The High 5

Measuring Resilience to Climate Change in Ethiopia

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Light Up & Power Africa

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Abstract

Resilience comprises anticipative, mitigative, adaptive, reactive, and transformative capacities. This paper pioneer an approach of measuring resilience using the Resilient Capacity Index (RCI) by considering all the dimensions. Principal Component Analysis (PCA) was used to give relevant weights to the different indicators. OLS and censored regression analysis were used to identify determinants of resilience. The findings indicated that HHs living in the same geographic locations have different levels of resilience. The average RCI for highland, midland and lowland were 0.14, 0.116 and 0.037, respectively, which indicates that HHs in the highland were relatively more resilient. In terms of the specific indicators, the lowland agro climate was better in anticipative, absorptive, and reactive capacities, while those in the highland and midland locations were better in their capacities to mitigate, adapt and transform. Similarly the result indicated that wealth, literacy level, saving behavior, and access to traditional early warning were determinants of resilience in the lowland. Vegetation cover, farm conservation, access to irrigation, and access to credit were determinants of resilience in the highlands, while types of land owned, access to conventional early warning, and access to disaster risk reduction/climate change adaptation (DRR/CCA) learning were important across all climatic zones.

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1. INTRODUCTION

1.1 Background

The frequency and magnitude of climate change- induced incidences are increasing in scale across the world, creating serious threats to lives and livelihood in recent years (Field et al. 2012). In 2011, the world faced the first drought-induced famine which plunged 13.3 million people into crisis in the region. Similarly multiple earthquakes, tsunamis, flooding, and other natural disasters have occurred across the other parts of the world. The World Bank predicts that the frequency and intensity of such disasters will continue to increase over the coming decades (DFID 2011). In general, climate change (CC) and its impact on both developed and developing countries have become the greatest challenges to progression out of poverty. The impacts are heterogeneous, however, across a diverse range of geopolitical scales. For instance, the risk is generally believed to be more acute in developing countries, because they rely heavily on climate-sensitive sectors, such as agriculture and fisheries and have low gross domestic products; high levels of poverty; low levels of literacy; and limited human, institutional, economic, technical, and financial capacities, as cited by Tesso, Emana, and Ketema (2012) from Madu (2012); Preston et al. (2008); and UNFCCC (2007). This means that the vulnerability of countries and societies to the effects of climate change depends not only on the magnitude of climatic stress but also on the sensitivity and capacity of affected societies to adapt to or cope to such stress.

It is in response to such CC-induced risks that the world has focused on resilience. There is currently a wave of enthusiasm for "building resilience." For many humanitarian and development actors, resilient households and communities are those that are effectively working themselves out of poverty for the long run, in spite of any immediate setbacks they may face (Oxfam 2013). Indeed, it is hoped, through the undertaking of such efforts, the negative impacts of disasters will be less severe, as resilience is understood to go beyond simply helping poor people to "bounce back."

Because of the diverse angle from which resilience is approached in programming, Winderl (2014), as quoted by Schipper and Langston (2015) indicated that resilience was voted the "development buzzword" of 2012, but has left many confused about what its meaning. Moreover, Frankenberger, and Nelson (2015) estimated that the total global spending on resilience programming exceeds $5 billion, which indicates the volume of financial, human, technological, and leadership resources it is consuming. In the 21st century resilience appears to fill a conceptual gap that other discourses, namely adaptation and vulnerability to climate change, appear not to have been able to satisfy.

1.2 Value Additions and Relevance to the AfDB's High 5s

Agriculture plays a dominant role in supporting rural livelihoods and economic growth over most of Africa. As the countries continue to depend on this sector for their economic progress, as well as livelihood development of their nations, the vulnerability of their economies to climate change and vulnerability will continue. This, in turn, challenges the extrication of the African people from multifaceted poverty. Evidence shows that the economic growth and social development of Africa has long been challenged by the shocks and stresses induced by climate change and variability. Many African countries lose significant proportions of their GDP to recurrent droughts, floods, landslides, epidemics, and other shocks. These are all impacts of climate change and variability. The 2015–16 El Niño provides recent evidence of how Africa is thought to be the region most vulnerable to these impacts.

As a means to combatting the climate change impacts, through reduction of poverty, promotion of sustainable development, and bringing about the structural transformation of Africa, the African Development Bank Group has set priority areas of engagement for the 2013–22 strategic period. On September 1, 2015, the eighth elected president of the African Development Bank Group set down a new agenda. The agenda contains the High 5s, development priorities for the institution. The High 5s are to: Light Up and Power Africa; Feed Africa; Industrialize Africa; Integrate Africa; and Improve the Quality of Life for the People of Africa. These focus areas are essential to transforming the lives of the African people and, therefore, consistent with the United Nations' agenda of Sustainable Development Goals (SDGs).

The renewed commitment and refinement of the High 5s reinforces the choices of the last five years, building on lessons learned and addressing the challenges of the future. It is a strategy that provides a response not only to sustainable growth, but also to the sustainable management of natural resources. Africa's development is so closely tied to nature, and economic growth is not sustainable without preserving the continent's natural capital, land, water, marine, forest, and energy resources. These commitments made at Rio+20, the United Nations Conference on Sustainable Development (UNCSD) in Rio de Janeiro, June 20–22, 2012. The bank's strategy of High 5s is founded on two major objectives, one of which is the transitioning to green growth. This objective ensures the achievement of the first agenda item, which is about sustainability of inclusive growth to improve the lives of African children. Africa's gradual transition to "green growth" will protect livelihoods; improve water, energy, and food security; promote the sustainable use of natural resources; and spur innovation, job creation, and economic development. Hence, at the core is the building of the resilience of households' livelihoods to climate change and variability to ensure sustainable improvement in the lives of people. It is in support of this priority of the bank that this research focuses on the measurement of households' resilience to climate change and variability.

Hence, this working paper is devoted to addressing the following objectives: (1) exploring the varieties of approaches used to measure resilience to climate change and variability; (2) developing a resilience measurement framework and methods; and (3) identifying key factors that affect the resilience levels of smallholder farmers residing in different agro climatic zones. The contributions of this paper beyond earlier work include the following: the adoption of resilience measurement in the context of smallholder farmers, the removal of arbitrariness in determining resilience levels, the development of a comprehensive approach that takes into account all dimensions of resilience, and the linking of the agenda to current policies.

2. LITERATURE REVIEW

2.1 Basic Concepts of Resilience

There is no shortage of literature on resilience, nor any shortage of conceptual issues to discuss. The purpose here is to identify the key dimensions of resilience that are generally common across different interpretations, by way of an exploration of why resilience is so attractive to current thinking about risk reduction. Stein (2013) compiled a list of resilience definitions, and more recent compilations of definitions can be found in Winderl (2014). Within the arena of community resilience to disaster risk alone, Norris et al. (2008) listed more than 20 representative definitions of "resilience"— each of which shares features with the others, yet is distinct.

The concept of resilience was first introduced by Holling (1973) in the field of ecology. According to Holling, "resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb change of state variables, driving variables, and parameters and still persist". Moreover, resilience is "the potential of a particular configuration of a system to maintain its structure/function in the face of disturbance, and the ability of the system to re-organize following disturbance-driven change and measured by size of stability domain." Resilience for socioecological systems is often related to three different characteristics: the magnitude of the shock that the system can absorb and remain within a given state, the degree to which the system is capable of self-organization, and the degree to which the system can build capacity for learning and adaptation (Holling 1973, 17).

The Resilience Alliance defines resilience, as applied to integrated systems of people and nature, as: (1) the amount of disturbance a system can absorb and still remain within the same state or domain of attraction; (2) the degree to which the system is capable of self-organization (versus lack of organization, or organization forced by external factors); and (3) the degree to which the system can build and increase the capacity for learning and adaptation. In this understanding, resilience is only a state that a system can achieve within given limits. Therefore, once a threshold is reached, transformation is needed to obtain a new state of resilience. The notion of moving beyond a threshold is a necessary component in thinking about well-being with regard to environmental change (Walker et al. 2006).

On the other hand, the United Nations Office for Disaster Risk Reduction (UNISDR) defined the terms resilience/resilient as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner by resisting or changing in order to reach and maintain an acceptable level of functioning and structure" (UNISDR 2009). Whereas, the Intergovernmental Panel on Climate Change (IPCC), which is one of the global institutions particularly noted for their work on global climate change issues, defined resilience as "the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change" (Field et al. 2012: 5).

The policy framework of the United States Agency for International Development (USAID) viewed resilience in the face of recurrent crisis as: the ability of people, households, communities, countries, and systems to mitigate, adapt to, and recover from shocks and stresses in a manner that reduces chronic vulnerability and facilitates inclusive growth (USAID 2012). In a relatively similar way, the UK's Department for International Development (DFID) put forth the working definition of "Disaster Resilience as the ability of countries, communities and households to manage change, by maintaining or transforming living standards in the face of shocks or stresses—such as earthquakes, drought or violent conflict—without compromising their long-term prospects" (DFID 2011: 6).

From these definitions and several others, the basic notion of resilience comprises the capacity to anticipate, mitigate, adapt to, react to and recover from shocks and stress. Hence, measurement of the resilience level in a community should then include all characteristics that can be factored into these dimensions.

2.2 Impact of CC and the Challenge to Progress Out of Poverty

Over the past decade, disasters have continued to exert a heavy toll and, as a result, the well-being and safety of persons, communities, and countries as a whole have been affected. Over 700,000 people have lost their lives, more than 1.4 million have been injured and approximately 23 million have been made homeless as a result of disasters. Overall, more than 1.5 billion people have been affected by disasters in various ways, with women, children, and people in vulnerable situations disproportionately affected. The total economic loss was more than $1.3 trillion. In addition, between 2008 and 2012, 144 million people were displaced by disasters. Disasters, many of which are exacerbated by climate change and are increasing in frequency and intensity, significantly impede progress towards sustainable development (UNISDR 2015).

Evidence indicates that exposure of persons and assets in all countries has increased faster than vulnerability has decreased, thus generating new risks and a steady rise in disaster-related losses, with a significant economic, social, health, cultural, and environmental impact in the short, medium, and long term, especially at the local and community levels. Recurring small-scale disasters and slow-onset disasters particularly affect communities, households, and small- and medium-sized enterprises, constituting a high percentage of all losses. All countries—especially developing countries, where the mortality and economic losses from disasters are disproportionately higher—are faced with increasing levels of possible hidden costs and challenges in order to meet financial and other obligations (UNISDR 2015).

The impacts of climate change and the vulnerability of poor communities to climate change vary greatly, but generally, climate change is superimposed on existing vulnerabilities. Climate change will further reduce access to drinking water, negatively affect the health of poor people, and will pose a real threat to food security in Ethiopia and other developing countries (UNISDR 2015). Even though the availability and accessibility to food and nutrition needs in rural Ethiopia is highly dependent on agricultural productivity and the performance of rural livelihoods systems, these sectors are highly sensitive to climate. Food insecurity patterns are seasonal and linked to rainfall patterns, with hunger trends declining significantly after the rainy seasons (USAID 2011).

According to Devereux and Maxwell (2001); Fischer et al. (2002); Kurukulasuriya and Rosenthal (2003) and Boko et al. (2007), it has long been recognized that climate variability and change have an impact on food production, although the extent and nature of this impact is yet uncertain. Broadly speaking, food security is less seen in terms of sufficient global and national agricultural food production, and more in terms of livelihoods that are sufficient to provide enough food for individuals and households (Devereux and Maxwell, 2001; Devereux, 2003 The key recognition in this shifting focus is that there are multiple factors, at all scales, that impact an individual's or household's ability to access sufficient food, income, health, markets, as well as a healthy environment (Devereux and Maxwell, 2001)

More generally, African people in their environment have always battled the vagaries of weather and climate. These struggles, however, are increasingly waged alongside a range of other stresses, such as HIV/AIDS, conflict, and land struggles. Despite good economic growth in some countries, like Ethiopia in recent years (OECD, 2004), large inequalities still persist, and some sources suggested that hopes of reaching the Millennium Development Goals (MDGs) by 2015 were slipping away (UNDP 2005). While climate change may not have featured directly in the setting of the MDGs, it is clear from the evidence presented above that climate change and variability is always an additional impediment to achieving sustainable development. For instance, food security attainment, which is the largest part of poverty reduction in developing countries, has components of food availability, access, and utilization. Climate variability, such as periods of drought and flood as well as longer term change, may—either directly or indirectly —profoundly impact on all the three components in shaping food security (Ziervogel et al. 2006).

Several reports have presented similar arguments to justify that progress out of poverty was greatly challenged in Ethiopia during 2015, due to successive seasons of drought. Smallholders and pastoralists report rising levels of indebtedness, forced sale of livestock, reduced food intake—both in numbers of meals and dietary diversity—and in some areas, the consumption of seeds significantly increased. These trends have culminated in rapidly worsening poverty levels in general and household food security in particular that was expected to deepen through to the main meher harvest of October and November 2016 (Chemonics 2015).

Specifically focusing on the 2015 Ethiopian situation, we see that chronic poverty is driven by the complex interplay of economic, natural, health, and social factors. Economic factors impacting food insecurity act through price inflation, limited access to markets, high unemployment rate, and limited livelihood opportunities. Agricultural production loss has ranged from 44 percent to 99 percent in some of the areas (Okidi et al. 2015). Natural factors contributing to the crises include inadequate and/or irregular rainfall, drought, crop failures, livestock mortality, natural resource degradation, and small plot sizes. Health factors include sudden illness, poor hygiene and sanitation practices, lack of access to health services, and poor understanding of maternal and child health and nutrition needs. Social factors contributing to poverty include low literacy levels, social marginalization especially for women, insecure land tenure rights, and the prevalence of harmful traditional practices (Anderson and Farmer 2015). These myriad factors highlight the complex and sensitive nature of poverty reduction. The impacts of these factors have been exacerbated by the 2015–16 El Niño weather events, which have resulted in the most severe drought and subsequent food emergency in decades. As of September 2015, the number of highly affected districts had increased by 46.3 percent since May 2015. The number of severe acute malnutrition (SAM) cases in July 2015 was 73 percent higher than those reported in January 2015.

2.3 Resilience Frameworks

In order to build the resilience of nations to the changing climatic conditions, various institutions have developed frameworks of their own, depending on their contextual understanding of resilience and programming frameworks for interventions. The following are some of the major resilience frameworks:

2.3.1 Sendai Disaster Risk Reduction Framework

The Sendai Framework for Disaster Risk Reduction 2015–30 was adopted at the Third United Nations World Conference on Disaster Risk Reduction, held from March 14–18, 2015, in Sendai, Miyagi, Japan. The critical importance of this framework within the context of global climate change-induced disaster risk was meant to enable countries to reiterate their commitment to address disaster risk reduction and the building of resilience to disasters, with a renewed sense of urgency in the context of sustainable development and poverty eradication; and to integrate, as appropriate, both disaster risk reduction and the building of resilience into policies, plans, programs, and budgets at all levels, considering both within relevant frameworks (UNISDR 2015). Taking into account the experience gained through the implementation of the Hyogo Framework for Action, the Sendai framework for action set the goal to be achieved as a reduction of hazard exposure and vulnerability to disaster, increased preparedness for response and recovery, and thus strengthened resilience. To this end, there is a need for focused action within and across sectors by nations—at local, national, regional, and global levels in the following four priority areas: (1) understanding disaster risk, (2) strengthening disaster risk governance to manage disaster risk, (3) investing in disaster risk reduction for resilience, and (4) enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation, and reconstruction (UNISDR 2015).

From the perspective of rural development, household poverty reduction, and meeting food security, the shortcoming of this framework is apparent in that it mainly focuses on the policy, strategy and governance levels and lacks rigorous focus at community and local development programming levels.

2.3.2 USAID Resilience Framework

Within the framework of USAID (2011) programming, while the concept of resilience has broad applicability to many of the environments in which the agency works, it has specifically focused on areas where chronic poverty intersects with shocks and stresses to produce recurrent crises and undermine development gains. In those places, the framework recommends the increasing of adaptive capacity—the ability to respond quickly and effectively to new circumstances—and improving the ability to address and reduce risk. In this pursuit, it applies policy and program guidance, with the intention to increase adaptive capacity, the improve ability to address and reduce risk, and improve the social and economic conditions of vulnerable populations. The conceptual framework for resilience distills certain key components, which are intended to provide for a broad frame of reference to consider in the development of context-specific strategies. At its core is the idea that there is a likelihood of finding recurrent crises in places where chronic poverty and exposure to shocks and stresses intersect. Then efforts focus on building resilience in those areas, where there is often low capacity to manage shocks. The framework places a priority on five key areas: **preparedness, mitigation, prevention**, and protection.

This framework is better in its multidimensional consideration of the various resilience components; however, from the perspective of poverty reduction and sustainable development of households and communities, the area which appears to be relatively weak is the lack of dimension to create the capacity to transform, so as to ensure bouncing back better. It is when this dimension is successfully integrated that a given development path is sustainable, and progress is kept on the right trajectory under any circumstances including shocks and stresses arising from CC.

2.3.3 DFID Resilience Framework

Resilience building is an overarching priority of the international development program of the British government through DFID. The definitions of resilience by DFID (2011) share four common elements: context, disturbance, capacity, and reaction. Together, these elements form a resilience framework that can be used to examine different kinds of resilience and help determine the level of resilience that exists. The framework basically emphasizes the adaptive capacity dimension of resilience. Where it considers capacity is in the ability of the system or process to deal with the shock or stress based on the levels of exposure, the levels of sensitivity, and adaptive capacities. Here, sensitivity and adaptive capacity are determined by the pool of assets and resources that can be mobilized in the face of shocks and stresses. Such assets and resources can be *social, human, technological, physical, economic, financial, environmental, natural, and political.*

Generally, the framework has its foundation on a sustainable livelihood framework that directly targets vulnerability. The framework considers vulnerability as the flipside of resilience and considers all the necessary capacities to reduce sensitivity and exposure, on one hand, and improve adaptive capacity, on the other hand. It is apparent that the framework limits resilience to the definitional opposition of vulnerability, by excluding all other important dimensions of resilience.

2.3.4 EU Resilience Framework

The EU resilience building program in Ethiopia (RESET) is an innovative one, which is based on the premise that chronic humanitarian and longer term needs and recurrent food insecurity, mainly—but not only—caused by drought can be more efficiently addressed via a longer term resilience approach that links humanitarian and development actions, rather than via short-term, reactive, rapid response actions and disconnected development activities. The strategy consists of an integrated approach wherein different partners, working in close coordination, implement a multi-sectoral resilience program together with the local authorities in a defined geographic area. Areas are called clusters of districts and are selected on the basis of their repeated vulnerability. This concept is based on four cornerstones for building resilience: improving the provision of basic services (health, wash, nutrition, etc.); and support to livelihoods; safety nets; and disaster risk reduction. These pillars are complemented by other areas of support such as: natural resource management (NRM), sustainable land management, climate change adaptation, and social protection (EC 2014).

The resilience framework is basically designed to address chronic food insecurity by intervening in multiple sectors. The fact that it considers multiple sectors—health; water, sanitation and hygiene (WASH; nutrition; livelihoods; NRM; DRR; and more—makes it relevant to building resilience. However, the framework has no intentional focus on the "building back better" households' livelihood under CC-induced shocks and stress for poverty alleviation.

2.4 Indicators and Measurement of Resilience

2.4.1 Indicators of Resilience

In the path of sustainable development and to keep households on the trajectory of progress out of poverty, several global development actors, like Oxfam (2013), have long asked the question, "What does it mean to be resilient in a poverty-stricken context?" So far the literature (for example, Adger et al. 2005), answers the question as a household, community, or a system able to maintain its core functions in times of stress, shocks, disturbances, etc. This is where the notion of "bouncing back" comes from, but for a poverty-stricken household, should a return to the status quo be an achievement to be aspired to? The answer for so many is categorically "no." Of course, poverty is seen as antithetical to resilience. Consequently, building resilience in the context of sustainable development must, at least in significant part, involve reduction of poverty and inequality. In other words, livelihood strengthening should be an integral part of promoting resilience in such contexts in which households do not only bounce back, but rebound better, so as to be extricated out of poverty (Adger et al. 2005).

Hence, the idea of "bouncing back," is a pivotal dimension of resilience, from which a social perspective has been interpreted to mean returning to the previous state after a disturbance, yet the critique emphasizes that the previous state may not have been a good state to be in at all, and could be undesirable in the context of continuous and permanent CC (Adger 2005; Klein et al. 2003). Indeed, one of the biggest conceptual issues is how to go from surviving to thriving, which is in line with sustainable development and well-being goals for the future.

A few of the frameworks examined are built around the sustainable livelihoods approach, using the five livelihood capital/assets as entry points for resilience. Frankenberger et al. (2014) suggested that resilience programming should have the goal of positive livelihood outcomes rather than resilience per se. In their resilience-programming framework, they suggested that resilience outcomes could be measured by development indicators, such as food security, nutrition, and poverty.

Therefore, the capacity to bounce back better depends on a range of factors that include ecological condition, institutional capabilities, governance system, socioeconomic factors, and several dozen others. Indeed, it is reasonable to assume that households are likely to be able to successfully adjust to shocks, disturbances, and change when they are part of larger coordinated efforts at the community-level and beyond. The social and institutional capability dimension, in particular, is concerned with the effectiveness of formal and informal institutions in reducing risk, supporting positive adaptation, and ensuring equitable access to essential services in times of crisis. In the absence of this capability, we can assume that local and non-local duty bearers will be less effective in fulfilling their responsibilities in supporting community members to reduce risk and/or successfully adapt. Critically, how well women and men, at risk or suffering a shock, can claim their rights from these institutions, determines their resilience.

Thus, the indicators that ensure resilience are drivers from social, economic, political natural, physical, and psychological areas, the integration of which ensures better adaptability, reduction of vulnerability, and building back better under all kinds of circumstances.

2.4.2 Measuring Resilience Level

The measurement of resilience is a new and rapidly developing area of research and practice (Winderl 2014; Bahadur et al., 2015). However, Levine (2014) proposed that numerically measuring resilience is impractical, highlighting that resilience cannot be measured as a singular entity due to the different degrees of threat or risk to which people are exposed. A growing number of civil society and other organizations have developed and highlighted resilience indicators as key components of a successful measurement program. Interestingly, some believe that resilience and vulnerability cannot be directly observed or measured (Luers et al. 2003; Patt et al. 2008b; Hinkel 2011), and instead require the identification of measurable "proxies" to represent the various ways in which resilience manifests. These can be taken from data-driven field studies, or deduced from assumptions about social, environmental, economic, and political circumstances. However, basing proxies on assumptions means that if the rationale behind the assumptions is incorrect, the proxies will not portray resilience accurately. The assumptions may be based on generalizations about certain groups of people based on gender, age, ethnicity, or inferred implications about resilience from the proxies without any statistically proven relationship between the two (Rohrbach and Mazvimavi, 2006).

Notwithstanding the growing enthusiasm for promoting resilience, there is currently no agreement on how this construct is defined, let alone how it can be measured (Mayunga 2007). One reason why measuring concepts such as resilience and adaptive capacity is challenging is because we can only assess whether a system has successfully coped or adapted after the fact (Dodman et al. 2009). In other words, we have to wait until after the shock or change has taken place in order to assess the effectiveness of the intervention in question. The serendipitous convergence of these two ideas has given birth to an overwhelmingly large number of frameworks for the evaluation, assessment, and understanding of resilience (Schipper and Langston 2015).

Oxfam (2013) used a more thorough and technical treatment of the Alkire–Foster method and its use in the measurement of multidimensional poverty, which can be found in Alkire and Foster (2011). The method involves developing several composite indices based on a number of indicators that reflect various manifestations of the multidimensional construct of interest, for instance, poverty. The international Multidimensional Poverty Index (MPI), for instance, is based on 10 indicators that fall under three dimensions, as presented by Alkire and Santos (2010). However, one of the critical limitations with this method is that it arbitrarily assumes a certain cut off point, usually at 2/3, where those above are called resilient and those below are non-resilient. There has been no convincing logical argument as to why this cut-off point is made. Moreover, resilience is very difficult to have a clearly defined cut-off point, given that such points have to depend on the magnitude of shocks and stresses against the existing capacities.

Recently, a methodology was developed by Kathryn (2015) at the University of Buffalo Regional Institute using a composite of 12 indices. The method basically follows the computation of an index for each of the 12 factors, based on their variance from the central mean, and then compiles them into one index for each metropolitan for comparison purposes. The index comprises key variables of the metropolis like infrastructure, economic growth, regional demography, and connective and other variables. This method appears to be more relevant compared with the previous one, in the sense that it treats resilience as a relative rather than absolute measurement. Moreover, it makes room for the consideration of several variables into the analysis.

However, the method is basically for the metropolises of the most developed world and has not been contextualized to rural and developing countries. In addition, the consideration of the average value of the different factors, as opposed to such methods as the Principal Component Analysis (PCA), is another weak point. Finally, the indicator composition is less precise in taking the different dimensions when compared to the concept of resilience in the arena of poverty reduction and sustainable development.

Apart from those included in Table 1, several dozen other resilience measurement approaches have been developed by a range of institutions and individuals. All the frameworks have their own objectives, indicator sets, and approaches. Some of them included the Assessments of Impacts and Adaptation to Climate Change (AIACC) Sustainable livelihood approach for assessing community resilience to climate change, where resilience is captured by "measuring the improvement of quality of life without compromising livelihood options for others," alongside measuring the "capability of people to make sustainable living within system approach," and focuses on measuring community coping and adaptive capacities towards climatic variability and extremes.

Similarly, the work done by Action Research on Community Adaptation in Bangladesh is a monitoring and evaluation framework, which focuses on community-based adaptation projects, and as such, emphasizes adaptive capacity rather than resilience. The indicators also focus on transformed resilience through knowledge and capacity, and the strengthening of the long-term adaptive capacity of the climate-vulnerable poor. ARUP (2014) worked on cities' resilience, which is more used by Rockefeller Foundation. The indicators were based on four categories, 12 indicators and 48 sub indicators, observing assets, systems, behaviors, and practices. The aim is to provide "a holistic articulation of resilience which equates to the elements of a city's immune system."

Many more frameworks: Community Based Resilience Analysis (UNDP) (2014); Climate Resilience and Food Security: A framework for planning and monitoring (International

Institute for Sustainable Development;: Mayunga's Capital-based approach (Mayunga 2007); Feinstein International Center (2012); Tracking Adaptation Measurement Development (TAMD) resilience framework by UNISDR Disaster Resilience Scorecard for Cities (UNISDR 2014); Technical Assistance to NGOs are some notable examples. All of these works have made their own contributions within the development of methodology in resilience studies. That is to say, inasmuch as they add to the methodological complexities and confusion that one confronts in trying to find a clear path of measuring resilience; but they do have also their own stake in the progress made to study resilience broadly.

Table 1. Summary of the review approaches used for measuring resilience

Organizations and individuals	*Indicators used*	*Methodological approaches*	*Limitations*
Twigg (2009)	Hypothesized characteristics of the community, HHs, gov't, etc.	Characteristics Approach	▪ For any given context, we do not know for certain what these characteristics actually are.
Africa Climate Change Resilience Alliance (ACCRA) Oxfam GB (2013)	Considers different dimensions of resilience: Livelihood viability, innovation potential, contingency resource and case support, integrity of natural and built environment, social and institutional capability	Multidimensional approach using Alkire and Foster (2011) method	▪ Under the Alkire-Foster method, binary cut-offs are specified for each indicator, which involves, inevitably, a degree of arbitrariness in defining these cut-offs ▪ Characteristics included are subjective, less measurable which can cause measurement errors ▪ Difficulty of capturing district level with HH-level data, does not differentiate characteristics according to their level of importance
Schipper, and Langston (2015)	12 out 17 sets of indicators from group learning, flexibility; Options, Adaptation, and Integration	No clearly definition of methodology, but treats resilience separately for the different indicators	▪ Lacks comprehensiveness in measurement ▪ It does not include all the dimensions that compose resilience
Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED) (2015)	- Indicators of ability to anticipate, avoid, plan for, cope with, recover from, and adapt to climate-related shocks and stresses were compiled based on DFID (2014) - Indicators were meant to measure progress made in terms of resilience due to project intervention	Uses the comparison of indicators values for the pre- and post-intervention	▪ The framework does not address whether resilience addressed is individual or collective ▪ The "to what" (the relative nature of resilience is also not addressed) ▪ Indicator sets verge on being too general, containing too much "background" information that provides no or unrelated information about resilience ▪ Results are too general ▪ Indicators are only project-specific outcomes

Self-evaluation and Holistic Assessment of Climate Resilience of Farmers and Pastoralists (SHARP) (2015)	- Sector-specific indicators are used - 13 agriculture-related and agroecological-based resilience indicators developed by Oelofse (2012)	- Self-assessment by the farmer considering resilience as a process - Assumed to empower farmers to strengthen their own resilience through being able to measure their own progress	
Asian Cities Climate Change Resilience Network (**ACCCRN**) **(Tyler et al. (2014)**	- Constructed for local planning and monitoring changes in climate resilience in the urban context of the Network - As adaptation and resilience are not directly measurable, it used proxies - Indicators were developed for vulnerability, depending on specificity of city	- 152 indicators across 10 different sectors.	▪ **Complexities of the indicators used** ▪ **Bulkiness of the information brought into the measurement** ▪ **Different context must have their own specific indicators** ▪ **Resilience is not measured directly, but** emphasis on **vulnerability does not fully capture the entire spectrum of resilience**

Source: Compiled by authors 2016

3. METHODOLOGY

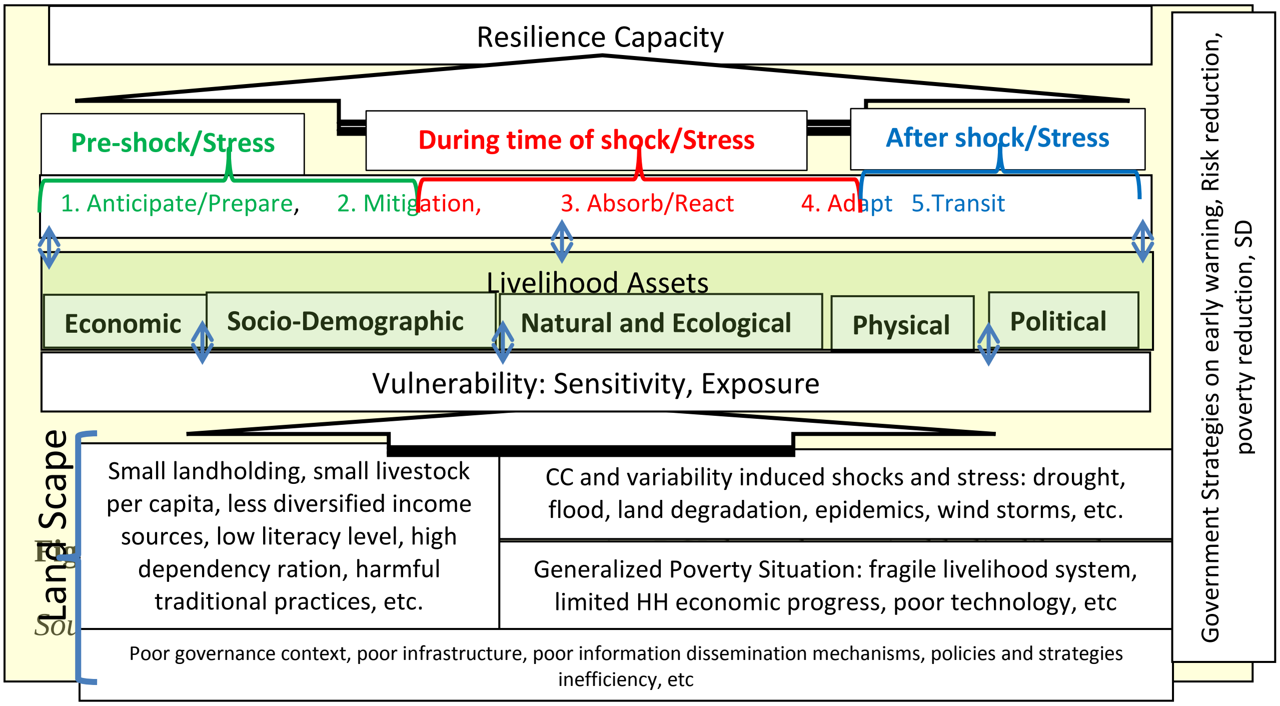
3.1. Data Source and Types

The data for the research was obtained from a survey of 453 farm households across the central part of Ethiopia. The households were selected from three distinct agro climatic zones, namely 15 percent from highland (>2500 m above sea level), 40 percent from midland (1500–2500 m above sea level) and 45 percent from lowland (500–1500 m above sea level). The areas get rainfall during both belg (February to April) and meher (June to September) seasons. The average annual rainfall of the areas ranges from 840 mm to 1600 mm while the mean annual temperature varies between 150C and 190C, depending the agro ecology.

A two-stage random sampling technique was used to select farm households from the respective agro climatic zones. At the first stage, three districts were selected randomly, and then each district was categorized into three agro climatic zones. In the second stage, a random sample was taken from each of the different agro climatic zones in proportion to their population size. A structured questionnaire was used to interview the household head. Data collected from the households include household demographic characteristics, economic activities, social actions and interactions, physical and environmental settings, institutional factors, and climate change-related factors. The data were collected a few years prior to the current incidences of the Horn of African crises, induced by El Niño in 2015. However, during 2015–16, the districts from where the data were sourced became highly vulnerable to the crises. In this regard, revisits were made to the study sites in June 2016, to undertake qualitative assessment using Focused Group Discussion (FGD), Key Informant Interview (KII) and physical observations, so as to triangulate the indicators and key dimensions of resilience against the prevailing reality on the ground. In addition, secondary data relevant for this analysis were obtained from the National Meteorological Service Agency (NMSA), Central Statistical Authority (CSA), and zonal and district agricultural offices.

3.2 Method of Analysis

3.2.1 Conceptual Framework and the Resilience Capacity Index and



The measurement of the resilient level for this study followed an approach that was recently developed by Kathryn (2015), at the University of Buffalo Regional Institute, which is called the Resilience Capacity Index (RCI), with some improvements in terms of measurement, contextualization, and inclusion of additional resilience dimensions. The Kathryn (2015) approach of a single statistic summarizing a region's score on equally weighted indicators appears to be less intuitive. Therefore, in this study Principal Component Analysis (PCA) was applied to attach relevant weight to the different indicators. PCA is frequently used in research that constructs indices for which there are no well-defined weights, such as asset-based indices used for the measurements of wealth across different social groups. The argument here is that, as with the asset-based indices for wealth comparison, there are no well-defined weights assigned to the resilience indices. Therefore, PCA generates the weights, based on the assumption that there is a common factor that explains the variance in the resilience indicators. Instinctively, the principal component of a set of variables is the linear index of all the variables that captures the largest amount of information common to all the variables. Accordingly, the component scores from the PCA measured the weighted sum of score for each of the variables.

As the study subjects are farm households in a rural setting, unlike the earlier study which used city-related variables, this study employs indicators that are common to the rural context. Consequently, 28 different types of indicators in 5 different dimensions of resilience were used in constructing the indices. Higher indicator scores (index) consistently correspond to more levels of resilient outcomes.

3.2.2 Defining the Resilience Indicator: Sustainable Development and Poverty Reduction

Conceptualization of the components of resilience has become a significant part of the "new" thinking about resilience, which is linked to promoting resilience as a development agenda, whereas, the ability and methods to measure resilience are contested. The review of literature as shown in Section 2 of this paper indeed revealed that what counts as an indicator of resilience has been defined and redefined in semi-chaotic fashion, depending on different interpretations of what the concept means, as well as how best to go about measuring it. Due to the need for context-specific, accurate, and reliable indicators based on available data, universal indicators cannot exist. Nevertheless, this review has found that universal principles of resilience are necessary to ensure that there is accountability and, above all, that it is truly resilience that is being measured. The irony, of course, is that both the use of indicators, as well as resilience as a concept, is still debated.

Even though the different sets of indicators or dimensions of resilience appear to be of significant importance on their own, given the diverse range of vulnerability angles to context-specific shocks and stresses, it was found to be necessary that the combination of the different dimensions make resilience more holistic. Hence, the analysis suggested that the combinations, accompanied by qualitative information on context, may provide a sense of direction (built or reduced resilience). In Ethiopia, even though the largest share of building resilience circles around livelihood and household well-being, existing evidence from literature suggests that resilience cannot be measured solely through indicators of improved livelihoods and well-being, but also with significant inclusion of information on the other community dimensions.

Underlying this is the important question of how many indicators are necessary to accurately tell a story of resilience. Furthermore, what can be done when no information is available for the most important indicators? These are major questions that need to be considered in the development of indices. Consequently, for the purpose of this paper, a sustainable livelihood framework's assets were taken into account, while defining indicators in terms of anticipative/ preparedness; reactive/absorptive; mitigative, adaptive, and transformative capacities of resilience. Similar literature such as the five characteristics of resilience (Aware, Diverse, Self-Regulating, Integrated, and Adaptive) of Rodin (2013) and Schipper and Langston (2015) is much closer to our framework, though slight differences exist.

According to Christophe et al. (2012), in the resilience spectrum, we move from absorptive resilience to adaptive resilience, and finally to transformative resilience, which underlines the important of extending the dimensions to the transformative level rather than limiting the dimensions to the adaptive level alone. Below are the key dimensions of resilience and their indicators used for the Ethiopian study to develop RCI for each HH and agro climatic zone (see Annex 1).

Anticipative and preparedness capacity: It is not merely knowing how to get out of an approaching disaster when necessary (that is, knowing evacuation instructions), but having a far more profound awareness of what risk actually implies and of attitudes toward risk within a community. Anticipation principally entails the capacity to identify potential hazards significantly ahead of time so that households and community members can take appropriate measures. This could involve a comprehensive knowledge of traditions and access to conventional early warning information systems, as well as comprehending information about how the circumstances are changing on social, ecological, political, and economic levels. Rodin (2013) indicated this to be learning capacity, which also includes the ability to share information with others and assess which sources of information are reliable and useful for the purposes of preparedness and recovery, in the context livelihood-threatening incidences. See, also, Gaillard et al. (2010).

Mitigation capacities: As part of the long-term development strategy and extrication of HHs from longstanding poverty situations, appropriate measures should be developed within the livelihood system of households, which would enable households to minimize the magnitude of impact of shocks or stress and protect them from further deterioration of the livelihood conditions. Such characteristics include physical conservation level of farmlands, proportion of land under vegetation cover, agroforestry practices, plot fertility and diversity, and more.

Absorptive/reactive capacity: The capacity to absorb and withstand livelihood-defining events is an important characteristic of resilience. It concerns the ability to withstand disruption without complete collapse, and the ability to return to a functioning state, as highlighted by the Resilience Alliance approach (Walker et al. 2006). More importantly, households do possess an ingredient capability for a large degree of self-regulation. This includes the capacity to call upon the existing social networks as a safety net or, for example, if there is significant shortage of food availability, the household should be able to sustain itself on what is available or adjust feeding habits and swiftly to alternative means of survival. Absorptive capacity also includes the need for sustainable livelihoods; reactions that may sometimes depend on institutional arrangements, family ties, reliance on already stored wealth, and key assets. This will enable the protection of livelihood from total collapse.

Adaptive: One of the unequivocally important characteristics needed for households to have, given the increasing incidences of shocks and stress emanating from climate change and variability, is the capacity to retune or adjust their livelihood operations to the changing context. This is about aligning the household's and the community's actions to the changing context. It is this acquired and inherent nature that allows for the capacity to build back better and maintain sustainability of development in the process of getting back on the trajectory of continued progress out of poverty after the shocks or stresses are over. Such characteristics, for example, could include adjusting the cropping calendar, growing rice in flooded areas, and more. The capacity to adapt significantly depends on literacy, past experience, risk/reduction knowledge, and access to financial assistance to meet cash constraints during time of shocks or stress.

Transformative: Even though several definitions of resilience capture transformative capacity, much of the recent work on measuring resilience from a multidimensional approach have not appropriately captured this characteristic. In essence, the indicators of transformative characteristics do not only make bouncing back to the path of progress out of poverty, but also ensure the existence of positive progress even during the time of shocks and stresses. This is about even changing threats to opportunities, including new asset acquisition during the crises, new opportunity grasped as an area of livelihood engagement, such as engaging new business activities, looking for a more productive system like getting farming under irrigation, taking up new technologies, and more. This paper attempts to bring such dimension into the measurement of resilience from the perspective of sustainable livelihood development.

All these factors are combined into an index that gives an overall quantitative "resilience score." The score clearly shows where investments need to be made to further build resilience. By using this quantitative approach, decision-makers can objectively target their actions and measure their results over time. The Resilience Capacity Index systematically compares resilience across regions, households, or even countries. The formula used to develop the index is given as follows:

$$R(j) = (\sum_{i,j=1}^{n}\left(\frac{a_{ij}-\bar{a}_{ij}}{\sigma}\right) * PC_{1i} + (\sum_{i,j=1}^{n}\left(\frac{b_{ij}-\bar{b}_{ij}}{\sigma}\right) * PC_{2i} + \ldots + \sum_{i,j=1}^{n}\left(\frac{e_{ij}-\bar{e}_{ij}}{\sigma}\right) * PC_{5i}) \ldots\ldots. (1)$$

$$R(j) = (\sum_{j=1,i=1}^{j=m,i=n} ANT_i + \sum_{j=1,i=1}^{j=m,i=n} REA_i + \sum_{j=1,i=1}^{j=m,i=n} MIT_i + \sum_{j=1,i=1}^{j=m,i=n} ADT_i + \sum_{j=1,i=1}^{j=m,i=n} TRA_i) \ldots. (2)$$

Where $R(j)$is the overall resilience capacity index for the j^{th} region or household, and ANT_i is the anticipative/preparedness index of the i^{th} region/household, REA_i is the reactive and absorptive index of the i^{th} region/household, MIT_i is the mitigation index of the i^{th} region/household, ADT_i is the adaptive index of the i^{th} region/household, and finally, TRA_i is the transformative index of the i^{th} region/household. PC_i are the principal components of the i^{th} indicator of resilience.

In the analysis, the model brings together ranges of variables. Hence, PCA is used to attach relative weight to the indices, following the works of Deressa, et al (2008); Madu (2012); and Tesso, et al (2012). Hence the weighted values indices for all the variables were obtained using the first principal component. PCA is frequently used in research that constructs indices for which there are no well-defined weights, such as asset-based indices used for the measurements of wealth across different social groups. The argument here is that, as with the asset-based indices for wealth comparison, there are no well-defined weights assigned to the different variables of resilience under the different dimensions. Therefore, PCA generated the weights, based on the assumption that there is a common factor that explains the variance in the resilience level. Instinctively, the first principal component of a set of variables is the linear index of all the variables that captures the largest amount of information common to all them. Accordingly, the first component scores from the PCA measured the weighted sum of the score of all variables. In this connection, the qualitative data for some of the variables were transformed to quantitative using the Likert-type scale with a value ranging from 0 to 1.

3.3 Determinants of Resilience: OLS and Censored Regression

The above diagram and measuring tools provide a framework for understanding the most effective combination of short- and long-term strategies for lifting families out of cycles of poverty and hunger promulgated by climate change-induced shocks and stress, through building resilience. It is based on the principle that the factors that make households more resilient and maintain them on the path of continuous progress out of poverty and food insecurity must first be understood, and then strengthened. Unlike some of the earlier frameworks which focused only on one side of the coin, this resilience framework looks at the root causes of household vulnerability, as well as predicts how well households will cope with future crises or disasters. However, given the fact that RCI is constructed using 28 indicators does not mean that all the indicators are equally important. Moreover, it would not be possible for a single entity to invest in all of them to bring about the desired level of resilience and ensure progress out of poverty. Hence, it is important to identify the most important and determining factor of resilience for programming purposes.

Now the resilience level as measured by RCI appears as a dependent variable. As the RCI puts the households on a range of the resilience index, the dependent variable ranges from positive values to extreme negative values, where positive values mean higher levels of resilience and the negative values mean relatively lower levels of resilience. In this way, the resilience to climate change-induced shocks and stresses was made continuous rather than discrete. In this connection, the OLS regression model for resilience to climate change impact is given as:

$$Y_i = x_i\beta + u_i\ ,\ \ u_i/\ x_i, c_i \sim N(0, \sigma^2),\ \ cov(u, c) = 0 \quad \text{……………………………………………….. (3)}$$

On the other hand, in order to identify the factors for a better level of resilience and ensure the robustness of the result, a censored regression model was also applied. Because a considerable number of the HHs did have a RCI of negative and zero values, the dependent variable can be censored. In such a data set, an appropriate alternative is censored regression. Censored models were originally developed to deal with corner solution outcome; however, they can be used to estimate models of both cases: censored and corner solution (Wooldridge 2009). Hence, by censoring the data at zero, the model specification for the regression can be given as:

$$Y_i = x_i\beta + u_i\ ,\ \ u_i/\ x_i, c_i \sim N(0, \sigma^2),\ \ cov(u, c) =\ 0 \quad \text{……………………………………………...(4)}$$

$$w_i = \max\,(y_i\,, c_i) \quad \text{..}(5)$$

$$P(W_i = C_i\,/X_i)\ = P(Y_i \geq\ C_i\,/X_i)$$

$$= P\big(U_i \geq C_i -\ X_i\beta\big) = 1 - \Phi[\left(C_i - \frac{X_i\beta}{\sigma}\right)] \text{..}(6)$$

The density of W_i given X_i and C_i is

$$f\big(W_i\,/C_i\,, X_i\big) = 1 - \Phi\left[\left(C_i - \frac{X_i\beta}{\sigma}\right)\right],\ w = C_i$$

$$= \left(\frac{1}{\sigma}\right)\emptyset,\ \left[\left(C_i - \frac{X_i\beta}{\sigma}\right)\right],\ w >\ C_i \text{..}(7)$$

The likelihood function of the censored model is

$$L\ (\ \beta,\ \sigma^2/X_i,\ C_i) = \prod_{w_i<C}\left(\frac{1}{\sigma}\right)\emptyset\,\frac{(w - x_i\beta)}{\sigma}\prod_{w_i\geq c}\Phi\,\frac{(w - x_i\beta)}{\sigma} \quad \text{..................................}(8)$$

where, X is the K vector of regressors, which included HH characteristics (age, sex, educational level), land size, labor, livestock ownership, extension services, credit services, income level, diversity of income sources, availability of perennial crops, market distances, number of relatives, farmer-to-farmer extension, irrigation, technology, crop diversification, and perception of CC) entered into the model, Y_i, the dependent variable, which in this case is the resilience level. β_s are parameters to be estimated and U_j is an HH-specific disturbance term. The analytical result of the censored regression model is presented in Annex 2.

4. FINDINGS

4.1 Trends of Climate Change-induced Shocks and Stresses

Data obtained from the central statistical authority (CSA 2007) for 10 consecutive years indicate that more than 3 million people were affected by the climate change-induced shocks and stress. During the same period, crops over an area of 460,894.5 hectares were damaged by flooding, insect outbreaks, hailstorms, alien weeds, disease and pests, and droughts, all of which were a result of climate change and variability. Out of the total annual crop damage 5, 3.38, 1.2, and 2.64 percent are attributed to flooding, hailstorms, insect outbreaks, and alien weeds, respectively.

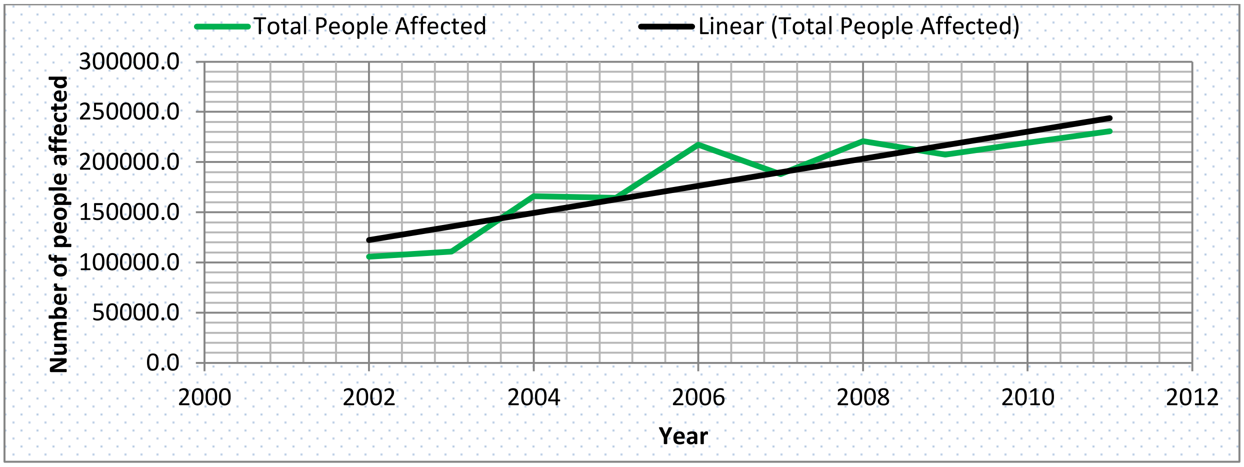


Figure 2. Trends of climate change induced shocks and stresses for the study area
Source: Computed from secondary data obtained from the zone office of agriculture

4.2 Magnitude, Impact, and Response to Climate Change-induced Shocks and Stresses

According to the IPCC (2007), individuals' or regions' vulnerability depends on their adaptive capacity, sensitivity, and exposure to changing climatic patterns. Unprepared farmers, due to low levels of anticipative capacity to climate variability and change, suffer to the level of losing their coping capacity. Witnessing to this fact, the situation of the study area showed the level of livelihood damage to natural events mounts to 75 percent at times. For instance, the study area was first in the nation in yellow rust outbreak that seriously affected the production of main enterprises during the year 2008, when farmers lost more than 50 percent of their production to drought and disease outbreak. The situation in the 2015 drought brought that loss to 90 percent in some areas (Chemonics, 2015). According to the data collected through household surveys, around 86.5 percent, 61.1 percent, 70.8 percent, and 58.2 percent of the households have suffered from crop damage, loss of access to food, loss of income sources, and damage to livestock production, respectively, due to the change in climate.

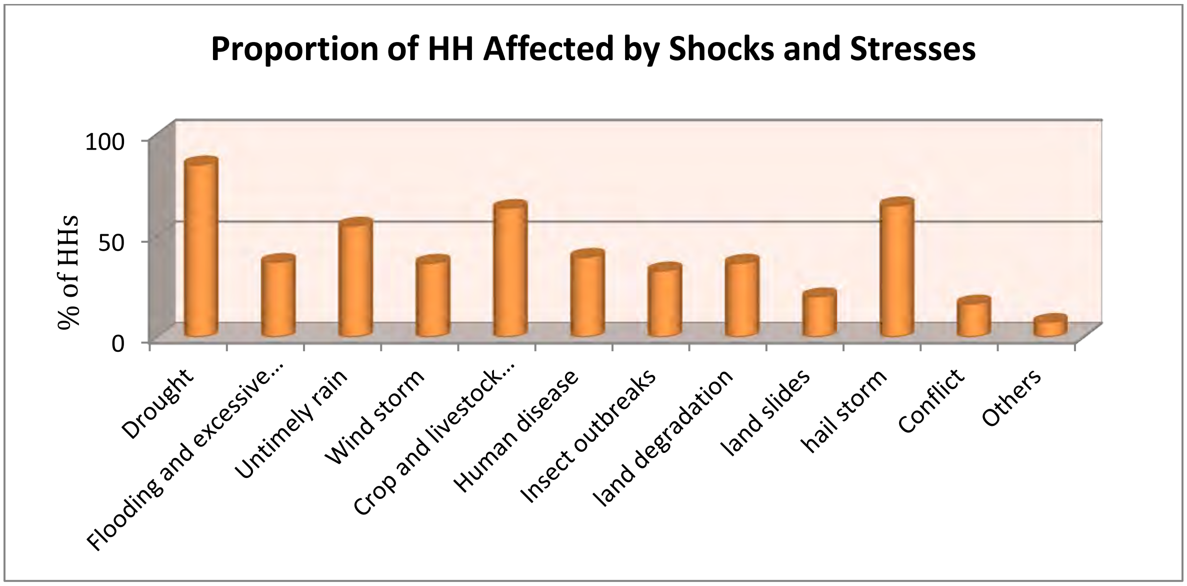


Figure 3. Proportion of HHs affected by climate change-induced shocks and stress
Source: Computed from secondary data obtained from CSA

The impacts of these climate change- and variability-induced shocks and stresses manifested in a variety of ways, including lives and livelihood losses. The biggest impact of the shocks was crop losses, losses of income, reduced access to food, deterioration of livestock health, and herd size losses. Extreme situations, such as death of people and livestock have also occurred, which completely challenged households' coping and adaptive capacities. This, in turn, led to the deterioration the poverty level of households and posed another level of challenges in breaking the vicious cycle.

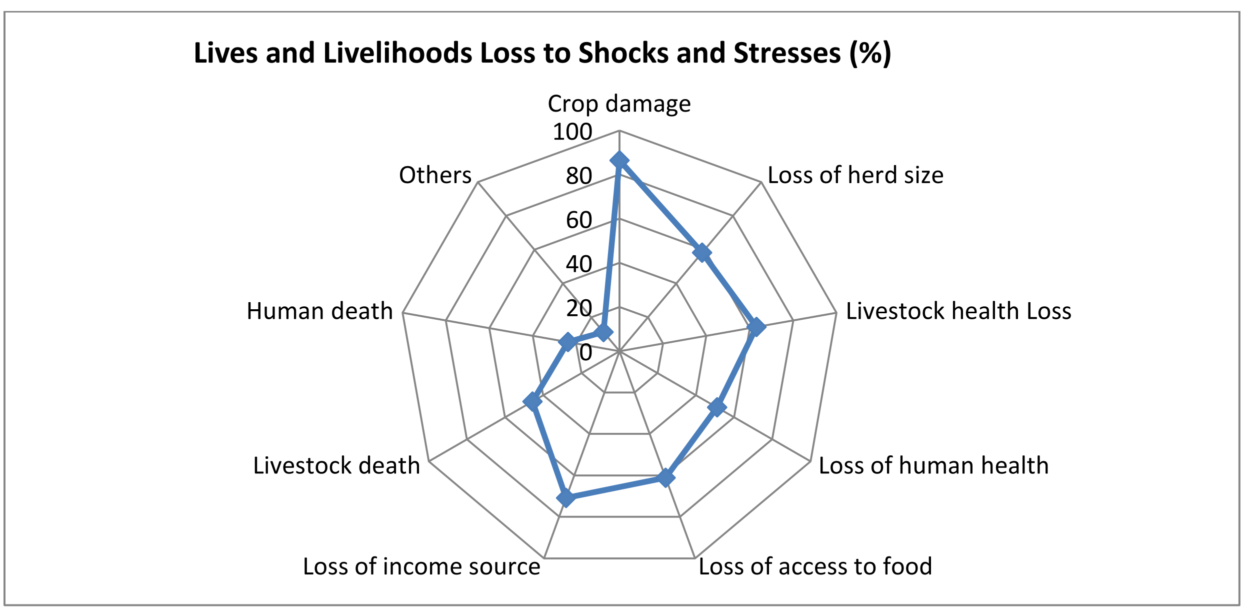


Figure 4. Impact of climate change-induced shocks and stresses on lives and livelihoods
Source: Computed from survey data

4.3 Measuring a Household's Resilience

4.3.1 HHs' Resilient Capacity Index

As described in the methodology section, the Resilience Capacity Index (RCI) summarizes the different dimensions of resilience into a single statistic describing a household's and agro ecology's status on factors hypothesized to influence the ability of a the HH or a given agro ecology to "bounce back better" from a future unknown stress. The index permits comparisons to be made of the 453 different households included in the survey as well as comparisons of the 3 different agro climatic zones from which the households were selected. The indicators were measured to achieve a consistent logic by which a high value signifies higher levels of resilience capacity.

Using z-scores to determine the probability that a household or agro climate will fall within a range of the mean, for example, within 1 standard deviation of the mean, is appropriate only for variables exhibiting a normal distribution, that is, a roughly symmetrical distribution of values above and below the mean. Because some RCI indicators have asymmetrical rather than normal distributions, it is not possible to calculate z-score probabilities (see Annex 3). Rather, Figure 5 presents the RCI distribution for all the households included in the survey.

The value of the RCI ranges from -7.18 to a maximum of 2.44. In this analysis, neither negative mean vulnerability nor positive mean resilience, rather the indices show the relative resilience level of one HH to the other. As apparent from Figure 5, even though the majority is concentrated at the mean, several households lie at the positive extremes, which indicates households with a better level of resilience, and others lie at the negative extreme with relatively lower levels of resilience to shocks and stresses. Such extreme cases are always important, as it suggests a unique mix of livelihood strategies, asset endowments, practices, and resilience dimensions. It is these households at the extreme ends that are programmatically important, to support those at the lower level based on the knowledge obtained from those at the higher end. Such learning, beyond the quantitative analysis, requires a thorough investigation of the conditions of those households by applying other qualitative approaches. This is done to answer the question of what are the peculiar characteristics of those households at both extremes ends that require either intervention or represent a model for intervention.

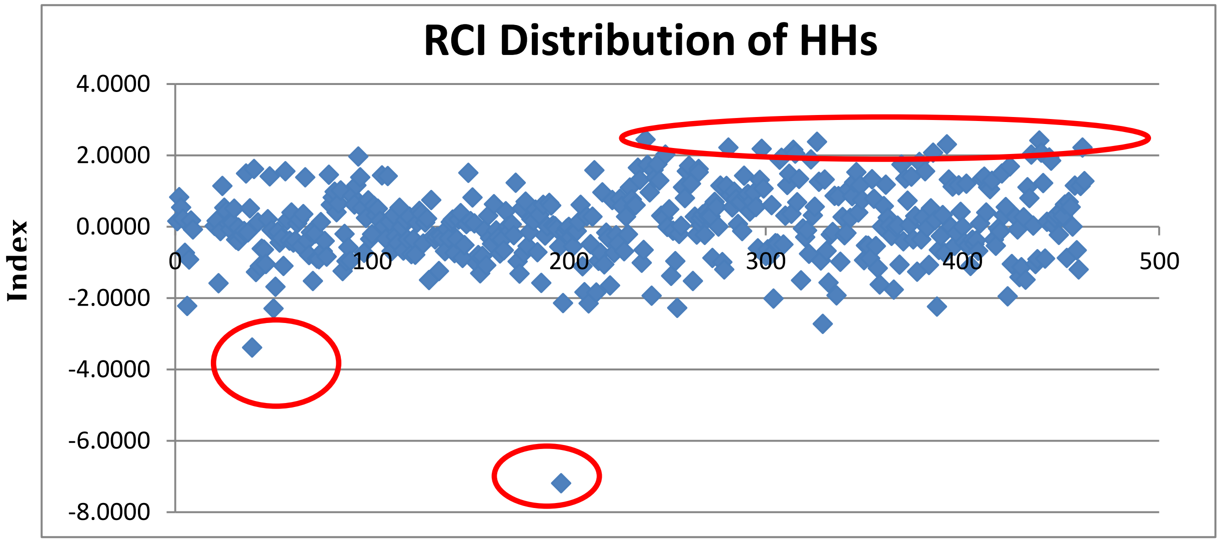


Figure 5. RCI distribution for the individual household
Source: Computed from survey data

The primary lesson from this result is that even if a HH lives in the same locality, under the same environmental constraints, and is exposed to the same types of shocks and stresses, its level of resilience can greatly differ. This means that, in addition to exposure to different external conditions, a HH's characteristics, resource endowments, practices, and other internal situations have significant importance in managing shocks, adapting, and transiting. HHs with better scores in the indicators of anticipative, reactive, mitigative, adaptive, and transformative capacities have higher values of the RCI, while those households with lower scores on these indicators have lower RCI values and appear at the negative extremes of the RCI score. Therefore, the improvement in the level of resilience is a function of all the resilience dimensions. Development programs that aim at poverty reduction and welfare improvement on a sustainable basis should mainstream these indicators into their programming.

The RCI score, however, answers only what made them better or worse, and somehow fails to give a detailed account of how the different internal characteristics interplay in building resilience. To understand the "how" requires an investigation of how the HHs managed their livelihoods, climate information, technology, and other actions—a participatory approach employed by revisiting those households for detailed analysis in June 2016, following the El Niño crises. The following box presents the qualitative analysis of the information obtained from HHs at both extremes of the resilience continuum.

Box 1: Qualitative Analysis

Following the 2015 El Niño crises, visits was made to the homes of those HHs having higher levels of resilience scores. The assessment regarding what made some of the HHs relatively more resilient, compared to the rest reveals the following: even though size of land ownership is important, during a period of extended drought, what is more important is not the size but rather the location of the farmlands in relation to homesteads. Those farmlands closer to the homestead tend to be protected against negative impact of human and livestock interferences and characterized by efficient utilization of scarce moisture. Land closer to homestead also enjoys manure, composting, and other organic fertilizers. Moreover, the coverage of trees over the lands, ownership of land in multiple agro climatic zones, the slope of the land, the nature of the soil, accessibility to swampy areas, and several other factors are important in enabling a farmland to play a critical role in a HH's resilience. Similarly, ownership of livestock becomes a negative factor when a drought season extends longer, since it results in water sources drying up and complete losses of pasture. In those circumstances, HHs with relatively larger amounts of livestock suffer the most, as they will not be able to feed, medicate, and take care of all their livestock. This results in thinly sharing of available feed and veterinary services, which ultimately results in the loss of too many livestock. In many cases, HHs tend to abandon donkeys, mules, and horses and focus on keeping their cattle alive during a serious drought period. In this regard, beyond number, the composition of livestock is found to be important in ensuring resilience. For instance, HHs owning small ruminants (especially, goats), camels, and poultry survive better, while HHs with cattle and other large ruminants suffer.

Also, during the type of wider, deeper and extended period of crisis, as experienced in 2015, the available local institutions become devastatingly weakened. It is not a surprise that during the visit, none of the local institutions were serving any purpose in supporting households to recover from the crises, except to provide for minimal support in the case of burial ceremonies. Hence, it is not merely the number of institutions engaged, but the type, quality, strength, and purpose of the institutions that are more important to determining the resilience levels of households.

4.3.2 Agro climate and RCI

Neither the making of comparisons for all of the 453 HHs surveyed, nor the derivative of policy action is easy if the analysis is to be made for each of the individual households. Thus, the alternative approach used is the analysis of resilience by agro climatic location. The HHs residing in each of the different zones differ in their natural, physical, socio demographic, livelihood activities, and economic characteristics. Therefore, HHs were classified into three categories, depending on their agro climatic zones. These include highland, midland, and lowland agro climates.

The geographic set of much of the study areas is mostly plains with some mountainous areas and the altitude ranging between 1300–2700 meters above sea level (CSA 2007). Figure 6 presents the RCI by agro climatic classification.

RCI by Resilience Dimension and Agroclimate

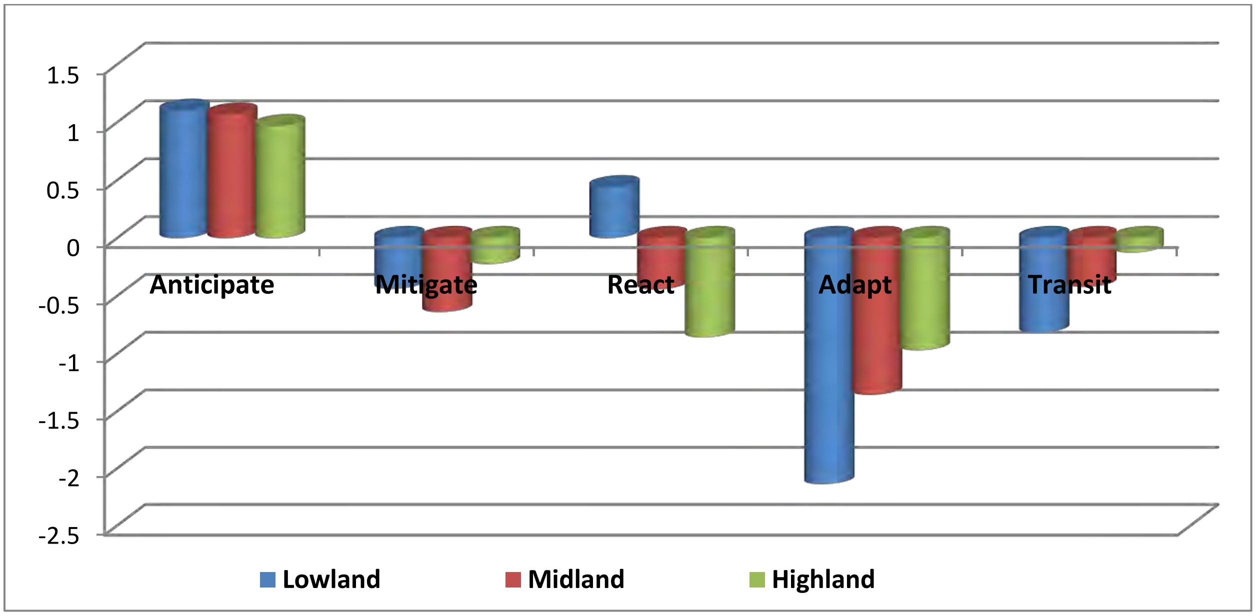


Figure 6. RCI by resilience dimensions and agro climatic zones
Source: Computed from HH survey data

The four dimensions of resilience have shown a clear pattern as one moves from a lowland agro climate to highland areas. The capacity to anticipate and preparedness is better in the lowland areas, followed by the midland, and then by highland areas. This can be evidenced by the fact that the lowland areas have already been experiencing extreme weather events and are more inured to operating under stressful situations. The midland and highland agro ecologies usually enjoy better rainfall distribution and moderate temperatures for operating their farms, whereas the lowland areas frequently suffer from rainfall variability, mounting temperatures, and insect infestations. Because of these experiences, the communities in the lower locations are relatively better in anticipating future shocks and stresses. Of course, among Ethiopian households residing in the lowland areas, there is usually a better knowledge of a traditional early warning system (EWS) and faster flow of climate information. This might have helped those households to have a better anticipative and preparedness capacity relative to those in the other climatic zones.

Similarly, the reactive or absorptive capacities of those households residing in the lowland agro climatic zone are better as compared to those in the midland and highland areas. This is because the farming systems and other livelihoods systems of the community members have developed the capacity to thrive through changing contexts and have stronger capacities and experience, which has enabled them to better absorb shocks and stresses. This is largely due to the fact that HHs owning relatively larger farm sizes with moderate slopes, high social networks with communal life and resource sharing, with more favorable amounts of livestock holding and wealth accumulation, are located in this zone. These resources and practices enable HHs to absorb shocks and stresses.

However, the highland agro ecologies showed the highest level of resilience index score in terms of mitigation, adaptation, and transformation, followed by the midlands and then the lowlands. This is due to a relatively better level of education among those surveyed, as well as relatively better access to extension services, access to credit, engagement in alternative livelihoods, access to better technology, access to water for irrigation and long years of agricultural experience. The values of the indices for these indicators decrease as one moves from the highland areas to the midland and then to the lowland areas.

4.3.3 RCI by Agro climatic Zones and Sustainable Livelihood Assets

Another alternative way of making comparisons among households in different agro climatic zones is the use of RCI for the assets of the sustainable livelihood framework. Especially, in a poverty reduction program, the use of an index for assets makes program intervention easier than the use of resilience dimensions. Based on the same survey data, Figure 7 clearly indicates that the lowland agro climatic zone is better, in terms of economic assets and some of the natural resources, to cope with stress and shocks. This is directly linked with the previously discussed finding that the households in the lowland areas are better endowed with larger sizes of farmland, better wealth levels, more livestock ownership, better fertility of land, and greater number of plots in diverse locations. Hence, further investment in these assets will ensure the productivity of the lowland and transformation of the farming systems to reduce food insecurity and poverty.

On the other hand, the highland is relatively more endowed with socio demographic and physical assets, followed by midland area. This is in line with the previously noted findings of the resilience dimensions, where the highland areas are better in terms of long years of experience, educational levels, access to extension services, access to credit services, as well as being more dominated by male-headed households, with married couples living together, greater access to DRR training, better institutional engagements, more access to irrigation, and a better level of land under vegetation cover to mitigate and adapt to recurring crises. Therefore, in order to ensure sustainable development and poverty reduction, development actors and government should provide tailored interventions to build upon these localized livelihood assets.

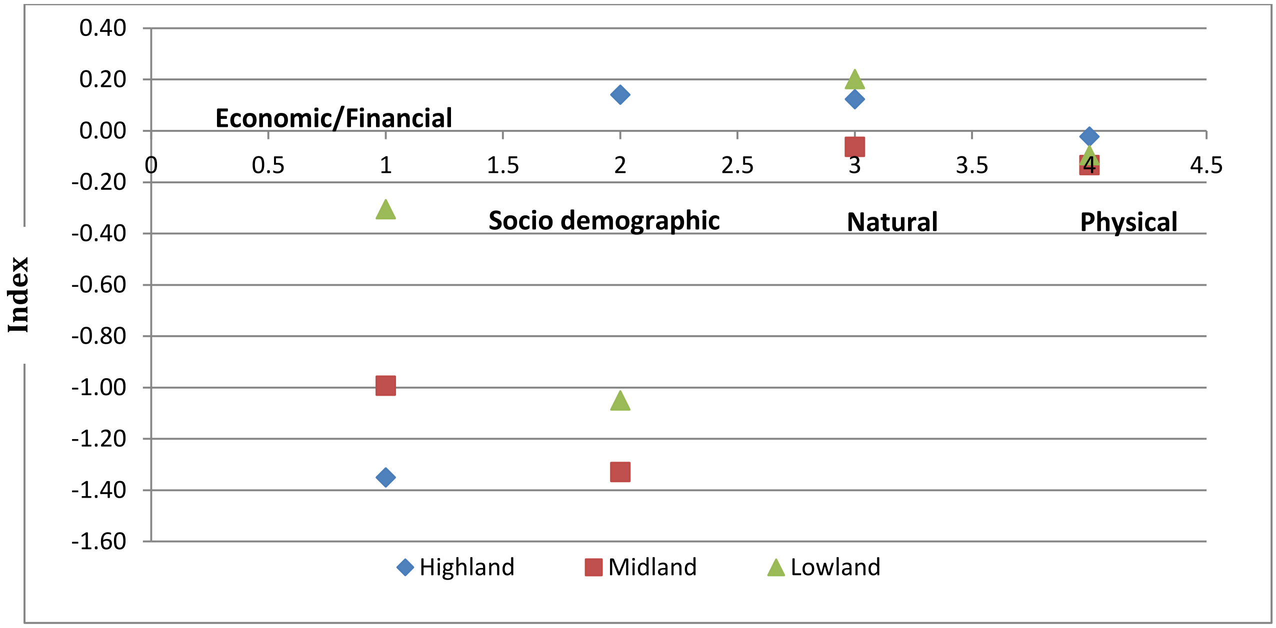


Figure 7. RCI by sustainable livelihood assets for the different agro climatic zones
Sources: Computed from HH survey data

4.4 Determinants of Resilience

It is noted that several factors affects the resilience level; however, it is important to identify the most important ones for interventional design to bring about the desired level of changes. The identification of the programmatically relevant variables will also enable the formulation of clear policy action in building the resilience of households and communities impacted by CC-induced shocks and stress. The RCI fails to do so. In countries where resources are relatively scarce and the scale of vulnerability is high, intervention to improve resilience to climate change must be directed at those factors with maximum impacts. In some instances, the factors cannot be treated separately. However, intervention may not be required for a given predictor if its assessment reveals that it is present at high levels; therefore, regression analysis is conducted using OLS and censored Tobit (Annex 2) to identify these factors. Both regression outcomes showed similar and comparable results, which indicate the robustness of the result.

In this connection, around 30 independent covariates were included in the regression model, of which 22 have shown a meaningful and significant relationship with resilience levels of households. Twelve of the 22 significant variables have shown statistical significance under all conventional probability levels. Table 2 presents the regression results of the OLS, while Annex 2 shows the regression results for the censored regression. The description of the model results is discussed as follows.

4.4.1 *Traditional and Conventional EWS*

The Ethiopian communities have developed rich sets of experiences and explanations relating to the environments they live in. These "knowledge systems" are today often referred to as traditional ecological knowledge or indigenous or local knowledge. In relation to the climate change-induced shocks and stress, traditional people have the depth of knowledge on how to interpret color of cloud, direction of wind, migration of birds, growth of aligned crops, reactions of animals to environment, and more. In the study area, the traditional early warning has profound importance on local livelihood decisions, as opposed to the conventional ones, as confirmed by the model results. Out of the several factors assumed to improve the anticipative capacity of community, access to traditional early warning systems has shown a significant relationship to level of resilience at all conventional probability levels for the aggregated data. Therefore, households having access to traditional EWS have 0.06 points higher likelihoods of becoming more resilient, as opposed to their counterparts who do not have access to information through the traditional EWS. For the disaggregated data, traditional early warnings appeared to be significant determinants of resilience for the lowland agro climate, with a regression coefficient of 0.2174, significant at 5 percent probability level. This result is similar to the statistical result found in the previous section, where access to traditional EWS is by far better in the lowland areas, as compared to the other agro climates.

On the other hand, throughout the study areas, access to conventional early warning information systems is very much limited. Moreover, the available system is less efficient in that it does not convey timely, predictive information to the farmers. The process involves the collection of information from development agents, which is then compiled at the level of peasant associations. The information from different peasant associations is then compiled at the district level. Information from several districts goes to the zone, then to the regional states, and finally to the federal disaster risk management office. The feedback with the interpretation and predicted scenarios follows the same length of channels before it reaches the ultimate beneficiary. Even though there is such breakdown in the system in accessing timely conventional early warning information, the variable remained a significant determinant of resilience at a 5 percent probability level for the highland, midland, and lowland, and with 0.474, 0.223, and 0.2103 regression coefficients, respectively.

4.4.2 *Physical Conservation, Coverage of Farmland by Trees, and Location of Farm Plots*

Factors used to mitigate the impact of climate change-induced shocks and stress are usually long term in nature. The impacts are observed over a period of time, and not just within one agricultural season, or even two. The solutions that emanate from a careful synthesis and integration of mitigation strategies go beyond mere agricultural production of smallholder farmers to broader sustainable development. Building resilience to climate change embodies a strong integration of mitigation measures for sustainable development. It is this underlying, quintessentially local capacity that underlies the rural livelihoods' sustainability under all conditions of climate change. Hence, strengthening resilience involves a conscious effort in the adoption and implementation of long-term mitigation practices that protect vulnerable people from losing income sources and ensuring the functioning of existing livelihood systems. To a certain extent, mitigation involves a broader application of measures as communities, agro climatic locations, or even countries attempt to control greenhouse gas emissions to stabilize climate change at an acceptable limit. Such interventions are beyond the capacity of households and community members.

At a household and community level, however, there are still practices that should be undertaken, including natural resource conservation, watershed treatments, coverage of land by forest trees, shifting of HH energy sources, the use of cut-and-carry feeding systems for livestock and development of alternatives for animal feeds, organic farming, optimizing the number of livestock held, use of crop rotation, reduced tillage, reduced biomass burning, and more. Some of these mitigation factors have been proposed by Danish Ministry of Climate, Energy and Building (2013). Based on this argument, three factors of mitigation measurement—including proportion of land under physical conservation, proportion of coverage of farmland by multi-purpose trees (agroforestry practices), and ownership of farm plots in different geographic locations—were found to be significant determinants of resilience level.

Accordingly, the proportion of land brought under physical soil and water conservation for the highland agro ecology was found to be statistically significant at all conventional probability levels with a regression coefficient of 0.938. This is due to the fact that in the highland areas, land is very scarce and the topography is one of undulating terrain. The population has already expanded farmlands into marginal, steeply sloping, and forested areas. The highland farming is thus highly vulnerable to soil erosion. Similarly, the amount of land under tree coverage (perennial trees and agroforestry) is a significant determinant of the resilience level for the highlands at all conventional probability levels, with coefficient of 0.716.

4.4.3 *Cultivated Land, Oxen Ownership, Marital Status, Institutional Participation and Family Size*

Absorptive capacity or persistence is strategy by which individuals and/or households moderate or buffer the impacts of shocks on their livelihoods and basic needs (Cutter et al. 2008). The elements can be seen as the core components of resilience. In much of the literature, absorptive capacity, which is the coping mechanism for responding to shocks and stress, is seen as one of the three structural elements (absorptive, adaptive, transformative) of the analytical framework aimed at understanding better what exactly "strengthening resilience" means (Christophe et al. 2012). Absorptive capacity leads to persistence in moving through the livelihood's defining moments while responding. However, when the absorptive capacity is exceeded, Cutter et al. (2008) indicated that individuals will then exercise their adaptive capacity for resilience.

In the analysis of the absorptive capacity for the Ethiopian farmers under study, several factors were included in the model. Wealth, measured in terms of the financial values of property owned, is found to be a significant determinant of resilience, with a coefficient of 0.277, significant at all conventional probability levels for the aggregate data. The size of cultivable land, which is the primary source of livelihood, is significant at all conventional probability levels for the highland, midland, and lowland zones, with regression coefficients of 0.151, 0.059, and 0.0267, respectively.

Based on the FGD conducted with HHs in the three agro climates during the second round of visits to the study site in June 2016, the number of oxen is found to be more important than amount of livestock. This is due to the fact that during extended periods of drought, livestock diseases occur and HHs having large amounts of livestock are more vulnerable, as compared to those with a small or optimal amount of livestock. For instance, during the day when the FGD was conducted in the Ada'a Nacho peasant association of the lowland agro climate, 4 out of 17 participants reported livestock death on the day the discussion was conducted. Most of the deaths were due to the new livestock disease outbreak and the deterioration livestock bodily conditions already, due to the lack of feed. Similarly, during such elongated period of crises, HHs tend to focus on the survival of cattle and other small ruminants, abandoning the other domestic animals. This exacerbates the loss of livestock for HHs with large herd sizes. Hence, the type of livestock is more important than the amount in terms of resilience building in response to environmental crises. Supporting this argument, the regression model indicated that number of oxen owned is significant at all conventional probability levels for both the midland and lowland zones, with regression coefficients of 0.1766 and 0.277, respectively.

While the sex of the HH head is only significant at a 10 percent probability level for the community members in the highland agro climate, marital status is significant only for the community members residing in the lowland agro climate at the 5 percent probability level, and participation in local institutions is significant only for the community members residing in the midland agro climate at the 5 percent probability level. On the other hand, the number of dependents in a household is a significant determinant of resilience at the 5 percent probability level for highland and lowland agro climates, with regression coefficients of 0.266 and 0.059, respectively.

4.4.4. *Literacy Level, Extension Service, Farming Experience, Access to Credit, and DRR/CCA Knowledge*

The most important pillar of resilience in climate change studies remains adaptation, which is unparalleled in comparison with the other dimensions. At the global level, the Field et al. (2012) recently reinforced this emerging prominence, pointing out: "Disaster risk management and adaptation to climate change focus on reducing vulnerability and increasing resilience to the potential adverse impacts of climate extremes." This adaptive resilience refers to the various adjustments (incremental changes) that people undergo in order to continue functioning without major qualitative changes in function or structural identity. For instance, the three preceding dimensions, discussed as anticipative, mitigative, and absorptive, describe the current state and build on what has been taking place in the past at the household or community level so as to be resilient, whereas adaptive capacity is the immediate actions or adjustments that one makes to overcome and sustain livelihoods. These actions involve incremental adjustments and changes that can take many forms (for example, adopting new farming techniques, changes in farming practices, diversifying of livelihood bases, and engaging in new social networks).

Out of several factors included in the model, literacy level, extension services, farming experience, access to credit, and disaster management/CCA knowledge are significant determinants of the level of resilience. With regard to the literacy level, significant percentages of the lowland area residents were illiterate, with 71 percent were unable to read and write. The regression result also indicated a coefficient of 0.036, which is significant at the 10 percent probability level. The same result was supported by the response from the FGD conducted in June 2016, wherein only 1 out of the 17 participants was able to read and write. On the other hand, during the FGD, the community members have indicated that there is sufficient agricultural extension service, especially in advising the HHs on farming systems. However, they have indicated that the tendency to put the advice into practice was low. This could be associated with the low literacy level and the fact that some of the extension technologies were in a package, which the HHs could not afford. In this connection, the model result showed that the factor was significant at 10 percent for the midland and at 1 percent for lowland areas, with regression coefficient of 0.058 and 0.1055, respectively.

While experience in terms of years of farming was a significant determinant for the highland agro climate with a coefficient of 0.008 at 5 percent, access to credit was significant for the midland agro climate with a coefficient of 0.356 at 10 percent. Access to awareness-raising meetings and training on DRR and CCA were found to be significant determinants for the highland agro climate (at 1 percent), midland agro climate (at 5 percent), and lowland agro climate (at 1 percent), with coefficients of 0.228, 0.0707, and 0.14, respectively.

4.4.5. Non-farm Engagement, New Technological, Small-scale Irrigation, Market-oriented Agriculture

In the simplified resilience frameworks of Christophe et al. (2012), transformative exercise appears to be one of the three strong pillars of building resilience to CC impacts. Unlike any of the other frameworks, the salient point of their framework is the fact that transformative action of resilience emerges as the most important guarantee for building back better during and after climatic shocks and stresses, as it ensures transformational responses.

In some contexts like that of the study area, where the frequency and magnitude of CC impacts are growing year after year, even though a needed change occurs, it still overwhelms the adaptive capacity of the household, community and/or ecosystem. Hence, in this case transformation will have to happen. Incremental changes are no longer sufficient to withstand the CC and ensure resilience. Instead, there is a need for transformative action, resulting in alterations in the individual's way of life or the community's primary structure and function.

Table 2. Regression result for determinants of resilience

Variables	*Aggregate*		*Highland*		*Midland*		*Lowland*	
	Coefficient	*Std. Error*	*Coefficient*	*Std. Error*	*Coefficient*	*Std. Error*	*Coefficient*	*Std. Error*
Lowland Agroclimate	-0.175*	0.089						
Sex			0.467*	0.267				
Wealth	0.185***	0.048					0.2715***	0.067
Educational level	0.029**	0.014					0.036*	0.0133
Marital status					0.294*	0.151		
Institutional participation	0.129***	0.030			0.2118***	0.0543	0.0623*	0.03
Size of land cultivated	0.041***	0.005	0.151***	0.0282	0.0529***	0.00834	0.0267***	0.0066
Number of farm plots	0.088***	0.018			0.112***	0.0251	0.0937***	0.02898
Area of land under perennial crops			0.716***	0.249				
Proportion of land under conservation	0.349***	0.093	0.938**	0.3639				
Proportion of land under improved tech	0.409***	0.080			0.364**	0.1343	0.386***	0.1003
Number of oxen	0.191***	0.033			0.1766***	0.0539	0.227***	0.0501
Area of land under irrigation			0.1369**	0.0642				
Frequency of agricultural extension contact	0.068***	0.018			0.058*	0.0339	0.1055***	0.0231
Years of agricultural experience	0.005**	0.002			0.008**	0.002767		
Access to credit			0.356*	0.109				
Market participation	0.255***	0.068			0.2062**	0.1026	0.337***	0.1096
Number of non-farm engagement					-0.134*	0.08		
Access to independent early warning	0.1456**	0.064					0.2174**	0.0878
Access to conventional early warning system	0.236***	0.065	0.474**	0.219	0.223**	0.1006	0.2103**	0.0932
Access to DRR training	0.14***	0.020	0.228***	0.0707	0.104**	0.0365	0.14***	0.0283
Savings							0.392*	0.1538
Dependency ration	-0.093***	0.025	-0.266**	0.0939			-0.095**	0.037
Constant	-2.573	0.168	-3.563***	0.534	-2.58***	0.26	-3.563***	
Prob > F	0		0.000		0.000		0.000	
R-squared	0.6725		0.787		0.725		0.725	
Adj R-squared	0.6515		0.686		0.673		0.673	

Sources: OLS regression output

These transformational changes often involve shifts in the nature of the system or introduction of new state variables and possibly the loss of others, such as when a household adopts a new direction in making a living or when a region moves from an agrarian to a resource extraction economy.

In general, transformative capacity of resilience is about the transformation of threats to opportunities. However, according to Brooks, Adger, and Kelly (2005), the transformation of threats to opportunity depends, to a great extent, on innovation. That is, the capacity to innovate is central to a way of building back better, for adaptive as well as transformative actions. In countries like Ethiopia, where traditional values and beliefs still have a paramount importance in community actions and interactions, these shifts may include a combination of technological innovations, institutional reforms, behavioral shifts, and cultural changes—which often involve questioning values, challenging assumptions, and capacity to closely examine fixed beliefs, identities, and stereotypes. In other words, they must challenge the status quo.

Engagement in too many nonfarm enterprises, each of which yield a lower level of return, was found to negatively affect the level of resilience for community members residing in the midland, with a regression coefficient of -0.134, significant at the 10 percent level. This is because taking up too many nonfarm enterprises consumes the available small capital, labor, and time of the HH, competing with agricultural activities. It thinly spreads the available meager resources and leads to inefficient allocation of resources. On the other hand, the proportion of farmland brought under modern technology utilization, such as improved seed—especially, drought-tolerant and early maturing ones—is the most important innovative approach in such recurrent drought-affected areas. The model result indicates that improved seed usage is a significant determinant of resilience for the midland and lowland areas, with regression coefficients of 0.364 (at 5 percent) and 0.386 (at 1 percent), respectively.

Another important transformative action for better resilient capacity is the intensity of engagement in market activities and the tendency to grow more market-oriented farm products. The more a household becomes market-oriented in their farming, the more it is profit driven; hence, specialization and innovation become the guiding principles. In this connection, the degree of commercialization, as measured by the proportion of farm product marketed over total product value was found to be significant determinant of resilience for the midland and lowland areas, with regression coefficients of 0.2062 (at 5 percent) and 0.337 (at 1 percent), respectively.

Finally, another very important transformative action is the shift from rainfed to irrigated crops. FGD participants during the June 2016 visit noted that after a series of consecutive rainfall failures, significant numbers of the community had organized themselves into groups and acquired water-pumping machines from the government on a loan basis for purposes of irrigation. Consequently, those HHs have started the production of potato, tomato, cabbage, and onion for consumption and for supplying of the extra to the local market. The regression result for the aggregate showed a significant relationship between areas brought under small-scale irrigation and the level of resilience, with coefficient of 0.137 significant at the 5 percent probability level.

5. CONCLUSION, LIMITATIONS, AND RECOMMENDATIONS

5.1 Conclusions

Many of the world's experts on resilience are feeling overwhelmed by the multitude of resilience frameworks that are emerging on a regular basis from a diversity of academics, researchers, development actors, and policymakers. The evolution of the depth and width of the growth in the area has added confusion, as many of them are developed in isolation, with few links to preceding frameworks. The fact that there are no standards and no agreement on even what resilience means has left the field "messy." This observation does not refer to variations in how the definition is worded or framed, but to the multitude of "principles," "qualities," "dimensions," and "characteristics" that go beyond a simple definition and aim to describe what resilience is about. Especially, for some, that have a pursuit of best practices to be employed in the sustainable management of agriculture to build smallholder farmers' resilience; it is complicated by the extent of the governance and institutional changes that must be considered. From a more practical perspective, the usual attempts made to measure the resilience of communities to climate change-induced shocks and stress in the arena of sustainable livelihoods, through quantitative measures, highlights the complex and historically intertwined relationship between vulnerability, adaptation, and resilience.

Moreover, the range of indicators that must be brought into the same weighting scale for measuring the resilience level of a particular subject of interest creates difficulties in so many ways. In the first place, the scale of the indicators are different—for instance, the measurement of the size of alternative means of income, governance issues, infrastructure, and several other indicators, whereby some are household-specific while others are specific to the regional level or even national level presents hurdles to defining an appropriate methodological approach. More simply, indicators themselves are, of course, problematic and bring their "baggage" with them to the resilience frameworks. Indicators are only able to indicate and do not to provide scientific "proof" or detailed explanations of change. That is why Choptiany et al. (2015) said that indicators can only provide insights into relative resilience.

However, based on this particular work for the measurement of resilience at household and agro climate levels in Ethiopia, certain important conclusions can be drawn. In the first place, measurement of resilience should be able to take into account all the necessary dimensions of resilience, which include anticipative/preparedness, mitigation, reactive/absorptive, adaptive and transformational actions. None of the early attempts to measure resilience has been performed this way. Therefore, this study can be considered a first attempt at measuring resilience following its conceptual definition. Second, all the necessary indicators of the different dimensions should be developed based on purpose, context and existing tools, if the measurement is to be comprehensively holistic. Even though some of the dimensions appear to be relevant and more important in some instances, all components must be valued equally. Third, appropriate methodology should be made in place to allow subjective and objective measurements to be complied into a defined measurement system. Finally, based on the framework, methodology, and tools used in the development and measurement of resilience levels, households residing in the same vicinity are shown to have different levels of resilience based on the varieties of their personal and external characteristics, as well as differences in various agro climatic. Hence, a combination of different approaches must be used to measure resilience, as shown above, by the use of resilience dimensions and a sustainable livelihoods approach. These ensure the robustness of the results obtained. Based on a different regression model applied, such as OLS or censored regression to the data used for this study, some of the different factors determining resilience level are the same across all agro climatic zones. Nevertheless, there are particular factors that uniquely determine the level of resilience for the different agro climates.

5.2 Limitations

An important outcome that in all the literature reviewed was found to be one of the biggest weaknesses of resilience frameworks is the challenge and complexity in the measurement process. Such complexities add other layers of challenges to designing and implementing appropriate interventions to build resilience. For the measurement of resilience levels for this study in Ethiopia, given the fact that 28 variables of the 5 dimensions included were of different measurement units during data collection, bringing them into standard index had multiple complexities. Moreover, the absence of a direct variable to measure resilience level is evidence of the need for bulk information to complete household-level or community-level analysis, which in turn makes more difficult the applicability of the framework developed for this paper, as well as others, to practically deliver resilience building for poverty reduction and sustainable development.

Given the realities of countries like Ethiopia, where the range of hazards and vulnerable conditions are varied across geographic and time scale, another hurdle for resilience measurement is that, first, it is a relative measurement and does not tell us exactly what level of intervention is needed for each level of resilience; and second, the resilience measurement takes into account only the capacities available and does consider the magnitude and distribution of hazard. This means that there should have been a specified level of resilience required for a given level of hazard. In other words, the calculated level of resilience does not tell you as to which hazard—droughts, floods or any other—that a particular level of index would enable you to be resilient.

5.3 Recommendation

The recommendations out of this study are the following:

- Development actors and policymakers should examine the contexts that include the types of shocks and stresses, the magnitudes of impact, communities' diverse capacity, and the existing natural and physical conditions of the geographic setting when performing resilience programming, and crafting strategies and policies;
- Interventions should be specific to individual HHs, community, and geographic areas. This is because even HHs residing in the same location are greatly different in their level of vulnerability, as well as resilience;
- A careful selection of an appropriate framework and intervention package for resilience must be made for a particular setting, as there has been no one-fits-all framework that has been developed;
- The resilience intervention package should be comprehensive in that it must focus on all the dimensions of resilience. It is the combination of those dimensions that ultimately brings the desired level of change, and not from a single dimension implemented in isolation;
- In all resilience programming, triangulation using various approaches ensures the preciseness and robustness of intervention package.

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APPENDICES

Annex 1. Resilience dimension and set of indicators for the study area

Key Resilience Dimension	*Set of Indicators*	*Key Resilience Dimension*	*Set of Indicators*
Anticipate/ Preparedness	Traditional EWS, conventional EWS, market information, climate change information (rainfall, temperature, etc.), climate information through extension systems, etc.	**Adaptive**	Literacy level, formal extension services, age of HH head, years of farming experience, access to credit during shocks and crises, DRR/CCA knowledge
Mitigation	Physical conservation, tree coverage, plots diversity and locations, land fertility, etc.	**Transformative**	Nonfarm (livelihood changes), access to irrigation, use of improved technologies (seeds, fertilizer), level of engagement in a market, etc.
Reactive/ Absorptive	Wealth, land, livestock ownership (oxen), gender, marital conditions, engagement in diverse local institutions, density of relatives in a community, etc.		

Annex 2. Censored Tobit regression result for determinants of resilience

Variables	*Regression Coefficient*	*Std. Error*
Highland	0.22**	0.096
Midland	0.139*	0.082
Wealth	0.126**	0.051
Literacy level	0.038**	0.015
Institutional participation	0.13***	0.033
Size of land cultivated	0.041***	0.0047
Diversity of farm plots	0.069***	0.0185
Land conservation level	0.282**	0.104
Proportion of land under improved technology	0.446***	0.079
Number of oxen	0.248***	0.036
Freq. agricultural extension contact	0.074***	0.02
Years of farming experience	0.004**	0.002
Access to credit	0.186**	0.0655
Market participation	0.289***	0.0797
Access to ind. EWS	0.271***	0.07
Access to conventional EWS	0.238**	0.0712
DRR/CCA knowledge	0.131***	0.021
Saving	0.854*	0.471
Dependency ration	-0.063**	0.027
Constant	-2.697***	0.216

Number of observations = 450	
209 left-censored observations at rcipca <=0	
241 uncensored observations	
0 right-censored observations	
LR chi2(27) = 441.09	
Prob > chi2 = 0.0000	
Log likelihood = -267.87751	
Pseudo R2 = 0.4515	

Sources: Model output
***,**, and * significance level at 1, 5 and 10 percent probability levels, respectively

Annex 3. Frequency distribution of RCI by households