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This paper discusses Ethiopia's planned climate adaptation interventions and the barriers that impede implementation of adaptation policies at the local level by using the case study of Raya Azebo district. Data was collected through reviews of policy documents, focus group discussions with farmers and interviews with relevant government actors. Results indicate that climate change is addressed in various policy documents but there is limited progress in implementation of these policies. The study identified various barriers to climate adaptation policy implementation which included a lack of financial resources, poor coordination among institutional actors and local actors' low technical capacities for addressing climate change. The study contributes to the literature of climate change policy planning and implementation in low-income and lower-middle-income countries and suggests measures to overcome the existing barriers to climate change adaptation policies.

Keywords: climate policy, climate adaptation, policy barriers, smallholder farmers, Ethiopia

Introduction

Climate change remains one of the biggest environmental issues facing the world. The sixth assessment report of the Intergovernmental Panel on Climate Change (IPCC) indicates that climate change is widespread, rapid and intensifying in all regions of the globe with 1.09°C higher surface temperature in 2011–2020 than in 1850–1990 (IPCC, 2021a). In Africa, the report indicates with high confidence that surface temperature and mean sea level have increased at a higher rate than the global average, with the frequency and intensity of heavy rainfall projected to increase in most countries over the coming decades (IPCC, 2021b). The latest Working Group II assessment of the IPCC report further outlines the severe impacts of climate change on Africa's ecosystem and people including species extinction, loss of human life, heightened poverty and food insecurity, increased water scarcity and loss of natural resources (Trisos et al., 2022). Ethiopia, the second most populous country in Africa, is highly vulnerable to the impacts of climate change (Cochrane

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and Singh, 2017). The country has experienced eight serious droughts between 1980 and 2015, five of which caused famine (World Bank, 2010; FEWS NET, 2015). The Tigray region of Ethiopia, where the study was conducted, in particular, is at extreme risk of climate change impacts through severe and recurrent droughts (Meze-Hausken, 2000; Gebrehiwot and van der Veen, 2013). Climate change has caused major consequences for key sectors in Ethiopia such as agriculture, forestry, water and health (FDRE, 2019). Agriculture is the most climate sensitive sector in the country and smallholder farmers are highly vulnerable due to their high dependence on rain-fed production (Gezie, 2019).

Climate change mitigation alone is not adequate to substantially reduce the adverse impacts of climate change (Mata and Budhooram, 2007; Fawzy et al., 2020). This is because, as indicated in the IPCC report, 'effective implementation depends on policies and cooperation at all scales and can be enhanced through integrated responses that link mitigation and adaptation' (IPCC, 2014, 26). In the climate change literature, scholars define and classify adaptation in different ways (see Smit et al., 2000; Smit and Wandel, 2006; Adger et al., 2007). For example, adaptation can be defined as 'adjustments to reduce vulnerability or enhance resilience in response to observed or expected changes in climate and associated extreme weather events' (Adger et al., 2007, 720). The IPCC classifies adaptation into three types: anticipatory, autonomous and planned adaptation (IPCC, 2007, 869). Based on this classification, anticipatory adaptation takes place before impacts of climate change are observed; autonomous adaptation does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems; while planned adaptation is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state (IPCC, 2007, 869).

Poor communities residing in low-income and lower-middle-income countries such as Ethiopia are unlikely to adapt successfully on their own (Leary et al. 2007; Spires et al. 2014). It is therefore widely recognised that planned or policy-driven adaptation measures are required in assisting local communities to adapt to climate change (Smit and Wandel, 2006; Berman et al., 2015; Zougmoré et al., 2016; Tripathi and Mishra, 2017). In response, governments across several low-income and lower-middle-income countries have formulated various policies and strategies to facilitate adaptation (UNFCC, 2020).

Since climate change has emerged as an international political issue, Ethiopia has been participating in various international efforts to reduce the country's vulnerability to climate change (Eshetu et al., 2014). The country ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1994. As a member of UNFCCC, Ethiopia produced and submitted the first National Adaptation Programme of Action

(NAPA) in 2007 to address climate change through adaptation measures (NMA, 2007). In the preparation of the NAPA document, thirty-seven adaptation options were identified of which eleven were prioritised (Table 1).

Table 1 List of adaptation options prioritised under the National Adaptation Programme of Action (NAPA)

No.	Prioritised adaptation options
1	Promoting drought/crop insurance programme in Ethiopia
2	Strengthening/enhancing drought and flood early warning systems in Ethiopia
3	Development of small-scale irrigation and water harvesting schemes in arid, semi-arid and dry sub-humid areas of Ethiopia
4	Improving/enhancing rangeland resource management practices in the pastoral areas of Ethiopia
5	Community-based sustainable utilisation and management of wetlands in selected parts of Ethiopia
6	Capacity-building programme for climate change adaptation in Ethiopia
7	Realising food security through multipurpose large-scale water development project in Genale-Dawa Basin
8	Community-based carbon sequestration project in the Rift Valley System of Ethiopia
9	Establishment of national research and development centre for climate change
10	Strengthening malaria containment programme in selected areas of Ethiopia
11	Promotion of on-farm and homestead forestry and agroforestry practices in arid, semi-arid and dry sub-humid parts of Ethiopia

Source: NMA (2007, 11)

This document was criticised for not representing and consulting important stakeholders such as local communities (Adem and Bewket, 2011; Oates et al., 2011). In 2010, Ethiopia's Programme of Adaptation to Climate Change (EPACC) replaced the NAPA, aiming to build a climate-resilient economy by designing adaptation options through the inclusion of actors from the federal to local levels (Eshetu et al., 2014). Following EPACC, Ethiopia's National Adaptation Plan (NAP-ETH) was launched in September 2017. NAP-ETH falls under Ethiopia's Climate-Resilient Green Economy (CRGE) strategy, through which the country envisions to reach middle-income status by 2025 and a carbon-neutral economy by 2030 (FDRE, 2011). The vision of NAP-ETH is 'to create climate change impact resilient development for Ethiopia and its people' (FDRE, 2019, 45). Its strategic priorities are to integrate climate change adaptation in Ethiopia's long-term development pathways; building effective institutions and governance structures; mobilising finance for implementation and capacity development; and enhancing research in the area of climate change adaptation (FDRE, 2019). NAP-ETH closely aligns with Ethiopia's second Growth and Transformation Plan (GTP II), which recognises the vulnerability of key economic sectors such as the

agricultural sector to the effects of climate change and considers the appropriateness of adaptation and mitigation efforts (MOFED, 2010).

Whilst progress related to adaptation policy formulation in low-income and lower-middle-income countries is encouraging, the translation of policies into concrete adaptation actions appears to be lagging behind (Adenle et al., 2017; Runhaar et al., 2018; Dedicatoria et al., 2019). The IPCC's sixth assessment report (AR6) particularly notes that adaptation gaps are greater among lower-income populations and with the current progress of adaptation planning and implementation, the adaptation gap is expected to widen (IPCC, 2022). Adaptation policies often fail to realise their stated goals due the existence of various barriers that hinder implementation processes (Dupuis and Knoepfel, 2013; Eisenack et al., 2014). Adaptation barriers (or constraints) can be defined as 'factors that make it harder to plan and implement adaptation actions' (Klein et al., 2014, 899). Unlike adaptation limits which are considered to be absolute, barriers to adaptation can be surmountable 'with concerted effort, creative management, change of thinking, prioritisation and related shifts in resources, land uses, institutions […] with sufficient political will, social support, resources, and effort' (Moser and Ekstrom, 2010, 22027).

Studies done across high-income and low-income and lower-middle-income countries have highlighted a wide array of barriers hindering the planning and implementation of adaptation policies. Although the list of barriers reported in the literature is exhaustive, some scholars have attempted to aggregate them into key categories (Biesbroek et al. 2013; Spires et al. 2014; Ekstrom and Moser, 2014; Giles et al. 2021). According to Giles et al. (2021), the main categories are: 1) institutional; 2) informational; 3) financial; 4) behavioural/psychological; and 5) technical barriers. Institutional barriers frequently discussed in the literature mainly relate to a lack of political willingness to prioritise adaptation actions (Pasquini et al., 2013; Archie et al., 2014; Lonsdale et al., 2017; Banwell et al., 2020) and the challenges of coordinating actors across various scales and sectors to address climate change issues (Waters et al., 2014; Juhola, 2016, Azhoni et al., 2017; Davies et al., 2020; Basson et al., 2020). The literature has also discussed informational barriers that are, for example, linked to decision makers' lack of sufficient scientific knowledge on climate change and the absence of timely and accurate climate data to guide adaptation decision making at the local level (Clar et al., 2013; Pasquini et al., 2013; Archie et al., 2014; Singh et al., 2018; Ryan and Bustos, 2019; IPCC, 2022). Further, a number of studies have identified financial barriers as the most pervasive impediments to implementing adaptation policies (Adenle et al., 2017; Ampaire et al., 2017; Oulahen et al., 2018; Nkiaka and Lovett, 2018; Basson et al., 2020).

These studies on barriers to adaptation policy implementation provide useful explanation of the origin of barriers, their interdependencies and how they can be overcome. However, assessments focusing on if and how planned adaptation initiatives

are implemented at the local level remain limited, both globally and in Africa (Epule et al., 2017; Berrang-Ford et al., 2019; Olazabal et al., 2019). Only a few studies go beyond reporting broad and generic adaptation barriers to: assess the status (progress) of planned adaptation actions at the local level; determine whether there is adaptation implementation gap; and explore the effectiveness of adaptation interventions and implementation challenges unique to those specific locations, particularly from the experience of local communities which are often the targets of policy-driven adaptation interventions. It is well recognised that the processes and outcomes of adaptation at the grassroots level, and the associated barriers, are highly context-specific (Biesbroek et al., 2013; Eisenack et al., 2014; Spires et al., 2014). Policies designed to reduce the risk of climate change can only be successful if they consider site-specific factors including location, gender and income among other things (IPCC, 2022). Given this, there is call in the literature for more empirical research that captures location-specific assessment of adaptation actions and existing barriers to policy implementation (Spires et al., 2014; Ford et al., 2015; Mackay et al., 2019). In this paper, taking Raya Azebo district as a case study, we respond to this call by assessing the status of planned adaptation interventions that are in place to support smallholder farmers at the local level and examining whether barriers exist that limit effective adaptation policy implementation. Through this analysis, the paper seeks to inform future discussions and efforts aiming at narrowing the gap between adaptation policy and practice in low-and lower-middle-income countries.

Research context

The Tigray national regional state is located at the Northern tip of Ethiopia. Geographically, it is situated between 12 15' N and 14 57' N latitude and 36 27' E and 39 59' E longitude. The regional state is made up of seven administrative zones and thirty-five rural districts. The total population of the region is 4.3 million out of which 83 per cent live in rural area (CSA, 2007). The altitude of the Tigray region ranges from 1,500–3,000 m above sea level. A large part of the Tigray region is covered by semi-arid (81.5 per cent), followed by arid (16.91 per cent) and dry sub-humid agro-ecologies (1.63 per cent) (Haftom et al., 2019). In the region, average annual minimum and maximum temperatures have increased by 0.72 and 0.36°C respectively from 1954 to 2008 (Gebrehiwot and van der Veen, 2013). Annual rainfall totals across the different districts of the region show both increasing and decreasing trends from 1980 to 2009 (Gebre et al., 2013), while monthly rainfall distributions exhibit high variability, characterised by late or early cessation of rainfall in the months of crop planting dates (Jacob et al., 2013; Berhane et al., 2020). For the period of 2030–2050, the short season rainfall amounts are projected to decrease, while mean maximum temperature would increase by 2.3 and 2.7°C, respectively (Hadgu et al., 2015). The change in climate

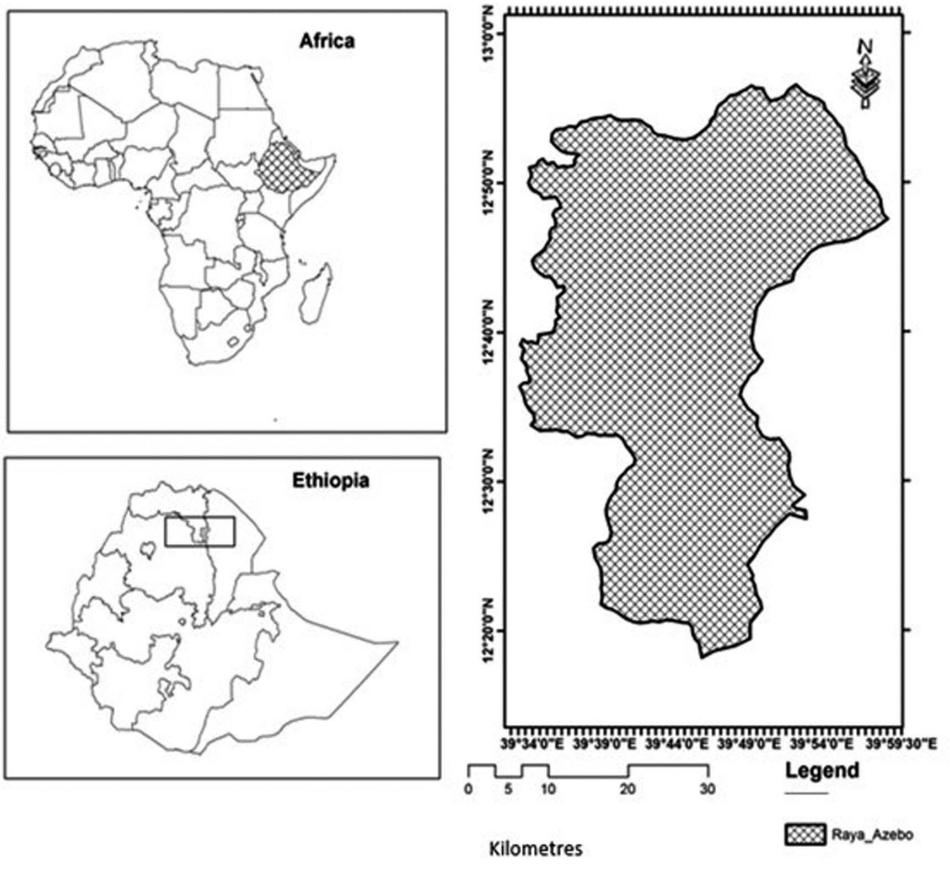

Figure 1 Location map of Raya Azebo district
Source: TBFED (2018, 21)

is shifting ago-ecological zones towards desert and semi-arid classifications, thereby affecting crop production across some parts of Africa (Kala et al., 2012). In the Tigray region of Ethiopia, evidence shows that wheat and barley will migrate upward along the altitudinal gradients in the next eighty years, and suitable areas for these crops are expected to decline significantly with future changes in climate conditions (up to 16–100 per cent) (Gebresamuel et al., 2022). However, the yield of maize and sorghum may increase in some parts of Tigray due to projected increase in the long season rainfall totals (2030–2050) (Hadgu et al., 2015).

Raya Azebo district is located in the Tigray national regional state of Ethiopia (Figure 1). The district lies between 12°47'50.22" N latitude and 39°38' 36.44" E longitude in the southern part of the Tigray region. Based on the national census conducted in 2007, the district had a total population of 135,870 (CSA, 2007).

According to the data obtained from the district Bureau of Agricultural and Rural Development (BOARD), the total area of the district is 1,343 km^2, of which cultivable land comprises 35.15 per cent and grazing land 29.32 per cent. The majority (96.9 per cent) of the cultivable land in the district is rain-fed and only 3.1 per cent is irrigated land. In this district, the agricultural production system is mixed crop-livestock farming. The main crops produced are teff, sorghum and maize. The study selected Raya Azebo as a case study district because it is one of the most vulnerable districts in Ethiopia to the impacts of climate change (Meze-Hausken, 2000; Gebrehiwot and van der Veen, 2013). Although climate change vulnerabilities of smallholder farmers were used as the main criteria to select the case study district, the first author's understanding of the language spoken in the Tigray region was also taken as an additional criterion.

Method

Fieldwork was conducted between December 2016 and February 2017 in Raya Azebo district. The research strategy adopted in this study was a qualitative method that involved focus group discussion with smallholder farmers, in-depth interviews with key informants and an analysis of published and unpublished documents related to climate change adaptation in Ethiopia. Two focus group discussions (FGDs) were conducted with smallholder farmers in Raya Azebo district. The first focus group included a total of eleven smallholder farmers (including $n = 5$ men and $n = 6$ women). This focus group discussion aimed to assess government-led adaptation interventions that are in place in Raya Azebo district and their adequacy in terms of supporting smallholder farmers to adapt to climate change impacts. The second focus group discussion was conducted with a group of ten smallholder farmers ($n = 5$ women and $n = 5$ men). The purpose of this focus group discussion was to examine the effectiveness of existing government-led adaptation interventions in Raya Azebo district and explore implementation challenges. We chose to follow mixed-gender focus groups because we realised that issues of the discussion topics are equally experienced by both genders and would not undermine women's ability to voice their concerns more freely. In terms of age composition, focus group participants were aged between thirty and sixty-three. The first FGD was conducted for two hours in a place where the participants gather for local-level meetings and social events, while the second FGD was held for an hour in an area where they participate in the government-led planned adaptation interventions.

In addition, a total of twenty-five in-depth interviews were conducted between December 2016 and February 2017 with district, regional and national-level government officials, from the following six different organisations: 1) Ministry of Environment, Forest and Climate Change (MEFCC); 2) the National Meteorological Agency

(NMA); 3) Tigray Environmental Protection and Land Use administration agency; (4) Tigray Regional State Bureau of Agriculture and Rural Development; 5) Raya Azebo District Bureau of Agriculture and Rural Development; 6) Raya Azebo District Finance and Economic Development Office. The key informants were purposively selected based on an expert sampling method. Further, the document analysis involved :(1) Ethiopia's NAPA; (2) Ethiopia's CRGE; (3) EPACC; (4) Ethiopia's National Adaptation Plan (NAP-ETH); (5) Tigray Regional Programme of Plan on Adaptation to Climate Change (TRPPACC).

The above in-depth interviews were conducted by the first author using questions designed to be flexible to accommodate the specific information needed from each key informant and to allow the respondents to share their views more freely. Interviews with national-level key informants were held in the capital, Addis Ababa, while interviews with regional and district-level key informants were conducted in Mekelle, the provincial capital, and Raya Azebo district, respectively. The interviews lasted between thirty minutes and one hour. All interviews were digitally recorded and translated into English from Amharic and Tigrigna languages. We then used thematic analysis to analyse the qualitative data. First, all the transcripts were read through multiple times. Following that, we used an open coding strategy to identify which barriers to the implementation of adaptation policy were reported by the interviewees. Direct quotes from interviewees were used to explain the results.

Results and discussion

The status of planned adaptation interventions in Raya Azebo district

Analysis of policy documents indicates that the issue of climate change and the need for adaptation is well recognised in Ethiopia (Table 2). As shown in Table 2, the country has made good progress in formulating climate-related policy documents at the national and regional levels.

The key objective of the NAPA and EPACC is more or less similar – i.e. to facilitate the implementation of adaptation actions across the various regions of Ethiopia to tackle the current and future impacts of climate change. The objective of the CRGE strategy is to follow a green economy path whilst improving resilience to climate change. The development of a green economy strategy is based on four pillars: 1) agriculture (the implementation of agricultural and land use efficiency measures); 2) forestry (conserving and re-establishing forests); 3) power (expanding renewable and clean power generation); and 4) transport, industrial sectors and buildings (advancing to modern and energy efficient). The aim of the national adaptation plan (NAP-ETH) is to reduce climate change vulnerability mainly by facilitating the integration of climate change adaptation into the country's development programmes and projects.

Table 2 Summary of key climate-related policy documents in Ethiopia

Climate-related policies and strategies in Ethiopia	Key tenets of each policy document
Ethiopia's NAPA	• Climate-related factors are largely documented as the main contributing factors to vulnerability • Non-climatic factors such as population pressure and weak institutions are acknowledged but there is no focus on how these factors contribute to vulnerability
Ethiopia's Programme of Adaptation to Climate Change (EPACC)	• This policy recognises that impacts of climate change will continue to threaten Ethiopia and thus adaption is required to protect the country from such impacts
Ethiopia's CRGE	• This document focuses on climate resilience and green economy • The strategy emphasises on managing risks and increasing resilience to absorb climatic-linked impacts in Ethiopia
Ethiopia's National Adaptation Plan (NAP-ETH)	• NAP-ETH focuses on mainstreaming climate change adaptation into development programmes • The document aims to establish resilient systems that can recover from climate-linked risks through strengthening coordination among key stakeholders such as federal ministerial offices, regional bureaus and academic institutions
Tigray Regional Programme of Plan on Adaptation to Climate Change (TRPPACC)	• The document recognises the vulnerability of rural livelihoods to climate change in the Tigray region of Ethiopia and with this recognition, the document aims to strengthen the adaptive capacity of local communities through fifteen prioritised adaption options in key vulnerable sectors such as agriculture, water and natural vegetation

To investigate how well the above adaptation policies and strategies are translated into concrete action at the local level, focus group participants were asked to indicate any government-led adaptation interventions that are taking place in Raya Azebo district. Despite the district's high vulnerability to climate change impacts (Gebrehiwot and van der Veen, 2013), focus group participants indicated only one intervention (i.e. the natural resource management (NRM) programme) that has been active in the Raya Azebo since 2013. This was confirmed by regional and district-level government officials who facilitate the implementation of the NRM programme across the Tigray region and in the study area, respectively.

> There is a lot of discussion about climate change and the need to support farmers through adaptation projects and programmes. But except the NRM programme, there is no meaningful work in Raya Azebo district as well as in other parts of the Tigray region. (Key informant 11, 2016/ 2017)

> So far, we are only implementing the NRM programme in Raya Azebo. There is no other policy-driven adaptation intervention. Farmers usually depend on their knowledge and resources to adapt to climate change impacts. (Key informant 1, 2016/17)

The Ethiopian government considers NRM as an important adaptation action to reduce the effects of climate-linked risks. In the NAPA document, community-based NRM is one of the twenty prioritised adaptation actions for implementation (NMA, 2007). Participation in the NRM programme is compulsory and farmers aged between 18–65 need to provide forty days of free labour (January to March) to implement the NRM activities (i.e. such as developing SWC structures on communal lands).

During focus discussion, participants noted that the government is doing nothing when it comes to investing in the most effective adaptation measures (e.g. providing drought resistant crops and installing irrigation facilities). For example, one focus group participant said:

> Raya Azebo is highly exposed to frequent and extreme droughts. But we are not getting the support we need from the government. For example, we need improved seeds that can withstand the drier conditions. We also need modern irrigation facilities installed in this district. Without that [irrigation access], our dependency on rain-fed farming has become very riskier and unprofitable. These are our priorities when it comes to managing the drought effects, but our priorities are not the priorities of our government. (Participant 2, FGD 1, 2016/17)

Access to climate information (e.g. seasonal rainfall forecasts and drought early warning messages) was also considered by focus group participants as one of the most needed services which enables farmers to adapt to climate change impacts. However, this important service is lacking in the study area. Talking about this issue, one of the focus group participants stated:

> We need access to timely climate information. This information is important for us to make crop and livestock management decisions [e.g. adjusting crop planting dates, livestock mobility and destocking]. This is the type of service we need to get from the agricultural extension workers. However, they are only focused on collecting taxes and loans for the government. Climate information service is totally unavailable in this area. (Participant 5, FGD 1, 2016/17)

Overall, excluding the NRM programme, this study confirms that policy-driven adaptation programmes or interventions are very scarce in Raya Azebo district. As indicated above, there are several formulated adaptation policies and strategies in Ethiopia. Yet the findings suggest that the mere presence of formulated policies on paper does not necessarily ensure implementation at the local level.

In the absence of adequate government support, farmers of the case study area would be highly exposed to future climate-linked risks and may be forced to engage in short-term and riskier coping strategies that will eventually undermine their capacity to adapt to climate impacts successfully. The findings, therefore, underscore the need

to translate policies into concrete adaptation actions to meet the needs and priorities of smallholder farmers at the local level.

Outcomes of the NRM programme and implementation challenges

Despite the implementation of the NRM programme in Raya Azebo district, focus group participants expressed great concerns regarding the effectiveness of the constructed SWC techniques and their potentials in reducing climatic risks. For example, they indicated that the constructed soil bunds (*fanya juu bunds*), particularly those constructed in steep areas, get eroded during high flooding events and cause more erosion to their farms. This was also confirmed by district-level government officials, who mainly attributed topographic factors for the ineffectiveness of the constructed soil bunds. For example, one of the key informants said:

> I share the farmers' concern. Due to the topography of the area, these measures [soil bunds] are not effective and suitable for the local area. Since it is an order that we received from higher officials [national-level government actors], farmers had to build them anyway. These higher-level government actors simply need large areas to be treated by SWC [soil and water conservation] technologies, but they do not give equal emphasis to its effectiveness. (Key informant 5, 2016/17)

In addition, focus participants noted that the constructed stone bund structures harbour rats and rodents which are causing considerable damage to field crops. The focus group discussion was conducted on-site, right after the farmers finished constructing the soil and water conservation (SWC) measures. Some of the focus group participants said:

> As you can see, we have spent so much of our time building these structures [soil bunds]. But they will easily be eroded when the rain comes. We have been doing this for so long, but we did not see any improvement on the environment. (Participant 6, FGD 2, 2016/17)

> We just finished constructing stone bunds. These activities are very labour intensive, but we have not observed any of the positive outcomes. Instead, the constructed stone bunds are creating habitats for rodents, and these pests are significantly destroying our crops. No one really wants to participate in these activities if it was not mandatory. (Participant 2, FGD 2, 2016/17)

Besides issues surrounding the ineffectiveness of the NRM activities, focus group participants noted that the implementation of the NRM activities overlap with the timing of their farming season. This is consistent with work by Meshesha and Birhanu (2015) who have similarly found conflicting time schedules between the government-led NRM programme and the farmers' crop growing season in the southern region

of Ethiopia. Due to this challenge, the NRM activities are diverting farmers' labour away from farming operations. Another focus group participant who was participating in the NRM activities said:

> This is the time we are supposed to prepare our land for the coming rainy season. But the whole community is here participating in the NRM programme. If we do not participate in this programme, we would be required to pay a non-attendance fee of 100 Ethiopian birr/day. (Participant 3, FGD 2)

When asked about the challenge associated with the timing of the NRM programme, a district-level official who is responsible for coordinating the programme at the local level commented:

> We understand that the timing of NRM activities is overlapping with the local farming season. We have reported this issue to higher-level officials [regional-level government actors]. But so far, nothing has changed. As we are local actors, we cannot decide when and how the NRM activities should be implemented at the local level. (Key informant 8, 2016/17)

Taken together, the NRM programme is the only planned adaptation which is translated from policy-level priority into actual implementation. Yet, all the above interview results demonstrate that national-level government actors simply designed one-size-fits-all policy without consulting regional-level actors and local communities in the policymaking and implementation process. The findings provide a clear indication that the NRM programme is externally initiated and imposed on farmers without taking into consideration its effectiveness and adaptability to local circumstances and farming context. The mandatory nature of the programme and a lack of time flexibility in programme implementation suggest that the programme did not consult the farmers beforehand. However, it is well acknowledged that for the NRM programme to be effective and sustainable, local communities need to actively participate in key decisions relating to the planning and implementation of the resources they manage (Bewket, 2007; Chirenje et al., 2013).

For the NRM programme to be successful in the study area, first, alternative SWC technologies that are suitable for the local context need to be introduced by involving local farmers in the process. Second, the programmes should be implemented by farmers on a voluntary basis without obstructing their farming activities (i.e. implementation should be carried out during dry season). Third, implementing actors need to regularly monitor and evaluate the effectiveness of the implemented SWC technologies to ensure their fitness to the local context and to avoid unintended outcomes.

Barriers to implementation of adaptation policies at the local level

A lack of financial resources at the local level

Successful implementation of adaptation policies in low-and lower-middle-income countries is determined by the presence of sufficient financial resources (Motsa, 2011; Prasad and Sud, 2019). Interviews held with officials from the Bureau of Agriculture and Rural Development both at district and regional levels revealed that no budget is particularly allocated to implement agricultural-related adaptation strategies in the district of Raya Azebo. For instance, most of the budget that is allocated for the agricultural sector from 2013–2016 has been used to pay staff salaries and for administrative purposes (Table 3). There was no evidence available at the district level that indicates the use of the budget for support of agricultural adaptation strategies such as the dissemination of drought resistant crops to local farmers.

Table 3 Annual budget allocated from 2013–2016 by sector in the Raya Azebo district

Sector	Type	Annual budget in (Ethiopian Birr: 1 birr = US$0.029)			
		2013	2014	2015	2016
Agriculture and rural development	Salaries	4,484,578	6,652,772	8,383,724	8,383,724
	Administration	1,1178,093	1,487,510	2,151,460	2,177,805
Education	Salaries	23,991,260	35,480,708	37,897,776	55,890,764
	Administration	1,051,860	35,480,708	1,530,308	1,444,802
Health	Salaries	5,625,472	9,023,306	11,447,209	15,518,543
	Administration	1,502,100	1,860,879	2,147,641	17,735,725
Water, mines and energy	Salaries	705,004	932,345	494,554	651,749
	Administration	350,308	310,350	460,009	503,845
Rural roads construction	Salaries	514,371	514,371	460,009	503,845
	Administration	104,174	101,968	186,682	140,304

Source: RADEFO (2017, 5)

The CRGE strategy of Ethiopia has a CRGE facility which is established within the Ministry of Finance and Economic Cooperation (MFEC) and it is through this CRGE facility that climate funds are supposed to be allocated to sectoral ministry offices, and regional and local governments, to support the implementation of adaptation programmes. In the NAP-ETH it is stated that: 'the financing and implementation of NAP-ETH will be led by the existing CRGE mechanisms that are in place at national, regional and district levels' (unpublished document). However, the findings of this study indicate that there is no CRGE facility unit established within the district finance and economic development office in Raya Azebo district. Thus, there is no mechanism in place that climate change-related funds from the national levels can be dispersed to the local level.

It appears that there are two different perspectives regarding finance to the implementation of adaptation policies at the local level. On the one hand, all the interviewed key informants at the regional and district levels and some national-level government officials assert that there is sufficient adaptation finance at the national level. But this finance does not trickle down to the local level to support vulnerable communities with concrete adaptation measures. The following quotes taken from regional and national-level key informants, respectively, highlight this:

> We know that the ministry office [MFEC] receives a huge amount of financial support [adaptation fund] from international donors. But we do not see the money here. (Key informant 17, 2016/2017)

> Most of the climate fund is mainly used for nationally designated priorities [e.g. for national policy documents preparation, capacity building activities on climate change awareness etc]. Sometimes the resource is misused for irrelevant activities. There is little to no fund that goes towards the implementation of concrete adaptation actions at the local level. (Key informant 21, 2016/2017)

On the other hand, most of the interviewed key informants at the national level claimed that there is very limited adaptation finance at the national level, and as a result, it is difficult to translate adaptation policies into practice at the local level. One of the key informants from MEFCC stated: 'we do have several formulated policies and strategies, but they are still on paper due to the scarcity of financial resources'. Several efforts were made to verify this claim by interviewing the coordinators of the CRGE facility within the MFEC, but they were not willing to be interviewed. It was also difficult to access project documents and reports that reveal information on adaptation finance, due to the reluctance of the responsible national-level government officials (both from MFEC and MEFCC) to share information. However, other independent sources show that as of December 2020, Ethiopia has received over US$ 106 million adaptation finance from multilateral climate funds (Table 4).

Indeed, billions of dollars in climate finance are being allocated to low-and lower-middle-income countries but the needs and priorities of local communities are often unmet (Tietjen et al., 2019). In Ethiopia, it is the regional and local government actors who closely work with smallholder farmers. Regional and local government actors' lack of climate finance would surely impede their efforts in supporting local farmers with the necessary adaptation actions. Global climate finance providers should therefore consider channelling part of the adaptation finance directly to local-level actors. Devolved climate finance, which adopts decentralised structures to deliver climate finance to local governments in Kenya, Tanzania, Mali and Senegal, is proving to be successful in channelling finance rapidly, to support vulnerable communities through adaptation measures (IIED, 2017). Other alternative approaches can also be used in Ethiopia such as making adapta-

tion finance more accessible to traditional financial institutions, e.g. Iqub and Idir, so the finance can be administered by local-level actors to benefit smallholder farmers.

Table 4 Approved funding from designated multilateral climate funds in Ethiopia as of December 2020

Fund	Fund type	Theme	Amount of funding approved (USD millions)
Adaptation for Smallholder Agriculture Programme (ASAP)	Multilateral	Adaptation	11
Global Environment Facility (GEF)	Multilateral	Adaptation	5.32
Adaptation Fund (AF)	Multilateral	Adaptation	9.99
Least Developed Countries Fund (LDCF)	Multilateral	Adaptation	0.2
The Africa Adaptation Programme	Multilateral	Adaptation	2.47
Special Climate Change Fund (SCCF)	Multilateral	Adaptation	0.995
Least Developed Countries Fund (LDCF)	Multilateral	Adaptation	5.3079
Global Climate Change Alliance (GCCA)	Multilateral	Adaptation	10.8000
Least Developed Countries Fund (LDCF)	Multilateral	Adaptation	4.9000
Least Developed Countries Fund (LDCF)	Multilateral	Adaptation	6.2770
Least Developed Countries Fund (LDCF)	Multilateral	Adaptation	5.84
Green Climate Fund (GCF)	Multilateral	Adaptation	45

Source: Online secondary materials

Most importantly, it is mainly the responsibility of national-level government actors to channel the required adaptation finance to local-level actors through a transparent system. Because international climate funds are often inadequate to meet adaptation needs (Ghosh and Vazquez, 2018; Prasad and Sud, 2019), we suggest that the Ethiopian government should consider in-country public and private sources of adaptation financing. For example, green bonds (also known as climate bonds) are increasingly being recognised as potential sources of raising finance for climate change adaptation (Banga, 2019; Ngwenya and Simatele, 2020). Hence, the Ethiopian government can use this kind of approach to encourage citizens as well as the private sector to invest in bonds that are specifically aimed at financing climate change adaptation measures.

Poor coordination among institutional actors

Climate change adaptation is widely recognised as a multi-level effort that requires strong coordination between stakeholders operating at multiple levels of governance from the local level to regional, and national levels (Bauer and Steurer, 2014; Bellali et al., 2018). Interviews conducted with six national-level government officials revealed

that a lack of strong vertical coordination across government levels (i.e. from national, to regional, to local) and horizontal coordination between stakeholders operating at the same level (e.g. across line ministries, departments and agencies) has created communication gaps and ultimately constrained the successful implementation of adaptation policies at the local level. Mentioning horizontal coordination challenges between line ministries, one key informant from the NMA said:

> Various actors from line ministries [e.g. ministry of agriculture] have participated in the formulation of the National Adaptation Programme of Action document. But during the implementation process, they did not have the time to regularly meet and engage with the staff of the National Mereological Agency. They thought it was our sole responsibility to implement all the activities. (Key informant 19, 2016/2017)

The analyses of policy documents suggest that poor coordination among institutional actors could be partly attributed to the failure of the policy documents to clearly identify key institutional actors, and their responsibilities and linkages to implement the envisioned adaptation plans and programmes. For example, the EPACC document did not provide any information about institutional actors who participated in the formulation of the document as well as how the prioritised adaptation strategies will be implemented and by whom. The 2017 NAP-ETH document listed sectoral institutions such as the Ministry of Agriculture and Natural Resource Management, Ministry of Water and Irrigation and other commissions/agencies as key implementers of the adaptation strategies. However, there is no clear explanation of how the ministry offices will interact and enforce the NAP-ETH plan.

One reason for weak coordination among institutional actors at ministry level is due to continued structural changes within the ministry offices. For example, a key informant from MEFCC explained:

> Our ministry office [MEFCC], has been established five years ago. But still there is a structural change within the ministry office every year. When there is continuous structural change within the ministry offices, the roles and responsibilities of staff members also change. This creates communication gaps and leads to poor coordination among institutional actors. (Key informant 23, 2016/2017)

A lack of uniform institutional structure across sectors and regions was also considered by national-level officials to be the cause of weak top-down coordination between institutional actors and for the subsequent limited implementation of national adaptation plans at the local level. At the national level, the MEFCC is the primary institution for climate change policies and their implementation. However, this institution has no representation in the Tigray region. As one of the key informants from MEFCC commented: 'it is extremely difficult to coordinate climate-related adaptation activities when you do not have similar institutions operating at regional and district levels'.

According to another key informant from MEFCC, a lack of uniform institutional structure is observed not only in the Tigray region but also across other regions of Ethiopia including in the Amhara and Oromia regions. This is attributed to Ethiopia's governance system that allows regions to have their own institutional autonomy. Mentioning the Tigray case for example, the key informant stated:

> Regions in Ethiopia are autonomous. Thus, our office [MEFCC] has no mandate to influence the Tigray region to establish similar institution that could represent MEFCC. Since there is no uniform institutional arrangement, coordination between us [MEFCC] and regional government actors in Tigray is still very loose. This is hampering the conversion of national adaptation policies into practice at the local level. (Key informant 22, 2016/2017)

In sum, beyond the pervasive issues of top-down policy formulation and inadequate financial resources which are hampering the effective implementation of adaptation policies on the ground, the above quotes further highlight that institutional coordination challenges equally delayed the implementation of concrete adaptation actions. More specifically, the findings affirm that coordination among the relevant line ministries, offices, departments and agencies that are involved in climate issues in Ethiopia is weak and unstructured due to complex and multidimensional factors. This implies that even if sufficient climate finance might be readily available, coordination challenges will still delay the implementation of adaptation policies at the local level. The findings thus highlight the need to overcome communication and coordination challenges that exist between actors responsible for designing and implementing climate change adaptation policies in Ethiopia. One mechanism that can help overcome poor coordination among institution is the establishments of multi-stakeholder platforms. Such platforms bring together multiple actors to discuss common challenges, opportunities and policy measures (Warner, 2006) and they have been shown to have promising results in tackling climate change issues (Pinkse and Kolk, 2012; Ampaire et al., 2017; Acosta et al., 2019).

Limited technical knowledge of local-level actors to address climate change

According to some national and regional-level government officials, a lack of skilled human power and limited technical knowledge of local-level government actors on climate change issues present another set of challenges for effective implementation of adaptation policies. For example, within Raya Azebo District Bureau of Agriculture and Rural Development, there are no staff members who are particularly tasked to coordinate and lead climate change issues and activities. One official from the MEFCC said:

> These are the biggest challenges for us [a lack of skilled human power and low technical capacity of district-level staff on climate change issues]. When we try to

> work closely with district officials to implement adaptation projects, they have limited knowledge on climate change issues. It is not easy to implement national adaptation policies in this kind of situation. (Key informant 25, 2016/17)

Most of the interviewed officials from the Bureau of Agriculture and Rural Development possessed limited knowledge on climate change issues. For example, when asked basic questions about the causes of climate change, six out of eight local-level officials did not know the causes. Only two local-level staff indicated human-made causes of climate change such as deforestation, burning of fossil fuels and agricultural-related activities. When asked about technical knowledge gaps at local levels, a key informant from MEFCC commented:

> Our mandate is to strengthen the technical capacity of regional officials. Regions have the same responsibility of building the technical capacity of the respective lower-level government actors [i.e. district-level staff]. In my opinion, the regional officials are not doing their job. So, it is not a surprise if the district officials know nothing about climate change. (Key informant 22, 2016/2017)

Successful implementation of climate change action depends to some extent on how aware and knowledgeable implementing actors are about the policies (Eshetu et al. 2014). Yet in this study, most of the interviewed local officials are not even aware of the existence of national, regional and local adaptation policies, strategies and plans. For example, there is a regional adaptation plan called Tigray Regional Programme of Plan on Climate Change Adaptation which is prepared by the Environmental Protection, Land Administration and Use Agency (TEPLUAA). However, when one interviewee from Raya Azebo district BOARD was asked about this document, he answered: 'We do have agricultural-related policy documents, but I do not know anything about this specific climate policy documents that you are referring to' (Key informant 14, 2016/2017)

The limited awareness of local government officials of the existing important national/regional policy documents suggests poor communication and limited information sharing practice among the various government actors across all levels. During field observation, national and regional climate change adaptation policy documents were kept on office shelves without being shared to the relevant local government actors. An example is the NAP-ETH document which has been prepared both in hard and soft copies since August 2017 and is available at the MEFFC office. At the time of this study, however, the document has not been accessed by district-level government actors.

Some of the key informants from the government office at district level attributed their inadequate involvement in climate-related consultative workshops, trainings and policy formulation process as the reason for their limited understanding of climate change issues as well as their lack of awareness about the existing climate-related

national/regional policies and plans. To some extent, this claim has been proven during fieldwork observation. At the time of this study, the first author of this paper has had the opportunity to participate in a workshop that has been organised in Mekelle city, focusing on strengthening the seasonal weather forecast system in the Tigray region. In the workshop, several national and regional-level government officials including from the National Meteorological Agency (NMA) of Ethiopia and the TEPLUAA had participated. However, none of the district-level government officials from Raya Azebo district were invited to this important workshop. In an interview, one of the district-level government officials said:

> I have served as an early warning expert for eleven years in the Disaster Prevention and Preparedness department. Part of my work is to conduct drought risk assessment in every *tabias* [villages] of Raya Azebo district. I have never been invited to any regional-level workshops relating to climate change. (Key informant # 1 from RDAE)

Engaging local government actors in policymaking process creates a sense of ownership of the policies and thereby enables successful implementation of climate change adaptation (Ampaire et al., 2017). Interview results indicate that none of the local-level government officials had participated in the process of national or regional adaptation policy making. The TRPPACC also did not provide any information on the participation of local and district-level governments in the formulation of this document. In the national adaptation policy document (i.e, NAP-ETH), let alone district-level actors, regional-level officials did not participate in the policy formulation process. Interviews held with the MEFCC revealed that only ministerial level government officials had participated in the preparation and consultation of NAP-ETH.

Due to the local nature of climate change adaptation, local actors are at the front line of its implementation and their technical knowledge on climate change is critical for successful implementation of adaptation measures (Measham et al., 2011; Conway and Mustelin, 2014). In Raya Azebo district, it is the development agents and agricultural extension workers (local actors) who closely work with smallholder farmers. Hence, an increased focus should be given to technical capacity building for these local actors both at district and local levels. Examples of measures that can help strengthen the technical capacities of local actors may include knowledge building on the causes of climate change and its consequences on socio-ecological systems, regular information on past and projected climate trends and training on vulnerability assessment techniques.

Unlike previous capacity building efforts, which are mostly externally driven and short-term (Khan et al., 2019), country-driven capacity building interventions should be pursued for a more sustainable and effective outcome. This may require supporting capacity building institutions such as public universities and local and agricultural schools to deliver the capacity building measures. It is also important to

recognise the dynamic nature of individuals' capacity (e.g. it may improve or decline over time) (LaFond and Brown, 2003). Hence, we emphasise that climate-relevant capacity building effort should be understood as a continuous process that needs to be measured through regular monitoring and evaluations, rather than a one-off task.

Conclusion

The IPCC's sixth assessment report concluded that human-induced factors have already altered the earth's climate system in every region across the world, and extreme events including heatwaves, heavy precipitation, drought and tropical cyclones are projected to intensify unless significant cuts in global carbon emissions (CO_2) and enhanced adaptation actions take place in the coming few decades. Recognising the existence of various constraints, one of the key findings of this report is that there are wide gaps between current levels of adaptation actions and what is required to deal with the increasing risks of climate change, particularly in low-income countries.

This paper discussed the government adaptation interventions in Raya Azebo district of Ethiopia and examined the barriers that impede effective implementation of adaptation policy at the local level. Results indicated that the issue of climate change is well recognised in the country and progress has been made in formulating adaptation policies. However, the case study shows that concrete adaptation actions which are targeted to support smallholder farmers at the local levels are still inadequate. The study found the NRM programme to be the one and only government-led adaptation intervention in the study area, but even this intervention has serious pitfalls in its design and implementation. Farmers consider the intervention to be ineffective, unfitting to the local context and a distraction from their agricultural activities.

We found interlinked barriers that hinder the effective implementation of adaptation policy at the local level. In particular, rigid and top-down national adaptation policies which are formulated and implemented without the consultation of regional (local) actors and vulnerable communities impeded the successful implementation of adaptation interventions on the ground. This challenge is further compounded by weak horizontal (e.g. inter-ministerial collaboration) and vertical coordination across the various governance levels (national-regional-local). Moreover, we found financial and human resources to be serious bottlenecks for the observed discrepancies between the formulated adaptation policies and their tangible implementation at the local level.

Our findings suggest more broadly that addressing policy implementation barriers including institutional coordination challenges, financial resources and local government's technical capacity constraints will be critical to facilitate and support smallholder climate adaptation at the local level. However, specifically in Raya Azebo district, overcoming these barriers per se will not ensure the successful implementation of adaptation policy on the ground unless the current armed conflict between

the Ethiopian federal government and the Tigray regional state is peacefully resolved. Particularly Tigray's agricultural sector – the main livelihood source of smallholder farmers – has been severely impacted by the devastating war due to the disruption of farming activities, the widespread looting and damage of agricultural facilities, the breakdown of agricultural input supply chains and the collapse of agricultural extension services (Nyssen et al., 2021; Demissie et al., 2022). Therefore, post-conflict planned adaptation interventions in the region should give priority to this important sector together with peacebuilding initiatives.

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References

Acosta, M., Ampaire, E., Muchunguzi, P., Okiror, J., Rutting, L., Mwongera, C. and Mwungu, C. (2019) 'The role of multi-stakeholder platforms for creating an enabling climate change policy environment in East Africa', in T. Rosenstock, A. Nowak and E. Girvetz (eds), *Investigating the Business of a Productive, Resilient and Low Emission Future, The Climate-Smart Agriculture Papers*, Cham, Springer, 267–276.

Adem, A. and Bewket, W. (2011) *A Climate Change Country Assessment Report for Ethiopia*, Forum for Environment, Addis Ababa, Ethiopia, https://www.southernvoices.net/en/resource-centre/reports-cases/99-a-climate-change-country-assessment-report-for-ethiopia.html (accessed 19 October 2019).

Adenle, A., Ford, D., Morton, J., Twomlow, S., Alverson, K., Cattaneo, A. and Ebinger, J. (2017) 'Managing climate change risks in Africa: a global perspective', *Ecological Economics*, 141, 190–201.

Adger, W. N., Agrawala, S., Mirza, M. M. Q., Conde, C., O'Brien, K., Pulhin, J., Pulwarty, R., Smit, B. and Takahashi T. (2007) 'Assessment of adaptation practices, options, constraints and capacity', in *Climate Change 2007: Impacts, Adaptation and Vulnerability* (Working Group II Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change), IPCC, https://www.ipcc.ch/site/assets/uploads/2018/03/ar4_wg2_full_report.pdf (accessed 15 September 2021).

Ampaire, E. Jassogne, L., Providence, H., Acosta, M., Twyman, J., Winowiecki, L. and Van Asten, P. (2017) 'Institutional challenges to climate change adaptation: a case study on policy action gaps in Uganda', *Environmental Science & Policy*, 75, 81–90.

Archie, M., Dilling, L., Milford, B. and Pampel, C. (2014) 'Unpacking the "information barrier": comparing perspectives on information as a barrier to climate change adaptation in the interior mountain West', *Journal of Environmental Management*, 133, 397–410.

Azhoni, A., Holman, I. and Jude, S. (2017) 'Contextual and interdependent causes of climate change adaptation barriers: insights from water management institutions in Himachal Pradesh, India', *Science of the Total Environment*, 576, 817–828.

Banga, J. (2019) 'The green bond market: a potential source of climate finance for developing countries', *Journal of Sustainable Finance & Investment*, 9(1), 17–32.

Banwell, N., Gesche, S., Vilches, R. and Hostettler, S. (2020) 'Barriers to the implementation of international agreements on the ground: climate change and resilience building in the Araucanía Region of Chile', *International Journal of Disaster Risk Reduction*, 50(101703), 1–9.

Basson, F., Dayamba, D., Korahire, J., Dipama, M., Zougmore, F. and Neya, T. (2020) 'Institutional barriers to climate change adaptation in Burkina Faso: how could we go around them?', *Journal of Sustainable Development*, 13(5), 67–78.

Bauer, A. and Steurer, R. (2014) 'Multi-level governance of climate change adaptation through regional partnerships in Canada and England', *Geoforum*, 51, 121–129.

Bellali, J., Lisa, S., Francis O. and Benson, O. (2018) *Multi-Level Climate Governance in Kenya. Activating Mechanisms for Climate Action*, https://www.adelphi.de/de/system/files/mediathek/bilder/Multi-level%20climate%20governance%20in%20Kenya%20-%20vled%20-%20adelphi.pdf (accessed 21 December 2019).

Berhane, A., Hadgu, G., Worku, W. and Abrha, B. (2020) 'Trends in extreme temperature and rainfall indices in the semi-arid areas of Western Tigray, Ethiopia', *Environmental Systems Research*, 9(1), 1–20.

Berman, R. J., Quinn, C. H. and Paavola, J. (2015) 'Identifying drivers of household coping strategies to multiple climatic hazards in Western Uganda: implications for adapting to future climate change', *Climate and Development*, 7(1), 71–84.

Berrang-Ford, L., Biesbroek, R., Ford, D., Lesnikowski, A., Tanabe, A., Wang, M. and Heymann, J. (2019) 'Tracking global climate change adaptation among governments', *Nature Climate Change*, 9(6), 440–449.

Bewket, W. (2007) 'Soil and water conservation intervention with conventional technologies in northwestern highlands of Ethiopia: acceptance and adoption by farmers', *Land Use Policy*, 24(2), 404–416.

Biesbroek, R., Klostermann, E., Termeer, J. and Kabat, P. (2013) 'On the nature of barriers to climate change adaptation', *Regional Environmental Change*, 13(5), 1119–1129.

Chirenje, I., Giliba, A. and Musamba, B. (2013) 'Local communities' participation in decision-making processes through planning and budgeting in African countries', *Chinese Journal of Population Resources and Environment*, 11(1), 10–16.

Clar, C., Prutsch, A. and Steurer, R. (2013) 'Barriers and guidelines for public policies on climate change adaptation: a missed opportunity of scientific knowledge-brokerage', *Natural Resources Forum*, 37(1), 1–18.

Cochrane, L. and Singh, R. (2017) *Climate Services for Resilience: the Changing Roles of NGOs in Ethiopia*, https://reliefweb.int/report/ethiopia/climate-services-resilience-changing-roles-ngos-ethiopia (accessed 20 March 2020).

Conway, D. and Mustelin, J. (2014) 'Strategies for improving adaptation practice in developing countries', *Nature Climate Change*, 4(5), 339–342.

CSA (Central Statistical Agency) (2007), *The 2007 Population and Housing Census of Ethiopia: Statistical Report for Tigray Region*, http://phe-ethiopia.org/pdf/tigray.pdf (accessed 20 December 2018).

Davies, J. E., Spear, D., Ziervogel, G., Hegga, S., Ndapewa Angula, M., Kunamwene, I. and Togarepi, C. (2020) 'Avenues of understanding: mapping the intersecting barriers to adaptation in Namibia', *Climate and Development*, 12(3), 268–280.

Dedicatoria, M. and Diomampo B. (2019) 'Status of climate change adaptation in Southeast Asia region', in M. Alam, J. Lee and P. Sawhney (eds), *Status of Climate Change Adaptation in Asia and the Pacific*, Springer Climate, Cham, Springer, 153–182.

Demissie, B., Nyssen, J., Annys, S., Negash, E., Gebrehiwet, T., Abay, F. and Wolff, E. (2022) 'Geospatial solutions for evaluating the impact of the Tigray conflict on farming', *Acta Geophysica*, 70, 1285–1299.

Dupuis, J. and Knoepfel, P. (2013) 'The adaptation policy paradox: the implementation deficit of policies framed as climate change adaptation', *Ecology and Society*, 18(4), Article 31.

Eisenack, K., Moser, C., Hoffmann, E., Klein, J., Oberlack, C., Pechan, A. and Termeer, J. (2014) 'Explaining and overcoming barriers to climate change adaptation', *Nature Climate Change*, 4(10), 867–872.

Ekstrom, A. and Moser, C. (2014) 'Identifying and overcoming barriers in urban climate adaptation: case study findings from the San Francisco Bay Area, California, USA', *Urban Climate*, 9, 54–74.

Epule, E., Ford, D., Lwasa, S. and Lepage, L. (2017) 'Climate change adaptation in the Sahel', *Environmental Science & Policy*, 75, 121–137.

Eshetu, Z., Simane, B., Tebeje, G., Negatu, W., Amsalu, A., Berhanu, A. and Trujillo, N. (2014) *Climate Finance in Ethiopia*, Overseas Development Institute, London and Climate Science Centre, Addis Ababa, https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8995.pdf (accessed 5 June 2019).

Fawzy, S., Osman, A. I., Doran, J. and Rooney, W. (2020) 'Strategies for mitigation of climate change: a review', *Environmental Chemistry Letters*, 18, 1–26.

FDRE (Federal Democratic Republic of Ethiopia) (2011) *Ethiopia's Climate-Resilient Green Economy Green Economy Strategy*, https://www.undp.org/content/dam/ethiopia/docs/Ethiopia%20CRGE.pdf (accessed 30 March 2019).

FDRE (Federal Democratic Republic of Ethiopia) (2019) *Ethiopia's Climate Resilient Green Economy. National Adaptation Plan*, https://www4.unfccc.int/sites/NAPC/Documents/Parties/Final%20Ethiopia-national-adaptation-plan%20%281%29.pdf (accessed 30 April 2020).

FEWS NET (Famine Early Warning System Network) (2015) *Illustrating the Extent and Severity of the 2015 Drought. Famine Early Warning Systems Network/USAID*, https://reliefweb.int/map/ethiopia/ethiopia-special-report-illustrating-extent-and-severity-2015-drought (accessed 30 March 2019).

Ford, J. D., Berrang-Ford, L., Bunce, A., McKay, C., Irwin, M. and Pearce, T. (2015) 'The status of climate change adaptation in Africa and Asia', *Regional Environmental Change*, 15(5), 801–814.

Gebre, H., Kindie, T., Girma, M. and Belay, K. (2013) 'Trend and variability of rainfall in Tigray, northern Ethiopia: analysis of meteorological data and farmers' perception', *Academia Journal of Agricultural Research*, 1(6), 88–100.

Gebrehiwot, T. and van der Veen, A. (2013) 'Climate change vulnerability in Ethiopia: disaggregation of Tigray Region', *Journal of Eastern African Studies*, 7(4), 607–629.

Gebresamuel, G., Abrha, H., Hagos, H., Elias, E. and Haile, M. (2022) 'Empirical modeling of the impact of climate change on altitudinal shift of major cereal crops in South Tigray, Northern Ethiopia', *Journal of Crop Improvement*, 36(2), 169–192.

Gezie, M. (2019) 'Farmer's response to climate change and variability in Ethiopia: a review', *Cogent Food & Agriculture*, 5(1), https://doi.org/10.1080/23311932.2019.1613770.

Ghosh, B. and Vazquez, K. (2018) *Mobilizing Financing for Sustainable Climate Adaptation: Opinion*, https://www.devex.com/news/opinion-mobilizing-financing-for-sustainable-climate-adaptation-93929 (accessed 13 March 2019).

Giles, J., Grosjean, G., Le Coq, F., Huber, B., Le Bui, V. and Läderach, P. (2021) 'Barriers to implementing climate policies in agriculture: a case study from Viet Nam', *Frontiers in Sustainable Food Systems*, 5, 1–15.

Hadgu, G., Tesfaye, K. and Mamo, G. (2015) 'Analysis of climate change in Northern Ethiopia: implications for agricultural production', *Theoretical and Applied Climatology*, 121(3), 733–747.

Haftom, H., Haftu, A., Goitom, K. and Meseret, H. (2019) 'Agroclimatic zonation of Tigray region of Ethiopia based on aridity index and traditional agro-climatic zones', *Journal of Agrometeorology*, 21(2), 176–181.

IIED (International Institute for Environment and Development) (2017) *Going Local: Fast Tracking Climate Finance to the Most Vulnerable*, https://pubs.iied.org/pdfs/17441IIED.pdf (accessed 10 April 2020).

IPCC (Intergovernmental Panel on Climate Change) (2007) *Climate Change 2007: Impacts, Adaptation and Vulnerability* (Working Group II Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change), IPCC, https://www.ipcc.ch/site/assets/uploads/2018/03/ar4_wg2_full_report.pdf (accessed 1 June 2022).

IPCC (Intergovernmental Panel on Climate Change) (2014) *Climate Change 2014: Impacts, Adaptation, and Vulnerability* (Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change), IPCC, https://www.ipcc.ch/site/assets/uploads/2018/02/ar5_wgII_spm_en.pdf (accessed 2 June 2022).

IPCC (Intergovernmental Panel on Climate Change) (2021a) *Climate Change 2021: The Physical Science Basis* (Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change), IPCC, https://www.ipcc.ch/report/ar6/wg1/ (accessed 10 June 2022).

IPCC (Intergovernmental Panel on Climate Change) (2021b) *Sixth Assessment Report* (Working Group I: The Physical Science Basis Report), IPCC, https://www.ipcc.ch/report/ar6/wg1/downloads/factsheets/IPCC_AR6_WGI_Regional_Fact_Sheet_Africa.pdf (accessed 11 June 2022).

IPCC (Intergovernmental Panel on Climate Change) (2022) *Climate Change 2022: Impacts, Adaptation and Vulnerability* (Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change), IPCC, https://report.ipcc.ch/ar6wg2/pdf/IPCC_AR6_WGII_FinalDraft_FullReport.pdf (accessed 7 June 2022).

Jacob, M., Frankl, A., Haile, M., Zwertvaegher, A. and Nyssen, J. (2013) 'Assessing spatio-temporal rainfall variability in a tropical mountain area (Ethiopia) using NOAA's rainfall estimates', *International Journal of Remote Sensing*, 34(23), 8319–8335.

Juhola, S. (2016) 'Barriers to the implementation of climate change adaptation in land use planning: a multi-level governance problem?', *International Journal of Climate Change Strategies and Management*, 8(3), 338–355.

Kala, N., Kurukulasuriya, P. and Mendelsohn, R. (2012) 'The impact of climate change on agro-ecological zones: evidence from Africa', *Environment and Development Economics*, 17(6), 663–687.

Khan, M., Mfitumukiza, D. and Huq, S. (2019) 'Capacity building for implementation of nationally determined contributions under the Paris Agreement', *Climate Policy*, 20(4), 499–510.

Klein, R. J. T., Midgley, G. F. and Preston, B. L. (2014) 'Adaptation opportunities, constraints, and limits', in IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability*: Part A: Global and Sectoral Aspects (Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change), IPCC, https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap16_FINAL.pdf (accessed 15 September 2021).

LaFond, A. and Brown, L. (2003) *A Guide to Monitoring and Evaluation of Capacity Building Interventions in the Health Sector in Developing Countries. Measure Evaluation Manual Series*, https://pdf.usaid.gov/pdf_docs/pnada065.pdf (accessed 2 March 2020).

Leary, N., Adejuwon, J., Barros, V., Batimaa, P., Biagini, B., Burton, I. and Dougherty, B. (2007) 'A stitch in time: lessons for climate change adaptation from the AIACC project' (Working Paper Number 48), International START Secretariat, Washington, DC.

Lonsdale, W. R., Kretser, E., Chetkiewicz, L. B. and Cross, S. (2017) 'Similarities and differences in barriers and opportunities affecting climate change adaptation action in four North American landscapes', *Environmental Management*, 60(6), 1076–1089.

Mackay, S., Hennessey, N. and Mackey, B. (2019), *Barriers to the Implementation of Climate Change Adaptation Plans and Action: Considerations for Regional Victoria*. Griffith University, Brisbane, https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0038/489476/Policy-Brief-1-Barriers-to-the-implementation-of-climate-change-adaptation-plans-and-action.pdf (accessed 21 September 2021).

Mata, L. J. and Budhooram, J. (2007) 'Complementarity between mitigation and adaptation: the water sector', *Mitigation and Adaptation Strategies for Global Change*, 12(5), 799–807.

Measham, T. G., Preston, B., Smith, T., Brooke, C., Gorddard, R., Withycombe, G. and Morrison, C. (2011) 'Adapting to climate change through local municipal planning: barriers and challenges', *Mitigation and Adaptation Strategies for Global Change*, 16(8), 889–909.

Meshesha, Y. B. and Birhanu, B. S. (2015) 'Assessment of the effectiveness of watershed management intervention in Chena Woreda, Kaffa Zone, Southwestern Ethiopia', *Journal of Water Resource and Protection*, 7(15), 1257–1269.

Meze-Hausken, E. (2000) 'Migration caused by climate change: how vulnerable are people inn dryland areas?', *Mitigation and Adaptation Strategies for Global Change*, 5(4), 379–406.

MOFED (Ministry of Finance and Economic Development) (2010) *Federal Democratic Republic of Ethiopia. Growth and Transformation Plan 2010/11–2014/2015*, http://extwprlegs1.fao.org/docs/pdf/eth144893.pdf (accessed 3 April 2016).

Moser, C. and Ekstrom, A. (2010) 'A framework to diagnose barriers to climate change adaptation', *Proceedings of the National Academy of Sciences*, 107(51), 22026–22031.

Motsa, B. (2011) 'Financial barriers to the implementation of climate change adaptation measures', in L. Masters and L. Duff (eds), *Overcoming Barriers to Climate Change Adaptation Implementation in Southern Africa*, Africa Institute of South Africa, Pretoria, 141–161.

Ngwenya, N. and Simatele, M. (2020) 'The emergence of green bonds as an integral component of climate finance in South Africa', *South African Journal of Science*, 116(1–2), 1–3.

Nkiaka, E. and Lovett, C. (2018) 'Mainstreaming climate adaptation into sectoral policies in Central Africa: insights from Cameroun', *Environmental Science and Policy*, 89, 49–58.

NMA (National Meteorological Agency) (2007) *Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia*, Addis Ababa, Ethiopia, https://unfccc.int/resource/docs/napa/eth01.pdf (accessed 11 June 2016).

Nyssen, J., Negash, E. and Annys, S. (2021) 'How Ethiopia's conflict has affected farming in Tigray', *The Conversation*, https://theconversation.com/how-ethiopiasconflict-has-affected-farming-in-tigray-166229 (accessed 11 June 2022).

Oates, B. N., Conway, D. and Calow, R. (2011) 'The "mainstreaming" approach to climate change adaptation: insights from Ethiopia's water sector' (Background Working Paper), Overseas Development Institute, https://pdfs.semanticscholar.org/cb27/2d8bcd9dcdfbo9c052a4537af356cae382ac.pdf (accessed 12 April 2016).

Olazabal, M., de Gopegui, R., Tompkins, L., Venner, K. and Smith, R. (2019) 'A cross-scale worldwide analysis of coastal adaptation planning', *Environmental Research Letters*, 14(12), 124056.

Oulahen, G., Klein, Y., Mortsch, L., O'Connell, E. and Harford, D. (2018) 'Barriers and drivers of planning for climate change adaptation across three levels of government in Canada', *Planning Theory & Practice*, 19(3), 405–421.

Pasquini, L., Cowling, M. and Ziervogel, G. (2013) 'Facing the heat: barriers to mainstreaming climate change adaptation in local government in the Western Cape Province, South Africa', *Habitat International*, 40, 225–232.

Pinkse, J. and Kolk, A. (2012) 'Addressing the climate change-sustainable development nexus: the role of multistakeholder partnerships', *Business and Society*, 51(1), 176–210.

Prasad, R. and Sud, R. (2019) 'Implementing climate change adaptation: lessons from India's national adaptation fund on climate change (NAFCC)', *Climate Policy*, 19(3), 354–366.

RADFEDO (Raya Azebo District Finance and Economic Development Office) (2017) 'Raya Azebo district annual budget allocated by sector (2023–2016)' (unpublished report), Raya Azebo district, Tigray region, Ethiopia.

Runhaar, H., Wilk, B., Persson, Å., Uittenbroek, C. and Wamsler, C. (2018) 'Mainstreaming climate adaptation: taking stock about "what works" from empirical research worldwide', *Regional Environmental Change*, 18(4), 1201–1210.

Ryan, D. and Bustos, E. (2019) 'Knowledge gaps and climate adaptation policy: a comparative analysis of six Latin American countries', *Climate Policy*, 19(10), 1297–1309.

Singh, C., Daron, J., Bazaz, A., Ziervogel, G., Spear, D., Krishnaswamy, J. and Kituyi, E. (2018) 'The utility of weather and climate information for adaptation decision-making: current uses and future prospects in Africa and India', *Climate and Development*, 10(5), 389–405.

Smit, B. and Wandel, J. (2006) 'Adaptation, adaptive capacity and vulnerability', *Global Environmental Change*, 16(3), 282–292.

Smit, B., Burton, I., Klein, R. J. and Wandel, J. (2000) 'An anatomy of adaptation to climate change and variability', in S. M. Kane and G. W. Yohe (eds), *Societal Adaptation to Climate Variability and Change*, Dordrecht, Springer, 223–225.

Spires, M., Shackleton, S. and Cundill, G. (2014) 'Barriers to implementing planned community-based adaptation in developing countries: a systematic literature review', *Climate and Development*, 6(3), 277–287.

TBFED (Tigray Bureau of Finance and Economic Development) (2018) 'GIS layers, administrative boundaries of Tigray' (unpublished document from TBFED GIS section), Mekelle, Ethiopia.

Tietjen, B., Rampa, F. and Knaepen, H. (2019) *Finance to Adapt: Making Climate Funding Work for Agriculture at the Local Level* (Briefing Note No. 111), The European Centre for Development Policy Management (ECDPM), https://ecdpm.org/publications/finance-adapt-climate-funding-agriculture-local-level/ (accessed 10 September 2021).

Tripathi, A. and Mishra, A. (2017) 'Knowledge and passive adaptation to climate change: an example from Indian farmers', *Climate Risk Management*, 16, 195–207.

Trisos, C. H., Adelekan, I. O., Totin, E. A. et al. (eds) (2022) 'Africa', in *Climate Change 2022: Impacts, Adaptation and Vulnerability* (Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change), IPCC, https://report.ipcc.ch/ar6wg2/pdf/IPCC_AR6_WGII_FinalDraft_FullReport.pdf (accessed 8 June 2022).

UNFCC (United Nations Framework Convention on Climate Change) (2020) *Progress in the Process to Formulate and Implement National Adaptation Plans*, https://unfccc.int/documents/266467 (accessed 28 September 2021).

Warner, J. (2006) 'More sustainable participation? Multi-stakeholder platforms for integrated catchment management', *Water Resources Development*, 22(1), 15–35.

Waters, E., Barnett, J. and Puleston, A. (2014) 'Contrasting perspectives on barriers to adaptation in Australian climate change policy', *Climatic Change*, 124(4), 691–702.

World Bank (2010) *Ethiopia: Economics of Adaptation to Climate Change*, Washington, DC, World Bank, http://documents.worldbank.org/curated/en/310391468340238724/pdf/686500ESW0P1130UBLIC00EACC0Ethiopia.pdf (accessed 25 December 2018).

Zougmoré, R., Partey, S., Ouédraogo, M., Omitoyin, B., Thomas, T., Ayantunde, A. and Jalloh, A. (2016) 'Toward climate-smart agriculture in West Africa: a review of climate change impacts, adaptation strategies and policy developments for the livestock, fishery and crop production sectors', *Agriculture & Food Security*, 5(26), 1–16.