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The state of local adaptive capacity to climate change in drought-prone districts of rural Sidama, southern Ethiopia

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ABSTRACT

The paper assesses local adaptive capacity of rural households in three drought-prone districts of rural Sidama using Africa Climate Change Resilience Alliance's (ACCRA) Local Adaptive Capacity Framework (LACF). Randomly selected401 households were approached to collect relevant data on the state of local adaptive capacity. Additional qualitative data were gathered from key informant interviews and focus group discussions so as to substantiate the findings from HHs data. Gridded satellite rainfall data (1983–2014) was also used to examine the trend of growing season rainfall and drought incidents over the years under consideration. The collected data was analysed vis-à-vis the five parameters (livelihood resources, institutions and entitlements, knowledge and information, innovation and technology, and flexible forward looking decision making and governance) of the framework. The findings indicated that growing season rainfall had declined and seven droughts of different magnitude happened over the three decades under consideration. Further, despite government's endeavor to build adaptive capacity of rural households through different programs, the state of local adaptive capacity to climate change is in its infantile stage entailing further selective intervention to strengthen adaptive capacity in sustainable manner.

1. Introduction

Climate change and variability-induced impacts have emerged as one of the formidable challenges undermining development and poverty reduction endeavours in Sub-Saharan Africa (SSA) (Gebreyes et al., 2017; Di Falco, 2018; James et al., 2018). The 4th IPCC report claims that *'By 2020, between 75 million and 250 million people are projected to be exposed to increased water stress due to climate change'* (IPCC, 2007, p. 13), and crop yield in some African countries could be reduced by 50% by 2020 due to climate change (IPCC, 2007). Given unequivocal evidences on increasing global warming and associated negative impacts on development and poverty reduction (IPCC, 2007, 2014), development pathways have shown commitment in addressing such an imminent challenge through different mechanisms. A case in point is the Sustainable Development Goals (SDGs) (2015–2030) which through its 13th goal opted for '…urgent action to combat climate change and its impacts' (Nam, 2015). The first objective of the goal calls for '*strengthening resilience and adaptive capacity to climate-related hazards and natural disasters in all countries'*. Similarly, the third objective emphasises on *'Improving education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning'* (Nam, 2015). Both of the objectives clearly urge the need for building adaptive capacity at national and local levels so that climate change induced impacts on poverty reduction and sustainable development can be minimized.

On the other hand, empirical literature on climate change adaptation calls for adaptive capacity development of communities and households in order to minimize climate change -induced impacts (Ludi et al., 2011; Jones et al, 2017). To this end, many developing countries have been implementing different policies and programs that build the adaptive capacities of vulnerable communities to climate change related impacts. Building adaptive capacity of households is important not only because it boosts resilience to adapt to

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gradual climate changes, variability, and extremes but also it provides options for households respond to these challenges (Smit and Pilifosova, 2003; Engle, 2011). However, building adaptive capacity of households has not been easy because it is a function of several context specific factors and also for it is a process (Smith et al., 2000; Adger et al., 2005a; Engle and Lemos, 2010). The factors that constitute adaptive capacity to climate change related-effects may include managerial ability, access to financial resources, use of technology, infrastructure, information and skills, governance, and institutions and networks (Smith et al., 2000). Moreover, building adaptive capacity is a process which has a range, commonly called an adaptive limit. An adaptive limit is a stage where a system tolerates different stresses based on the stage of adaptive capacity building process. Most of the time, households and communities can adapt to smaller climatic fluctuations and moderate deviances from the normal, but coping with extreme events and large scale deviations usually lies outside of the coping range (Smith and Wandel, 2006). In terms of the time limit, shorter tolerance is known as coping ability while a longer tolerance is called adaptive capacity (Smith and Wandel, 2006).

Despite the indispensible role of adaptive capacity in adapting environmental stresses including climate change related shocks, little is known about the state of adaptive capacity at local level. This is partly because adaptive capacity is a relatively new area of research compared with other dimensions of adaptation such as sensitivity, vulnerability, and exposure (Vincent, 2007; Engle, 2011; Jones et al., 2017). Further, since building adaptive capacity is a process, it entails periodic appraisal to identify leverage points to (re)design appropriate intervention strategies. In this regard, little empirical findings and assessment methods exist on local adaptive capacity assessment to inform researchers, policy makers and practitioners working in the area of adaptive capacity development in particular and sustainable development in general. Thus, the main objective of this paper is to assess local adaptive capacity of rural households in three drought-prone districts of Sidama in light of government intervention strategies purposed to build adaptive capacity and reduce vulnerability.

2. Adaptive capacity concept, assessment methods and their limitations

The definition of adaptive capacity has been evolving over time (Jones et al., 2017) in climate change adaptation discourse. The 3rd (2001) and the 4th (2007) IPCC reports defined adaptive capacity as *'The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences'* (IPCC, 2001, p. 982; IPCC, 2007, p. 869). In the two IPCC reports, 'adjustments' are indicated as responses to variability and extremes, and the 'ability to make adjustments' is referred to a broad entity called a 'system'. The 5th IPCC report (2014), on the other hand, defined adaptive capacity as *'The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequence'* (IPCC, 2014, p 118). In the 5th report, the stimuli for adjustment processes included 'gradual changes' in addition to 'climate change-induced variability' and 'extremes'. Moreover, the adjustment processes in the fifth report subsumed 'human', 'institutional', and 'any other living organisms' responses to the effects of variability, extremes, and gradual changes. Further, 'the effects of climate change' of the first two reports are replaced with 'potential damages', which depend on the level of adaptive capacity and the types of adaptive responses. The framing of adaptive capacity has evolved in relation to the stimuli, the effects, and ability to adapt getting more attention in climate change adaptation and development discourse.

There are two ontological approaches to measure adaptive capacity. These are inductive (data driven) and deductive (theory-driven) approaches (Vincent, 2007; Below et al., 2012). The inductive approach focuses on identifying determinants, indicators, and a composite adaptive capacity index score based on expert opinion/judgement or through correlation with past climate change-induced disaster(s). The approach uses, proxy variables as a benchmark to measure adaptive capacity. It has been criticized for a lack of spatiotemporal validity, unrealistic assumptions, and also for oversimplifying complex realities to justify donors' monetary value (Smith and Wandel, 2006; Vincent, 2007). Despite the above limitations, most of the studies carried out to measure adaptive capacity have used quantitative approaches and were conducted at country levels (Swanson et al., 2000; Sietchiping, 2006; Mwamba, 2012; Defiesta and Rapera, 2014; Schramski et al., 2018) though adaptive capacity is context specific and unevenly distributed (Smith and Wandel, 2006; Engle, 2011).

The quantification of adaptive capacity by using mathematical techniques has been a problematic and contested approach because of the processes involved and intention behind the measurement (Vincent, 2007; Below et al., 2012; Jones et al., 2017). The first challenge in measuring adaptive capacity is that the selection of determinants and indicators are based on intuitive understandings of human and environment nexus, most of which are intangible and process oriented (Brooks and Adger, 2005; Vincent, 2007; Below et al., 2012; Jones et al., 2017). As a result, developing determinants and indicators can oversimplify complex systems, risking inaccurate representations of the intended context (Adger and Vincent, 2005; Adger, 2005b). Secondly, the indicators selected under each determinant are not valid enough to measure the intended variables consistently among all households. In other words, the ranking and subsequent values given are based on experts' judgment and cannot have the same strength for all households (Brooks et al., 2005). Thirdly, the nature of the relationship between the indicators is based on assumptions that are unrealistic in different scenarios. For example, the availability of a market or weather information helps to boost adaptive capacity of households based on the assumption that the information is fairly accessible, reliable, and that the households use them consistently, which are not always true (Adger and Vincent, 2005). Fourthly, the determinants and indicators of adaptive capacity are dynamic, which vary with time and other contextual factors (Smith and Wandel, 2006). That is, the main determinant or best indicator in a given year may not be the most suitable indicator for the next year (Vincent, 2007). Besides, the quantification of the determinants and indicators of adaptive capacity is motivated by '*growing pressure from donors to demonstrate the impact of development interventions and showcase value for money in their activities' as* noted by Constas et al. (2014); cited in Jones et al. (2017, p. 8), rather than identifying key areas of interventions. Given these limitations, instead of constructing an adaptive capacity index using a quantitative approach, an alternative approach is to identify and assess key elements of local level adaptive capacity so as to target leverage points in adaptive

capacity development intervention (Vincent, 2007; Ludi et al., 2011; Below et al., 2012).

The second ontological approach to assess adaptive capacity is the theory-driven deductive approach, which uses theories and frameworks to map cause-effect relationships among the various constituent variables of adaptive capacity with the aim of identifying leverage points for building adaptive capacity. African Climate Change Resilience Alliance (ACCRA) carried out a study in Ethiopia by using this deductive approach in three research sites (Ander Kello, in Afar; Kase-hija in Oromia, and Wokin in Amhara). Though ACCRA's study used qualitative methods to assess adaptive capacity at local level, it was not able to provide any data at the individual household level across the five dimensions considered in the study (Ludi et al., 2011).

However, the ontological approach used to measure local adaptive capacity in this study is not immune from limitation due to the fact that adaptive capacity is a latent and dynamic concept. Some of these include possibility of exclusion of some indicators, the dynamic nature of the indicators, limitations to use the findings in top–bottom policy making contexts, and limited institutional capacity at lower levels (Matewos, 2019b). So, future research work may solve the above limitations by integrating both approaches for adaptive capacity assessments.

3. The national and study area contexts

3.1. The national contexts

Ethiopia is one of the most vulnerable countries to climate variability and change-induced effects (Bewket et al., 2015; Ethiopian Panel on Climate Change (EPCC), 2015; Echeverría and Terton, 2016). In the 20th century alone, Ethiopia has witnessed twelve extreme droughts that claimed the lives of hundreds of thousands and affected the livelihoods of over 50 million people (Seleshi and Zanke, 2004; Gidey et al., 2018). The General Circulation Models (GCMs) forecasts over Ethiopia predict that the magnitude and frequency of climate change and variability related impacts are expected to increase in the future (MoWR and NMA, 2007; Adem and Bewket, 2011; EPCC, 2015; Kassie et al., 2015; Kiros et al., 2016; Wodaje et al., 2016). As a response to the recurrent climate change-induced impacts, Ethiopia has been responding to climate variability and change through policy and institutional reforms (Bewket et al., 2015; Echeverría, & Terton, 2016). The Ethiopian government submitted a National Adaptation Program of Action (NAPA) to the United Nations Framework Convention on Climate Change (UNFCCC) in 2007. Ethiopia has also developed the 'Ethiopian Program of Adaptation to Climate Change' (EPACC) in 2010, Agriculture Sector Programme on Adaptation to Climate Change (ASPACC) in 2011, and has developed 'Climate Resilient Green Economy' (CRGE) with the ultimate aim of building climate resilient green economy by 2025. In addition to the policy and institutional reforms, the country has been working with different international stakeholders for solidarity, equity, and justice in global climate change. In line with this, Ethiopia has ratified the UNFCCC (1994) and the Kyoto Protocol (2005) that were purposed to reduce GHGs emissions.

The Ethiopian National Adaptation Program of Action (NAPA), by using a 'Multi-Criteria Assessment', identified eleven prioritized projects that build the adaptive capacity of the country (MoWR and NMA, 2007, p. 60). Some of the strategies developed to strengthen adaptive capacity of the farmers include, promoting a drought/crop insurance program, enhancing early warning systems, developing small scale irrigation and water harvesting schemes. Further, improving rangeland resource management practices, realizing food security, establishing community based carbon sequestration programs, launching national research and development centres for climate change, strengthening the malaria containment program, and promoting on-farm and homestead forestry and agro-forestry practices were also indicated in the document.

Despite the policy provisions and institutional (re)arrangements, climate change induced impacts have been undermining the national economic performance and the country's endeavour to reduce poverty (Echeverría and Terton, 2016). For instance, it was reported that from 1991 to 2010, the growth estimates were reduced by 2–9% because of climate change-induced impacts (Asaminew, 2013). Under worst-case scenarios, economic impacts of climate change may reduce Ethiopia's GDP up to 8% (Amsalu et al., 2017). In general, with the current trajectory in temperature and rainfall variability, higher vulnerability, and lesser resilience to climate change-induced impacts, the country is projected to experience a 6% decline in total agricultural output, on average, in the coming years (Kreft et al., 2015). Weak adaptive capacity has been one of the reasons limiting the households' ability to respond to climate change-induced impacts. In relation to this, factors such as poverty, lack of access to information, land, and credit services are the major once (Bryan et al., 2009).

3.2. The study area contexts

The Southern Nations Nationalities and Peoples' Regional State (SNNPR) of Ethiopia is one of the nine administrative regions of the country, which comprises about 20% of the total population and 10% of the area of the country (SNNPRS-BoFED, 2015). The Sidama Administration Zone is one of the 14 zones in the SNNPRS. With a total population of 3,677,370 in 2014 (SNNPRS, 2015), it is the most populous zone in the region. The zone is found in the central-eastern part of the region bounded by Oromiya in the North, East, and Southeast, by Gedieo Zone in the South, and Wolayita Zone in the west. The Zone lies between 6^0 10′ to 7^0 05′ North latitude and 38^0 21′ to 39^0 11′ East longitude. The total area of the zone is 6981.9 km^2 (SZFEDD, 2007: 4) (Fig. 1).

This study was carried out in three drought-prone districts (Hawassa Zuria, Boricha and Loka Abaya) of the Sidama Administrative Zone (Fig. 1). The districts are located in the heart of East African Rift Valley. Variable rainfall and higher temperature characterizes the districts compared to other districts of the Zone. A total of 576,865 population and 113,285 households live in the districts. About 97% of the population in these districts lives in rural areas where drought-prone agriculture is their source of livelihood. Agro-pastoral communities dominate the south-western parts of the study area where climate-related animal diseases are

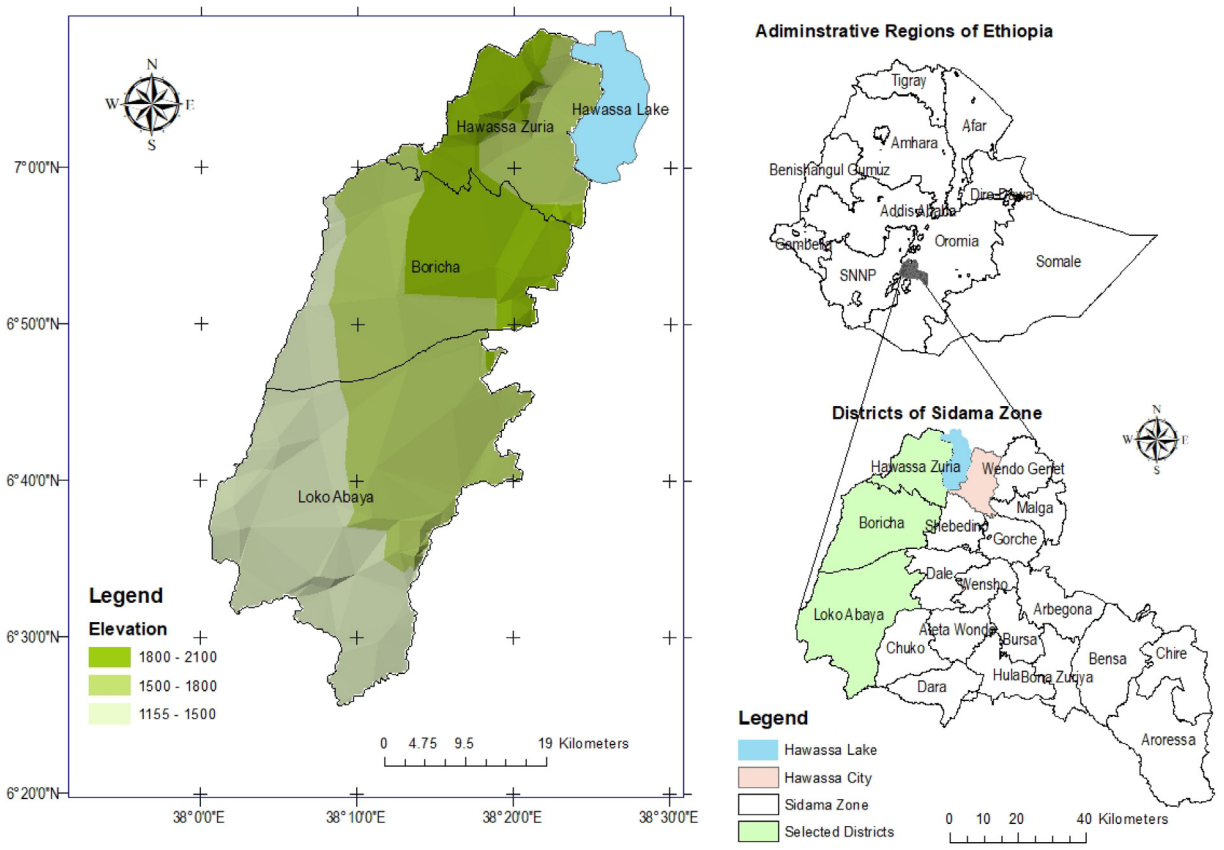

Fig. 1. Geographic location of the study area.

prevalent. Diverse climate characterises the drought-prone districts of Sidama Zone. Altitude ranges from 560 to 2300 m above sea level and the average annual rainfall ranges between 700 and 1200 mm. The rainfall pattern in the area is bimodal, which occurs in the summer and spring seasons. The summer (*Kremt*) rains last from June to September while the spring (*Belg*) rain begins in February and end in late May. Both the summer and spring rain are irregular and unpredictable, resulting in frequent losses of harvest and cattle.

Also, there is severe livestock and human diseases (for example, malaria, cholera, and trypanosomiasis) in the area largely due to the inhospitable climate. The perennial Bilate River, which dissects Wolayita and Sidama Zones, drains the western part of the area. The eastern part lacks perennial rivers, and households largely depend on water collected from artificial ponds and hand-dug shallow wells for domestic and watering livestock. The area experiences severe water shortages when the ponds run out of water during the December-February dry period. Climatic extremes, such as flooding, extreme droughts, and hunger have been recurrent in study area. The above climate related hazards have exposed thousands of households to food insecurity since they are outside of their coping range. The problem worsened in 2016 necessitating large-scale emergency relief for about hundred thousand people, which is highest in recent documented drought history of the area (Matewos, 2019a) The problem has also prompted interest from the academia including this research

4. Methods

4.1. Research strategy and data

The study employed a mixed research strategy where qualitative and quantitative data were collected from different sources. Cross sectional household survey, key informant interviews and focus group discussions were used to collect relevant data. The target population of this study included all rural households residing in the selected three districts of Sidama. A total of seven kebeles were selected from the three districts based on their climatic conditions, accessibility, population size, and population density. Accordingly, Hanja Cafa, Haldada Dela, and Korangoge from Boricha district, Muticha Gorbe and Sala Kore from Loka Abaya district, and Doyo Cala and Doyo Otilicha from Hawassa Zuria districts were selected for the study (Table1). The issues of accessibility may cause the question of representativeness of the kebeles and this can be one of the limitations of the study. But, longitudinal rainfall and temperature data and expert interviews can minimize representation bias since they represent the entire districts.

Table 1
Distribution of rural population and sampled HHS in selected districts.

Districts name	Total Rural population	Total HHs	Kebele Name	Sampled HHs	Total
Boricha	299,175	58,823	Hanja Cafa	66 (25)*	189
			Haldada Dela	66(18)	
			Korangoge	57(22)	
Loka Abaya	122,445	25,278	Muticha Gorbe	36(11)	93
			Sala Kore	58(22)	
Hawassa Zuriya	155,245	29,184	Doyo Chala	53(19)	119
			Doyo Otilicho	66(26)	
TOTAL	576,865	113,285		401(1 4 3)	401

()*female headed HHs.
Source: Own compilation from SNNPRS, BoFED (2015).

According to Southern Nations Nationalities and Peoples Regional State (SNNPRS), BoFED, (2015) population projection data, 576,865 population and 113,285 households live in the districts. The optimum sample size for the study was calculated based on Krejcie and Morgan (1970). As to this formula, the acceptable sample size at 95% confidence interval and 5% margin of error for 750,000 people is 382. Considering attrition, a 5% contingency (19 households) was added. The total 401 sample sizes was distributed in proportion to the number of the households in each district yielding 189 households for Boricha, 93 households for Loka Abaya, and 119 households for Hawassa Zuria (Table 1). The respondents were household heads who were selected by using systematic random sampling where every fifth households were approached to collect survey data. Female-headed households were also included proportionately in all the districts. Accordingly, about 36% of the respondents were female headed (Table 1). The field data collection process was carried out from April to May 2017 with the assistance of trained data collectors supervised by the principal investigator. The collected quantitative data were encoded into SPSS Statistics Software (Version 20). Descriptive and inferential techniques (mean and percent) were used to analyze and interpret the results.

To substantiate the findings of the household survey data, qualitative data were also gathered through key informant interview and focus group discussions. Senior experts from the three districts offices (Agriculture & Natural Resources Management, Livestock and Fishery, Forestry and Climate Change, Water, and Health) were included to answer open ended questionnaire. The questions were focused on the state of policy and institutional interventions to build adaptive capacity of farmers in the study area. A total of 22 expert questionnaires were administered in the five offices at the district level. Accordingly 8 senior experts from Hawassa Zuria, 6 from Boricha, and 8 from Loka Abaya were involved as key informant. Three focus group discussions (FGD) with the farmers were also carried out in each of the three districts. The participants of the discussion were farmers from different kebeles. Each focus group discussion involved 9 farmers and a total of 27 farmers were involved in the process. The FGD participants were male farmers of different age groups. Language and ethnicity were not considered since the households in the study area speak one language and belongs to single ethnic group (The Sidama). The Administrators of the seven sampled kebeles were also approached to explain the state of local adaptive capacity of the farmers. The qualitative data were analysed by systematic thematization to augment the quantitative results.

In order to strengthen the claims of rainfall changes and variability, and subsequent adverse impacts on the farmers in the study area the study used monthly RF data of 129 gridded points (4*4 kms) for the years 1984–2014 documented by The National Meteorological Agency of Ethiopia. Evaluating the characteristics of local level temperature and RF data is important for designing and implementing climate change adaptive strategies, building adaptive capacity of smallholder farmers.

4.2. Analytical framework

This study used Africa's Climate Resilience Alliance's (ACCRA) Local Adaptive Capacity Framework (LACF) to assess local adaptive capacity LACF. It is a theory-driven deductive approach that uses LACF to map cause-effect relationships among five categories (livelihood resources, institutions and entitlements, knowledge and perception, innovation and technology, and flexible forward looking decision making and governance) of variables (Fig. 2 and Table 2).

The LACF is preferred because despite the growing needs know the state of local adaptive capacity for different interventions, very little is known about the tools and frameworks used to assess climate change adaptive capacity programs at local levels (Jones et al., 2017). The LACF was developed by ACCRA in 2010. It is a consortium of five organizations (Care International, Oxfam GB, Save the Children UK, World Vision UK, and the Overseas Development Institute (ODI)), and was established in 2009. Since then, the LACF has been implemented in three African countries (Ethiopia, Uganda, and Mozambique) in eight research sites. The framework has five parameters. Namely: (1) the asset base, (2) institutions and entitlements, (3) knowledge and perception, (4) innovation and technology, and (5) flexible forward looking decision making and governance. This framework was selected because it has been practically tested and shown to be effective in different African countries, including Ethiopia. The five parameters refer to the following meanings and variables in this context (Table 2 and Fig. 2).

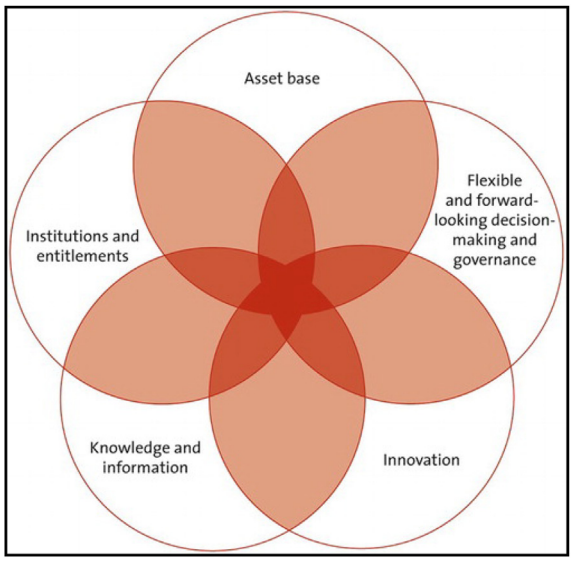

Fig. 2. LAC framework of ACCRA (adopted from Jones et al., 2017, p. 5).

Table 2
Brief description of LAC framework & corresponding variables used.

The five dimensions of LAC framework	Brief description	Major issues addressed
Asset base	Availability of important and diverse livelihood assets that enable to respond during climate change induced effects.	Landholding size, land use right, livelihood characteristics, and participation in on-farm & off-farm livelihood activities
Institutions and entitlements	Existence of an appropriate and evolving institutional environment that allows access and entitlement to key assets and capitals.	Availability of formal and informal institutions and their functions; issues of entitlement
Knowledge and information	The ability to generate, receives, assess and disseminate knowledge and information that enhances adaptive responses and capacities.	Literacy level, access to weather forecast, early warning, market, and government support information
Innovation	Availability of technologies and innovations, and enabling environment to learn, adopt and adapt technologies that boost adaptive capacity	Agricultural inputs, extension services, small scale irrigation
Flexible Forward-looking Decision Making (FFDM) and governance	ability to anticipate, incorporate and respond to different environmental changes in relation with governance and rational and proactive decision making	Types and characteristics of adaptive decisions made by the farmers

5. Results and discussions

5.1. Growing season rainfall changes and drought incidents

The analysis of gridded satellite data (1983–2014) of the three districts have shown that growing season (spring and summer) rainfall had declined for the years under consideration (Fig. 3). The nature of RF in the study are is bimodal where almost equal amount of RF are experienced during spring (*Belg*), and summer (*Kiremt*) seasons constituting 40% and 41% of the total annual RF of the study area respectively. The remaining 19% is accounted by winter season RF. Both Belg and Kiremt RF are important because they are seasons where most of the crops are grown. The two growing season rainfall amounts exhibited more variability than the annual RF with CV values of 23%. Annual, *Kiremt*, and *bega* RF amount have shown decreasing trend over the years under consideration (1983–2014). However, the decreasing trend is statistically significant only for *Belg* RF at $p = 0.05$ level. Winter RF has shown slightly increasing trend though the result is statistically insignificant (Fig. 3). The analysis of standard rainfall anomalies (RSA) has shown that the study area has experienced seven droughts of different magnitude. The year 2009 was the driest year in the last three decade which coincides with the 2009/10 extreme drought all over the country. The years 1999 and 2012 were also years of severe drought in the study area. The other four moderate drought years were in 1984, 2000, 2002, and 2004 (Fig. 4). According to the key informants, drought incidents had severe human and economic consequences on smallholder farmers mainly because of limited adaptive capacity of the community.

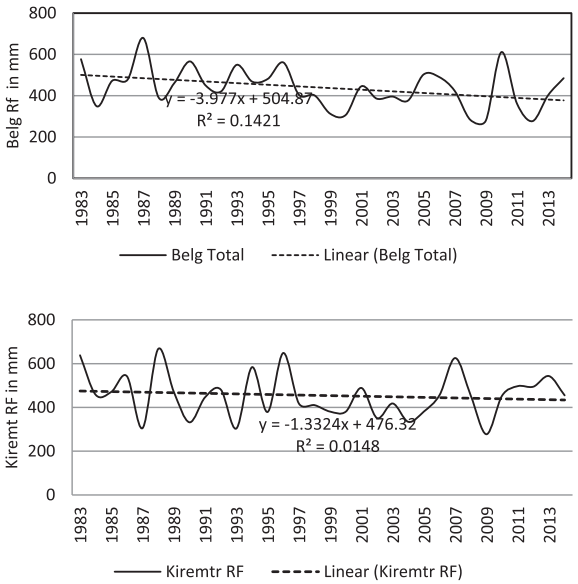

Fig. 3. Belg and Kiremt RF in the study area (1983–2014) Source: Own computation from Ethiopian Meteorology Agency Data.

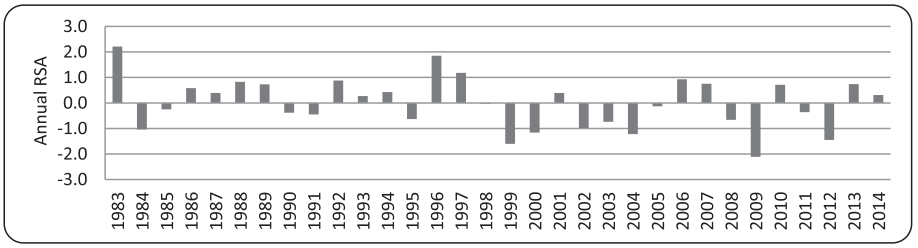

Fig. 4. Annual rainfall standard anomalies in the study area (1983–2014) Source: Own computation from Ethiopian National Meteorological Agency data.

5.2. The state of adaptive capacity in the study area

5.2.1. Livelihood resources

Livelihood resources are one of the factors that enable households or communities to respond during climate change induced effects (Cooper et al., 2008). In reference to this, land holding size, land use right certificate, livelihood characteristics, and participation in on-farm and off-farm livelihood activities play pivotal roles.

5.2.2. Land holding size

In the study area, more than half (55%) of the sampled households have 0.5 ha or less. The mean land holding size in the area is 0.76 ha which is slightly larger than the regional and national average which was 0.75 ha in 2005 (Ellis and Woldehana, 2005). This is because the study area is of semi-arid climate condition where population density is relatively lower. About 86% of the sampled households have a land holding size of one hectare and less. Since land is one of the most important assets and a source of rural livelihood, smaller land holding size in the face of changing climate means weaker adaptive capacity greater vulnerability. Land holding size and family annual income is strongly correlated in Ethiopia (Hassan and Nhemachena, 2008; Headey et al., 2014). In the study area context, declining land holding size because of population growth, which is 2.7% per year (SNNPRS-BoFED, 2015), is causing mass migration of youth to the cities according to the key informants in the study area. This in turn decreases labour availability in rural areas affecting the amount of income generated by the households. The finding is consistent with other studies in southern Ethiopia, which revealed rural land scarcity is one of the push factors for youth outmigration to urban centers (Bezu and Holden, 2014; Cochrane and Cafer, 2018). The declining land holding size decreases households' income encourages the labour force to migrate to cities, where there is little job opportunity for unskilled labour, and eventually weakening adaptive capacity of the farmers in the study area. land reform was done in 1974 (45 years back) in Ethiopia and current uneven distribution of land holding size raise the question of equity during the process may necessitate land reform in the future.

5.2.3. Land use right certificate

Holding a land-use certificate is another important issue in relation with rural land productivity. It is a certificate that government

give to the farmers to ensure land use right because land is owned by the government in Ethiopia. This is because tenure security affects farmers' perception to manage their land from degradation of different types. It also affects investments and agricultural productivity of the land (Holden and Yohannes, 2002). Some 15% of the sampled households do not have land use right certificate. Land tenure certification has not finalized in the study area. A review of agricultural research in Ethiopia by Cochrane has shown that land use right certificate affects soil and water resources management activities by increasing productivity of the land (Cochrane, 2014). Another study in Ethiopia also indicated that farmers with the certificate have stronger motivation to engage in soil and water resources management practices which strengthen their adaptive capacity and increase farmers' agricultural productivity (Woldearegay et al., 2018; Matewos, 2019a).

5.2.4. Livelihood characteristics

Rain-fed crop production and animal husbandry are the main sources of livelihoods in the study area because of the absence of irrigation, as it is the case in other parts of the country (see Bazezew et al., 2013; Belay et al., 2017). Most of the sampled households (95%) were engaged in rain-fed crop production. About 47% and 44% respondents practice mixed farming and animal husbandry respectively. These livelihood activities are heavily reliant on rainfall which is very erratic and declining from time to time in the two (spring and Summer) growing seasons (Fig. 3) This heavy reliance on rainfall is one of the main factors that have made the households vulnerable to food insecurity and recurrent hunger as it has been a case in other rural parts of Ethiopia (Abegaz, 2017). To minimize the heavy reliance on rained agricultureand minimize climate change-induced impacts, context specific livelihood diversification is crucial (Osbahr et al., 2010; Cochrane and Cafer, 2018). Specifically, the involvement of households in on-farm and off-farm activities plays a pivotal role in this regard. However, the analysis of data on livelihood diversification revealed that most the households were not engaged in on-farm and off-farm livelihood activities. The overall level of participation in non-farm and off-farm livelihood activities in the study are 16%, which is much lower than the Sub-Saharan Africa (SSA) average which stood at 42% in 2005 as Ellis (2005) cited in (Bazezew et al., 2013). Daily labour, petty trade and casual labour were practiced by 22%, 19% and 15% of the sampled households respectively. Engagement in non-farm activities has been limited in the study area because of bureaucratic loan services, limited awareness on off-farm livelihood options, market and transportation access related problems. The above factors have limited farmers' livelihood options and weakened their adaptive capacity.

The undiversified nature of livelihoods in many developing countries is attributed to poverty, a lack of access to market information, limited credit service, absent skill training programs, ineffective extension services, low levels of awareness, and problems related with market access (Agrawal, 2010; Bazezew et al., 2013; Alobo, 2015). The key informants in the study area also reported that the reasons for the undiversified nature of the livelihood are high illiteracy which was 48%, poverty, and limited awareness on the advantages of livelihood diversification. The undiversified nature of livelihood activities has seriously weakened their adaptive capacity. This is evident in drought years where the farmers need urgent emergency relief once they lost their harvest or/and cattle.

The PSNP support had been one of the mechanisms through which vulnerable HHs were supported by the government. Of the total sampled HHs 37% reported that they were getting the PSNP support. Regarding the impact of the program, 70% of the beneficiaries replied that it helped them to adapt climate change induced effects. Among the beneficiaries of various schemes of the program, beneficiaries of supports in kind and loan service replied that the supports helped them to adapt climate change in sustainable manner than the users of direct cash and food item support. So, the program need to expand and strengthen the support in kind and that of loan services to make the program more effective and sustainable. Another social strategy of households during climate change-induced shocks is through social Self-help Community. They major once include *Jirte* (mourning clubs); *Dee* (labour sharing clubs) that have roles during climate change induced effects. The experts from the districts argue that because of the expansion of Christianity, church related institutions are replacing the roles of indigenous self-help local institutions. The main roles of these self-help institutions are supporting people during times of mourning and also during climate related extremes such as flooding and hunger.

5.2.5. Institutions and entitlements

Institutional environment is complex in Ethiopia, where both formal and informal institutions compete and sometimes overlap in their functions and influences (Ludi et al., 2011). Formal institutional roles in adaptive capacity development in the study area were found to be very weak (Matewos, 2019b). The intervention polices, strategies and programs designed at national levels were not transferred into action strategies at the lower level, according to key informants in the districts. Thus, despite the claims of national policies and programs, the adaptive strategies were not being implemented at local levels. Except, integrated watershed management (IWSM) which was being practiced in the form of campaign, other strategies indicated in NAPA and other policy documents such as crop insurance, small scale irrigation and water harvesting, building adaptive capacity of local institutions, building multi-purpose water dams, carbon sequestration, promoting on-farm and homestead forestry, and agroforestry were yet to be implemented in the study area. Weak institutional capacity at the district level was attributed to limited technical, logistical, technological, and financial capacities that severely limited the capacity to carry out their activities (Matewos, 2019b).

The study also tried to explore the services provided by local health, education, and microfinance institutions. Education and health institutions boost awareness of the local community, decrease their vulnerability, and increase their productivity (Adger and Vincent, 2005; Brooks et al., 2005). To this end, primary school education and health posts were available in every kebele. However, the household members had to travel longer distances (1–2 h every day) if they are to attend secondary school (9–10) and to get health services. Improving access to quality education and health services can strengthen adaptive capacity of the households. Regarding access to microfinance institutions, all the three districts had micro finance offices in the district towns and there were endeavors to decentralize the services to the kebele level by appointing a service agent, which the households locally calls the '*Omo*

agent'. However, only 4% of the sampled households reported that they had Omo agent in their kebele. During key informants' interview, the kebele administrators claimed that the agents were available in all rural kebeles. The gap could be because of the lack of information on the side of the households or the absence of the agent. A study over eleven African countries showed that more financial and other resources at farmers' disposal can help them to use available information to change their adaptive practices in response to climate change and variability (Hassan and Nhemachena, 2008; Bryan et al., 2009). Although microfinance services were available at district levels, nearly half (49%) of the sampled Households had not borrowed money from microfinance institutions. In an attempt to further investigate the reason behind, the households were asked the reasons why they were not using rural credit services. Some 45% blamed the criteria set as difficult to meet, whereas 36% claimed that they did not want to borrow money. About 16% of the respondent replied that the higher interest rates were the reason behind for not borrowing. A study carried out in southern Ethiopia also indicated that inflexibility in repayment terms and financial penalties, which can even cause the loss of assets, were similarly reasons for of the lower attention to borrow money from microfinance institutions (Cochrane and Thornton, 2017).

Informal local institutions also play pivotal role in building adaptive capacity of households (Agrawal, 2010). In relation to this, communal pooling of resources is an adaptive strategy that involves communal ownership of resources, sharing and mobilization of wealth, labour, or incomes across households during times of environmental shocks (Agrawal, 2010). Communal resources such as grazing lands and water ponds are important livelihood assets where households use during climate change induced shocks. However, because of population growth, climate change, and subsequent environmental consequences, these communal resources have been declining from time to time. Of the sampled households, only 15%, 12%, and 11%, respectively, reported that they had communal grazing land, forest resources, and communal water pond in their locality. The existing communal resources use is strongly affected by societal values and beliefs. Societal values and beliefs that are undemocratic, non-transparent and non-inclusive influence the use of communal resources. For example, the role that women play in a family and a village in developing countries is strongly influenced by religious and cultural values (Adger et al., 2013). Men usually have more access to communal resources, more heard than women, and have stronger decision-making privilege though women disproportionately shoulder most of the household burden of family care (Uphoff, 1992). Thus, lack of communal resources to be pulled during environmental shocks and discrimination based on gender, ethnicity, wealth status had weakened farmers' adaptive capacity.

Access to, and control over, assets affects adaptive capacity of individuals and households. Institutions that promote equity, participation and democracy enhance adaptive capacity and the vice versa. In the study area, discrimination based on gender, ethnicity, wealth status, and political ideology were reported households which negatively affect their adaptive capacity. Sex-based discrimination was reported by 16% respondents, where females were discriminated during their daily social activities. Discriminations based on clan and ethnicities were also reported by 16% and 16% respectively. Gendered discrimination extends to control over resources owned by the households. In this regard, some 19% of the sampled households reported that it is the husbands who decide on the properties owned by the family. The figure for women participation in family resources decisions is higher compared with the national and regional average which was 10% and 14% respectively in 2016 (CSA, 2016). Male dominance over family resources decisions limits females' role in family issues.

The participation of women in climate change adaptation decisions is crucial for women are primary family caretakers and can provide rich ideas on how to manage the livelihood activities of their families. Despite their potential role in shaping adaptive strategies of their families, their participations in family, village, kebele and district level climate change adaptation dialogues had been minimal. Only 24% of the sampled households reported that women participate in climate relate issues regularly at households' level. Their level of participation decreases as we move from family level to district level. Weak institutional services and problems of entitlement, lesser participation of females in climate change adaptation decisions have weakened adaptive capacity of households in the study area.

5.2.6. Knowledge and information

Knowledge and information refers to the ability of households and communities to generate, receive, assess and disseminate knowledge and information that enhances adaptive responses and capacities. In this regard, education plays important role because it enables people to have more access to information on improved technologies, and other relevant information needed for climate change adaptation (Hassan and Nhemachena, 2008). Of the sampled households, 48% were illiterate and this had affected their ability to access and use information and technologies, which would have helped them to adapt climate change and variability –induced impacts.

Access to relevant and updated information on weather forecast, market conditions, and early warning are important in climate change adaptation (Shiferaw et al., 2014). Early warning information was not accessible to more than half (52%) of the sampled respondents. Whereas 77% and 81% of the sampled households reported that they had access to weather forecast and market information. According to focus group discussion with the farmers, the main problem with weather forecast and market information is that the information is not specific and updated enough in their context. Besides, the media that forecast weather information had not been accessible to most of the farmers. The quality of weather forecast information is so vital because poor forecast information can actually be damaging to poor farmers (Cooper et al., 2008; Bryan et al., 2009). This is mainly because households access to modern channels of information such radio, TV and newspaper is very limited. The endeavor of government to avail relevant agriculture-related information for farmers through their mobile phone *'8028 free call service'* is very ambitious because only 36% of the sampled households had mobile phones. As is the case elsewhere in rural areas, social networks and marketing places remain the main sources of market information. Some 76% of the respondents replied that marketplaces are the main sources of information for buying and selling goods and services. Family members and relatives are other important sources of information in the study area as reported by 65% and 63% households respectively. Therefore, limited access to knowledge and information has limited the adaptive

capacity of farmers in the study area.

5.2.7. Innovation and technology

Innovation and technology enable households and communities to improve their existing adaptive practices, resources utilization habits, and their adaptive behaviours in response to environmental stresses including climate change induced impacts (Wongtschowski et al., 2009). To this end, the use of modern agricultural inputs and agricultural extension services are identified as important to enhance soil and water management practices whereby increasing agricultural productivity (Cooper et al., 2008; Hassan and Nhemachena, 2008).

The survey data shows that the number of households who were using improved seed varieties, inorganic chemical fertilizer, and line sowing technology were higher compared with other agricultural technologies and inputs. About 98%, 92%, and 87% of the sampled households reported that they were using improved seed varieties, chemical fertilizers, and line sowing technologies in their farms. However, the problem with the use of these modern agricultural inputs, according to FGD participants, was the cost of these imputes, which is expensive for many rural farmers to afford, specifically during the years of bad harvest. Since the farmers are expected to pay back the debts of the inputs, this seriously weakens their adaptive capacity especially in bad harvest years. In bad harvest years, they usually sell their assets to pay back the debts. Other studies in Africa also revealed that the costs of agricultural inputs are hard to afford for farmers (Shiferaw et al., 2014).

In drought prone environments where there are severe shortages of water for various agricultural practices, small scale irrigation, rain water harvesting, and the use of improved animal fodder are crucial to strengthen adaptive capacity of the households and communities (Rockström, 2003; Cochrane, 2014). Nonetheless, only 5%, 7% and 13% of households reported that they were using small scale irrigation, rain water harvesting, and improved animal fodder in their farms. There had been no small-scale irrigation scheme in study area districts and water harvesting practices were very weak. The farmers interviewed in the districts revealed that they had been not practicing rainwater harvesting because they were not convinced about its benefits because of poor work on their behavioural changes. The practice had technical problems according to focus group discussion participants, including the design of the ponds. The failure to use the above agricultural technologies has limited their adaptive capacity since they experience serious water shortage to grow crops and water their livestock during drought years.

Soil and water conservation practices had been weak in the study area, where some 32% of the sampled households did not practice soil terracing, which is an important mechanism to control soil erosion. Moreover, soil and water management practices, such as building water drainage channels, planting trees and planting grasses were implemented by only 19%, 39%, and 11% of the sampled households respectively. Most of soil and water conservation activities had been implemented in the form of campaign and hence lack continuity to yield the intended results, according to the key informants. This had made the households more vulnerable to climate change induced effects limiting their capacity to retain their soil nutrients and moisture.

5.2.8. Flexible forward-looking decision making (FFDM) and governance

This refers to the ability to anticipate, incorporate and respond to different environmental changes by the farmers and the government. It also encompasses proactive adaptive decision making and governance practices. In order for this to occur, decisions and governance systems need to be proactive and participatory such that they duly consider institutional, environmental, socio-economic and political contexts (Klein and Huq, 2003; Ayers and Huq, 2009).

Farmers' adaptive responses against environmental shocks can affect livelihoods resources unless the farmers consider their potential impacts. Specifically, short-term and immediate reactive responses to climatic extremes can degrade the asset base and become maladaptive practices. Most of the farmers included in this study practice short term coping strategies and this has degraded the asset base of the farmers. Some of the widely used short-term coping strategies used by the farmers include reducing food consumption 60%, selling livestock 55%, waiting for emergency relief support 55%, selling trees 31%, migrating to urban centers 29%, and selling land use rights 15%. All of the above strategies are maladaptive reactive responses taken by the households so as to survive climate change induced shocks. They are practiced due to the lack of other alternatives. These practices have degraded the resource base of the farmers and had weakened their adaptive capacity.

Literature on environmental governance strongly pronounces public participation in decision making (O'Neill, 2001; Parkins and Mitchell, 2005). One of the ways to enhance environmental governance is through public participation. Public participation in climate change adaptation decisions include providing input to formal decision-making structures through different mechanisms. With respect to this, the participation of the households and local community in climate change adaptive strategies of the government was in its early stage. Only 16% of the sampled households reported that they were fully aware of climate change adaptive strategies of the local government in their surroundings. Moreover, only 11% reported that they were consulted on the adaptive strategies being implemented by the government. This means public participation in climate change adaptation practices was very minimal. This has weakened the feeling of belongingness on government adaptive strategies being implemented in the study area.

6. Conclusions and policy recommendations

6.1. Conclusions

The paper assessed the state of local adaptive capacity by using ACCRA's LACF. The framework used five parameters namely: livelihood resources, institutions and entitlements, knowledge and information, innovation and technology, and flexible forward looking decision making and governance to assess local adaptive capacity.

Based on the assessment, livelihood resources deteriorated because of different factors. There is a declining land holding size which affected the income status of the farmers weakening their adaptive capacity. There is also heavy dependency on rain-fed agriculture where there is a little irrigation practice. Most of the sampled households (95%) were engaged in rain-fed crop production where the rainfall was variable and declining. This has made the households vulnerable to food insecurity and recurrent hunger. The involvement of households in on-farm and off-farm activities was very much limited. This undiversified nature of livelihoods is attributed to persistent poverty, lack of access to market information, credit service, and weak skill trainings. This undiversified nature of the livelihoods in the study area has deteriorated the adaptive capacity of the farmers.

Local formal institutions were not playing their roles in building the adaptive capacity of the households. The services and supports provided by formal local institutions were very weak and limited because of poor human, material, and financial capacities. Communal resources were also declining from time to time as a result of climate change, population growth, and resultant environmental consequences. The study also identified some level of gender, clan and political ideology-based discrimination, male dominance over family resource decisions and low level of women participation in climate change related decisions all of which are indications of weaker adaptive capacity at household and community levels.

Limited adaptive capacity was also witnessed in relation with literacy, access to information, and medias through which information are channelled to the households and communities. Agricultural technologies such as small scale irrigation, rainwater harvesting, using drought resistant varieties, and improved animal forage were in their infantile stage to build households' adaptive capacity. Besides, soil and water conservation practices lack of continuity and were not strengthening adaptive capacity of farmers.

Most of the adaptive decisions of the farmers were short term, and reactive targeted to overcome climate change induced shocks and had become maladaptive practices. Low level of participation and awareness in government adaptive decisions were also another indication of poor climate change adaptive governance in the study area that is weakening adaptive capacity of farmers. In general, assessment of adaptive capacity in the study area by using ACCRA's LAC framework clearly depicted very weak adaptive capacity in all dimensions..

6.2. Policy recommendations

There should be clear livelihood resources management policy provisions to maximize benefits from livelihood resources

Strengthening formal and informal local institutions working on adaptive capacity development of rural areas

Diversifying pro-poor livelihood strategies of the farmers through increasing use of rural microfinance, availing market information, and improving awareness on available livelihood strategies

Strengthen adaptive capacity of farmers through expanding rural road network, expanding small scale irrigation, diversifying livelihood activities, increasing access to information.

Working on behavioural change components of the farmers on soil and water resources management practices, capacitating local institutions, and diversifying pro-poor livelihood strategies to boost local adaptive capacity.

Giving more emphasis for human capital development such as education, women empowerment, land use right certification, and participation of the households in adaptation decisions

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Abegaz, K.H., 2017. Determinants of food security: evidence from Ethiopian Rural Household Survey (ERHS) using pooled cross-sectional study. Agric. Food Secur. 6 (1), 70.

Adem A., Bewket, W. 2011. A climate change country assessment report for Ethiopia. In Forum for Environment, Addis Ababa.

Adger, W.N., Brooks, N., Bentham, G., Agnew, M., Eriksen, S., 2005b. New indicators of vulnerability and adaptive capacity. Tyndall Centre for Climate Change Research, Norwich.

Adger, W.N., Arnell, N.W., Tompkins, E.L., 2005a. Successful adaptation to climate change across scales. Global Environ. Change 15 (2), 77–86.

Adger, W.N., Barnett, J., Brown, K., Marshall, N., O'brien, K., 2013. Cultural dimensions of climate change impacts and adaptation. Nat. Clim. Change 3 (2), 112.

Adger, W.N., Vincent, K., 2005. Uncertainty in adaptive capacity. C.R. Geosci. 337 (4), 399–410.

Agrawal, A. 2010. Local institutions and adaptation to climate change. Social dimensions of climate change: Equity and vulnerability in a warming world, 2, 173-178.

Alobo Loison, S., 2015. Rural livelihood diversification in sub-Saharan Africa: a literature review. J. Develop. Stud. 51 (9), 1125–1138.

Amsalu, W., Georg Hirte, Hermann Lotze-Campen, & Stefan Tscharaktschiew. 2017. Economic Effects of Climate Change in Developing Countries: Economy-wide and Regional Analysis for Ethiopia.

Ayers, J.M., Huq, S., 2009. Supporting adaptation to climate change: what role for official development assistance? Develop. Policy Rev. 27 (6), 675–692.

Bazezew, A., Bewket, W., Nicolau, M., 2013. Rural households livelihood assets, strategies and outcomes in drought-prone areas of the Amhara Region, Ethiopia: Case Study in Lay Gaint District. Afr. J. Agric. Res. 8 (46), 5716–5727.

Belay A., Recha, J., Woldeamanuel, T., Morton, J. F. 2017. 1. Smallholder Farmers' Adaptation to Climate Change and Determinants of their Adaptation in the Central Rift Valley of Ethiopia. Impact of El Niño on Biodiversity, Agriculture, and Food Security 23-24 February 2017 Haramaya University, Ethiopia, 63.

Below, T.B., Mutabazi, K.D., Kirschke, D., Franke, C., Sieber, S., Siebert, R., Tscherning, K., 2012. Can farmers' adaptation to climate change be explained by socio-economic household-level variables? Global Environ. Change 22 (1), 223–235.

Bewket W., Radeny, M., Mungai, C. 2015. Agricultural Adaptation and Institutional Responses to Climate Change Vulnerability in Ethiopia.

Bezu, S., Holden, S., 2014. Are rural youth in Ethiopia abandoning agriculture? World Dev. 64, 259–272.

Brooks, N., Adger, W.N., Kelly, P.M., 2005. The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. Global Environ. Change 15 (2), 151–163.

Brooks, N., Adger, W. N. 2005. Assessing and enhancing adaptive capacity. Adaptation policy frameworks for climate change: Developing strategies, policies and measures, 165–181.

Bryan, E., Deressa, T.T., Gbetibouo, G.A., Ringler, C., 2009. Adaptation to climate change in Ethiopia and South Africa: options and constraints. Environ. Sci. Policy 12 (4), 413–426.
Cochrane, L., 2014. Agricultural intensification in Ethiopia: Review of recent research. Afr. J. Agric. Res. 9 (31), 2377–2390.
Cochrane, L., Cafer, A., 2018. Does diversification enhance community resilience? A critical perspective. *Resilience* 6 (2), 129–143.
Cochrane, L., Thornton, A., 2017. A socio-cultural analysis of smallholder borrowing and debt in southern Ethiopia. J. Rural Stud. 49, 69–77.
Constas, M., Frankenberger, T., Hoddinott, J. (2014). Resilience measurement principles: Toward an agenda for measurement design. Food Security Information Network, Resilience Measurement Technical Working Group, Technical Series , 1.
Cooper, P.J.M., Dimes, J., Rao, K.P.C., Shapiro, B., Shiferaw, B., Twomlow, S., 2008. Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: an essential first step in adapting to future climate change? Agric. Ecosyst. Environ. 126 (1–2), 24–35.
CSA, 2016. Ethiopia Demographic and Health Survey, 2016. Central Statistical Authority, Addis Ababa, Ethiopia.
Defiesta, G.D., Rapera, C.L., 2014. Measuring adaptive capacity of farmers to climate change and variability: application of a composite index to an agricultural community in the Philippines. J. Environ. Sci. Manage. 17 (2).
Di Falco, S. 2018. Adaptation to climate change in sub-Saharan agriculture. In Agricultural Adaptation to Climate Change in Africa (Vol. 83, No. 106, pp. 83–106). ROUTLEDGE in association with GSE Research.
Echeverría, D., Terton, A. 2016. Review of current and planned adaptation action in Ethiopia. CARIAA working paper; no. 8.
Ellis, F., Woldehanna, T. 2005. Ethiopia participatory poverty assessment 2004-05. Ministry of Finance and Economic Development (MoFED): Development Planning and Research Department.
Engle, N.L., 2011. Adaptive capacity and its assessment. Global Environ. Change 21 (2), 647–656.
Engle, N.L., Lemos, M.C., 2010. Unpacking governance: building adaptive capacity to climate change of river basins in Brazil. Global Environ. Change 20 (1), 4–13.
Ethiopian Panel on Climate Change. 2015. First Assessment Report, Working Group II Agriculture and Food Security, Published by the Ethiopian Academy of Sciences.
Gebreyes, M., Zinyengere, N., Theodory, T. F., Speranza, C. I. 2017. Introduction: Grounding Climate Change, Vulnerability, and Adaptation in Africa. In Beyond Agricultural Impacts (pp. 1–11). Academic Press.
Gidey, E., Dikinya, O., Sebego, R., Segosebe, E., Zenebe, A., 2018. Analysis of the long-term agricultural drought onset, cessation, duration, frequency, severity and spatial extent using Vegetation Health Index (VHI) in Raya and its environs, Northern Ethiopia. Environ. Syst. Res. 7 (1), 13.
Hassan, R., Nhemachena, C., 2008. Determinants of African farmers' strategies for adapting to climate change: multinomial choice analysis. African J. Agric. Res. Econ. 2 (1), 83–104.
Headey, D., Dereje, M., Taffesse, A.S., 2014. Land constraints and agricultural intensification in Ethiopia: a village-level analysis of high-potential areas. Food Policy 48, 129–141.
Holden, S., Yohannes, H., 2002. Land redistribution, tenure insecurity, and intensity of production: a study of farm households in Southern Ethiopia. Land Econ. 78 (4), 573–590.
IPCC. 2001. Climate change 2001 IPCC third assessment report. Intergovernamental Panel on Climate Change Geneva, IPCC Secretariat.
IPCC. 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 976pp.
IPCC. 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.
James, H., Janie, R., Stephen, T., 2018. Urgent action to combat climate change and its impacts (SDG 13): transforming agriculture and food systems. Curr. Opin. Environ. Sustain. 34, 13–20.
Jones, L., Ludi, E., Jeans, H., Barihaihi, M., 2017. Revisiting the Local Adaptive Capacity framework: learning from the implementation of a research and programming framework in Africa. Clim. Dev. 1–11.
Kassie, B.T., Asseng, S., Rotter, R.P., Hengsdijk, H., Ruane, A.C., Van Ittersum, M.K., 2015. Exploring climate change impacts and adaptation options for maize production in the Central Rift Valley of Ethiopia using different climate change scenarios and crop models. Clim. Change 129 (1–2), 145–158.
Kiros, G., Shetty, A., Nandagiri, L., 2016. Analysis of variability and trends in rainfall over northern Ethiopia. Arabian J. Geosci. 9 (6), 1–12.
Klein, R.J., Huq, S., 2003. Climate change, adaptive capacity and development. World Scientific.
Kreft, S., Eckstein, D., Dorsch, L., Fischer, L. 2015. Global Climate Risk Index 2016: Who Suffers Most From Extreme Weather Events? Weather-related Loss Events in 2014 and 1995 to 2014.
Krejcie, R.V., Morgan, D.W., 1970. Determining sample size for research activities. Educ. Psychol. Meas. 30 (3), 607–610.
Ludi, E., Tesfaye, K., Levine, S., 2011. Preparing for the Future Understanding the influence of development interventions on adaptive capacity at local level in Ethiopia. Oxfam Policy Pract.: Clim. Change Resil. 7 (4), 1–64.
Matewos, T., 2019)b.. Deconstructing institutional roles in climate change adaptation: The case of local public institutions in drought-prone districts of Sidama, Southern Ethiopia. Environ. Sci. Policy 98, 47–53.
Matewos, T., 2019)a.. Climate change-induced impacts on smallholder farmers in selected districts of Sidama, Southern Ethiopia. Climate 7 (5), 70.
MoWR and NMA. 2007. Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia. National Meteorological Services Agency, Ministry of Water Resources, Federal Democratic Republic of Ethiopia, Addis Ababa.
Mwamba, L. O. 2012. Vulnerability and Adaptability: Modelling the Adaptive Capacity of Rural Households to Environmental Changes.
Nam, U.V., 2015. Transforming our world: The 2030 agenda for sustainable development. Division for Sustainable Development Goals, New York, NY, USA.
O'Neill, J., 2001. Representing people, representing nature, representing the world. Environ. Plan. C: Govern. Policy 19 (4), 483–500.
Osbahr, H., Twyman, C., Adger, W., Thomas, D., 2010. Evaluating successful livelihood adaptation to climate variability and change in southern Africa. Ecol. Soc. 15 (2).
Parkins, J.R., Mitchell, R.E., 2005. Public participation as public debate: a deliberative turn in natural resource management. Soc. Natural Res. 18 (6), 529–540.
Rockström, J., 2003. Resilience building and water demand management for drought mitigation. Phys. Chem. Earth, Parts A/B/C 28 (20–27), 869–877.
Schramski, S., McCarty, C., Barnes, G., 2018. Household adaptive capacity: a social networks approach in rural South Africa. Clim. Dev. 10 (3), 230–242.
Seleshi, Y., Zanke, U., 2004. Recent changes in rainfall and rainy days in Ethiopia. Int. J. Climatol. 24 (8), 973–983.
Shiferaw, B., Tesfaye, K., Kassie, M., Abate, T., Prasanna, B.M., Menkir, A., 2014. Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: Technological, institutional and policy options. Weather Clim. Extremes 3, 67–79.
Sietchiping, R., 2006. Applying an index of adaptive capacity to climate change in north-western Victoria, Australia. Appl. GIS 2 (3), 16–18.
Smit, B., Pilifosova, O. 2003. From adaptation to adaptive capacity and vulnerability reduction. In Climate change, adaptive capacity and development (pp. 9–28).
Smit, B., Wandel, J., 2006. Adaptation, adaptive capacity and vulnerability. Global Environ. Change 16 (3), 282–292.
Smith, B., Burton, I., Klein, R.J., Wandel, J., 2000. An anatomy of adaptation to climate change and variability. Clim. Change 45 (1), 223–251.
SNNPRS-BoFED. (2014/2015). Annual abstract SNNPRS Bureau of Finance and Economic Development annual STATISTICAL ABSTRACT. 2003 E.C. Data Collection –dissemination Core Process. Hawassa, Ethiopia.
Swanson, D., Hiley, J., Venema, H. D. 2000. Indicators of adaptive capacity to climate change for agriculture in the Prairie Region of Canada: an analysis based on Statistics Canada's Census of Agriculture. International Institute for Sustainable Development.
SZFEDD. 2007. Sidama Zone Socio-economic Profile. Sidama Zone Finance and Economic Development Department. Hawassa Ethiopia.
Uphoff, N.T., 1992. Local institutions and participation for sustainable development. Sustainable Agriculture Programme of the International Institute for Environment and Development, London.
Vincent, K., 2007. Uncertainty in adaptive capacity and the importance of scale. Global Environ. Change 17 (1), 12–24.
Wodaje, G.G., Eshetu, Z., Argaw, M., 2016. Temporal and spatial variability of rainfall distribution and evapotranspiration across altitudinal gradient in the Bilate River Watershed, Southern Ethiopia. Afr. J. Environ. Sci. Technol. 10 (6), 167–180.
Woldearegay, K., Tamene, L., Mekonnen, K., Kizito, F., Bossio, D. 2018. Fostering Food Security and Climate Resilience Through Integrated Landscape Restoration Practices and Rainwater Harvesting/Management in Arid and Semi-arid Areas of Ethiopia. In Rainwater-Smart Agriculture in Arid and Semi-Arid Areas (pp. 37-57). Springer, Cham.
Wongtschowski, M., Verburg, M., Waters-Bayer, A., 2009. Strengthening local adaptive capacities: the role of local innovation in supporting climate-change adaptation. Addis Ababa.