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Building Resilience to Climate Change in Ethiopia

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1. Introduction

Climate induced hazards such as droughts, floods and rising temperatures pose a major threat to the livelihoods of the poor in Ethiopia. The country has experienced 15 drought episodes between 1965 and 2015, some of which resulted in substantial humanitarian crises. For example, the 1984-85 drought, which resulted in the worst famine in the country's history, took some 300,000 lives. During the period 1991-2008, Ethiopia lost a cumulative amount in the range of 13-40 percent of its current level of agricultural output due to climate change (Aragie, 2013). Furthermore, in 2015-2016 the country experienced one of worst El Niño-induced droughts in decades, with below-average rainfall leading to 50–90% harvest failure affecting more than 10.2 million people (on top of the 7.9 million people already covered under PSNP).[1] Ethiopia's drought history further indicates that vulnerability to drought is highest in the pastoral areas in the lowlands and in the densely populated, food-insecure areas in the highlands. Within the arid and semi-arid areas of the country, the regions of Afar, Somali, Tigray and low lands of Oromia, are among the most vulnerable to climate shocks, given low levels of service provision and infrastructure development, and the frequency of droughts and floods (Deressa et al., 2008).

Most of the global climate models project an increase in precipitation in both the dry and wet seasons in Ethiopia. On the other hand, studies with more detailed regional climate models indicate that the direction of the expected precipitation change is uncertain. The temperature is likely to continue to increase for the next few decades with the rate of change as observed. The impacts of the ongoing and projected climate change and variability are widespread in both socio-economic and natural systems. It is predicted that changes in climate will lead to recurrent droughts and heavy rainfall in different parts of Ethiopia, reducing the amount of land that can be used for agriculture and decreasing crop productivity. The economic impact of climate change depends on the extent of annual weather variability and extremes, but recent major droughts have reduced GDP by 1% - 4%. Future climate change could reduce Ethiopia's GDP by 8-10% in 2050 (Irish Aid, 2018) The government's Climate Resilience Strategy for Agriculture and Forestry indicates that under some extreme scenarios the impact of climate change on all sectors could reduce GDP by 10% or more by 2050 (FDRE, 2015). The potential decrease in GDP due to climate change could impact Ethiopia's ambition to reach middle-income status by 2025 and is likely to slow down poverty reduction. Mideksa (2009) also found that climate change will make the prospect of economic development in Ethiopia harder by reducing agricultural production and output in the sectors linked to agriculte, which is likely to reduce Ethiopia's GDP by about 10% from its benchmark level; and by raising the degree of income inequality in which the Gini-coefficient increases by 20%, which is likely to further decrease economic growth and fuel poverty.

The livelihood of the vast majority of the poor rely on the agricultural sector, which is highly vulnerable to recurrent climate related hazards. Agricultural outputs are projected to fall while agricultural commodity prices increase. As formal insurance schemes are largely absent in poor countries, and informal risk sharing mechanisms cannot be effective in the face of a covariate shock like drought, poor households are forced to resort to damaging coping strategies in the face of adverse climate shocks. Either they choose to deplete their productive assets to smooth consumption over time, or they let their current consumption level decline with the aim of

1 See USAID (2016).

smoothing assets and hence avoid future income fluctuations. However, as the former can put them in an asset poverty trap and the latter can lead to an erratic consumption path affecting their well-being, both strategies hurt households' resilience. This is even worse for households at the bottom of the income distribution, who are unlikely to have any significant assets, and in the face of a drought shock, are likely to instead disinvest in human capital. For example, in the 2015-2016 drought, households in the poorest quintile in drought-affected areas of Ethiopia were able to finance, on average, only a third of their minimum daily calorie intake on their own. Households were thus forced to use desperate coping mechanisms, for instance increasing their debts and restricting dietary diversity mainly to cereal consumption (GOE/Humanitarian Partners, 2016). Coping mechanisms such as these invariably lead to protracted vulnerability with lower resilience capacity as a consequence.

Taken together, the above is a clear manifestation of the country's vulnerability to the adverse effects of climate change. Thus, buffering the economy from severe climate shocks and building resilience to climate change induced shocks is an urgent matter for Ethiopia. It is with this sense of urgency that the government of Ethiopia is taking proactive action to address climate change concerns. The launch of the Climate Resilient and Green Economy Strategy (CRGE) in 2011, which includes improving resilience to climate change as one of its main objectives, is one clear indication in this regard.[2] The inclusion of CRGE as one of the cross cutting elements in the country's current growth and transformation plan (GTP II) also shows the government's commitment to address climate change related issues. The GTP II acknowledges that in the long-term, if climate change is not tackled, growth itself will be at risk. Another major step is the launch of the National Adaptation Plan (NAP-ETH) in 2017, which aims to mainstream climate change adaptation initiatives with ongoing development efforts including PSNP and SLMP. NAP-ETH also adds health and education sectors that are highly sensitive to climate change and yet not part of the CRGE priority sectors.[3]

Even if these efforts help in enhancing resilience capacities of rural households in recent years[4], current assessments show that Ethiopia's preparedness to increase resilience, as measured by the country's ability to leverage investments and convert them to adaptation actions, is still low. According to the 2017 ND-GAIN index, which summarizes a country's vulnerability to climate change and its readiness to improve resilience, Ethiopia ranks 163 out of 181 countries, is the 23rd most vulnerable country, and the 30th least ready country.[5] This accentuates the need for concrete action to reduce vulnerability and increase resilience in the face of adverse climate shocks. In terms of building resilience to climate change in Ethiopia, three pillars can be identified:

i) Actions taken at household level to enhance adaptive capacity, including choice of livelihood strategies, asset accumulation, adoption of new agricultural technologies, access to and use of weather forecasts and market information systems, crop choices etc.;

[2] There were also other government efforts before the adoption of CRGE in 2011, to adapt to adverse impacts of climate change. These include Ethiopia's Adaptation Plan of Action (NAPA) developed in 2007, regional and sectoral adaptation strategies and Ethiopia's Program of Adaptation to Climate Change (EPACC) developed in 2010/2011. (FDRE, 2019)

[3] The Intended Nationally Determined Contribution (INDC), which summarizes efforts to address vulnerability of livelihoods and landscapes to climate impacts is another measure taken by the government to address issues of climate change adaptation. Ethiopia submitted its INDC to United Nations Framework Convention on Climate Change (CNFCC) in 2015. FDRE(2019)

[4] For instance emerging evidence shows that the adverse effects of the most recent severe drought in the 2015/16 agricultural season were managed fairly well.

5 Notre Dame Global Adaption Initiative (2019), accessed on 30-08-2019.

ii) Supportive government programs including public safety nets and other government led climate smart initiatives like water and land management practices;

iii) Institutional factors including land tenure security, social networks and gender-based considerations.

Against this background, the main objective of this review paper is to assess the role that each of the above factors play in building resilience to climate change in Ethiopia, assess the evidence base in each case, and identify areas for further research.

The paper proceeds as follows: Section II presents and assesses the ongoing efforts in the literature to conceptualize, define and measure resilience, section III explores the potential role of different factors in building resilience to climate change in Ethiopia, documents the available empirical evidence in each case and identifies the knowledge gap. Section IV summarizes and gives some concluding remarks.

2. Resilience: Concept, Definition, and Measurement

There has been growing efforts to conceptualize, define and measure resilience, reawakening the interest of researchers, practitioners and policymakers to provide planning, prediction, and better targeting of interventions. This section first discusses concepts and definitions and then provides examples of measurements in practice.

2.1 Concepts and definitions

Resilience is typically considered as a capacity of a system to recover after shock to its pre-perturbed state (Folke et al, 2004; Alinovi et al., 2008; Smith et al., 2014; Barrett & Constas, 2014). A similar, albeit more elaborate formulation is used by the IPCC (2012), defining *resilience* as the ability of a system and its component parts to anticipate, absorb, accommodate or recover from the effects of a hazardous event in a timely and efficient manner. This approach considers both antecedent as well as post-event adaptive ability which allow the system to absorb impacts and cope with natural disasters and that helps the system to adjust and learn in response to the natural disasters.

Three types of resilience capacity are generally recognized: (1) absorptive capacity: the ability to minimize exposure to shocks and recover quickly when exposed; (2) adaptive capacity: the ability to make informed choices about alternative livelihood strategies based on changing conditions; and (3) transformative capacity: system-level enabling conditions, or lasting resilience (Smith and Frankenberger, 2017).

A system can refer to different levels of aggregation such as the individual, household, village, district, or country. It may also denote an entirely different entity such as the biosphere – including vegetation and bio-diversity. For the purpose of this study, two types of resilience - based on two systems - will be relevant to consider: socio-economic resilience, exemplified by households, villages, and districts, and vegetation resilience, exemplified by the conditions of plants at the level of plots or larger geographical areas. While the latter focus on supply-side availability of sufficient food to feed a growing population, with due emphasis on the role of shocks to production, the former emphasize the demand side of food security, to individuals' capacities to access food to feed themselves and utilization of foods through better nutrition, preparation, and feeding practices, and the stability of these conditions over time (FAO, 2008; Maxwell and Smith, 1992; Upton et al., 2016).

At a much more concrete and operational level, resilience as a development concept could refer to the capacity over time of a household to avoid poverty in the face of various shocks (Barrett and Constas 2014). This definition implies resilience is an outcome-based concept (such as food security/poverty), emphasizes long-lasting development consequences and explicitly requires agent's actual adoption of livelihood adaptation strategies to offset the negative impacts of a shock. The definition also considers resilience in terms of stochastic well-being dynamics. This definition implicitly considers both actions that reduce the risk of households falling below a certain level of well-being (ex-ante), and actions that help households cope after a crisis occurs (ex-post).

2.2 Measurement

From a practical measurement point of view, the fundamental issue in resilience measurement involves examining the relationship between shocks, capacities, responses, and current and future states of wellbeing. This implies that there is no single indicator that measures resilience. Moreover, because resilience is not directly measurable, most of the resilience analysis approaches make use of quantifiable proxies or indicators of resilience (Jones and Tanner 2015). Hence, measuring resilience is highly variable, based on the understanding and weight given to concepts such as absorptive, adaptive, and transformative capacity. Likewise the researcher has to consider the scale at which to undertake the measurement; households, villages, districts, or entirely different systems. The following sections will first outline some common measures of socio-economic resilience, and then provide a few examples of vegetation resilience.

2.2.1 Socioeconomic resilience

Socioeconomic resilience is the ability of a unit to sustain the impact of a shock in terms of socioeconomic outcomes. A core challenge in measuring socioeconomic resilience, is that it is not directly observable. Rather, it is a latent ability of an individual, household or community that can in principle only be approximated through comparisons of pre- and post-shock outcomes. Resilience is thus concerned with a counterfactual: is a household (or some other unit of analysis) able to resist a shock, then it is considered resilient. This poses some challenges to resilience researchers within development economics, as this in practice requires time series data for a household that is simultaneously shock-hit and non-shock hit. Panel data with comparable treatment and control groups can to some extent solve this problem, but is rarely readily available in a developing country setting. Further complicating things, most households may not be hit by a shock at all during the study period.[6]

To get around this hindrance, some researchers have suggested different iterations of resilience indices, based for instance on asset holdings, that can tell us something about the likelihood of households to experience a negative outcome as a consequence of being exposed to a shock.

[6] Unluckily for the researcher but rather more luckily for the subjects of the study.

For instance, the *Household Livelihood Resilience Approach* (HLRA), which builds on the sustainable livelihoods approach and its five capital assets, has been developed to measure resilience (Quandt, 2018). The approach is based on creating the composite asset index by averaging the individual indicator scores for each of the five livelihood capital assets for each household (Campbell et al., 2001; Erenstein et al., 2007). Another take on a resilience index, is FAO's *Resilience Index Measurement Analysis* (RIMA) approach (FAO, 2016). RIMA was developed to answer empirical questions such as: which households and what areas are most in need, which dimensions of resilience need to be supported, and to what extent policy actions have altered the resilience of target populations. RIMA is calculated by measuring resilience as a latent variable through some observable variables, identified through factor analysis. A third version of a resilience index can be found in Kusumastuti et al. (2014), which proposes a resilience index of a community, the *Individual Disaster Resilience Index*. The index is a composite indicator of the presumed relationship between community preparedness measures and the derivation of a community vulnerability score of the area. Other examples of resilience indices constructed using principal component analysis are Alinovi et al., (2010), Demeke and Tefera (2011), and Smith et al. (2015).

A risk with resilience indices, however, is that they might not be sufficiently independent from what they are measuring (Béné, 2013). For instance, if a researcher wants to use an index to evaluate the effect of an intervention aiming at increasing livelihood diversification, and simultaneously uses a resilience index of which livelihood diversification is a component to evaluate it, then any increase in livelihood diversification resulting from the intervention will mechanically translate into an increased resilience. Therefore, indices may not always be apt to answer empirical questions about resilience.

Panel data with a sufficient number of observations subject to similar shocks may be used to derive more independent indicators of resilience. Drawing on panel data, it is for instance possible to calculate the recovery time of a unit to bounce back to a previous state or a defined threshold, or to calculate the wealth or income loss incurred by the unit as a consequence of the shock. For instance, McPeak and Little (2017) uses panel data on pastoralists in southern Ethiopia and northern Kenya to calculate the recovery time after a drought of different subgroups within the pastoralist communities. Another example in the Ethiopian context is Vaitla et al. (2012), who uses a panel dataset from Tigray in northern Ethiopia to calculate the impact of a shock on a number of different assets, and estimating factors associated with resilience to the shock. Other studies drawing on panel data to estimate resilience in the Horn of Africa are Vollenweider (2015) and Barrett and Cissé (2016).

The choice of whether an index based approach or a panel data approach is most adequate depends largely on the data available.

2.2.2. Vegetation resilience

Another approach to measuring resilience is to measure the resilience of the vegetation as such. That is, instead of measuring how well households, villages or districts withstand a climatic shock in terms of sustained consumption or other socioeconomic parameters, this approach aims at measuring how well the vegetation in itself copes with the adverse weather conditions.

There are two principal ways of measuring the resilience of plants or vegetation. The first is to use remote sensing data to measure the resilience of the vegetation cover. A recent example of this approach in an Ethiopian context is Ali et al. (2018). In their study, they use satellite data on vegetation cover and soil moisture (specifically the Soil Adjusted Vegetation Index, SAVI, and the Land Surface Water Index, LSWI) as outcome variables, to measure the impact of an Ethiopian SLM (sustainable land management) intervention called the Tana Beles Integrated Water Resource Development (TBIWRD) project. The authors then compare the vegetation and soil moisture of the areas subject to the project, with those in their immediate surroundings. Assuming that, all things equal, the development of the vegetation and the soil moisture would have been similar in the treated and the surrounding areas, the authors subsequently employ a difference-in-difference specification to estimate the causal effect of the intervention.

The second way of measuring the resilience of plants or vegetation is to measure the agricultural resilience, that is, how well the crop yield stands in the face of a climatic shock. An example of this approach is Schmidt & Tadesse (2019). Similar to Ali et al. (2018) they also evaluate a SLM program aiming to increase the resilience of farmers against land degradation and erosion. As the outcome variable they use survey panel data on value of agricultural production collected in 2010 and 2014, and compare areas that were subject to the SLM interventions for various amounts of time to a comparison group.

Another study, specifically aiming at investigating the resilience of agricultural output in the face of droughts is Kosmowski (2018). The study aims at investigating the impact of the construction of terraces and contour bunds on the level of crop yield households were able to maintain during the 2015/2016 Ethiopian drought. The study utilizes remote sensing data on temperature and rainfall to estimate drought exposure, and then, drawing on national survey data, compare households that used terraces and contour bunds with households that did not, using propensity score matching. The results indicate that treated plots gave 9.5% and 7% higher yields during the period, for terraced plots and plots with contour bunds respectively.

As in all the three examples mentioned above, vegetation, plant or agricultural resilience in an Ethiopian context has mostly been measured in relation to evaluating the impact of different sustainable land management (SLM) interventions. Other examples of research along this line are Schmidt & Tadesse (2013), Pender & Gebremedhin (2006), Kassie et al. (2007), and Araya et al. (2012).

3. Building Resilience in the context of Ethiopia

In recent years, Ethiopia has witnessed major progress in poverty reduction and improvement in resilience capacities following ongoing efforts to adapt to adverse climate shocks. Despite this, a high degree of vulnerability to climate induced shocks continue to be the distinguishing features of rural livelihoods in Ethiopia. Given that building resilience to climate change is a multi-dimensional process and that it is a function of different capacities, it is crucial to understand how each capacity is influenced by different factors. This in turn helps us to draw some lessons from recent success stories and identify 'what works best' in the context of Ethiopia. In particular, the degree of resilience both at household and community levels depends not only on the severity and frequency of the shock but also on the absorptive, adaptive and transformative capacities of the unit in question. Our aim in this section is, therefore, to show how these different resilience capacities are influenced by different actors at different levels and to document the existing evidence in the area. While section 3.1 discusses choices related to households and/or their members including short term coping strategies and livelihood changing activities, which respectively influence absorptive and adaptive capacities, sections 3.2 and 3.3 respectively focus on supportive government programmes and institutional factors, which by and large determine transformative capacity.

3.1. Building Resilience to Climate Change in Ethiopia: Actions at the household level

In the face of adverse climate induced shocks, households resort to different strategies to avoid shortfalls in consumption. This response depends on the severity and frequency of the shock, households' current socio-economic status and alternative options available at their disposal including own saving and informal risk sharing mechanisms such as borrowing. In this sub-section, we aim to show how resilience to climate change is understood in the context of Ethiopia by exploring the different strategies that rural households use to deal with adverse climatic shocks. To this end, we broadly categorize actions taken at household level into coping mechanisms and long-term adaptation strategies. Having discussed how the different choices under each category matter for building resilience to climate change, we assess the available evidence and identify gaps for further research.

Household coping strategies and resilience capacity

In countries like Ethiopia where access to rural credit and formal insurance schemes are often lacking, self-insurance through saving and informal risk sharing mechanisms are among the most common coping strategies that households use in the face of adverse shocks. Both of these strategies need ex-ante actions, mainly building up precautionary saving and forming informal networks (Dercon, 2002). In the event of a shock, households with better savings or social capital will be able to more easily smooth their consumption. On the other hand, those that do not have enough savings or social network will be forced to rely on last-resort negative coping strategies such as selling off productive assets. Such irreversible coping strategies, however, tend to have high opportunity cost and result in a much lower rate of recovery, consequently leading to lower resilience capacity in the future. In general, selling off productive assets such as livestock, renting out farm land for longer period, selling coffee at its lowering stage, cutting trees, etc. have long lasting negative effects and could force households into a poverty trap. For instance, during the 2015/16 drought, many farm households in Kombolcha area of the Amhara region in Ethiopia "resorted to the undesired sale of livestock (particularly cattle and small ruminants), and cutting of trees for firewood. Some used their savings to meet basic family requirements such as food and low-income households temporarily migrated to nearby towns to earn wages" (Singh et al., 2016, p.8). This was mainly due to lack of income and savings, which in turn was partly caused by subsistence livelihoods and lack of access to financial services (Singh et al., 2016).

Most of the traditional coping strategies adopted by Ethiopian farmers, particularly those associated with a wider range of shocks, provide only a partial insurance mechanism (Mogues, 2011), tend to be very localized, and are limited in scope (Dercon, 2009) implying that resilience strategies of farm households differ across geographic locations. In particular, the diversity of the agro-climatic zones means that the degree of vulnerability and resilience capacity varies across the different parts of the country; calling for a context specific approach to building resilience. Tesso et al. (2012) for instance, find farmers living in the highland areas of the North Shewa zone of the Oromia regional state to be less resilient compared to those living in the midland and lowland areas. When disaggregated by location, households residing in the highland areas on average take 3.7 years, while those residing in the midland and the lowland areas, respectively, take 3 years and less than 1.5 years to fully bounce back from impacts of adverse climatic shocks. In the specific setting of the Tesso et al. (2012) study, farmers living in the highland areas are relatively more vulnerable to the risks of climate change as compared to lowlanders. According to these authors this is mainly because of the steep sloping topography of farmlands, frequency of natural shocks, low experience of highlanders to adopt to climate change impacts and degradation of farmlands to erosion. On the other hand, the lowland is less vulnerable because of better experience of operating agricultural activities under stressful conditions, moderate slope of farm lands, relatively bigger size of farm land with optimal number of farm plots, better access to credit, better fertility level of farmlands, better adaptation to changing climatic conditions and relatively better access to early warning information. This difference in vulnerability requires a heterogeneous approach to building resilience to climate change in highlands and low lands.

Similarly, the pastoral and agro-pastoral production systems in Ethiopia are getting more vulnerable to climate change and less able to support the basic needs of people living in the area, due to substantive changes to the socio-economic, and ecological environment over the past two to three decades. Although the climatic conditions and hardships are roughly similar in most pastoral areas, the people inhabiting these areas differ in their socio-cultural traditions, herd compositions, coping strategies and in the degree of their integration into the market economy (World Bank, 2003). This area is in general affected by frequent droughts and natural resource (water and grazing land) based conflicts, because of the growing scarcity and lack of innovation (Kassa Belay, et al, 2005).

In terms of resilience, pastoral and agro pastoral communities have centuries old coping or adaptive strategies that include livestock and cereal exchanges, herd diversification, herd splitting, eating wild fruits and leaves of trees and herbs; mortgaging and sales of assets; distress migration; borrowing; clan interdependence, income generation from diverse economic activities, use of resources not normally exploited such as felling trees for charcoal (Kassa Belay, et al, 2005) are some of the actions used for reducing negative effects of climate shocks. Coping strategies of the lowland communities (pastoral and agro-pastoral areas) have, however, been changing over time. The growing restricted mobility, due to sporadic internal and external political unrest as well as dwindling resource base, led to the concentration of herds in certain areas and to localized range degradation. Thus, understanding the dynamics of coping strategies and resilience to climate change remains one of the key issues for further study.

Adaptation strategies for building resilience to climate change

Household-level resilience to climatic shocks and stressors is also to a large degree determined by the adaptive capacity. Households with greater adaptive capacity exhibit greater resilience, while those with low levels of adaptive capacity exhibit a slow or no recovery. This capacity in turn, depends on the level of income, savings, social capital, and availability of water and feed for livestock (Vollenweider, 2015). Some of the key actions that can help households build adaptive capacity and hence resilience to impacts of climate change include: (i) Maintaining optimal/the required number of productive assets, (ii) having better access to irrigation, (iii) investing on farmland, (iii) improving soil fertility through usage of organic inputs, (iv) use of improved production technologies and practices, (v) planting drought resistant varieties, (vi) diversifying income sources, (vii) building a stronger saving culture and social capital, and (viii) local institutional supports. For example, for farmers living in the central highlands of Ethiopia, access to and use of livelihood resources such as farmlands and livestock holdings, diversity of income sources, infrastructure, ecological stability and social capital are the main determinants of resilience through adaptive capacity (Asmamaw et al., 2019). According to these authors having one more enterprise than the normal livelihood system was found to increase the probability of recovery from shocks by 14 percent, while households with more livestock were likely to be more resilient to climate change induced shocks. In terms of capacity, absorptive capacity was found to be the leading contributing factor to resilience followed by adaptive and transformative capacities. This implies the need for strengthening both the adaptive (adjustment strategies) and transformative (system-level change) capacities of households through early warning system, social protection, climate change information, etc. to prepare, anticipate and cope with impacts of adverse shocks and to ensure long-term resilience.

The literature has identified adoption of climate-smart practices such as agro-forestry, soil conservation, manure and agricultural water management systems as important adaptation strategies for smallholder farming systems in high rainfall variability areas (Thorlakson, 2011; Schoeneberger et al., 2012; and Arslan et al., 2013; and Teklewold et al., 2019). Agro-forestry, for instance, is a strategy that combines trees with agricultural crops or livestock and it enhances farmers' ability to adapt to climate change because of the multiple benefits it delivers, including food provision, supplementary income and environmental services. Integrating trees and shrubs into food crop farming systems helps address food insecurity, increases $CO2$ sequestration, and reduces the vulnerability of agricultural systems, which enhance the resilience of smallholders to current and future climate risks (Teklewold et al., 2019).

Crop switching is also considered as one of the key adaptation strategies identified in prior studies (eg. Maddison, 2007; Bryan et al., 2009; Gbetibouo, 2009; Deressa et al., 2009). However, if such switching decisions are not defined narrowly it could be misleading as crop abandoning could be either associated with climate change or motivated primarily by price changes. For instance, farmers who were affected by the 2015-16 drought and rainfall variability, moved away from cereal crops production towards extensive 'chat' farming in some zones of the Amhara region (Singh et al., 2016). One reason for this could be that cereal crops cannot tolerate as much change in soil moisture conditions as 'chat'. The other possible reason is that 'chat' has attractive markets and can be used as good source of income. Farmers living in Kolla (lowland) and Weynadega (middle land) areas of Semien Shewa zone of Ethiopia also switched away from crops such as maize and fava bean primarily due to climate change, and a large majority of them have adopted mung bean for which price is the main driver followed by climate change (Tessema et al., 2018). This demonstrates the importance of opportunities, in this case a favourable price, in adapting to risks.

In sum, the different actions taken at household level are important in building resilience to climate change in rural Ethiopia. Even if short term coping strategies appear to help households in enhancing their absorptive capacity, this is unlikely to bring sustainable solutions to building resilience. This is because such strategies involve dissaving/de-cumulating own assets or borrowing from others, both of which exposes households to future vulnerability. The long-term adaptation strategies, on the other hand, constitute the most important aspect of resilience building at household level in rural Ethiopia. These strategies, which help to enhance adaptive capacity, involve investment on livelihood enhancing activities that are needed to ensure household resilience in a more sustainable way, and deserve due consideration from policy makers.

In terms of the knowledge gap, even if the existing empirical work on shocks and household coping/adaptation strategies can give us a useful insight for analysis of resilience, they can at best be taken as indirect evidence. Further empirical work is thus needed to get a deeper understanding of how actions taken at the household level interact with building resilience capacity. This is particularly important for adaptation strategies. In relation to this, it is also important to assess the role of household characteristics, including gender, on adoption of various resilience enhancing adaptation strategies. Moreover, as the degree of vulnerability of different agro-climatic zones to climate induced shocks varies, so does resilience enhancing strategies. It is therefore important to conduct a more disaggregated analysis, so as to design a context specific approach to resilience building in the face of adverse shocks.

3.2. Supportive government interventions and Resilience

Cognizant of the potential adverse impacts of climate change on sustainable development, the issue of climate change has become a top priority in government development agendas. The CRGE vision and strategy was designed with the aim of countering the adverse impacts of climate change and Ethiopia becoming a climate resilient middle-income economy by 2025 (FDRE, 2011). The government is making various efforts towards achieving the objectives of the CRGE. Some of these efforts are directly linked to the CRGE vision and are particularly designed to tackle climate change issues. In other instances, the government makes large-scale supportive interventions that in one way or another contribute to the country's effort in building resilience to climate change. Even if these programmes do not have climate change issues as their main area of focus, they include components that can enhance the adaptive capacities of households to climate change in the future.

The main objective of this section is thus to discuss the potential role of supportive government programmes towards building resilience to climate change in Ethiopia, and to document the available evidence in this regard. This is done with a particular focus on the Ethiopian Productive Safety Net Program (PSNP) and the Sustainable Land Management Program (SLMP).

3.2.1. The Ethiopian Productive Safety Net Program (PSNP)

In recent years, there is growing consensus in the literature that the role of social protection programmes should take climate change issues into account as climate induced shocks are likely to erode the poverty reduction gains achieved through such programmes.[7] In the last decade, the literature has coined the concept of 'adaptive social protection' – which is a mechanism to integrate climate change adaptation and disaster risk reduction in the design and implementation of social protection programmes (Davies et al, 2009).[8] Following this, a growing body of work is recognizing the role of social protection programmes in reducing vulnerability to climate induced shocks and stresses, and hence in building resilience (see Ulrichs, Slater and Costella (2019), Godfrey-Wood (2011), Kurikose (2012, 2013) and the papers cited therein). Thus, as currently conceptualized in the literature, social protection programmes have the potential to strengthen resilience to climate change, enhance adaptive capacity and hence reduce vulnerability of the poor to future shocks and stressors.

In a similar manner, social protection in Ethiopia has been identified as one policy tool to protect peoples' livelihoods from the impacts of adverse shocks, and a key pillar in the climate change and disaster risk management strategies. Accordingly, the government started the Ethiopian PSNP in 2005 with the aim of bringing sustainable solution to chronic food insecurity problems. The main objective of the PSNP is to smooth household consumption through predictable transfers to the poor and chronically food insecure households. For households with able-bodied members this transfer is given conditional on participating on labour-intensive public works.[9] The PSNP thus aims to prevent asset depletion at the household level while building community assets via public works activities.

The four different phases of the PSNP clearly show how the role of the PSNP has been changing over the years to accommodate issues of building resilience to climate change. In phase 1 (2005-2010), the PSNP's role was by and large restricted to a safety net function focusing on a timely provision of transfers to help households graduate from food insecurity. In phase 2 (2010-2015), the scope of the PSNP widened to include not only absorptive capacity but also anticipatory and adaptive capacity. The latter was made possible through the launch of the Household Asset Building Program (HABP) and the Risk Financing Mechanism (RFM) that are designed to enable poor households and communities better cope with transitory shocks. In Phase 3 (2015-2020), climate change considerations including building resilience to climate change through climate change adaptation and mitigation continue to be the focus of the PSNP (Ulrichs and Slater, 2016).

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[7] See for example Devereux and Sabates-Wheeler (2004).

[8] For related discussion see also Béné et al. (2013) and Ulrichs, Slater and Costella (2019).

[9] PSNP also has a second component called direct support where government gives an unconditional transfer (food or cash) for labor-constrained households who could not take part in public works activities.

The PSNP and Resilience Nexus

Public works employment is one way through which PSNP can impact resilience to climate change among chronically food insecure households. In the words of Kuriakose (2012), public work programmes yield a “double dividend” as they provide a paid employment while building community assets. The labour-intensive public works under the Ethiopian PSNP provide income transfers for beneficiary households, allowing them address their short-term food gaps in the face of adverse climate shocks. In this way, the income transfer can prevent asset depletion (distress asset sale) enabling chronically food insecure households to have a buffer against future climate related shocks (see also Devereux and Guenther (2009) and Bene et al. (2012a)).

Apart from the income transfer, the labour-intensive public works under the PSNP build community assets that can make households and communities more resilient to future adverse climate shocks. In recent years, there is a growing body of work that acknowledges the potential impact of public works activities on climate change adaptation and strengthening resilience to the adverse impacts of climate change (see Bene et al., 2013, McCord, 2013, Kuriakose, 2013, and World Bank, 2013b). Soil and water conservation are the common public work activities that most public work projects undertake (Kuriakose, 2013), and the Ethiopian PSNP is no exception. In Ethiopia, some 60% of the PSNP sub projects are in soil and water conservation (World Bank, 2013a). This is important in terms of enhancing resilience as water shortage, land degradation and soil erosion are among the common climate change induced threats to rural livelihoods in Ethiopia (see also World Bank, 2013b and McCord, 2013).

Moreover, the Household Asset Building Program (HABP), the PSNP’s complementary component, is likely to increase the role of PSNP in building resilience to climate change. The HABP is designed to enable PSNP beneficiaries to get access to credit and demand driven agricultural extension services (Berahne et al., 2011). By helping households to diversify their income sources, HABP can thus make PSNP beneficiaries become less reliant on climate sensitive livelihoods and hence reduce their vulnerability to climate related shocks. Thus, the combined effect of the public works and the HABP would make the PSNP play a ‘transformative’ role.10 Finally, in 2013 the government introduced the Climate Smart Initiative (CSI), by directly incorporating climate change considerations in the design and implementation of the PSNP and the HABP. The explicit inclusion of climate change issues in the PSNP and the HABP is aimed at enhancing adoption of climate smart technologies among PSNP beneficiary households, leading to increases in adaptive capacity and hence resilience to climate-induced shocks. The CSI initiative is thus in line with the evolving concept of ‘adaptive social protection’ discussed above.

PSNP and Resilience: Assessing the Available Empirical Evidence

[10] For evidence on the combined effect of PSNP and HABP, see Berhane et al. (2011). The authors did the evaluation for various outcomes including asset accumulation, food security, yield, output, and agricultural investment over the period 2006-2010.

Even if there is a growing discussion in the literature regarding the potential role of the PSNP and the HABP in building resilience to climate-induced shocks, rigorous empirical evidence in this regard is limited and it has only been emerging in recent years. Based on the outcome variables these studies consider, we can categorize them into three strands.

The first strand includes studies that analyze impacts of the PSNP alone or together with HABP on changes in different household level outcomes and give indirect evidence on the role of the PSNP in building resilience. The papers in this category mostly focus on outcomes that have implication for adaptive resilience, as defined in section 2. Accordingly, these studies examine impacts of the PSNP on livelihood diversification (Weldegebriel and Prowse, 2013 and Weldegebriel, 2016), asset accumulation (Gilligan, Hoddinott and Taffesse, 2009, Gilligan et al., 2009, Berhane et al., (2011) and Andersson et al., (2011)), use of improved agricultural technologies, agricultural output and yield, as well as on borrowing for productive purposes (see Gilligan, Hoddinott and Taffesse (2009), Hoddinott et al (2012)).11

The second strand of the literature, unlike papers in the first strand, directly examine the impact of the PSNP on resilience. One recent contribution in this regard is the paper by Knipenberg and Hoddinott (2017). These authors conceptualize resilience as the "capacity that adverse stressors and shocks do not have long lasting adverse development consequences", and apply this concept to assess the impact of the PSNP on the longer-term impacts of drought on household food security. Accordingly, they show that the PSNP helps to strengthen resilience against adverse shocks. In particular, receipt of PSNP payments is found to reduce the initial impact of drought shocks by 57 percent and eliminate adverse impacts on food security within two years, as compared to non-beneficiary households, for whom bouncing back to their pre-shock level of food security take four years.12

Yet, a third strand of the literature evaluates the impact of the PSNP on different components of household resilience. This strand follows the recent practice in the literature of conceptualizing resilience as the capacity to absorb, anticipate, adapt and transform in the face of adverse climate shocks (see Bene et al., 2012b and Bahadur et al., 2015). The recent paper by Ulrichs, Slater and Costella (2019) is a case in point for papers in this category, and shows that social protection increases the capacity of individuals to absorb the adverse impacts of climate related shocks. However, as this is a qualitative work relying on desk-based review of existing studies it needs to be corroborated with empirical evidence.

In sum, the existing evidence in the area gives us some insight on the impact of the PSNP on various household level outcomes, particularly those related to adaptive capacities. However, further research is needed to get a deeper understanding of the impact of Ethiopia's PSNP on household and community resilience. For instance, although the roles of public works, HABP

[11] See also Filipski et al (2017) for economy wide effect of the PSNP including increasing agricultural production and non-farm household income.

[12] See also Béné et al. (2012). However, unlike Knippenberg and Hoddinott (2017) the resilience implication drawn in Béné et al. (2012) is by comparing PSNP beneficiaries with and without shock scenario, and their analysis does not show the length of time it takes the two groups to bounce back to their pre-shock level, which is the key point for resilience analysis.

and CSI in building resilience to climate change is widely acknowledged, rigorous empirical analysis is needed to substantiate this.

3.2.2. The Sustainable Land Management Program (SLMP)

The Sustainable Land Management Program (SLMP) is a project initiated by the Ethiopian government, in collaboration with a plethora of international donors, including the German Development Bank (KfW), and the World Bank. Launched in 2009, the programme has run in three phases, the last one starting in 2019 and re-named the Resilient Lives and Livelihoods Project (RLLP), each with a budget in the 100 million dollar range. It runs with the aim of strengthening sustainable land management practices through investments in landscape and integrated watershed restoration and development, capacity building of local, regional and federal stakeholders, and land certifications.

In doing so, the project aims to reverse ongoing land degradation caused by unsustainable land use in the implementation watersheds. Soil erosion and soil nutrient loss owing to unsustainable land management has been approximated to cost around 2-5% of agricultural yields yearly in Ethiopia, and this risks aggravating due to climate change (Sonneveld, 2002; Yesuf, Mekonnen, Kassie, & Pender, 2005; World Bank, 2013). Furthermore, unsustainable land use leads to lower levels of soil water content, making agriculture more vulnerable to drought spells. Reversing this is assumed to lead to increased resilience to droughts, and higher yields. Sustainable land management is thus of the essence to Ethiopia's development strategy and is also recognized as such in governmental development plans.

In practice, the programme follows a decentralized approach, where partial funding and technical support are provided from the federal and regional level for community level initiatives like planting trees, constructing bunds or terraces, implementing new grazing techniques, and closing off of degraded land for rehabilitation.

Research on the programme has been very scarce but not non-existent. The project has had an internal M&E system, but this has mostly reported on outputs of the project rather than impact level indicators. In terms of external research, there have been two scientific studies worth highlighting, both of which have been mentioned previously in this review under the section on vegetation resilience.

The first one is Schmidt & Tadesse (2019) which evaluates how the SLMP has impacted crop yields, and is the sole external impact evaluation looking directly at the SLMP. Drawing on a panel survey collected in 2010 and 2015 by IFPRI, the Ethiopian Watersheds Survey (EWS), which gathered data on the 2009 and 2013 yields of 1810 households in SLMP and non-SLMP watersheds, the study tests whether treated watersheds experienced higher yields 4 years after the initiation of the project. Results indicate that while crop yields generally increased, no statistically significant effect of having been exposed to the SLMP could be detected.

Secondly, Ali et al. (2020) investigates the effect of the Tana Beles Integrated Water Resource Development Project (TBIWRD) – an SLM project very similar in its structure to the SLMP –

on levels of vegetation, soil moisture and erosion.13 They use RSD for the outcome variables (NDVI, SAVI and LSWI) comparing treatment areas with the areas immediately surrounding them (except for a "buffer zone" of 5 kilometres). Results indicate that implementation areas experienced a strongly significant positive effect on the outcome variables compared to the control areas. These results are in turn supported by measurements from hydrological stations, which on average indicate that soil erosion decreased in the implementation areas.

3.3. The Role of Institutional Factors

One of the overarching issues in the effort to build a climate resilient economy in the context of Ethiopia is the role of institutional factors. The negative impacts of climate change are arguably most felt by agrarian and rain-fed economies. It is such vulnerability that has underscored the importance of mechanisms that enhance the agricultural sector's capacity to better cope with the adverse climate change impacts. The need for substantial increases in food production to meet the demands of a growing population adds further pressure for growth in the agricultural sector.

The institutional environment in which households/communities reside is important for the degree of resilience. There is a large body of literature highlighting the importance of tenure security, education and social capital in enhancing land related investment, and thereby agricultural productivity. Despite yield stability being an important consideration to farmers and national authorities (Smale et al. 1996), much of the research has focused on the causes of low agricultural productivity and the long term productivity gains that may accompany new agricultural productivity enhancing technologies (Antle and Crissman 1990). Given this, the aim of this sub-chapter is to extend the focus to include responses to climate change vulnerability. Specifically, the section sets out to look at the degree to which institutional factors such as property rights (in the form of land tenure security) education and information, as well as social capital contribute to building resilience in the context of Ethiopia.

There has been a recent increase in interest in new ways of strengthening both individual and communal land rights in Africa. This is related to the recognition that there is a need to remedy some of the perceived shortcomings of the existing systems, particularly by strengthening customary land rights, recognizing occupancy without full title, improving female land ownership, and decentralizing land administration. In addition, previously formalized land rights tend to take a patrilineal shape, with poor and vulnerable household groups, particularly women, losing out in the process. The paragraphs below describe the links between each of the institutional factors and climate resilience briefly.

Land tenure security:

The more recent literature on land related investment suggests that many of the investments in land that farmers make to increase economic returns also play a role in reducing vulnerability to climate variability (e.g. Gebremedhin and Swinton 2003; Deressa et al. 2009; Kato et al.

[13] An earlier version of this article have been available since 2018 as a World Bank working paper (see Ali et al., 2018).

2009; Di Falco and Veronssi 2013; Boardman and Favis-Mortolock 1993). Therefore, it is likely that stronger property rights incentivize farmers to make investments in land that improve their resilience to climate change.

Education:

The benefits of soil conservation efforts such as stone terracing and tree plantation may take years to be realized, often due to the absence of fully-functioning landmarkets and other institutional constraints in the rural areas of developing countries (Banerjee and Ghatak 2004; Reardon and Vosti 1995).14 In addition, many households often cannot invest sufficient amount in conservation, not only for financial reasons but also because of education. Indeed some research has found that the ability of agricultural households to earn supplementary incomes from non-agricultural sources that could be invested into conservation efforts is often determined by education and family characteristics (e.g., Eskander, Barbier, and Gilbert 2015). That is, education can be an important factor influencing the choice of farm households that would lead to climate resilience.

Social Networks:

The adoption of conservation measures such as soil conservation and water harvesting technologies has been very low (Kassie et al., 2012). While several factors have been identified as barriers to soil conservation investment in Africa, social capital - particularly its role in enhancing soil conservation as a climate adaptation tool - has rarely been investigated. Therefore, assessing to what degree social capital aides in adaptation investment is a pertinent research objective. The justification for it is presented as follows.

Pervasive economic and social risk is an aspect of life for rural households in low-income countries and semi-arid lands. The enormous scope and diversity of these shocks, both covariate or idiosyncratic, contribute to the lack of a viable formal insurance market. As a result, unlike farm households in developed countries that can trade away the risk of crop failure in the insurance market, in developing country settings, such markets are lacking and farmers employ relatively sophisticated methods to offset such risks. While there is a wealth of evidence suggesting an important role of social capital in mitigating against income risks in general, the growing literature on the links between social capital and climate change adaptation provides mixed evidence. Proponents of the positive role of social capital in mitigating against the risks of climate change pursue the argument that an individual's adaptation behavior is triggered by his or her recognition of the need to adapt, the perceived climate risk, the costs of adaptation and the potential reduction in damage. Social networks and social skills can possibly affect these determinants of adaptation behavior, although the causal direction is not always clear.

[14] Banerjee and Ghatak (2004) note that the benefits of land-improving investments are normally realized with a one-period lag.

Climate information:

So far, empirical evidence in Africa shows that perceptions of climate change and climate risk is a decisive variable in adaptation decision-making and that farmers base their decision to adapt their farming practices not only on changes in average conditions, but also on a number of other climate factors observed through personal experience such as extreme events, rainfall frequency, timing, and intensity, and early or late frosts, highlighting the importance of climatic perceptions (Mulwa et al. , 2017; Bryan et al., 2013, Madison et al., 2007).

However, the dissemination, uptake and use of climate related information, one of the foremost methods responsible for enabling managing climate risk in agrarian economies, remains strikingly low in Africa. While a rich body of literature attests to their perceived potential in terms of significant shifts in behaviour and risk management, empirical investigation of their actual risk reducing and management impact remains scant. Hence assessment of the risk reducing impacts of the Early Disaster Warning and Preparedness activities, with its pre-disaster information generating features would contribute greatly to building community resilience.

Early warning systems are expected to provide reliable climate forecasts to help people choose optimal state-contingent livelihood strategies, both to avoid disaster and to capitalize on temporary, favorable states of nature. It is in due recognition of this several development agencies have directed attention and funding to establishing Famine Early Warning Systems (FEWS) over the past two decades (Barrett 2002, Walker 1989). It is due to this that, a big push has been made to augment FEWS with computer models of coupled atmospheric-oceanic circulation patterns that translate data on wind speed and direction, topography and sea surface temperatures into seasonal precipitation forecasts issued one to six months ahead (Barrett et al., 2011).

The Early Disaster Warning and Preparedness Ministry works on ensuring the collection and communication of data to farmers and communities; training and the use of networks to co-ordinate resilience responses between community's and delivery agencies; ensuring the dissemination of information to promote effective climate resilience so that options can be implemented in the local context; Enhancing drought and flood warning systems, flood forecasting and drought monitoring system, proper use of climate information; Information, risk profiling, risk screening (FDRE, 2015).

Institutional factors- gender based differences:

The key institutional factors in building climate resilience discussed above (tenure security, education, social capital) will likely have gender-differentiated implications. Tenure insecurity of female headed households might stem from formal barriers, associated with limited land access through land allocation by communities and inheritance from families. It might also come from informal barriers, where women's ability to exercise their rights may be limited by lack of effective control over the land, lack of legal knowledge, customary laws overruling constitutional rights, weak implementation of the laws, lack of physical capacity and financial problems. Female members of a rural household are generally less educated than male members. Further, female headed households are not regarded as proper farmers and land owners, and this might greatly affect their propensity to engage in climate adaptive investment. This differentiation would help in understanding the gender-climate change-welfare inter-linkages in Ethiopia that are cut across the different themes of this research project.

4. Conclusion

Ethiopia has a long history of drought exposure and the frequency of extreme weather events is increasing over time. This is likely to impede growth in GDP as well as poverty reduction, as the impacts of droughts for various reasons seem to disproportionally fall on the rural poor. Lacking formal insurance schemes, they are often forced to resort to counter-productive coping strategies, such as selling off productive assets, increasing debts, or restricting dietary diversity – coping mechanisms that invariably lead to protracted vulnerability and lower future resilience. Thus, building resilience to climate change in rural Ethiopia is a crucial matter; especially in terms of improving adaptive and transformative capacity.

In terms of resilience measurement, we follow the practice in the existing literature and identify two major approaches. While one relates to the ability of households and communities to withstand and bounce back from shock in terms of socio-economic outcomes, the second one is a vegetation resilience which refers to the ability of plants and agricultural yields to withstand adverse climate conditions. Socioeconomic resilience is mostly measured using various types of resilience indices compiled through survey data, whereas vegetation resilience is measured either through survey data on agricultural yields, or remote sensing data on greenness and soil moisture.

Although there is no consensus in the literature on how to define and conceptualize resilience, it is becoming a common practice to frame resilience to climate change in terms of three capacities: absorptive capacity, which refers to the ability to mitigate the immediate impact of a shock, and more long term adaptive and transformative capacities that involve livelihood and system reconfiguration. These resilience capacities are influenced by various actors at different levels. Accordingly, in this paper we have discussed and reviewed the existing evidence on three pillars of resilience building in Ethiopia: (1) Household resilience enhancing actions, (2) supportive government programmes, and (3) institutional factors affecting resilience.

In relation to resilience enhancing actions taken at the household level, the existing evidence shows that rural households in Ethiopia use both ex-post coping strategies and ex-ante adaptation strategies. Even if short term coping strategies can help in increasing absorptive capacity in the face of adverse shocks, they are less likely to bring sustainable solutions to resilience building as such strategies, at times, involve actions that can jeopardize future resilience capacities – cutting dietary needs, dissaving/de-cumulating assets or borrowing from others. To ensure household resilience in a more sustainable way, household actions related to long-term adaptation strategies including investment on livelihood enhancing activities are needed, and deserve due consideration from policy makers.

Adoption of climate-smart practices (agro-forestry, soil conservation, agricultural water management systems) are important to strengthen the adaptive capacity of rural households in areas with high rainfall variability. Even if the existing empirical work on shocks and household coping/adaptation strategies can give us useful insight for analysis of resilience, they can at best be taken as indirect evidence. Further empirical work is thus needed to get a deeper understanding of how actions taken at the household level interact with building resilience capacity. Moreover, as the degree of vulnerability of different agro-climatic zones to climate induced shocks varies, so does resilience enhancing strategies. It is therefore important to conduct a more disaggregated analysis, so as to design a context specific approach to resilience building in the face of adverse shocks.

To supplement actions taken at the household level and to counter the potential disastrous impact of climate change and buffer the economy against the impacts of climate change, the government has issued a range of supportive government programmes aimed at enhancing resilience. In particular, within the framework of the CRGE, there has been increasing efforts to streamline climate change adaption initiatives with ongoing development efforts. In relation to this, we considered the available evidence on two large scale interventions: the Productive Safety Net Program (PSNP) with its sister programme, the Household Asset Building Program (HABP), and the Sustainable Land Management Program (SLMP) and its successor, the Resilience Landscape Livelihoods Project (RLLP).

The PSNP together with the HABP has the potential to contribute towards building resilience to the adverse impacts of climate change. While PSNP prevent asset depletion at the household level and build community assets via public works activities, the HABP aims at livelihood diversification and asset portfolio expansion of chronically food insecure households. Even if there is a growing discussion in the literature regarding the potential role of the PSNP and the HABP in building resilience to climate-induced shocks, rigorous empirical evidence in this regard is limited and it has only been emerging in recent years. Thus, there is a need for further systematic evaluation of the programme in building resilience, both in order to substantiate current findings, and estimate the wider impacts of the PSNP, including on vegetation and human resilience.

The SLMP and its current successor the RLLP, on the other hand, aim to promote sustainable land management through capacity building and investments in integrated watershed and landscape management. Even if the SLMP has been running over the last few years since 2008, the impacts of its various components are not yet known. There is no solid evidence as to whether the SLMP actually improved agricultural production as promised. Although efforts at Soil and Water Conservation (SWC) are routinely viewed as instrumental in reducing vulnerability to climate change, their impact has rarely been examined. Hence further research that address whether the SLMP brought about the expected impacts is important.

Finally, apart from the role of resilience enhancing household actions and supportive government interventions, institutional factors are also important in determining the resilience capacity of households and communities. Accordingly, in this paper effort was made to review the available evidence on four institutional factors: (1) land tenure security, (2) education, (3) social networks, and (4) gender based considerations.

Since land related investments have been consistently found to contribute to resilience, and stronger property rights are likely to incentivize farmers to invest on their land, it is reasonable to believe that land tenure security affects resilience. When it comes to education, studies suggest that the level of schooling is associated with the ability of households to earn supplementary income from non-farm sources. Thus, education can be an important tool on the way to diversified livelihoods. The role of social networks in climate adaption is being increasingly recognized, although opinions split regarding whether it aids or hinders adaption. Further research is necessary for a more conclusive answer. Gender considerations are crucial when evaluating climate adaption and resilience. Analyzing how gender differences and perceptions shape land tenure security, access to education, and generally participation in climate adaption is of the essence in order to understand the gender-climate change-welfare inter-linkages in Ethiopia.

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