes predicts increasing proportion of both vulnerable and destitute households (more than 70% in both beneficiary and non-beneficiary households). This is about 20% more than what is currently targeted by PSNP as a resilience building program.

The self-assessment result also confirms the predicted proportion of households under poverty trap (71%) and non-resilient households (79) based on the study MPT-based resilience assessment approach as predicted by resilience theory.

7.5. Concluding Remarks

Acknowledging household resilience as a stochastic phenomenon, this study has made an effort to investigate determinants of resilience to food security shocks in rural district of Tach Gayint using MPT-based measure of resilience. Stochastic distribution of returns for portfolio of household livelihoods results from the food income variations between years with different climatic conditions, denoted as the set of s = (1..., S) states of nature, it was possible to estimate the expected mean and variation of household food income portfolios as functions of the probabilities of different states of nature, and food income contribution of individual livelihood activities. Following methodological approaches of existing consumption vulnerability studies, household resilience was modeled as the probability that a household is capable of maintaining food security beyond the minimum wellbeing threshold. The probabilities were estimated based on MPT measures of portfolio expected mean and variance. A probit regression model was then estimated to identify determinants of household resilience status to food security shocks. Similarly, this study tests the robustness of MPT-based resilience measure with FAO-RIMA model and confirms the important role of MPT application for resilience assessment.

Household's self-resilience assessment also confirms the estimated proportion of households under poverty trap including the proportion of non-resilient households to food security shocks. Overall, this study suggests that the major source of poor household resilience is both structurally constrained adaptive capacity and high shock exposure. Therefore, resilience programs, in the study area and in similar areas that are designated as drought prone chronically food insecure districts of the country, should promote risk reduction measures while implementing programs designed to address structural causes of food insecurity. Expanding coverage of social protection programs with better linkages with risk management and other development programs would lead food insecure households on resilience pathways towards a more positive livelihood outcome.

8. IMPLICATIONS & CONCLUSION

8.1. Introduction

This thesis set out to understand why some households are more resilient than others with livelihoods constructed in the risky environments of Ethiopia. It adopted a systems approach to exploring the resilience properties of household livelihood systems using MPT analysis of portfolio structure & configuration of household food income sources. The analysis also includes shock coping behavior of households as system participants in shaping resilience trajectories. The findings provide a more systemic perspective on the determinants of household resilience to food insecurity – by documenting not only how resilience properties of the livelihood system constructed in the risky environments of the local context where wealth, diversity and connectivity of the system at household level that determine its resilience trajectories towards a positive livelihood outcome, but also how rural people deal with shocks and risks they face and how their choices and actions influence resilience outcomes. This chapter first present a brief review of the thesis purpose and key findings in light of its convergence and divergence with past similar studies, and then synthesizes its contributions and implications to both the academic literature and policies and programs related to food security as well as agriculture in Ethiopia in the context of risky environments characterized by protracted food crisis.

8.2. A Review of the Thesis Purpose

As this study focus on the complex issue of livelihood resilience and household food security, insights from various disciplines such as ecology, risk management as well as livelihood and food security were adopted to understanding resilience as both an emerging property of a complex adaptive social-ecological systems and as a measurable stochastic outcome variable. At the first stage of the study, the primary focus of the study was examining the combination and stracture of household portfolio of livelihood activities including a set of strategies and

options available to households to deal with risks and shocks. This defines the unit (system) of analysis-the household livelihood with food security as the primary livelihood outcome of concern that focuses on the food income obtained from different sources as the study measure of well-being. In this regard, principles of socio-ecological resilience were adapted to the system of concern, to propose an analytical set of metrices with which to assess the resilience properties of the livelihood system.

However examining existing properties of household livelihoods at system level is not enough to understand resilience trajectories towards a positive livelihood outcome, it also requires understanding the deliberate choices and actions of system participants (i.e. households and other external stakeholders) introduced to the system in response to shocks. This looks at the capacity of households to manage resilience which may include coping and ex-ante risk management behaviour of households to deal with shocks. Hence, as a second stage, the research design include analysis of household risk management choices including both ex-ante and ex-post strategies as well as external support targeted to the management of shocks. Finally, the first and the second stages were brought together to form a coherent research framework for assessing household resilience to food insecurity with the aim of addressing the central research question of the study. In this regard the role of system level properties as well as household and community characteristics including the nature of shocks the system is exposed to, could be determined to explain why some households are more resilient than others, which is a central research question of the study.

This thesis has therefore verified the critical importance of drawing insights from various disciplines for understanding the complex and multi-dimensional concept of resilience as applied to food security and livelihood systems. At conceptual level, resilience properties of systems as defined and established in the ecological literature and complementary insights from sustainable

livelihoods and risk management frameworks were used while at practical level, measurement approaches of household economy and MPT were employed as both are a systemic approaches offering a set of metrics relevant to examining a livelihood system, represented by a portfolio of household food income sources. In light of past resilience related studies, the key findings are presented below in an organized manner under the three research questions posed at the beginning of the thesis:

1. **How are resilience properties of household livelihood systems manifested in the risky environments of the local context?**

The first purpose of the thesis was to explore resilience properties of livelihood systems, at household level, constructed in the risky environments of Ethiopia (the case of Tach Gayint district) where recurring climate shocks undermine household livelihoods and food security. Based on the concept of ecosystem resilience, commonly defined as the capacity of a system to experience change while retaining essentially the same function, structure, feedbacks, and therefore identity (Walker et al., 2006), this study follow a similar resilience characterization as applied to the system of concern, where a livelihood system can be thought to be resilient if it can meet food security and other nonfood security objectives and still maintain its essential functions following a disturbance (E. D. Fraser et al., 2005; Le Vallě et al., 2007; Tincani, 2012). As applied to social-ecological systems, this study adapted the four properties of resilience (wealth, connectivity, diversity, and adaptive capacity) to livelihood systems and applied methodological approaches of Modern Portfolio Theory to measure all the four properties and to test the expected relationships between resilience properties as predicted by resilience theory.

Most of the sample households exhibited the expected patterns of increasing wealth, connectivity and diversity with increasing household resilience to food insecurity, particularly among sample households at lower level of wealth. At higher levels of wealth, sample households also exhibited

the expected pattern of declining diversity with increasing connectivity as these households tend to specialize on those few activities with higher return. As typical part of resilience, adaptive/response capacity also plays a critical role to maintain household resilience towards a positive food security outcome. Based on the relationship between these variables characterizing the adaptive cycle, pathological states i.e. deviations from the normal flow of the adaptive cycle were detected. In this regard, only two undesirable pathological states of poverty trap and rigidity trap found to be characterizing household livelihoods in the study area. Poverty trap which can be observed if households achieve lower food security levels at lower connectivity with lower resilience i.e., lower probability to maintain food security beyond the minimum livelihood protection threshold. Considerable proportion of sample households (73%) shows properties of poverty trap-where unviable livelihood system may persist at higher diversity and remain in the trap and continue to achieve negative livelihood outcome (food insecurity). In contrast, rigidity trap was observed if households achieve higher levels of food security at higher connectivity with higher resilience. Small proportion of households (14%) exhibited the pattern of rigidity trap.

As the study area is one of the risky environments in Ethiopia, more than 70% of sample households exhibited the characteristics of undesirable pathological state of poverty trap and only 21% of all sample households found to be food secure and resilient. However, this proportions varied by livelihood strategy groups. More of the households under Non-agricultural livelihood strategy groups are found to be outside of undesirable pathological state and more than one-third of them found to be food secure and resilient. This is mainly because these livelihood groups tend to diversify their livelihoods outside of agriculture. For example, 70% of these livelihood groups are categorized as higher levels of portfolio diversification. Similarly, these households also have relatively higher levels of response capacity as well as the capacity to manage resilience. Hence this confirms that livelihood diversification is a key strategy to

building household resilience to food insecurity in the risky environments of Ethiopia characterized by chronically food insecure and other similar characteristics with the study area.

2. **How do households deal with shocks and risks?**

Rural households in the study area were affected by different types of unexpected adversities including climatic, biological, socio-economic shocks. The study starts by understanding how households experience shocks in the past, particularly related to climate as well as their perceptions to future risks before examining the factors that determine risk response choices of households. The magnitudes of past shock experiences found to be significantly and positively correlated with perceived future risk levels and the latter is also found to be positively and significantly correlated with the decision of households to apply ex-ante risk management choices. Understanding this relationship is an important ground for effective process of risk communication between disaster management institutions and rural households. For example, an increase in perceived weather risk levels increases the likelihood that a household would use climate smart technologies such as improved varieties of crop and livestock breeds.

Location characteristics and nature of livelihood strategy group also affects household choices of ex-ante risk management strategies indicating the need for considering the local livelihood context in the design and promotion of hazard mitigation and climate change adaptation technologies. For example, non-agricultural livelihood groups tend to prefer savings/buffer stock as a risk management strategy rather than adopting climate smart technology which may be due to unavailability of technologies for such strategy groups.

In terms of shock reaction capacity, female headed households are less likely to have higher reaction capacity to shock than male headed households confirming with evidences documented in many vulnerability studies in Ethiopia (Dercon and Krishnan, 2000; Gray and Mueller, 2012; Hadley et al., 2008; Kumar and Quisumbing, 2013; Quisumbing, 2003) that female-headed

households are the most vulnerable groups during shock with limited adaptive and response capacity.

Access to market is also found to have a significant effect on the predicted household reaction capacity to shock. Access to market (Dercon et al., 2009; Dercon and Hoddinott, 2005b; Gabre-Madhin, 2001) has been a critical factor for food security and growth of the rural economy as well as an instrument in response to food emergencies during periods of shock. Households tend to expand food income per unit of expected loss primarily in response to weather shock and high wealth groups primarily tend to keep livestock as a buffer against shock which may increase their capacity to expand extra food income per unit of expected loss. A similar evidence is also documented by several studies in Ethiopia (Ali, 2015; Carter et al., 2004; Mogues, 2011; Mogues and others, 2006).

With poor insurance market for weather related shocks and failure of informal support networks due to the covariate nature of weather shock affecting the whole community at the same time (Ali, 2015; Hill et al., 2013; Tadesse and Brans, 2012), households often tend to react by drawing down assets and buffer stocks in response to adverse effects of weather shocks on household wellbeing. Since shock reaction capacity of sample households depends on the extra income obtained from migratory labor and livestock trade, monitoring people's access to labor and livestock market as part of early warning systems and promoting efforts targeted to reduce transaction costs for marketing such important buffer assets should be critical elements of emergency management systems at the local and regional levels.

3. Why are some households more resilient than others?

The problem of chronic food insecurity and vulnerability to shock are pervasive in the study area. Both household and community characteristics representing adaptive capacity variables and the context and shock variables are found to be significant in determining household

resilience status. This is because chronic food insecurity characterizes most households of the study area and significant proportions of households are non-resilient due to both underlying structural factors and recurring shocks. Moreover, the distribution of resilience across livelihood strategy groups and other household characteristics differ markedly indicating the need for differential targeting of food insecure households for resilience building programs. Household characteristics such as large household size, lower levels of education and under diversified livelihoods as well as constrained coping options related to labor and livestock sales with limited access to market centers significantly reduces resilience. This has an important policy implication for the type of resilience building programs needed to address the problem of different groups within the population.

PSNP with a DRM and asset building objective-which is the major resilience building program in Ethiopia have significant contribution to household shock reaction capacity during periods of food crisis (which is an important dimension of household resilience) while it appears to be not significant in determining the overall resilience status of households. Currently targeting approach for this program is based on geographical vulnerability despite differential adaptive capacity among households within the same geographical area. That is why considerable proportions of sample households excluded from the program while they exhibit the same or sometimes worst position relative to PSNP beneficiaries.

Overall, this study concluded that the major source of poor household resilience is both structurally constrained adaptive capacity and recurrent shock exposure with limited reaction capacity in dealing with shocks. The combined effect of both of these endogenous and exogenous factors contribute to keep more than three quarters of households in the state of poverty trap. Therefore, resilience programs, in the study area and in similar areas that are designated as drought prone chronically food insecure districts of the country, should address both structural

causes of food insecurity and transitory problems of food security due to shocks. Expanding coverage of social protection programs with better linkages with other development programs would lead food insecure households on resilience pathways towards a more positive livelihood outcome.

8.3. Methodological Contribution

One of the primary concern of both humanitarian and development communities has been the issue of methodology for measuring and assessing resilience. The application of the concept of resilience in policy-driven assessments has been limited by a lack of robust metrics to measure resilience within and across systems. However, there has been a considerable methodological development for measuring similar complex concepts such as famine vulnerability and several assessment and analysis tools developed to advance famine early warning and monitoring systems for early disaster response and recovery purposes. One of such methodologies includes HEA which is originally developed by Save the Children- UK. The approach was adopted by Ethiopian Early Warning Institution in 2005 as a standard tool to predicting famine and local food shortages. The country has been classified into more than 100 livelihood zones, a spatial scale at which patterns of similar livelihood portfolios practiced by communities and a baseline portfolio of food income sources and risk distributions has been established to model future food shortages combined with seasonal shock monitoring information.

Building on this approach for collecting information related to portfolio of household food income sources & risk assessments, this study demonstrated the application of MPT for measuring resilience properties of livelihood systems and assessing household resilience to food security shocks. As a complex concept no single measure will be able to capture completely the multiple dimensions of resilience. However, build on conventional vulnerability assessments combined with the application of MPT analytic measures, this study demonstrated the use of a

set of metrics that can help analyze and explain resilience properties of livelihood systems at household levels.

The approach could be replicated at larger scales for example at livelihood zone and regional levels by making use of livelihood and shock monitoring databases. The methodology could be used to advance existing famine early warning and vulnerability analysis tools to better inform both emergency response and development interventions.

There are at least five reasons that the proposed metrics are relevant to resilience building interventions in areas of risky areas characterized by recurrent food crisis. Firstly, understanding resilience of complex systems like livelihoods is the key principle for both humanitarian and development communities. In this regard, the proposed methodology provides a set of metrics, to analyze four essential aspects of resilience independently, which are already developed in various fields and sufficiently generic to apply to various scales. For example, it could be used for design of resilience building programs and targeting both in terms of geography and livelihood strategy groups. Second, because the metrics uses standardized measure of units (as percent of the minimum food needs) it is easily comparable between and within systems and allows prioritizing development and emergency resources for targeted interventions. Third, the metric would allow making use of existing HEA-based early warning and monitoring databases for modeling the resilience implications of future environmental or development scenarios. Fourth, as an emerging field of study the concept of resilience is being increasingly applied to social systems and there are multiple frameworks developed by various organizations and institutions for assessing resilience particularly in the context of protracted food crisis in most African countries prone to climate chocks. Since the proposed metric is not necessarily confined to a particular conceptual framework, it could be applied to test and compare the appropriateness of such frameworks and paves the way for the development of a more comprehensive framework

for assessing resilience of livelihood and food systems constructed in the risky environments. Finally, increased attention has been paid to how well-being evolves over time, with a focus on identifying cases of poverty traps in which prospects for growth and improvements in standards of living is impossible (Barrett and Carter, 2013; Carter et al., 2007; Carter and Barrett, 2006; Dercon and Christiaensen, 2011). In the economics literature, this has been identified and determined by threshold-based analysis of well-being trajectories. This is however based on limited numbers of state variables such as the changes in well-being as the outcome variable to define the state of the system of concern. The economics literature overlooks the changes in other driving variables of the system for example wealth, diversity and connectivity-interdependence between system components as well as its relation with systems at different scales. In this regard as applied to household livelihood systems, this study demonstrated the use of key system properties of the adaptive cycle, adopted from the ecological literature, to determine multiple pathological traps (deviations from normal flows). The properties of systems at a particular stage of the four systemic phases of the adaptive cycle (r, K, Ω, α) is determined by wealth of the system and the degree of connectivity between system components and the resulting resilience of the system to change. Based on critical thresholds that define nominal levels of either low or high for each of the three properties in the adaptive cycle, specific combination of these variables representing pathological states (Allison and Hobbs, 2004) including poverty traps were possible to be identified among sample households. This could be an important insight to complement existing threshold-based poverty trap approaches to the study of shock effects on household well-being and growth trajectories.

8.4. Policy Implications

The concept of resilience holds promise for policy planning to guiding efforts in areas affected by protracted crisis due to a complex set of factors including ecological fragility and underlying socio-political vulnerability conditions. Primarily the concept embraces the issue of holistic planning recognizing the need for multi-sectoral flexible policy planning processes to address persistent and recurrent food emergencies. In order to have a significant and lasting impact, actors involved in these regions will need to integrate the various elements and enablers of resilience into coherent strategies that address the current and future sources of vulnerability among poor households. Resilience approaches shift the humanitarian & development policy focus beyond just fixing problems.

In this regard, with the objective of improving the effectiveness of emergency intervention and reducing the need for assistance in the future, the humanitarian community has experimented with a variety of approaches, including "building back, better," "developmental relief," "saving lives and livelihoods," "post-disaster rehabilitation," and "supporting positive coping strategies." The starting point for formulating these approaches tends to be the crisis itself, and the debate often centers on what can be done from there forward to reduce future risk and promote improved security. However, resilience thinking unites these ideas within one conceptual framework. For example, the modified Tango-DFID resilience framework with the four measurable properties of resilience tested in this thesis – wealth, connectivity, diversity, and shock reaction capacity – supply policy makers with a list of minimal requirements necessary to foster resilience. This offers a holistic strategic insight with a focus on enhancing systemic resilience properties of household livelihoods as well as facilitating learning and flexibility for positive risk coping choices and actions of households as system participants. Examples are given below outlining how these concepts can be applied in agriculture and food policy programming including risk and emergency management systems with evidences established in this study on both the

systemic properties of resilient livelihoods and risk management behaviors of households in shaping pathways towards a positive livelihood outcome i.e. food security.

8.4.1. Understanding Household Portfolio Structure and Promoting flexibility in the Agricultural System for Diversification

With the application of Modern Portfolio Theory, one of the key lesson learnt from this study is the need for viewing economic units of farming households as investors who rationally allocate their key resources among portfolio of activities to achieve positive livelihood outcomes. Evidences are documented that households tend to diversify their livelihoods beyond just diversification of crops within the farming sector. Combined with perspectives from resilience theory, this study implied key policy insights to foster resilience among agricultural communities in the risky environments of Ethiopia.

Over the last decades Policy makers in Ethiopia have stressed the vital role of intensive farming with the objective of improving productivity through improved technologies and practices among smallholder farmers in achieving food security. However, in order to ensure resilience in the agricultural system of smallholder farmers, agricultural policy must also promote diversity to spread risk as well as to enable flexibility to exit from a risky agricultural business to a more resilient livelihood sector. Despite some progress in some agro-ecologies regarding cereals production ranging from 2 to 10 tons per hectare if the rains are favorable, the majority of chronically food insecure households who cultivate less than half a hectare happened to be not producing enough food for self-sufficiency even in a good year (Teshome, 2006). Rural households in risky environments of Ethiopia predominantly tend to focus on surviving and managing shocks from one season to the next with no prospect of escaping poverty through agricultural intensification alone (2006). Given unreliable rainfall and highly variable rain-fed

agricultural yield, promoting diversity in livelihood systems is vital due to the risks inherent in agricultural production, particularly in the ecologically fragile environments of Ethiopia.

This study also confirmed income diversification as a critical property of resilient livelihoods. An increase in livelihood diversification is positively and significantly correlated with the probability that a household will be meeting or exceeding the normative well-being (food security) threshold. Similarly, the study result shows that households with diversified livelihoods are more likely to have a higher ability to expand extra food income per unit of expected loss beyond the minimum survival threshold. In this regard, there are different ways to promote diversification. For example, in this study crop diversification within the farming system appears to be more preferable than mono-cropping to maintaining household resilience to food insecurity. This also include diversifying livestock types kept by smallholder farmers including small livestock types such as shoats and chicken. Primarily small livestock are kept as buffer assets against shock and related crop failure. Maintaining diversity of this key assets means maintaining household resilience against food security shocks.

On the other hand, income diversification outside of agriculture could also be promoted to not only enable rural livelihoods constructed in the risky environments to persist beyond the minimum survival threshold of wellbeing but also to facilitate change and exit from low return risky agriculture to a more resilient livelihood trajectory. As the later require a long term effort to establish enabling environments for change, considering the current reality of rural people in Ethiopia with increasing population and diminishing land size, intensive farming with improved access to technologies is not only an option but also necessary while enabling the flexibility for rural people to diversify their income sources. Although such alternative policies and pathways for smallholder agriculture compete for scarce public resources, and each represents an 'opportunity cost' compared to the other (Ellis and Maliro, 2013) in their study in the Sahel show

that a mix of policies can be affordable, allowing for strategic choice over the portfolio most likely to achieve a reliable consumption floor for the most vulnerable rural people. Studies in similar risky environments (Tincani, 2012) also shows that balanced efforts to enabling change as well as persistence is critical to keeping the livelihood system within the boundaries necessary for successful livelihood construction.

However, there are many constraints in Ethiopia related to policies, institutions and processes to enabling diversity and often do not reflect the optimal mix of policies allowing for exploiting appropriate portfolio of strategic choices. This may include underdeveloped markets for credit, labor and livestock which often do not support investments outside of agriculture. More importantly, Ethiopia's land tenure policy which is predominantly criticized for its lack of flexibility to allow rural households engaged in non-agricultural activities as the policy requires permanent residency with limited transferability of land rights. Empirical studies related to resilience and 'asset thresholds'(Carter et al., 2007, 2004; Dercon and Christiaensen, 2007) points to implication of such policies that may contribute to trapping millions of families in unviable livelihoods. This study also confirms that considerable households are in a state of poverty traps and for such asset-poor families with no prospect of making a sustainable living from their small plots of land, facilitating livelihood diversification could serve as an important strategic option as a way out of poverty for many poor households.

Similarly, poor synergies that exist between agricultural and social protection policies of Ethiopia often prevents chronically food insecure smallholders to take advantage of a positive complementary benefits, for example (Devereux and Guenthe, 2009) explores how the poor seasonal timing of Ethiopia's PSNP public work projects constrains agricultural production. It was also evident during community group discussion that other policies and institutions related to food security such as PSNP also lacks the flexibility to allow beneficiaries benefiting from

participation in seasonal off-farm activities without competing for labor. Fundamental understanding and mainstreaming of these issues into national agricultural policy to form a coherent strategy promoting diversification to achieve structural transformation required for a resilient livelihood system as a way out of poverty traps for many rural households in the risky environments. In conclusion, establishing a coherent national strategic framework, reflecting the flexibility and synergies required to balance implications of the various strategic pathways for smallholder agriculture and livelihoods, has an important role to guiding both development and humanitarian interventions designed to contribute positive resilience outcomes among households who construct livelihoods in the risky environments characterized by protracted food crisis.

8.4.2. Addressing long term vulnerability and Transitory Food Insecurity within an Integrated DRM and Food Security Framework

Following repeated food crisis in the late 1990s and 2000s, Ethiopian government, donors and NGOs all agreed that decades of interventions have not resulted in sustainable assets at household or community level (Rahmato et al., 2013). The critique on this relief oriented emergency system resulted in the introduction of Productive Safety Net Program (PSNP) in 2005 which represented the shift from food aid dominated humanitarian response system towards a more comprehensive food security programming with resilience building at its core. It was introduced as a development oriented predictable safety net with the aim of addressing both long term vulnerability and transitory crises.

The major objective of PSNP was to provide transfers to food insecure population in chronically food insecure districts in a way that prevents asset depletion at household level and creates assets at community level. The nature of transfer involves both unconditional transfers to those households who have no other means of support, as well as conditional transfers to those

households with able bodied labor in exchange for their participation in labor based public work activities such as rural road construction and building soil and water conservation structures in degraded lands. Within the broader National Food Security and DRM framework, the PSNP is a Disaster Risk Management initiative that focuses on building resilience of food insecure households to withstand shocks that cause not only negative livelihood outcome but also negative risk coping against recurrent shocks.

However, The PSNP alone cannot address the needs of all PSNP beneficiaries and the PSNP transfer can only help households withstand small to moderate shocks. Evidence suggests that although PSNP that represented a major new initiative to address the question of resilience, the program success could not go beyond just smoothing consumption of the chronically food insecure households. For example, studies related to PSNP (Devereux and Teshome, 2013; John et al., 2013) confirmed that the positive effects of the program are not robust enough to enhance resilience against the impacts of severe shocks despite its positive contribution to improve food consumption and wellbeing,. The system requires better integration with other food security and DRM programs if it has to build household resilience to food insecurity.

This is also confirmed in this study that for shock reaction capacity and resilience to food insecurity, beneficiary households achieve lower livelihood outcomes, despite some improvements in their transition to a relatively desirable wellbeing status as predicted by Markov Chain Process. This is primarily because, on one hand, the size of the transfer, in terms of cash and/or food, is simply too small to enable households to escape the shock cycle. For example, this study estimates the average transfer with food income contribution of less than 15% of the minimum survival threshold. Although the program regularly adjusted the size of transfer to consider the problem of inflation and related cost of living, increasing the size of transfer alone is unlikely to enable households to achieve resilience against shocks.

The PSNP certainly can help if applied in conjunction with other initiatives within the broader DRM framework. For example, some studies show that beneficiaries of PSNP and Household Asset Building Programs (HABP) were able to reduce their food gap by 18% more than beneficiaries of PSNP only. However, the HABP covers a small proportion of the total PSNP caseload, for instance in 2011 and 2012 only 1.8% of the households receiving PSNP public works support got the full HABP package (IFPRI, 2013). In this study, productive assets and improved access to agricultural inputs play a positive contribution to household resilience. Value of productive assets, such as land, livestock and agricultural implements, are found to be positively and significantly associated with the probability of a household to be resilient. Similarly, households with good access to agricultural inputs have a higher likelihood to be resilient than those with limited access indicating application of fertilizers and improved seeds within the cropping system would increase resilience to food insecurity through improved productivity. Therefore, in addition to PSNP transfer, improved access to credit and business development as well as agricultural extension services extended through the HABP packages could bring a significant positive contribution to household resilience.

The coverage of the PSNP may also limit resilience impact of transfers. Of the 27.5 million people living below the poverty line in Ethiopia, only 7.6 million receive PSNP support. According to a recent vulnerability survey at country level, 45% of Ethiopia's poor and vulnerable live outside PSNP woredas. Similarly, in the study area, only half of the population currently benefiting from the program while this study estimated more than 70% of the sample population exhibiting a state of poverty trap. The study area was targeted in 2004 and it is probable that vulnerability patterns have changed over this period and PSNP targeting might no longer reflect the districts vulnerability profile.

Although partial targeting is also a function of resource availability, this study points to two important implications for improved design and targeting of programs intended to address both the chronic vulnerability and transitory problems of food insecurity. First, the problem of food insecurity is pervasive and deep rooted in the study area and similar risky environments in Ethiopia. Hence, understanding resilience properties of livelihood systems and risk management behavior of households as system participants should inform the design of programs with resilience building objectives. PSNP should be considered as an integral part of the household livelihood portfolio and its implication in affecting resilience properties of the household economy in terms of wealth, diversity, connectivity and response capacity should be understood. Second, it is very important to have proper sequencing and combination of distinct activities or interventions capable of addressing immediate needs and longer term projects simultaneously. This may require close coordination between humanitarian and development actors especially through joint programming exercises. Expanding coverage of social protection programs with better linkages with other development programs would lead food insecure households on resilience pathways towards a more positive livelihood outcome.

8.5. Direction for Future Research

This thesis has identified key livelihood resilience properties and determinants of resilience to food insecurity at the micro-level context. However, it was not possible to investigate how these resilience properties relate with the wider drivers operating at larger scale. A broader study is necessary to understand the dynamics of such drivers of change for the overall resilience of the livelihood system. Important research questions still need to be addressed, particularly questions such as: Is the ecological wealth reached its critical threshold to support existing livelihood system? Are there evidences for a more transformative change away from such livelihood systems? In this regard, further research could be conducted to explore the potential of modern portfolio theory combined with perspectives from ecological theories to generate further insights

necessary to investigate these questions described above. The proposed metric needs to be refined to verify its applicability in different settings and across larger scales using existing livelihood and risk databases including other livelihood based early warning instruments employed in most African and Asian countries. This is particularly important to advance food security and early warning systems in determining not only emergency needs but also development needs which facilitates targeting and the design of resilience building programs. As an emerging field of study the concept of resilience is being increasingly applied to social systems and there are multiple frameworks developed by various organizations and institutions for assessing resilience. Particularly in the context of protracted food crisis in most African countries prone to climate shocks. Since the proposed metric is not confined to a particular conceptual framework, it could be applied to test and compare the appropriateness of such frameworks and paves the way for the development of a more comprehensive framework for assessing resilience of livelihood and food systems constructed in the risky environments.

8.6. Concluding Remarks

The problem of food insecurity is pervasive and deep rooted in the study area and similar risky environments in Ethiopia. Faced with widespread ecological fragility and underlying socio-political vulnerability conditions, many households find it extremely difficult to accumulate cash savings, livestock or food stores sufficient to weather the bad seasons, while some households persist in such environments, capable of maintaining household food security/exceeding the minimum wellbeing threshold. Unlike conventional vulnerability studies which focuses on the former households characterizing their lack of resilience or vulnerability to food security shocks, this study adopted the perspectives of resilience theory focusing on how the later households construct resilient livelihoods with positive food security outcome. Primarily this study set to address the key empirical questions posed by (Timothy Frankenberger et al., 2012) which are directing towards understanding of 1) why some households are resilient than others, 2) the factors

that affect households' choice of risk management strategies to prepare for and respond to particular shocks, and 2) how specific interventions may strengthen households' adaptive capacities to utilize strategies (either coping or adaptive) that better maintain their resilience to future shocks. Vulnerability theory emphasizes that livelihoods constructed in a risk-prone context are subject to lower likelihood to maintain the minimum wellbeing, stressing the negative aspects of the shock context leading to characterizing households as helpless economic units without a prospect for change. In contrast, resilience theory argues that livelihoods in such risky environments are being tested against shocks and possibilities of learning and acts of re-organization capabilities experienced. This enables some households to construct resilient livelihood systems against unpredictable shocks as they already have a flexible decision making norms with which to react to and benefit from change. Resilience theory provides a more forward-looking and balanced conceptual framework sufficiently incorporating the drivers enabling change allowing identification of a set of systemic properties necessary to foster resilience. Having such a balanced framework within which key attributes of resilience could be identified and fostered for positive livelihood outcome is a primary need for policy makers. Overall, this study concluded that poor household resilience is a function of both structurally constrained adaptive capacity and high shock exposure. Therefore, resilience programs, in the study area and in similar areas that are designated as risk prone chronically food insecure districts of the country, should address both structural causes of food insecurity and substantial reduction of risk/shock exposure through a comprehensive food security and DRM programming framework.

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APPENDIX I: HOUSEHOLD QUESTIONNAIRE

A PHD STUDY ON "HOUSEHOLD RESILIENCE TO FOOD SECURITY SHOCKS:

THE CASE OF TACH GAYINT WOREDA, SOUTH GONDAR ZONE, AMHARA REGION, ETHIOPIA

Household Questionnaire

Introduction

Greet the person you are interviewing, and introduce yourself. Explain where you are coming from.

> *"We are here to request your participation in a survey of households to study resilience properties of household livelihood systems in relation to the desired food security outcome in Tach-Gayint District. It is being conducted as part of a PhD study entitled 'Household Resilience to Food Security Shocks'. First, we would like you to know that your participation is voluntary. Second, we would like to assure you that your identities will at all times be kept confidential and that your answers will not be used in any way other than for the purpose of PhD study."*

"Do you have any questions before we continue?

"Are you willing to be interviewed?

[If they agree to be interviewed, start the interview. If the respondent is not willing, do not ask any of the questions and move to the next household.]

HOUSEHOLD IDENTIFICATION

ID	Name	Code
Livelihood Zone		
Kebele		
Village		
Household Head		

INTERVIEW IDENTIFICATION

Name of Interviewer:	
Date of Interview:	Day:_____ Month:_____
Start Time:	
End Time:	
Checked:	

A.1. HOUSEHOLD PROFILE

(1)	Is this a female-headed household? *(circle one)*	Yes: 1	No: 2
(2)	When was your household formed? *(write year)*		E.C.

A.2. HOUSEHOLD MEMBERS

ID Code	Name	How related to head of household? *(write code)*	Male [M] or Female [F] *(circle one)*	Age *(age in complete years)*	Can he or she read a letter or newspaper? *(circle one)*	Highest grade of school completed *(write number or 00 if none)*	Labor capacity *(write code)*	Was anyone sick/injured…in the last 12 months	(If yes for Q.8) How many days…unable to perform normal activities due to illness/injury
(1)		*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
			M F		Yes No			Yes No	
01		☐☐	1 2	☐☐	1 2	☐☐	☐	1 2	
02		☐☐	1 2	☐☐	1 2	☐☐	☐	1 2	
03		☐☐	1 2	☐☐	1 2	☐☐	☐	1 2	
04		☐☐	1 2	☐☐	1 2	☐☐	☐	1 2	
05		☐☐	1 2	☐☐	1 2	☐☐	☐	1 2	
06		☐☐	1 2	☐☐	1 2	☐☐	☐	1 2	
07		☐☐	1 2	☐☐	1 2	☐☐	☐	1 2	

Codes: How related to HH-head?

01 = household head
02 = wife
03 = son / daughter of head or wife
04 = son-in-law / daughter-in-law
05 = grandson / granddaughter
06 = father / mother of head or wife
07 = brother / sister of head / wife
08 = other relative of head/ wife
09 = adopted / step-child / foster child
10 = non-relative / servant

Codes: Labor capacity

1 = young child (too young to work)
2 = working child (herding livestock; domestic chores; childcare; may be hired or fostered out)
3 = adult (able to do full adult workload)
4 = working elderly (not able to do full adult workload)
5 = partially disabled (able to do light work only)
6 = permanently unable to work (physically or mentally disabled, or non-working elderly)
7 = seriously ill (unable to work for the past 3 months or more)

Codes: How many days unable to perform

1 = almost none; very healthy
2 = 5 or less days; rarely sick/injured
3 = 6–15 days; occasionally sick/injured),
4=16–25 days; frequently sick/injured
5 = more than 25 days; major illness/injury episodes

Note: If the household has more than 7 members, please turn the page and register them.

A.2. HOUSEHOLD MEMBERS

ID Code	Name	How related to head of household? *(write code)*	Male [M] or Female [F] *(circle one)*	Age *(age in complete years)*	Can he or she read a letter or newspaper? *(circle one)*	Highest grade of school completed *(write number or 00 if none)*	Labor capacity *(write code)*	Was anyone sick/injured…in the last 12 months	(If yes for Q.8) How many days…unable to perform normal activities due to illness/injury
(1)		*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
			M F		Yes No			Yes No	
01		☐☐	1 2	☐☐	1 2	☐☐	☐	1 2	
02		☐☐	1 2	☐☐	1 2	☐☐	☐	1 2	
03		☐☐	1 2	☐☐	1 2	☐☐	☐	1 2	
04		☐☐	1 2	☐☐	1 2	☐☐	☐	1 2	
05		☐☐	1 2	☐☐	1 2	☐☐	☐	1 2	
06		☐☐	1 2	☐☐	1 2	☐☐	☐	1 2	
07		☐☐	1 2	☐☐	1 2	☐☐	☐	1 2	

Codes: How related to HH-head?

01 = household head
02 = wife
03 = son / daughter of head or wife
04 = son-in-law / daughter-in-law
05 = grandson / granddaughter
06 = father / mother of head or wife
07 = brother / sister of head / wife
08 = other relative of head/ wife
09 = adopted / step-child / foster child
10 = non-relative / servant

Codes: Labor capacity

1 = young child (too young to work)
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3 = adult (able to do full adult workload)
4 = working elderly (not able to do full adult workload)
5 = partially disabled (able to do light work only)
6 = permanently unable to work (physically or mentally disabled, or non-working elderly)
7 = seriously ill (unable to work for the past 3 months or more)

Codes: How many days unable to perform

1 = almost none; very healthy
2 = 5 or less days; rarely sick/injured
3 = 6–15 days; occasionally sick/injured),
4=16–25 days; frequently sick/injured
5 = more than 25 days; major illness/injury episodes

Note: If the household has more than 9 members, please turn the page and register them.

B.1 Shocks

When considering the time period in the last five years, has there been any event causing a big problem (shock) affecting the household? Please think of any problems related to your family, farm, house or job.

1	2	3	4	5
Type of event *(write code)*	When did the event occur?	How often did the event occur?	Estimated severity of the event on your HH income/asset *(write code)*	Have you been able to recover? *(write code)*

Codes: Type of event

01= Drought
02= Food price inflation
03= Population pressure
04= Geographic isolation/inaccessibility
05= Livestock disease
06= Human disease
07= Flooding
08= Crop pests & diseases
09= Local conflict
10= Indebtedness
11= Frost
12= Hail storm
13=Strong wind

Codes: Shock severity

0=no impact
1=low impact
2=medium impact
3=high impact

Codes: Recovery status

1 = fully recovered
2 = partly recovered
3 = not recovered yet
98 = no answer
99 = not applicable

B.2 Risks

Now, please consider the following possible future events for the next 5 years

1	2		3	4	5		6
Type of event *(write code)*	Do you think that [event] will occur in the next 5 years?		How often, do you think, will [event] occur in next 5 years?	If [event] occurred within the next 12 months, what would be the impact on your HH income & asset *(write code)*	Do you do anything to prevent [event] from happening OR to mitigate its impact on your household's income and assets?		(If yes for Q.5 (B.2)) What do you do to prevent [event] from happening OR to mitigate its impact on your household's income and assets? (most important strategy only) *(write code)*
	yes	no			yes	no	

Codes: Type of event

01= Drought
02= Food price inflation
03= Population pressure
04= Geographic isolation/inaccessibility
05= Livestock disease
06= Human disease
07= Flooding
08= Crop pests & diseases
09= Local conflict
10= Indebtedness
11= Frost
12= Hail storm
13=Strong wind

Codes: Shock severity

0 = no impact
1 = low impact
2 = medium impact
3 = high impact

Codes: Risk management strategy

01 = Crop, plot, livestock diversification
02 = Income source diversification
03 = Savings
04= Switch to more secure income sources
05= Buffer stocks
06= Investment in physical and human capital
07= Contract insurances
08= Collective action for infrastructure, dikes, terraces, irrigation, etc.
09= use of drought-tolerant crops/livestock
10= other, please specify

C1. LAND OWNERSHIP AND ACCESS

(1) Do you (or any other member of your household) own any land? *(circle one)*	Yes:	1	No: 2
(2) Did you (or any household member) farm in the last farming season? *(circle one)*	Yes:	1	No: 2

(3) If **YES**, please tell us about, as of today, how many hectares of lands do your household own? (If none, write '0'). For lands include any land that belong to you, but sharecropped out, rented out or gave someone for cropping for free; do not include any land that you are sharecropping, renting or cultivating for free but you do not own the land.

Asset Type	# hectares own today*	Estimated value per hectare if sold today
Land		
Agricultural land	|____||____|____|	|____|____|____|____|____|
Homestead land	|____||____|____|	|____|____|____|____|____|
Pond	|____||____|____|	|____|____|____|____|____|
Other land	|____||____|____|	|____|____|____|____|____|

C2. CROP FARMING

(*1*) For each crop grown, how much of land planted and what inputs did you use in the previous farming season prior the survey?

		Labor				Inputs used						
		Hired labor		Family labor		fertilizer	Animal manure	pesticide	Improved varieties		Irrigation	
	Area planted	person days	hours worked/day	person days	hours worked/day	kg	kg	birr	yes	no	yes	no
Crop type	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
Maize												
Sorghum												
Millet												
Barley												
Wheat												
Teff												
Enset												
Groundnuts												
Sesame												
Horse Beans												
Haricot Beans												
Tomatoes												
Onions												
Other												

(*2)* For each crop grown, how much was harvested and what did you do with the harvest during the 12 months prior to the survey?

				Changes to the total production as of today				
	Units for Qt.	Qt. Produced	Qt. Sold	Price/unit sold	Qt. Consumed	Qt. Given away	Qt. Reserved for seed	Qt. Stored as of today
Crop type	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
Maize								
Sorghum								
Millet								
Barley								
Wheat								
Teff								
Enset								
Groundnuts								
Sesame								
Horse Beans								
Haricot Beans								
Tomatoes								
Onions								
Other								

Code for units: (1) gram-g (2) centigram-cg (3) cubic centimeter-cm^3 (4) number (5) meter-m (6) pairs (7) box (8) bundle (9) load (10) kilogram-kg (11) liter (12) milliliter (13) meter square-m^2 (14) *kuna*

D1. Livestock Production

(1) Did you keep any of the stock listed below 12 months' prior the survey? *(circle one) if yes, please tell us details for each stock kept.*

Yes : 1	No: 2

Please list the stocks you kept in the previous year

	Number owned one year ago	consumption	Sales		Number owned today	Cash expenditure for inputs		Labor			
								Hired labor		Family labor	
						for feed	veterinary treatment	person days	Average hours worked per day	person days	Average hours worked per day
	(Units)	*number of unites slaughtered*	*units sold*	*value per unit sold*	*(Units)*	*(Birr)*	*(Birr)*				
Type	*(a)*	*(b)*	*(c)*	*(d)*	*(e)*	*(f)*	*(g)*	*(h)*	*(i)*	*(j)*	*(k)*
Oxen											
Bulls											
Cows											
Heifers											
Calves											
Sheep											
Goats											
Donkeys											
Mules											
Horses											
Camels											
Poultry											

D.2. Livestock Production (Milk, Butter, Meat, Eggs)

(1) Did you get livestock products in the last 12 months' prior the survey?
(circle one) if yes Please tell us consumption and sales of livestock products

Yes: 1	No: 2

Consumption and sale of milk, milk products, & eggs	# of milking animals	Length of lactation (in days)	Average milk production per animal per day (c)	Quantity sold or exchanged	Price per unit sold	Quantity consumed	Other use (e.g. gifts, payment for labor)
Cow's milk							
Goats milk							
Sheep milk							
Eggs							
Other products…							

E.1. Off-Farm Employment Activities

(1) Has anyone of your household member worked as a wage-employee in the last 12 months' prior the survey? *(circle one) if no go to the next session*

Yes: 1	No: 2

Please tell us about casual labor/employment activities

Activity type	No. of people doing the activity	Hours worked per day	Days per month	Duration (# of months)	Total income received (in Birr)	Did you receive free meal?	
						Yes (1)	No (2)

if received in kind please estimate its monetary value (in Birr)

F.1. Non-Farm Activities/Self-Employment /Trade

(1) Has anyone of your household member engaged in non-farm/business/trading activities in the last 12 months' prior the survey? *(circle one) if no go to the next session*

Yes: 1	No: 2

Please tell us about self-employment, small business and trading activities

Activity / income source[6]	No. of customers per month	Sales per month (in Birr)	Expenditure for inputs per month (in Birr)	Profit per month (in Birr)	Transport cost (in Birr)	No. of people doing the activity	No. of days worked per month	Duration (number of months

[6] Checklist for self-employment: collection of firewood, charcoal, grass, handicrafts, brewing. Checklist for small business and trade: petty trade, trade, rental/hire, kiosks and shops.

G.1. ASSET INVENTORY

As of today, how many of the following assets does your household own? *(If none, write '0'.).* For livestock, include any animals that belong to you, but are being raised by other households. Do not include any animals that you are rearing for someone else but do not belong to you.

Asset	Number owned today	Number owned one year ago	Cost of replacing one *[Birr]*
	(a)	*(b)*	*(c)*
Productive assets			
Plough			
Sickle (*machid*)			
Pick axe (*doma*)			
Axe (*metrebia*)			
Hoe (*mekotkocha*)			
Spade (*akefa*)			
Traditional beehive			
Modern beehive			
Water pump (hand/foot)			
Water pump (diesel			
Grain mill			
Household goods			
Charcoal/ wood stove			
Kerosene stove			
Leather/ wood bed			
Modern chair			
Modern table			
Metal bed			
Wheelbarrow			
Consumer durables			
Mobile telephone			
Radio			
Television			
Jewelry (gold, silver)			
Bicycle			
Wristwatch			

H.1. ACCESS TO PHYSICAL RESOURCES

1	How do you rate the quality of access to community-owned (not privately held) resources such as farmland, grazing land, water sources, and woodlots?	no access poor access; usually restricted moderate; occasionally restricted and consistent access; can access as needed	0 1 2 3
2	What is the household's main source of drinking water?	piped household water public taps/standpipes tube wells/boreholes hand -dug wells protected springs rainwater collection unprotected springs/wells unprotected surface water sources other	1 2 3 4 5 6 7 8 9
3	What kind of toilet facility does your household use? If you know by observation, do not ask	Modern water closet Ventilated, build in latrine Outdoors latrine/hole on plot No facilities/Open Space Other	1 2 3 4 5
4	Type of dwelling	Tin house Wood and mud Bamboo Brick/stone house Mobile home Thatched	1 2 3 4 5 6
5	How many minutes does it take to reach the nearest paved road?	|___||___||___| minutes	
6	How much time does it take to reach the nearest market center?	|___||___| Hours |___||___| minutes	
7	How much time does it take to reach the nearest clinic?	|___||___| Hours |___||___| minutes	
8	How much time does it take to reach the nearest urban center?	|___||___| Hours |___||___| minutes	

I.1. SOCIAL CAPITAL

(1) How many close friends (not relatives) do you have these days? These are people you feel at ease with, can talk to about private matters, or call on for help

(2) If you suddenly faced a long-term emergency such as harvest failure, how many people beyond your immediate household could you turn who would be willing to assist you?

(3) Has anyone in the HH participated in the following types of associations?

Type of Association	yes	no	If yes…Degree of participation
farmer 's group			
agricultural/other labor-sharing group			
religious group/church			
neighborhood/village cultural association			
political group			
marketing cooperative			
credit or savings group			
women's group			
funeral cost -sharing group			
water users group			
youth association			

Codes: Degree of participation
0 = no one in the household participates in the group
1 = at least one household member is somewhat active
2 = at least one household member is very active in the group
3 = a household member is a leader of the group

J.1 Household expenditures

Expenditure activities	Total expenditure *(Birr)*
WEEKLY expenditure	
Cereals	
Cooking oil	
Meat	
pulses	
Sugar/salt	
Other foods	
Milling	
Tobacco	
Coffee	
Vegetables	
MONTHLY expenditure	
Transport	
Battery cells	
Candle/	
Soup	
Charcoal	
Kerosin/gas	
ANNUAL Expenditure	
Medical expenses/health care	
Cooking utensils	
Equipment/tools/seed	
Education/school fees	
Clothing/shoes	
Celebrations/social events	
Tax	
OTHER	

K.1. SAVING, LENDING & BORROWING

(1) Are you able to save any cash in the last 12 months? *(circle one)*		Yes 1	No 2
(2) If 'YES', approximately how much did you save in total last year?	*(Birr)*		
(3) Did you lend money to anyone during the last 12 months? *(Birr)*	Yes 1	No 2	
(4) About how much money did you lend over the last 12 months? *(Birr)*			
(5) Did you borrow money from anyone during the last year?	*(Birr)*	Yes 1	No 2
(6) About how much money did you borrow over the year?	*(Birr)*		

(7) Why did you borrow this money? *(Circle all that apply)*

To buy food for the family	1	For investment on the farm	5
For health expenses	2	For investment in livestock	6
For education costs	3	For investment in other income-earning activities	7
For social obligations	4	Other: _____	8

(8) Who did you borrow this money from? *(Circle all that apply)*

Private trader	1	Cooperative	6
Local farmer	2	Microfinance institution (eg ACSI)	7
Local lenders (Loan sharks)	3	NGO	8
Relative	4	Other: _____	9
Government agency	5	Other: _____	10

L.1. INFORMAL TRANSFERS

(1) In the last 12 months (between now and the same month last year), has your household received or given any of the following types of assistance from / to any friend or relative living outside the household?

[Note: Not from government or NGOs.]

Type of assistance	Received? Yes No	No. of transfers received	Total received *(Birr)* *	Given? Yes No	Number of transfers given out	Total given *(Birr)* *
	(a)	*(b)*	*(c)*	*(d)*	*(e)*	*(f)*
Remittances	1 2			1 2		
Other cash gift	1 2			1 2		
Food or grain gift	1 2			1 2		
Grain loan (no interest)	1 2			1 2		
Seed gift	1 2			1 2		
Seed loan	1 2			1 2		
Free labor	1 2			1 2		
Free use of oxen or plough (for farming)	1 2			1 2		
Free use of pack animals	1 2			1 2		

* Note: If the transfer was made in kind rather than in cash (eg seeds), ask the respondent to estimate the total value of the transfer in cash equivalent terms (eg what s/he would have paid to purchase these seeds)

M.2. FORMAL TRANSFERS

(1) In the past 12 months, what assistance did your household receive from government or aid agencies? Yes (1), No (2) if yes please provide the following information.

Type of assistance received	Total received (Birr) *	If received in exchange for labor, provide labor participation information			Program / Provider (use the code below) (1) PSNP (2) GOs (3) World Bank (4) Local GOs (5) International GOs (6) Other (specify)
		No. of people participated	No. of days per month	Duration (# of month)	

* Note: If the transfer was received in kind rather than in cash (eg fertiliser), ask the respondent to estimate the total value of the transfer in cash terms (eg what s/he would have paid to purchase the fertiliser)

N.1. FOOD SECURITY

(1) During the last year, did your household suffer any shortage of food to eat? *(circle one)*

Yes 1	No 2

(2) Which months in the last year did your household have problems satisfying its food needs? *(circle all that apply)*

Jan	Feb	Mar	Apr	May	Jun	Jun	Jul	Aug	Sep	Oct	Dec
1	2	3	4	5	6	7	8	9	10	11	12

O. Food and Income Sources During Good and Bad Years

After enquiring about the household's main food and income sources, ask households to report how often out of the past ten years (covering the period 2005-2014) they had encountered a bad, normal or good year in their main food and income sources. Please clearly present the criteria for defining each state, where a bad year = a production year with poor or no rains, poor or no harvest and poor or no pasture; a good year =good rains, good harvest and good pasture. a normal year= production year that does not reflect either of the two descriptions but a typical year with usual production conditions. The study reference year, the 2014 production year is considered as a normal year and detail information about normal state is already captured in the previous modules. Hence, this section of the questionnaire (from Q.1 to Q.5) focuses only on what happens to the food income sources during good and bad years.

For this exercise please draw three rectangles on the soil, designating the three states (a bad, normal or good year) and give 10 bean grains and ask to allocate them among the three rectangles. The relative number of bean grains in each state represents the subjective probability of facing a certain climatic event (either normal, adverse or favorable). Referring to only the good and bad years, please ask quantities produced and exchanged in the following food and income sources listed below from Q.1 to Q.5.

O.1. LIVESTOCK PRODUCTION (MILK, BUTTER, MEAT, EGGS)

		Good Year					Bad Year		
Livestock product	Unit of measure	# of milking animals	Length of lactation	Average milk production per animal per day	Quantity Sold/exchanged		Average milk production per animal per day	Quantity Sold/exchanged	
		(Units)	*# of days*	*litter/cow/day*	*(litter)*	*Unit price*		*(litter)*	*Unit price*
Cow's milk									
Goats milk									
Sheep milk									
Eggs					(numbers)	*Unit price*		(numbers)	*Unit price*
other livestock products									

O.2. LIVESTOCK PRODUCTION (LIVESTOCK SALES)

	Good Year				Bad Year			
Type of Livestock sold	# of units	Quantity sold/exchanged	Unit price	When sold?	# of units	Quantity sold/exchanged	Unit price	When sold?
Cattle								
goats								
sheep								
Equines								
chickens								

O.3. FOOD AND CASH FROM OWN CROP PRODUCTION:

		Good Year				Bad Year		
Crop (staple food crops, cash crops, vegetables, residues)	Unit of measure and weight	Quantity produced	When	Quantity sold / exch.	Price sold per unit	Quantity produced	Quantity sold / exch.	Price sold per unit

O.4. OFF-FARM EMPLOYMENT ACTIVITIES

Activity	Good year			Bad Year		
	No. of people doing this activity	Total payment received (in Birr)	Typical months the activity performed	No. of people doing this activity	Total payment received (in Birr)	Typical months the activity performed

if received in kind please estimate its monetary value (in Birr)

O.5. NON-FARM ACTIVITIES/SELF-EMPLOYMENT/TRADE

Activity	Good year				Bad Year			
	No. of customer per month	Sales/revenue per month (in Birr)	Cost per month for inputs (in Birr)	Profit per month (in Birr)	No. of customer per month	Sales/revenue per month (in Birr)	Cost per month for inputs (in Birr)	Profit per month (in Birr)

if received in kind please estimate its monetary value (in Birr)

P.1. Coping Strategies During Bad Year:

1. Did you use coping strategies listed below to expand food and income sources in response to shortages during bad years?

(If yes) Please tell us for how many days during the bad year that the food or income obtained from the strategy covers household food and non- food needs

Coping strategy	**Yes**	**No**	**If yes, how many days of the household food &non-food needs were covered from the food/income obtained from the strategy?**
Rely on casual labor for food	1	2	
Household members migrated to find work	1	2	
Rented out land to buy food	1	2	
Sold small animals	1	2	
Sold large animals (bulls, old cows, donkey, horses	1	2	
Sold household goods & consumable equip	1	2	
Sold firewood or charcoal	1	2	
Harvest immature crop (Green harvest)	1	2	
Borrow money/food from friends/ relatives	1	2	
Rely on less expensive or less preferred foods	1	2	
Collected bush products/wild food / hunt to eat or sell for food	1	2	
Sent children to stay with and eat at relatives or neighbors	1	2	
Reduced spending on non-food items	1	2	
Other *(specify):*	1	2	

Q.1. Self-Assessment of Household Situation

How would you describe the situation of your household now in comparison to last year, 5 years ago and 10 years ago?

Category	Now *(circle one)*	The same time last year (2007 EC.) *(circle one)*	5 years ago (2003 EC.) after the 2003 severe drought *(circle one)*	10 years ago (since the introduction of PSNP.) *(circle one)*
(97)	(98)	(99)	(100)	(101)
Household not formed at that time		0	0	0
DOING WELL – able to meet household needs by your own efforts, and making some extra for stores, savings and investments (e.g. buying livestock or other assets, improving farmland, improving housing etc)	1	1	1	1
DOING JUST OKAY - able to meet household needs but with nothing extra to save or invest	2	2	2	2
STRUGGLING – managing to meet household needs, but by depleting productive assets and / or sometimes receiving support from community or government	3	3	3	3
UNABLE TO MEET HOUSEHOLD NEEDS - dependent on support from community or government	4	4	4	4

APPENDIX II: COMMUNITY GROUP DISCUSSION

1. **Climate related hazards/shocks**

   a. Identification and list of climate related hazards/trends

   (What are climate related hazards/trends common in the kebele?)

   b. Prioritization of hazards/trends

   (Use pair wise ranking for prioritization of hazards)

Hazard	Drought	Flood	Frost	Conflict	pest	total	rank
Drought		R	R	R	R	4	1
Flood	C		R	C	C	1	4
Frost	C	C		C	C	0	5
conflict	C	R	R		R	3	2
pest	C	R	R	C		2	3

2. Hazard/shocks characterization

(Characterize the selected hazards in terms of impact, frequency, period of occurrence, and coping mechanism)

Hazards (*in their order of importance*)	Period of occurrence	Frequency in the last 10 years	Coping/adaptive mechanism

Zone 1: ABB; Zone 2: ATW

Legend	
OP	Own Production
MP	Market Purchase

3. Primary Food, Income and Expenditure cycles of the Poor

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Staple Foods and Sources												
Sorghum												
Teff												
Haricot been												
Maize												
Main Income Sources												
Ag Paid Labor Peak												
Livestock Sales												
Crop Sales												
Charcoal sales												
Fire wood sales												
Migratory labor wages												
Key Seasonal Expenditure												
Seeds												
Fertilizer/herbicides												
Staple food (Sorghum & Teff)												
Non-staple food												
Harvesting Labor												

					Legend		*LP* *P*	*Land preparation* *Planting*		*W* *H/GH*	*Weeding* *Harvest/Green Harvest*	
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Seasons												
Rainy season												
Dry season												
Lean season												
Primary Livelihood Activities												
Sorghum production												
Teff production												
Haricot been production												
Maize production												
Peak Cattle milk production												
Peak shoat milk production												
Livestock sales peak												
Labor sales peak												
Other Activities & Events												
Charcoal production												
Fire wood collection												
Wild food collection												
Migratory labor												
Peak staple purchase												
Peak staple prices												
Shocks and Hazards												
Malaria												
Drought												
Floods												
Crop pest & diseases												
Livestock diseases												

4. LIVELIHOOD SENSITIVITY MATRIX

Resources and Livelihoods	Climatic risks							
	Drought	Dry spells	Flood	Crop pest	Livestock disease	Malaria		
Frequency								
Ecosystem services								
Soil water								
Water supply								
Non-farm wood fuels								
Grazing and fodder								
Livelihood activities								
Sorghum production								
Teff production								
Maize production								
Haricot bean prod								
Cattle milk production								
Shoat milk production								
Livestock sales								
Charcoal production								
Fire wood collection								
Petty trading								
Agricultural labour								
… others								

- 1* no impact 2* low impact 3* medium impact 4* high impact 5* very high impact

5. Coping strategy	How much food/income expanded due to the strategy as compared to the normal months/years			Access constraints
	Poor HHs	Middle HHs	Rich HHs	
Rely on casual labour for food				
Household members migrated to find work				
Rented out land to buy food				
Sold small animals				
Sold large animals (bulls, old cows, donkey, horses				
Sold household goods & consumable equip				
Sold firewood or charcoal				
Harvest immature crop (Green harvest)				
Borrow money/food from friends/ relatives				
Rely on less expensive or less preferred foods				
Collected bush products/wild food / hunt to eat or sell for food				
Sent children to stay with and eat at relatives or neighbours				
Reduced spending on non food items				
Other *(specify):*				

APPENDIX III: KEY INFORMANT INTERVIEW

1. Risk Characteristics in the Area (Management Challenges) How have these disasters affected the wereda?

1a Disaster (in order of importance	1b Most common time of year [month(s)]	1c Years affected by the disaster (history)	1d What are the main causes of this disaster?	1e Types of effects of this disaster	1f Worst year	1g Have the effects increased or decreased over the last years?	1h What is the percent of population affected by this disaster in this wereda? (approx)	1i What characteristics of the community / inhabitants make them vulnerable to this disaster?	1j What are the strategies adopted by the community to cope with this disaster?
1									
2									
3									

2a. What are your impressions regarding population's awareness of hazards in this area?	
2b. What precautions do households in disaster prone areas take to prevent negative effects of disaster?	
(1) Activity	(2) Comments (reasons for selecting measure/activity; anticipated effects, etc.)

3. Description of the local disaster management system 3.a. No of employees in your office/institution dealing with hazards in this administrative area	
Position/responsibilities	Number of employees
Total number of employees	

3b. Activities of this institution (prevention, preparedness, response, adaptive measures, etc.)	
Activity	Description

3c. Other actors related to food security and risk/hazards management in this administrative area (NGO's, formalized community/local institutions, etc.)	
Actor / Institutions	Roles/Responsibilities/Activities