RiPPLE

Adapting to climate change in the water sector

Assessing the effectiveness of planned adaptation interventions in reducing local level vulnerability

Nanki Kaur, Million Getnet, Beneberu Shimelis, Zegeye Tesfaye, Gebeyehu Syoum and Endale Atnafu

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Research-inspired Policy and Practice Learning in Ethiopia and the Nile Region

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Research-inspired Policy and Practice Learning in Ethiopia and the Nile Region (RiPPLE) is a 5-year Research Programme Consortium funded by UKaid from the Department for International Development aiming to advance evidence-based learning on water supply and sanitation (WSS). The RiPPLE Consortium is led by the Overseas Development Institute (ODI), working with the College of Development Studies at Addis Ababa University; the Ethiopian Catholic Church Social and Development Coordination Office of Harar (ECC-SDCOH), International Water and Sanitation Centre (IRC) and WaterAid-Ethiopia.

RiPPLE Working Papers contain research questions, methods, analysis and discussion of research results (from case studies or desk research). They are intended to stimulate debate on policy implications of research findings as well as feed into Long-term Action Research.

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List of Acronyms

ADM	Adaptation decision matrix
CC	Climate change
DPCC	Disaster Prevention and Preparedness Commission
ETB	Ethiopian birr (national currency)
EWE	Extreme weather events
FGD	Focus group discussion
GCM	Global circulation models
HCS	Haraghe Catholic Secretariat
HH	Household
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated water resource management
LARS	Long Term Action Research Studies
LDC	Least developed country
LPA	Learning and Practice Alliance
MEA	Millennium Ecosystem Assessment
MUS	Multiple use systems/services
NAPA	National Adaptation Programme of Action
NMA	National Metrological Agency
PSNP	Productive safety net programme
WELS	Water Economy for Livelihoods Systems
WSS	Water supply and sanitation

Glossary of Ethiopian terms:

Belg:	Rainy season from February up to April
Chat:	Slightly hallucinogenic plant native to east Africa
Kebele:	An administrative division in Ethiopia, similar to a neighbourhood or ward
Meher:	Rainy season from mid-June to the end of September
Teff:	A fine grain which is a staple of the Ethiopian diet
Woreda:	An administrative division in Ethiopia, similar to a district

1 Executive summary

Access to water resources plays a key role in poverty reduction and economic growth. Access relies on a number of factors including, the interplay between water resources, the technology used to access these resources, and changes in demand for water, as well as the socio-political contexts that determine equitable access. Climate change (CC) is likely to have an impact on all of the above dimensions. Water resources are considered as among those resources most vulnerable to the impacts of CC with different parts of the world experiencing increased water stress or flooding. CC is also likely to undermine poverty reduction efforts, which will broaden the socio-political gaps that play a key role in determining equity in access to available water resources.

A number of CC impacts manifest themselves at the local level, where communities have historically had the capacity to cope with weather-induced changes in water availability, except in extreme cases of prolonged drought or extensive flooding. However, under a CC scenario, the increased magnitude and frequency of extreme weather events and increased uncertainty in existing climate variability is likely to undermine existing coping capacity and increasing local vulnerability to CC induced impacts.

The present study is part of the Growth Long Term Action Research Studies (LARS) of the RiPPLE programme. In order to assess the effectiveness of planned adaptation interventions, an impact and an adaptation assessment was carried out. To assess local coping capacity, a conceptual framework that focuses on the 'type and nature of adaptation' was employed. To assess the effectiveness of planned adaptation interventions in enhancing and/or creating local coping capacity, an 'adaptation decision matrix' is used.

Adaptation aims at reducing climate-induced vulnerability in systems. Vulnerability to CC is defined as a function of exposure, sensitivity and adaptive capacity. Hence adaptation aims to reduce exposure to climatic hazards, and/or enhance the capacity of systems to cope with its impacts. Based on the type and nature of adaptation, this study aims to assess if adaptation interventions and local coping strategies 'create, enhance and/or protect' household and community level assets, and, if this in turn reduces exposure to CC induced impacts and/or enhances the capacity to cope with the impacts.

This study was carried out in an agricultural, agro-pastoral and pastoral site in the highland, midland and lowland areas of the Oromia and Somali regions, Ethiopia. Each site corresponds to a livelihood zone used in the WELS study – the Wheat, Barley and Potato (WBP) LZ in the highlands; the Sorghum, Maize and Chat (SMC) LZ in the midlands; and the Shinile Agro-Pastoral (SAP) LZ in the lowlands.

Adaptation interventions in the water sector can take the form of targeted supply and demand side interventions and can also include broader interventions, like safety net programmes. Four planned adaptation interventions were selected and their effectiveness in enhancing and/or creating local coping capacity was assessed: (1) small-scale irrigation schemes; (2) rangeland management; (3) Multiple Use Systems/Services (MUS); and (4) social protection.

In Oromia, the study was carried out in Bukelcha Oromia *kebele* where MUS were assessed and in Chefe-aneni kebele where the PSNP was assessed. In Somali region, the study was carried out in Billa *kebele* where small scale irrigation was assessed and in Ayidora *kebele*, where an attempt was made to assess the role of rangeland management.

Climate change impacts

In Africa, due to the complexity of the physical, biophysical, and socio-economic feedback loops involved and the paucity of available data, it has been difficult to assess the final water balance between intense and seasonal rainfall, increased evaporative demands, reduced soil moisture and altering land use. As a result, change to regional hydrological systems in SSA is poorly modelled.

In the context of water resources, groundwater is of prime importance to rural water supplies in SSA as up to 80 percent of existing rural water supplies are groundwater-based. Moreover, with increased seasonality of surface water resources in future CC scenarios, there is likely to be an increased dependence on groundwater to meet domestic, agricultural and industrial water demands.

In Ethiopia, few studies have attempted to assess the impact of CC on water resources and on water based livelihoods and economic activities. Food security, water resources and health have been identified as vulnerable sectors. The livelihoods of agricultural communities dependent on rain-fed agriculture and pastoral communities have been identified as vulnerable to the impacts of CC. CC will have significant impact on farm productivity. Yields of some important cereal crops in Ethiopia may decline by up to 5 percent by the 2080s due to climate change. Only few studies have attempted to model the impacts of CC on water availability at a watershed level.

Local level perceptions related to climate change and its impacts

Local communities have identified changes in temperature, rainfall, soil moisture, river discharge and humidity as relevant indicators of CC. Respondents across the study sites identified an increase in temperature, leading to changing agro-ecological characteristics, drying and disappearance of fodder species as indicators. In terms of changes in rainfall, respondents identified an increase in seasonality in the rainfall pattern, which includes changes in timing, intensity and duration of rainfall. Both were identified as contributing to decreased soil moisture content, which in turn has resulted in early wilting of seedlings and disappearance of fodder species. In relation to humidity, perceptions across study sites indicate that the air is getting dryer. Respondents highlighted that there has been an increase in the frequency of floods and droughts.

Impacts of CC on the economic use of water

In both the pastoral and agro-pastoral study sites, CC has negatively impacted on the physical, financial and natural assets of communities. Amongst pastoral communities, the change in water availability, in terms of timing and amount, and increases in temperature, has impacted on the rangeland and on livestock watering points. These changes, along with other risks, have resulted in a decline in the herd size per household in all livestock types and a change in herd composition. A root cause analysis indicates that the major reasons for the observed trend are lack of fodder and livestock water availability and increasing incidence of livestock diseases. Looking at its positive side, it is good that pastoralists are resorting to more drought resistant animals. On its negative side, however, concentrating on few livestock types as opposed to a diversified herd may have negative consequences when it comes to other vulnerabilities like market failure or livestock diseases.

In the agricultural livelihood study sites (Bekelcha Oromia in the midland and Chefe-aneni in the highland), the dominant food crops include sorghum and maize and the dominant cash crops include vegetables and chat. According to respondents, CC has potentially contributed to a change in the pattern of crop production. A shift from producing highland crops like wheat to lowland crops like sorghum is reported, as well as a shift to more drought-resistant and early maturing crops like chat,

sweet potato, and pumpkin. Also, a shift towards single cropping as compared to double-cropping is observed.

Impacts of CC on the domestic use of water

Domestic sources of water in the study sites include deep and hand dug wells, irrigation canals, and developed and undeveloped springs. Increased variability in rainfall (delayed rainfall and reduced rainfall amounts) has resulted in decreased spring discharge and increased algal content in water bodies. In times of water stress, communities tend to de-prioritise sanitation concerns, which have knock-on impacts on education and health. Women and children also spend more time to collect water.

Coping strategies

Increased climate variability and extreme weather events have a significant impact on the economic and domestic use of water in all three livelihoods. The dominant coping strategies adopted by different wealth groups in the three livelihood zones can be summarised as:

1. There is greater capacity to deal with climate variability as compared to extreme weather events.
1. The coping capacity of better off groups is better than that of middle and poor wealth groups. This is due to a more diversified and larger asset base.
2. Better-off groups rely more on supply side water resource management interventions to address the impacts of climate variability, whereas poor and middle wealth groups rely more on demand side interventions to cope with the impacts of climate variability.

The most common coping strategies in the study areas are pastoral migration, asset diversification, food aid, and supply side and demand side interventions with regard to water. There a number of coping mechanisms, adopted especially by the poor and middle wealth groups, including forced labour migration, sale of assets, killing calves and travelling far distances to collect water that do not facilitate adaptation. They do not contribute to asset protection or accumulation and thus do not reduce exposure to climate hazards or help build capacity to deal with the impacts of CC.

Assessing the effectiveness of planned adaptation interventions

Small-scale irrigation: Findings confirm that small scale irrigation does enhance agricultural productivity and thus enhances the asset base of some households. However, it is a supply side intervention, and it is primarily the better off households that have access to such interventions. Secondly, the source of water plays an important role in determining the effectiveness of the intervention. Irrigation schemes that rely on surface water are vulnerable to the impacts of CC. Small scale irrigation that relies on boreholes has been assessed as a better investment option.

In terms the political feasibility of such schemes, access to the benefits of irrigation is very location specific. This includes location in terms of up-stream and down-stream users (e.g. between communities) as well as location in terms of distance of land from the irrigation channel (e.g. within the community). Therefore, mechanisms that facilitate equitable access are essential.

Rangeland management: Currently, no rangeland management interventions have been implemented in the study area. During the impact and adaptation assessment, pastoral communities highlighted that a number of fodder species and water points have been adversely impacted due to increased

climate variability and extreme weather events. It was assessed that pastoral communities are able to cope better with climate variability via migration and the use of donkeys to collect water as compared to coping with extreme weather events. In relation to extreme weather events, coping capacity rather undermines social systems and the robustness of migration as an adaptive strategy.

Planned adaptation interventions under rangeland management could build on existing coping capacity and fill gaps where this capacity is being undermined. The introduction of fodder species and the management of invasive alien species also have the potential of securing the asset base of pastoral communities.

Productive Safety-net Programme: Social protection (SP) aims to reduce vulnerability and increase resilience amongst local communities. It has the potential to create, enhance and protect assets and is increasingly being promoted as an effective adaptation strategy in countries where a 'development deficit' is identified as one of the main drivers of climate-induced vulnerability. In the study site a number of supply and demand side interventions have been implemented under the PSNP and include micro basin and pond construction, afforestation, and soil and water conservation (SWC) structures on the supply side, and the creation of local institutions such as water management institutions on the demand side. The PSNP could also play a role in enhancing adaptive capacity. For instance, the design of the cash transfer scheme in Ethiopia enables households to access and utilise other development interventions more effectively and has the potential to result in graduation and stimulate growth.

Multiple Use Water Services: MUS are defined as 'water supply services that incorporate both domestic and productive uses in their design and delivery'. MUS can be viewed as an effective tool for adaptation planning as it has the potential to facilitate coordinated planning of water resources between different users and uses. MUS interventions create and enhance the asset base of households. These have in turn reduced exposure to CC induced hazards and increased existing capacity to cope with impacts. Interventions related to training on health and sanitation have also filled coping/adaptive capacity gaps related to the health induced dimensions of CC.

In terms of political feasibility, due to the existing institutional set up, there is little coordination between different planning departments. In terms of financial feasibility, the government does not have the finances to construct and implement its own MUS projects.

Conclusion

Using the concept of net vulnerability to CC, i.e. the level of household vulnerability after the role of local coping capacity and planned adaptation interventions has been assessed in reducing the impacts of CC, it shows that:

1. Local communities do perceive a change in climate, in terms of increases in temperature, changes in humidity, soil moisture content and wind direction and, above all, changes in precipitation patterns;
2. In terms of impacts, climate-induced changes are likely to impact the economic and domestic use of water. These impacts are likely to be greater in the context of extreme weather events as compared to climate variability as there is greater capacity to cope with variability.

3. Local coping capacity to deal with climate variability exists. However, under increased uncertainty posed by climate change, this capacity is undermined. Local capacity to cope with extreme weather events is insufficient;
4. The assessed planned adaptation interventions build on coping capacity and fill gaps in coping capacity in many cases. However, a number of interventions will need to be climate proofed and will need to take into account aspects of equity to ensure continued effectiveness in the face of CC. Planned adaptation interventions will also need to address dimensions of political and financial feasibility.

In terms of policy recommendations, the study concludes that of the four interventions assessed - small-scale irrigation and rangeland management - have been formulated explicitly in the context of CC. The other two, social protection and MUS, have a role to play in addressing climate-induced vulnerability. The assessed adaptation interventions do create, enhance and protect household and community assets, and this in turn reduces exposure to climate-induced impacts and/or build capacity to cope with the impacts. However, the research also finds that such interventions will need to be strengthened to face the specific challenges posed by CC. It is thus suggested that planned adaptation interventions address climate-related challenges explicitly by ensuring that interventions are 'climate proofed' (responsive to changes in weather related events) and are able to ensure equitable access to the benefits that are delivered. Interventions will also need to address aspects related to political and financial feasibility if they are to be sustainable.

Small scale irrigation, to be effective in addressing the specific challenges of CC, should, wherever possible, rely on water resources that are less exposed to CC (i.e. groundwater rather than surface water). As small scale irrigation is a supply side intervention that is location specific and accessible only to better off wealth groups, issues of equitable access must be taken into account.

Rangeland management has the potential to enhance the coping capacity of pastoral communities and fill gaps where it does not exist. Initiatives aimed at promoting local management practices should build on available social and human capital in order to address conflict situations that are exacerbated by climate-induced impacts. Rangeland management interventions should focus on identifying suitable fodder species that are responsive to changes in herd composition. Water availability plays a key role in facilitating adaptation amongst pastoral communities. Interventions that enhance access to water resources will have to complement the identified planned adaptation interventions under rangeland management.

Social protection programmes like the PSNP have been assessed to play a significant role in enhancing adaptive capacity, but need to be climate proofed.

MUS play a role in enhancing adaptive capacity as they enhance the economic and domestic use of water. They also have the potential to initiate coordinated planning to address the cross-cutting challenges posed by CC. MUS require a well coordinated management system and hence the organisation and training of beneficiaries and stakeholders is essential. MUS can only achieve their objective of providing multiple services if there is sufficient water to support multiple uses. The impacts of CC are likely to bring water resource management back to being a central component of water planning. Thus, an assessment of available water resources and water resource management are key to enhance the availability of water.

2 Introduction

Access to water resources plays a key role in poverty reduction and economic growth (Bates et al., 2008). Access relies on a number of factors including the interplay between water resources, the technology used to access these resources, and changes in demands for water, as well as the socio-political contexts that determine equitable access.

Climate change (CC) is likely to have an impact on all of the above dimensions. For instance, the Fourth Technical Assessment Report prepared by the Intergovernmental Panel on Climate Change (IPCC), identifies water resources as one of the most vulnerable to the impacts of CC with different parts of the world experiencing increased water stress or flooding (Arnell, 2004). Menzel et al. (2007) outline how the effectiveness of existing technology choices for water supply in Africa and Asia will be undermined by CC. In terms of changes in demands for water, Faures (2008) shows how, in response to CC mitigation strategies, biofuel production can increase water pollution and result in the overuse of water for irrigation leading to significant impacts on water demand at national and sub-national levels. Finally, studies also indicate that CC is likely to undermine poverty reduction efforts (IPCC, 2001), which will in turn broaden the socio-political gaps that play a key role in determining equity in access to available water resources.

A number of these impacts manifest themselves at the local level, where communities have historically had the capacity to cope with weather-induced changes in water availability (except in extreme cases of prolonged drought or extensive flooding). However, under a CC scenario, the increased magnitude and frequency of extreme weather events (EWE) and the increased uncertainty in existing climate variability, is likely to undermine existing coping capacity, thereby increasing local vulnerability to CC induced impacts.

Recognising the need to reduce CC induced vulnerability, a number of countries are attempting to enhance local coping capacity and/or build capacity where it is insufficient or does not exist, by designing and implementing planned adaptation interventions.

For this purpose, least developed countries (LDCs), including Ethiopia, have invested in the process of preparing National Adaptation Programmes of Action (NAPAs). These programmes of action identify adaptation priorities aimed at reducing vulnerability to the impacts of CC.

The prepared NAPA documents are amongst the first attempts at initiating a process of planned adaptation. However, even though none of the prioritised adaptation options in the NAPAs have been implemented and assessed, the process has been criticised for a number of reasons. One such criticism states that the identified adaptation options 'repackage development interventions in the guise of CC adaptation projects' and will thus be ineffective in reducing CC induced vulnerability.

Whilst there is a need to strengthen the adaptation planning process, such criticisms may be unfounded and could delay the process of implementing identified adaptation interventions and the process of adaptive planning (learning by doing).

It is in this context of strengthening and facilitating the implementation of identified adaptation strategies that this study aims to assess the effectiveness of planned adaptation in Ethiopia.

3 Research and methodological framework

The study is one of the four studies that have been carried out as part of the Growth Long Term Action Research Studies (LARS) under the DFID funded RiPPLE programme (Research Inspired Policy and Planning in Ethiopia and the Nile region).

The study is based on the principle of action research[1]. The central research question of this study was identified by members of the Learning and Practice Alliance (LPA)[2] in Harar in 2008. The research has been designed and was carried out by government officials, members of staff at Haramaya University, and local and international RiPPLE staff members. It aims to facilitate learning by doing and provide an evidence base for decision-making and capacity building at the local, national and international level.

In order to assess the effectiveness of planned adaptation interventions, the study team carried out an impact and an adaptation assessment. This section provides an overview of the research framework, the study site, and the research methods.

3.1 Overall framework

Under the NAPA process, planned adaptation interventions aim at enhancing local coping capacity where it exists and/or creating capacity where it does not.

In this context, the study has assessed local coping capacity with the use of a conceptual framework that focuses on the 'type and nature of adaptation'. The study then used the 'adaptation decision matrix' to assess the effectiveness of planned adaptation interventions in enhancing and/or creating local coping capacity.

[1] Action Research is about 'earning by doing' – research with close links to implementation, which engages with and directly informs practice in the WSS sector through cycles of research, implementation of findings, and further learning. Links with local implementing partners will principally be achieved through the LPA process at regional and *woreda* level. The participation of LPA members in planning, research and reflection sessions will ensure the real input of local institutions. Hence the LARS will contribute to building the skill and knowledge of local partners for use in the implementation process.

[2] An LPA is a group of stakeholders from organisations working in the country, region or *woreda* in question, who meet periodically to share experiences on issues of joint interest. The organisations represented may be governmental, civil society or private sector, and may work in implementation, policy or research. Each LPA has a professional, full-time coordinator who is responsible for engaging stakeholders and driving the LPA process, with support from the RiPPLE office. In addition to regular meetings, LPA members are encouraged to interact on an ongoing basis. They are supported by the coordinators in developing new ways to work together (see http://www.rippleethiopia.org/page/learning-and-practice-alliances for further details).

3.1.1 Type of adaptation

By type of adaptation, we refer to the asset based adaptation framework as outlined by Moser and Satterthwaite (2008). Assets, which include natural, physical, financial, human and social capital[3], determine the level of household (HH) and community level exposure and sensitivity to CC *and* they also determine the extent to which HH and communities can cope with climate induced impacts. Asset based approaches to development are not new and include a concern for long-term accumulation strategies. Such asset accumulation policies/interventions aim at reducing vulnerability by creating, enhancing and protecting the asset base at the HH and community level[4]. In the context of CC, such asset accumulation strategies must be responsive to uncertainty and be able to reduce vulnerability to physical hazards as well social and economic risks.

3.1.2 Nature of adaptation

Definitions of adaptation in CC literature are numerous (Schipper, 2007). Essentially, adaptation aims at reducing climate-induced vulnerability in systems. Vulnerability to CC is defined as a function of exposure, sensitivity and adaptive capacity. Hence adaptation, broadly defined, aims to reduce exposure to climatic hazards, and/or enhance the capacity of systems to cope with its impacts.

Based on the type and nature of adaptation, this study aims to assess if adaptation interventions/local coping strategies 'create, enhance and/or protect' HH and community level assets, and, if this in turn reduces exposure to CC induced impacts and/or enhances the capacity to cope with the impacts (Table 2-1).

Table 3-1: A framework for adaptation: Type and nature of adaptation

Climate change	Type of adaptation	Nature of adaptation
Increased frequency and intensity of extreme weather events (floods and droughts)	*Asset protection*: Drought resistant crop varieties Building dykes	Reduces exposure to CC impacts
Increased climate variability leading to increased seasonality of water availability	*Asset enhancement*: Providing Insurance Climate proofing policies and investments	Builds capacity to cope with impacts
Increased climate variability leading to increased seasonality of water availability	*Asset creation*: Safety nets Creating new water points Providing access to assets	Builds capacity to cope with impacts

[3] **Physical capital**: is the stock of productive resources owned by HH, community, state, etc.; **Financial capital**: refers to the financial resources available to people (savings, supplies of credit); **Natural capital**: refers to the stock on environmental assets, like land, forests, water, etc., for rural communities, natural capital, like land and water are critical productive assets; **Social capital**: an intangible asset, defined as the rules, norms, obligations, reciprocity, and trust embedded in social relations, social structures, and a societies' institutional arrangements. It is embedded at the micro-institutional level (communities and households) as well as in the rules and regulations governing formalized institutions in the marketplace, political system, and civil society; **Human capital**: refers to investments in education, health, nutrition, etc. (Bebbington, et al., in, Moser and Satterthwaite, 2008).

[4] In the context of this study, Asset creation is understood as the creation of a 'new asset'; Asset protection is understood as the protection of an 'existing asset' so as to maintain status quos; and, Asset enhancement is understood as the enhancement of an 'existing asset'.

3.1.3 Adaptation decision matrix

The adaptation decision matrix (ADM) has been used to assess the effectiveness of the identified adaptation interventions. The ADM is a matrix-based decision making tool that sets up a series of criteria that allow the user to narrow down to the appropriate adaptation measures. The user sets up a table with evaluation criteria at the top, which can be replaced by other criteria as seen appropriate. The user then evaluates each adaptation intervention against these criteria, entering a simple 'yes', or, 'no' in the cells (Burton et al., 2006) This tool is frequently combined with expert judgement, as has been the case in this study, where expert interviews were also carried out. Table 3-2 below depicts the evaluation criteria used in this study to assess the effectiveness of adaptation interventions.

Table 3-2: Adaptation decision matrix

Adaptation intervention	**Evaluation criteria**			
	Does it build on existing coping capacity?	*Does it fill the gap where local coping capacity does not exist?*	*Is it a politically viable option?*	*Is it a financially sustainable option?*
Small-scale irrigation	Yes/No	Yes/No	Yes/No	Yes/No
Rangeland management	Yes/No	Yes/No	Yes/No	Yes/No
Multiple use services/systems	Yes/No	Yes/No	Yes/No	Yes/No
Productive Safety Net Programme	Yes/No	Yes/No	Yes/No	Yes/No

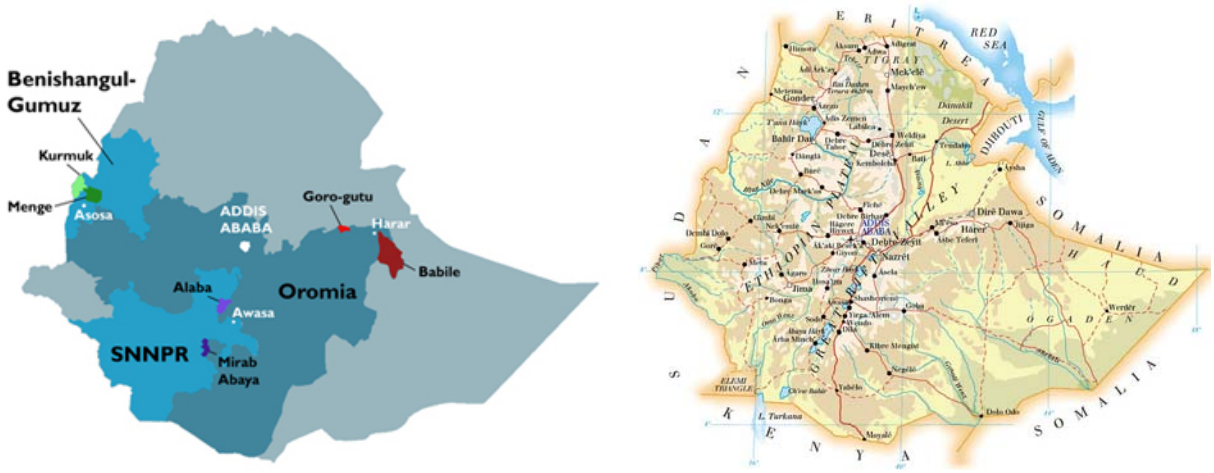
3.2 Overview of study site and interventions

3.2.1 The region

This study was carried out in an agricultural, agro-pastoral and pastoral site in the highland, midland and lowland areas of the Oromia and Somali regions, Ethiopia[5]. Within Ethiopia, these regions are likely to face high exposure to the impacts of CC and are characterised by a low level of coping capacity due to low income levels and lower levels of regional development.

5 Each site corresponds to a livelihood zone used in the WELS study, according to which each livelihood zone shares similar agro-ecological characteristics, market access, and livelihood activities pursued by the majority of the population. Accordingly, the livelihoods are characterised as: Wheat, Barley and Potato (WBP) in the highlands; Sorghum, Maize and Chat (SMC) in the midlands; and Shinile Agro-Pastoral (SAP) livelihood in the lowlands (Coulter et al., 2010).

Figure 3-1: Map of Ethiopia and the study region, Oromia



In its National Adaptation Programme of Action (NAPA), the Government of Ethiopia has identified farmers dependent on rain fed agriculture and pastoralist communities as the most vulnerable to the impacts of CC (NMA, 2007). In Oromia region, for example, about 40 percent of the territory is considered pastoral, with the vast majority being rangeland. Of the 27 million people in Oromia region, about 4.5 million belong to pastoral and agro-pastoral societies. The terrain of the Somali and Afar regions are largely lowland. Almost all of the 1.4 million inhabitants in Afar region are either pastoral or agro-pastoral, while of the 4.4 million inhabitants in Somali region, 3.74 million are considered pastoral (FDRE, 2007).

Research studies have also identified the Oromia and Somali regions as two of the most vulnerable areas within Ethiopia. Oromia's vulnerability has been correlated to the high frequency of floods and droughts (extreme weather events) and low access to technology, institutions and infrastructure. The Somali region's vulnerability has been correlated to lower levels of regional development (Temesgen et al., 2008).

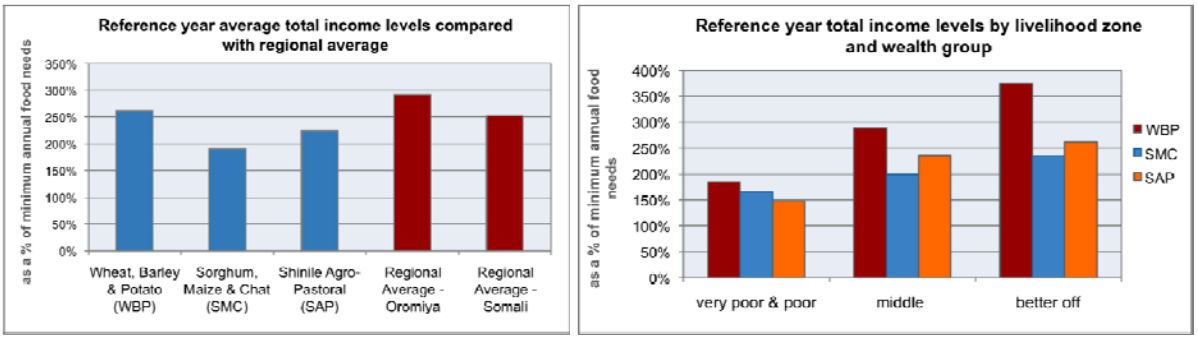
In the same light, Coulter et al. (2010) highlight that the total income levels (food and cash income) in all three livelihood zones of the study area in Oromia and Somali regions, fall below regional averages. Findings also highlight that income levels vary significantly between income groups.[6]

For instance, out of the three transect livelihood zones; households in the highland Wheat, Barley and Potato Livelihood Zone (WBP) have the highest average overall total income levels. The total income levels of the better off in highland livelihood zone is nearly 210 percent of the very poor/poor and better off households in midland Sorghum, Maize and Chat (SMC) and lowland Shinile

[6] Total income represents cash income and kilo-calories (kcals) from food converted into a common unit – in this case, kcals, presented as a percent of minimum kcal requirements (100 percent). Thus, for instance, figures above 100 percent kcal usually represent cash income that would be used for livelihoods protection needs such as purchase of inputs, schooling expenses, health costs, transportation, etc. Total income is a more useful figure in assessing livelihoods status than cash income alone because it makes comparable livelihood zones that are food and/or cash dominant (e.g. food crop dominant versus cash crop dominant versus pastoral livelihood zones). It also eliminates the problem of inflation's effect on cash figures over time.

Agro-pastoral (SAP) livelihood zones. Soil fertility and productivity, as well as the ability to purchase agricultural inputs, are higher in the highland and midland livelihood zones, contributing to higher levels of food and income from crop sales[7]. See Figure 3-2 below a comparison of total income levels and adjusted cash income levels across livelihood zones.

Figure 3-2: Comparison of cash and total income levels in the transect



Average cash income by livelihood zone (ETB)[8]		
Highland Wheat, Barley and Potato (WBP)	Midland Sorghum, Maize and Chat (SMC)	Lowland Shinile Agro-Pastoral (SAP)
4490	3795	4740

Source: Coulter, et al., 2010.

In terms of water resources, Figure 3-3 provides an overview of water resources and hydrological conditions in the study sites (Kebede and Zeleke, 2010). Springs are the principal source of water for highland and midland study sites (SMC and WBP), and boreholes, riverbed excavations and seasonal ponds are the primary water sources in the lowland study site (SAP). In the lowlands, the majority of water sources rely on groundwater.

Water recharge in the highland and midland livelihood zones (WBP and SMC) takes place from rainfall. In the lowland (SAP) livelihood zone the main recharge source to shallow aquifers is losing streams that emerge from the highlands and flash floods within the zone. Based on extrapolation, recharge varies between less than 50 mm per year in the lowland (SAP) to more than 100 mm per year in highlands and midlands (WBP and SMC). Aquifers in highland WBP and midland SMC are more sensitive to seasonal variability (changes in rainfall/climate) as compared to lowlands (SAP). In terms of water quality, there is a general decrease in quality as altitude decreases. For instance, the presence of salt in the lowland zone reflects the general water geochemistry evolution trend around the Ethiopian Rift valley and adjacent highlands, in which salt content has been found to rise as altitude falls from highlands to lowlands (Kebede, at al. 2007).

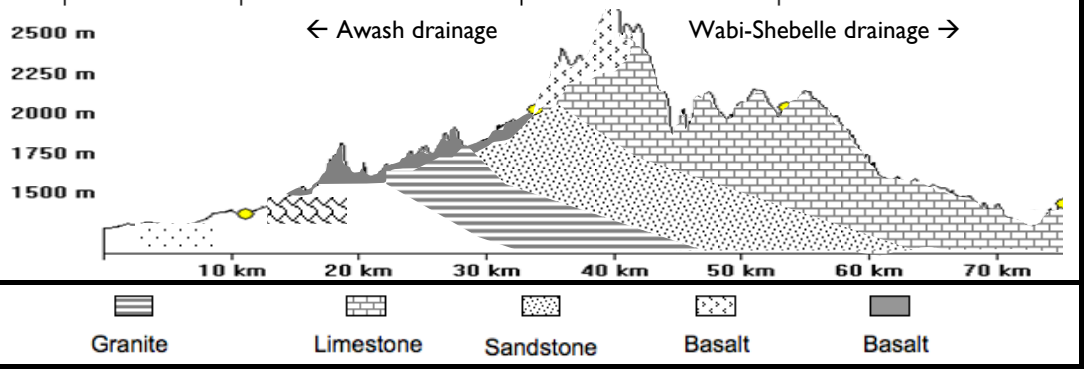
[7] The middle and better off people in the WBP zone spend over double that spent on inputs by the same wealth groups in the SMC zone.

[8] The reference year for WBP and SMC, in Oromia Region, was 2006-7, while the reference year for SAP was 2005-6. Cash incomes have been adjusted to 2005-6 levels so that income presented in ETB is comparable across livelihood zones.

Figure 3-3: Hydro-geological and water resource availability across livelihood transects

Hydro-geological, climatic, and water resource conditions in livelihood zones along a highland to lowland transect in east and west Hararghe and Shinile zones

	Shinile Agro-Pastoral (SAP)	Sorghum Maize & Chat (SMC)	Wheat, Barley & Potato (WBP)	Sorghum, Maize & Chat (SMC)
Water sources	Some boreholes, riverbed excavations, seasonal pools & ponds & rare base flows.	Cold springs dominant source of water for irrigation and domestic water supply. Springs represent discharge of groundwater to depressions formed by faulting. Ponds also common.	Cold springs and roof water harvesting are the common sources of water supply.	Cold springs are common sources of water supply; sinkholes and karsts also exist.
Climate	Dry, hot and arid with evaporation far exceeding rainfall. LTM* annual rainfall 600mm.	Mild temperatures, relatively higher rainfall than SAP. LTM annual rainfall 750mm.	Relatively cold mean annual temperature, high diurnal variation in temperature, lowest evaporation. Semi-humid climate. LTM annual rainfall 900mm.	Mild temperature, relatively higher rainfall than SAP. LTM annual rainfall 750mm.
Hydro-geology	Recharge to aquifers mainly from flash floods. Streams are seasonal. Aquifers are volcanic rocks, and groundwater is often saline. Deep groundwater tables.	Recharge to volcanic aquifers takes place from rainfall. Main discharge takes place to cold springs in depressions. Seasonal variation in spring discharge is indicative of local recharge with limited regional flows emerging into this zone. Rift-related faults are main source of ground-water occurrence and movement. Ground-water contains low total dissolved solids (TDC).	Recharge to aquifers takes place from rainfall. Isolated peaks are the site of groundwater scarcity or outflow. Discharge takes place in depressions or to springs. Shallow groundwater tables. Biological pollution likely.	Aquifers are mainly sedimentary rocks. Springs emerge at the food of the highlands. In some areas, limestone is karstified and is the main source of groundwater. Shallow groundwater tables. Biological pollution likely.



Source: Kebede and Zeleke, 2010.

Table 3-3: The interventions

Study site	Water sources	Agro-climatic zone	Livelihood	Intervention	Beneficiaries	Activities
Chefe-aneni kebele, District Gorogutu, Oromia region	11 springs (6 protected); 2 community ponds; 67 hand dug wells; 10 traditional hand dug wells; 3 improved wells	Highland 56% and midland 44%	WBP Mixed farming	PSNP	78 beneficiaries receiving direct support. 296 beneficiaries receiving paid public work. 540 beneficiaries receive credit.	Launched in 2005. Direct support in the form of cash/food transfers to create HH level assets and Waged labour to create community level assets. Provision of credits by the World Bank and the Federal budget.
Bekelcha-Oromia kebele, District Meta, Oromia region	Springs and artificial ponds	Highland 55% and midland 45%	SMC Mixed farming: cash crops (chat and coffee); food crops (maize, sorghum, wheat, barley and root crops); livestock production.	MUS	320 HH	Implemented by NGO (HCS) as part of water and sanitation project constructed in 2006-7. Expansion of existing spring; construction of 1 reservoir; 2 cattle troughs; 3 washing basins; training on water management and sanitation; and road maintenance.
Billa kebele, District Errer, Somali region			SAP Agro-pastoralist: cash crops (chat, fruit and vegetables); food crops (sorghum and maize); livestock (cow, oxen, sheep, goat, camel, donkey).	Small-scale irrigation	520 households (estimate)	Launched in 1984. Construction of diversion headwork; each HH provided with irrigable land, oxen and seed.
Ayidora kebele, District Errer, Somali region			Pastoralist	Rangeland management		

Adaptation interventions in the water sector can take the form of targeted supply and demand side interventions and can also include broader interventions, like safety net programmes. Based on a review of CC literature and adaptation policies (Burton et al., 2006; NMA, 2007), the study team selected the following four planned adaptation interventions and assessed their effectiveness in enhancing and/or creating local coping capacity:

1. Small-scale irrigation schemes: A prioritised adaptation project in the NAPA;
2. Rangeland management: a prioritised adaptation project in pastoral lowlands in the NAPA;
3. Multiple Use Systems/Services (MUS): An adaptation interventions outlined in the Technical Paper on Climate Change and Water (Bates et al., 2008);
4. Social protection: Social protection measures, which in Ethiopia take the form of the Productive Safety Net Programme (PSNP), have been identified in the broader adaptation literature as having the potential to facilitate adaptation to CC (Davies, et al., 2008).

Since adaptation interventions are yet to be implemented, site selection was determined by the existence of proxy interventions. In Oromia, the study was carried out in Bukelcha Oromia *kebele* where MUS were assessed as an adaptation strategy and in Chefe-aneni *kebele* where the PSNP was assessed. In Somali region, the study was carried out in Billa *kebele* where small scale irrigation was assessed as an adaptation intervention and in Ayidora *kebele*, where an attempt was made to assess the role of rangeland management as an adaptation strategy. Billa is an agro-pastoral site where livelihoods rely on irrigated agriculture and livestock rearing, while Ayidora is a pastoral site.

3.3 Methods

In order to assess the effectiveness of planned adaptation interventions, the study carried out an impact and adaptation assessment. A range of methods were used for data collection and analysis, including: participatory rural assessment (PRA), HH survey and secondary data collection. Details on the methods can be found in Annex1.

4 Study findings

This section is divided into three sub-sections. The first provides an overview of CC and its impact on the water sector. This includes a review of secondary literature on the impacts of CC on the water sector at a regional and national level, and a synthesis of local perceptions and secondary data related to current and historic weather trends in the study sites. The second and the third sections deal with local perceptions related to coping strategies and the effectiveness of planned adaptation interventions.

4.1 Climate change and its impacts

According to the IPCC Technical paper on CC and water (Bates, et al., 2008), 'observational records and climate projections provide abundant evidence that freshwater resources are vulnerable and have the potential to be strongly impacted by CC, with wide ranging consequences on human settlements and ecosystems.'

4.1.1 Regional projections and impacts

At a regional level, a number of assessments have attempted to assess the impact of CC on water resources. These rely, broadly, on the use of Global Circulation Models (GCM) used by the IPCC, and/or second generation climate models like the Millennium Ecosystem Assessment (MEA) (ODI / WaterAid, 2009).

Within Africa, due to the complexity of the physical, biophysical, and socio-economic feedback loops involved and the paucity of available data, it has been difficult to assess the final water balance between intense and seasonal rainfall, increased evaporative demands, reduced soil moisture and altering land use. As a result, change to regional hydrological systems in SSA is poorly modelled within the GCMs. For instance, white areas in Figure 4-1 denote regions where less than 66 percent of the GCMs agree on the level of change.

Figure 4-1: Percentage change modelled to global runoff patterns 2090–2099, relative to 1980–1999

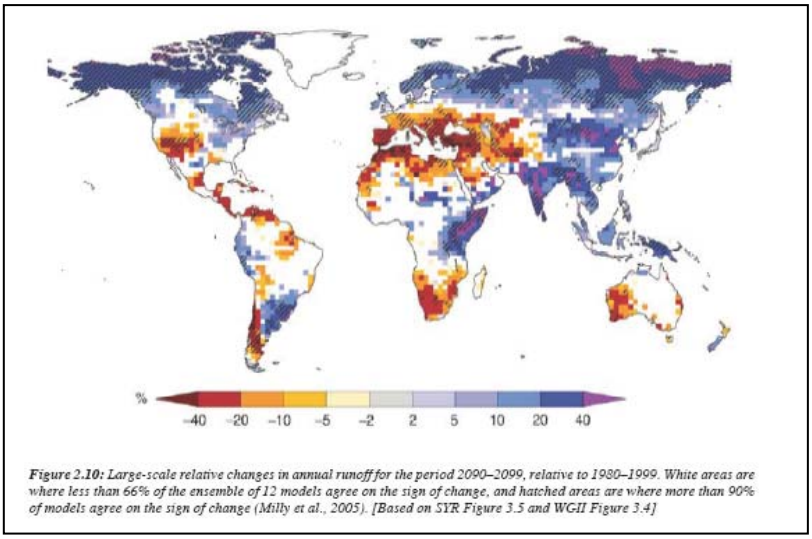


Figure 2.10: Large-scale relative changes in annual runoff for the period 2090–2099, relative to 1980–1999. White areas are where less than 66% of the ensemble of 12 models agree on the sign of change, and hatched areas are where more than 90% of models agree on the sign of change (Milly et al., 2005). [Based on SYR Figure 3.5 and WG-II Figure 3.4]

Source: Bates et al., 2008.

In the context of water resources, groundwater is of prime importance to rural water supplies in SSA as up to 80 percent of existing rural water supplies are groundwater-based (~400 million people). Moreover, with increased seasonality of surface water resources in future CC scenarios, there is likely to be an increased dependence on groundwater to meet domestic, agricultural and industrial water demands. Although groundwater is likely to be of slower response to projected CC than surface water systems, the critical effect of increased hydrological and climate variability to groundwater recharge is still very unclear (Kundewicz et al., 2007). This is largely due to the fact that available data on present groundwater recharge in SSA and South Asia is so limited that present quantities and patterns of recharge are largely unknown. Consequently, modelling of groundwater systems in global and regional climate models is almost impossible (ODI/WaterAid, 2009).

4.1.2 National level projections and impacts

In Ethiopia a few studies have attempted to assess the impact of CC on water resources and on water based livelihoods and economic activities.

At a national level, food security, water resources and health have been identified as vulnerable sectors (NAPA, 2008; IPCC, 2001). The livelihoods of agricultural communities dependent on rain-fed agriculture and pastoral communities have been identified as vulnerable to the impacts of CC (NMA, 2007). Yesuf et al. (2008) have indicated that CC will have significant impact on farm productivity. As highlighted above, Temesgen et al. (2008) have identified Oromia and Somali region as two of the most vulnerable agriculture-based regional states in Ethiopia. According to the estimates of UNEP (2006), yields of some important cereal crops in Ethiopia, Eritrea, Sudan, Zambia, Gambia and Ghana will decline by up to 5 percent by the 2080s due to climate change. NMA (2001) has predicted a reduction of wheat yield by 10.6 percent to 18.5 percent in central Ethiopia. Conway et al. (2007) have attempted to review and analyse the linkages between climate and macro-economic activity in order to assess the likely economic impacts of future CC in Ethiopia. The study highlights greater certainty with regard to increases in temperature and low confidence in future patterns of rainfall and extremes. It shows that the recent decline in belg rains has been linked with Indian Ocean warming and could be an emergent longer term trend. The study identifies agriculture and water resources as the key climate-sensitive sectors in Ethiopia. In terms of macro-economic effects of climate extremes in Ethiopia, the study found a correlation between GDP decline and major drought in the years of 1984 and 2001. In other years the relationship between national estimate of rainfall and economic performance is not predictable and also regional differences are obscured. In terms of the relationship between climate variability and agricultural production, wheat, maize and teff yields were found to be highly sensitive to future CC.

A few studies have attempted to model the impacts of CC on water availability at a watershed level. For instance, it is likely that the total average annual inflow volume into Lake Ziway might decline significantly due to projected CC impacts, resulting in insufficient water to meet future demands of the ever increasing population (Lijalem et al. 2006). Similarly, modelling studies indicate a substantial decrease in annual runoff over the Awash river basin (Kinfe, 1999).

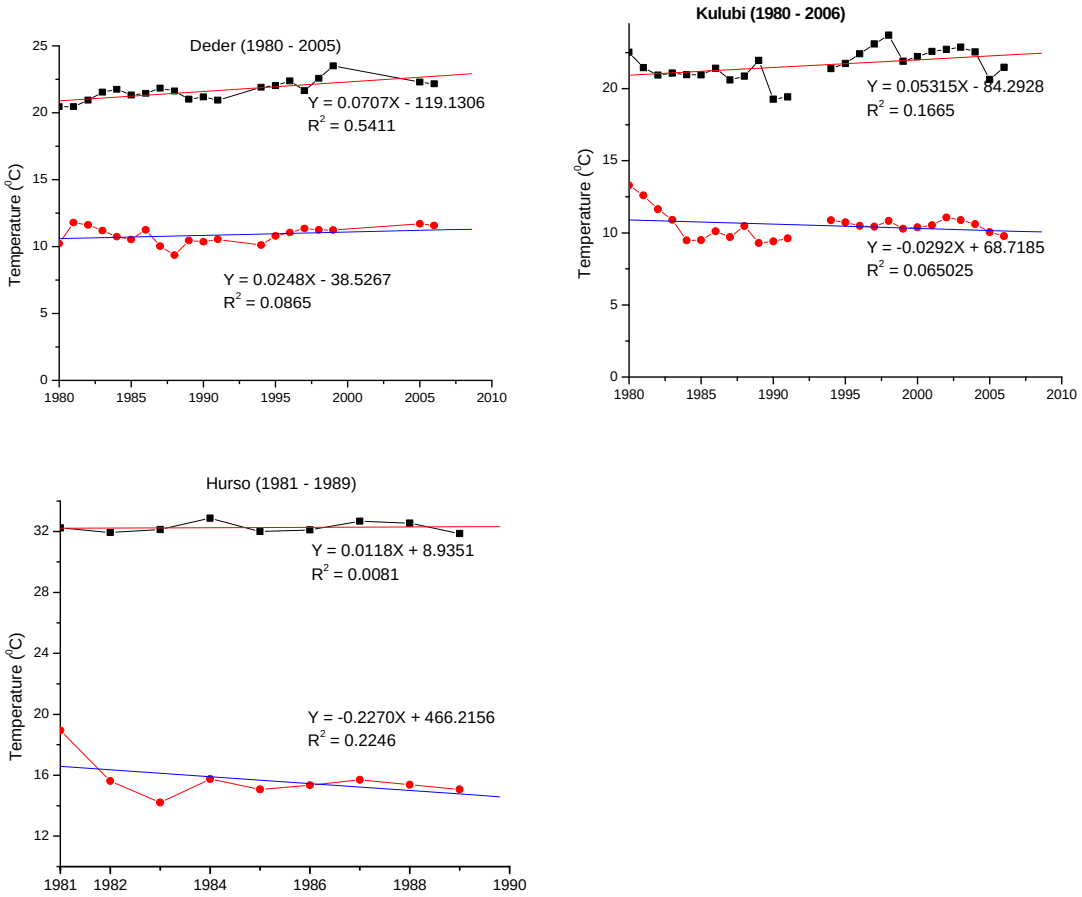
4.1.3 Local level perceptions related to climate change and its impacts

Local communities have identified changes in temperature, rainfall, soil moisture, river discharge and humidity as relevant indicators of CC. Focus group discussions in the study sites were aimed at assessing how these changes were different from historical and existing weather patterns.

CC induced changes in temperature

Respondents across the study sites identified an increase in temperature, with the *kola*, or warm zone replacing the *dega* (higher altitude), or cooler zone. Moreover, respondents cited the drying and disappearance of fodder species as indicators of increased temperature. Analysis of secondary data of temperature indicates slight increases in the annual maximum temperature for Deder (representing the midland Sorghum, Maize and Chat Livelihood zone) and Kulubi (representing the highland Wheat, Barley and Potato livelihood zone) and variability in the annual minimum temperature (Figure 3-2).

Figure 4-2: Maximum and minimum temperature readings of metrological stations near the study sites



Source: National Metrological Agency, 2009

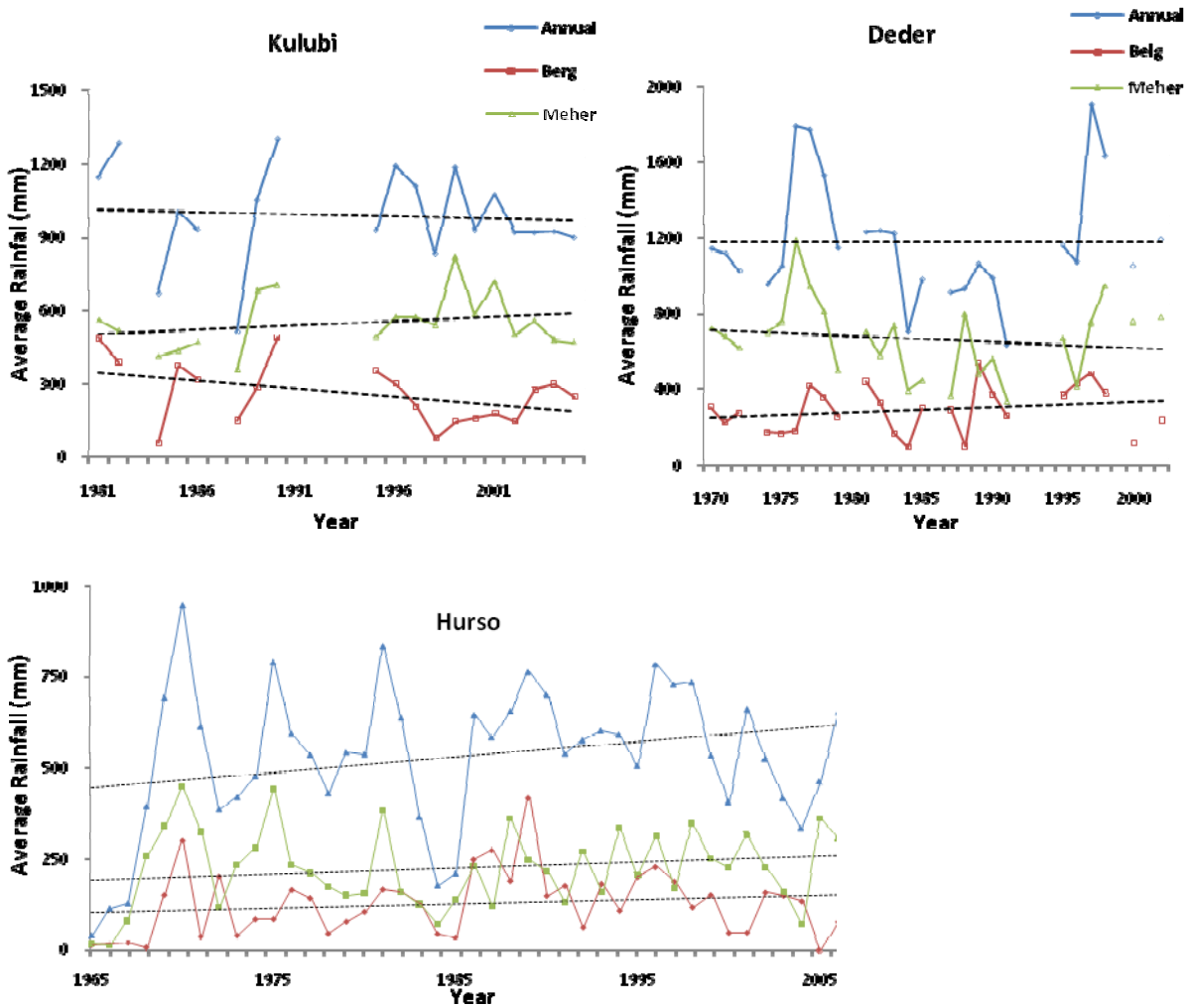
Changes in rainfall pattern

In terms of changes in rainfall, respondents identified an increase in seasonality in the rainfall pattern, which includes changes in timing, intensity and duration of rainfall. For instance, respondents stated that in normal years they have two rainy seasons: The meher (mid-June to end of September) and the belg (February to April). Respondents have experienced a change in the belg rainfall, which is increasingly delayed or fails completely. Collected data on rainfall patterns, as seen in Figure 4-3, depict only annual trends. These indicate a slight increase in rainfall in the area.

Changes in soil moisture and humidity

Rising temperatures and changes in the timing, duration, and intensity of rainfall were identified as contributing to decreased soil moisture content[9], which in turn has resulted in early wilting of seedlings and disappearance of fodder species. For example, camel fodder like *deremo*, *deref*, *housman*, *bekelhed* and *agar* (local names) have disappeared. A tree known as *harmuko*, which was eaten by camels and *koh*, which was eaten by all animals has also disappeared. In relation to humidity, perceptions across study sites indicate that the air is getting dryer. In Bekelcha and Chefe-aneni respondents relate humidity to wind direction, highlighting that the wind is increasingly coming in from areas which bring dry air. The disappearance of morning dew was cited as an important indicator of 'abnormal' weather patterns.

Figure 4-3: Trend lines of average rainfall of metrological stations nearby to study sites.[10]



Source: National Metrological Agency of Ethiopia, 2009.

[9] Soil moisture content also depends on soil type and vegetation cover.

[10] Rainfall readings with more than one month of data missing per annum are omitted.

In terms of EWE, respondents highlighted that there has been an increase in the frequency of floods and droughts. For instance, the cycle of EWE has decreased to two years as compared to the four year cycle experienced under 'normal' weather patterns. Respondents in the pastoral site of Ayidora, as shown in Table 4-1, highlights the devastating impact of more frequent EWE.

Table 4-1: Impact of extreme weather events on pastoral livelihoods.

Year occurrence	Local name	Its meaning
1987	Mekel	'Kill the calves' which was named after it forced the community to kill the calves of their livestock to save the big animals
1994	Efeso	Name of a bullet which creates fire, named after it burned their rangeland
1996	Meseletur	It literally means 'throw away your prayer mat' which was named after the drought weakened the people because of food shortage
2007	Fedhigugar	'Arrived at your seat', to mean that it caught them before they were ready

4.1.4 Impacts of CC on the economic use of water

The HH survey documented the impacts of identified trends in CC on the economic and domestic use of water across the three different livelihoods.

Impacts on pastoral and agro-pastoral livelihoods

In both the pastoral and agro-pastoral study sites, CC has negatively impacted on the physical, financial and natural assets of communities.

Amongst pastoral communities, the change in water availability, in terms of timing and amount, and increases in temperature, has impacted on the rangeland and on livestock watering points. These changes, along with other risks, have resulted in a decline in the herd size per HH in all livestock types (Figures 4-4 and 4-5). The slope of the trend line is higher for sheep followed by cow, goat and camel which means that the herd composition is altered and is shifting to more browsers (e.g. goats, camels) away from grazers (e.g. cattle, sheep). A root cause analysis indicates that the major reasons for the observed trend are lack of fodder and livestock water availability and increasing incidence of livestock diseases (Figure 4-6). A change in herd composition could be taken as a positive or negative trend in terms of adaptation. Looking at its positive side, it is good that pastoralists are resorting to more drought resistant animals (e.g. more strongly relying on goats and camels). On its negative side, however, concentrating on few livestock types as opposed to a diversified herd may have negative consequences when it comes to other vulnerabilities like market failure or livestock diseases.

Figure 4-4: Trend of household livestock ownership in Ayidora (Pastoral study site).

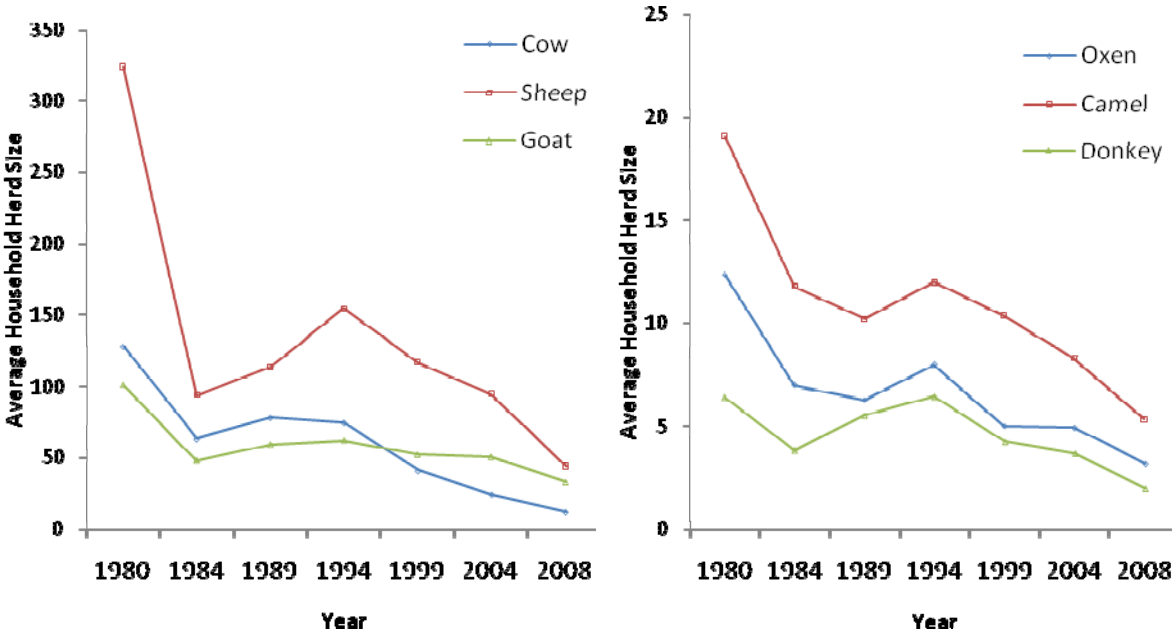
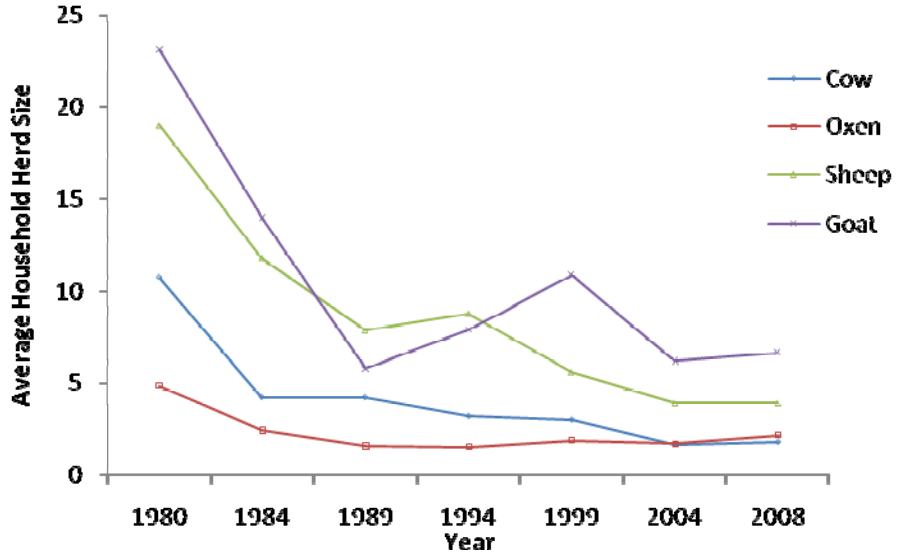
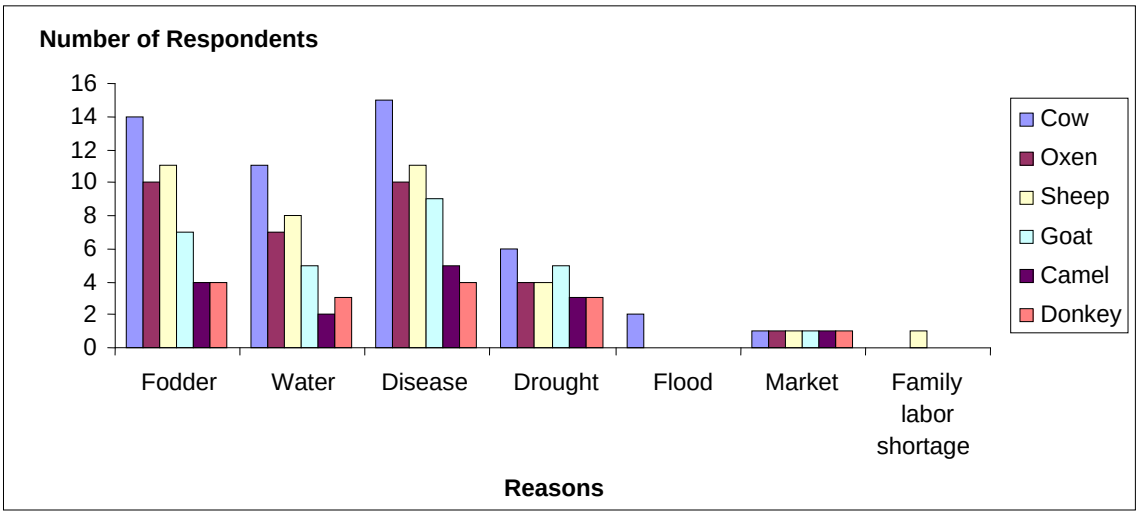


Figure 4-5: Trend of household livestock ownership in Billa (agro-pastoral study site).



Source: Household Survey, March 2009.

Figure 4-6: Reasons for reduction trend of livestock herd size.



Source: Household Survey, March 2009.

Impacts on agricultural livelihoods

In the agricultural livelihood study sites (Bekelcha Oromia in the midland and Chefe-aneni in the highland), the dominant food crops include sorghum and maize and the dominant cash crops include vegetables and chat.

Focus group discussions among the different wealth and women's groups in both *kebeles* highlighted that CC has potentially contributed to a change in the pattern of crop production. For instance, the women's group reported a shift from producing highland crops like wheat to lowland crops like sorghum. They also reported a shift to more drought-resistant and early maturing crops like chat, sweet potato, and pumpkin and reported a shift towards single cropping as compared to double-cropping.

Data from the HH survey supports local perceptions that highlight a decrease in food production. Figure 4-7 below shows that in the last 25 years there has been a decrease in the production of both maize and sorghum. It is difficult to say for certain that CC is directly responsible for this change. However, as shown in Figure 4-8 respondent farmers perceive CC to have contributed to increased temperature, rainfall variability and reduced soil fertility, which in turn have been identified as the causes of changes in agricultural productivity.

Figure 4-7: Maize and sorghum production trends

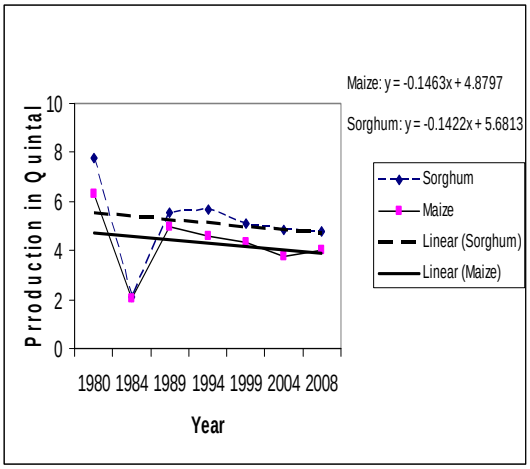
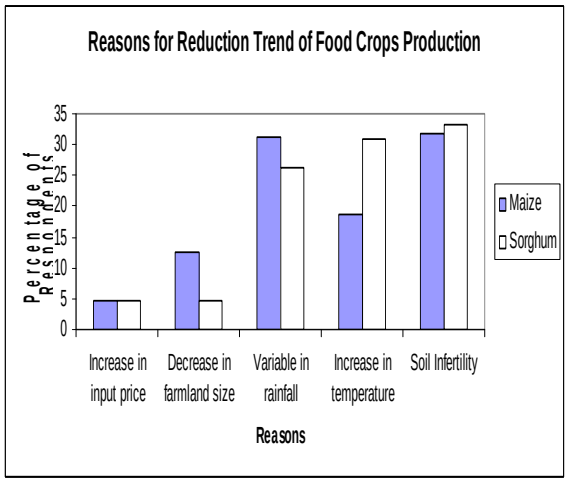
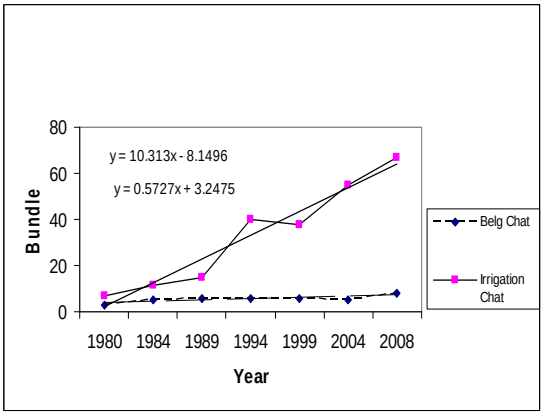


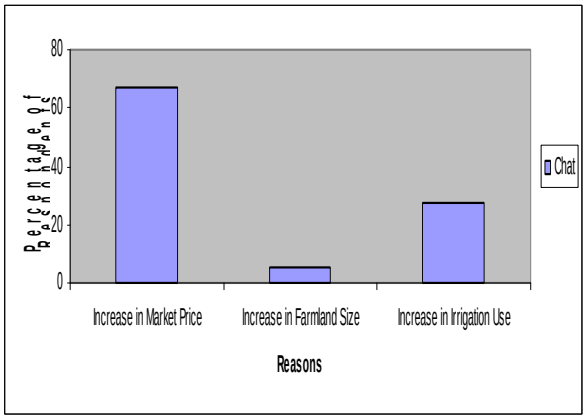
Figure 4-8: Reasons mentioned by respondents for changing yields



Source: Household Survey, March, 2009.

Figure 4-9: Irrigated and belg chat production trend and reasons for change





Source: Household Survey, March 2009.

Impacts of CC on the domestic use of water

Domestic sources of water in the study sites include deep and hand dug wells (in pastoral lowland areas), irrigation canals (in the agro-pastoral site), and developed and undeveloped springs (in the agricultural sites).

CC, in terms of increased variability in rainfall (delayed rainfall and reduced rainfall amounts), has resulted in decreased spring discharge and increased algal content in water bodies.

In times of water stress, communities tend to de-prioritise sanitation concerns, which have knock-on impacts on education as children are unable to attend school in dirty uniforms. Women and children also spend more time to collect water.

Table 4-2 below shows how communities prioritise water use during times of water stress.

Table 4-2: Priority in times of water stress.

(1 for the highest rank and 6 for the least)

Purpose	Rank for each *kebele*			
	Bekelcha	Chefe-aneni	Billa	Ayidora
Drinking	1	1	1	1
Cooking	2	2	2	2
Washing clothes	4	3	5	5
Bathing	5	6	4	4
Livestock drinking	3	3	3	3
Irrigation	6	5	6	-

4.2 Local coping capacity

As seen above, CC in the form of increased climate variability and extreme weather events has a significant impact on the economic and domestic use of water in all three livelihoods. This section outlines and assesses coping strategies adopted by households and communities to deal with CC induced impacts.

The dominant coping strategies adopted by different wealth groups in the three livelihood zones are summarised in Table 4-3 and are discussed in terms of the type and nature of adaptation they facilitate; that is, does local coping capacity, create, enhance and/or protect HH and community level assets, and does this in turn, reduce exposure to CC induced impacts and/or enhance the capacity to cope with the impacts.

Before discussing these in detail there are three trends that have emerged from the study findings in relation to local coping capacity. These include:

3. There is greater capacity to deal with climate variability as compared to extreme weather events.
4. The coping capacity of better off groups is better than that of middle and poor wealth groups. This is due to a more diversified and larger asset base.

5. Better-off groups rely more on supply side water resource management interventions to address the impacts of climate variability, whereas poor and middle wealth groups rely more on demand side interventions to cope with the impacts of climate variability.

Table 4-3: Type and nature of adaptation facilitated by local coping strategies.

Coping strategy	Wealth group	Type of adaptation	Nature of adaptation
Extreme weather events			
Pastoral migration	R, M, and P	Asset protection	Reduces exposure to CC impacts *and* builds capacity to cope with impacts
Asset diversification	R	Asset enhancement	Reduces exposure to CC impacts *and* builds capacity to cope with impacts
Improved crop variety	R	Asset enhancement	Reduces exposure to CC impacts *and* builds capacity to cope with impacts
Food aid	R, M, P	Asset protection	Builds capacity to cope with impacts
Credit		Asset protection	Builds capacity to cope with impacts
Labour migration	P	-	-
Killing new born calves	M & P	-	-
Sale of assets	P	-	-
Climate variability			
Supply side interventions			
Use of donkey to fetch water	R	Asset creation	Builds capacity to cope with impacts
Water storage/harvesting structures	R	Asset creation	Reduces exposure to CC impacts *and* builds capacity to cope with impacts
Pumps	R	Asset creation	Reduces exposure to CC impacts *and* builds capacity to cope with impacts
Land/soil moisture management	R, M, P	Asset enhancement	Reduces exposure to CC impacts
Demand side interventions			
Water management	R, M, P	Asset enhancement	Builds capacity to cope with impacts
Reduced water use for sanitation	P	-	-
Travelling far distance to collect water	P	-	-

Pastoral migration

As an adaptation/coping strategy, pastoral migration has been assessed as a strategy that protects assets. As a result, the nature of adaptation reduces exposure to climate induced impacts and it builds capacity to cope with the impacts of CC.

Migration reduces the exposure of livestock to EWE like floods and drought. By adopting this strategy, pastoral communities are able to reduce the number of livestock lost to EWE and are able to avoid situations where the physical condition of livestock deteriorates to such an extent that their

market value declines. Communities stated that by adopting such a strategy they can avoid distress sale of their livestock and are thus able to protect their asset base.

Asset diversification

As an adaptation/coping strategy, asset diversification has been assessed as a strategy that enhances the asset base of households. As a result, the nature of adaptation reduces exposure to climate induced impacts and it increases the capacity of households to cope with the impacts.

Examples of asset diversification from the cited local coping strategies include diversification of livestock (sheep, goat, and camel); diversification of agricultural crops (cash and food crops); and off farm income generating activities that are being undertaken by women's associations. As an adaptation/coping strategy, the option of asset diversification is accessible mostly to better off wealth groups.

In agricultural livelihoods, crop diversification, which includes the plantation of climate resilient crops as well as the plantation of a more diverse crop mix, reduces exposure to climate impacts like increased uncertainty in seasons and to increased intensity of extreme weather events like prolonged droughts. Crop diversification also builds the capacity of households to cope with climate induced impacts. For instance, better off households are able to save food crops in times of stressed periods and thus do not resort to the sale of assets.

In pastoral livelihoods, a diversified livestock base (camel, sheep, goats and donkeys) has traditionally enabled pastoralists to cope better with impacts of climate variability on fodder species. However, due to the increased intensity of climate induced impacts, communities outlined that they are often faced with permanent/long term changes in the rangeland (for example changes in fodder species, disappearance of particular fodder species). As a result, pastoralists have changed the composition of their herd and in the process have lost the diversity. Thus, climate induced impacts have undermined an otherwise robust coping/adaptation strategy.

Food aid

As an adaptation strategy, food aid has been assessed as a strategy that protects HH assets, as it enables households to avoid selling assets to purchase food. As a result, the nature of adaptation builds the capacity of households to cope with climate induced impacts. Food aid does not reduce exposure to climate induced impacts.

Water - Supply side interventions

As adaptation/coping strategies, a number of supply side interventions were assessed as having created assets at HH and community level. Depending on the source of water supply, the nature of adaptation facilitated by these interventions reduces exposure to climate induced impacts and it builds capacity to cope with impacts.

For instance, increasingly using water points that rely on groundwater create assets and reduce exposure to CC induced impacts, as groundwater is less exposed to changes in climate (temperature and precipitation). Coping strategies such as the use of donkeys to fetch water from distant places also create assets and thus increase the capacity to cope with water scarcity. However, they do not reduce exposure to climate induced impacts.

Water - Demand side interventions

As adaptation/coping strategies, demand side strategies were assessed as having enhanced the asset base of communities and households. As a result, the nature of adaptation reduces exposure to climate induced impacts and builds capacity to cope with impacts.

Water management institutions from the study site are examples of demand side interventions. Local water management committees regulate the use of water by implementing quota systems and prioritising water use. Such practices ensure that scarce resources are available to the community. They do not reduce exposure to climate hazards, but by securing community assets, they do enhance local capacity to cope with the impacts of climate variability.

Ineffective coping capacity

A number of coping mechanisms, adopted especially by the poor and middle wealth groups, including forced labour migration, sale of assets, killing calves and travelling far distances to collect water do not facilitate adaptation. They do not contribute to asset protection or accumulation and thus do not reduce exposure to climate hazards or help build capacity to deal with the impacts of CC.

4.3 Assessing the effectiveness of planned adaptation interventions

This section provides an assessment of the potential effectiveness of planned adaptation interventions. Effectiveness of the planned adaptation interventions has been assessed with the use of the ADM, with effectiveness criteria identified by the research team. Based on these criteria, the effectiveness of planned adaptation interventions was assessed vis-à-vis their role in building local coping capacity where it exists; filling the gap where it does not exists; and, assessing the political and financial viability of the proposed planned adaptation interventions. Expert interviews were also carried out to complement the ADM.

Table 4-4 provides an overview of the effectiveness of the planned adaptation interventions using the ADM. These are discussed in further details in the section below.

Table 4-4: Assessing the effectiveness of planned adaptation interventions

Adaptation intervention	**Evaluation criteria**			
	Does it build on existing coping capacity?	*Does it fill the gap where local coping capacity does not exist?*	*Is it a politically viable option?*	*Is it a financially sustainable option*
Small-scale irrigation Investment in: Small-scale irrigation; Ponds and boreholes; River diversion	Yes Increased water supply builds capacity to cope with CV, if drawn from groundwater	(?) Schemes are not climate proofed against EWE, increased variability and long term CC Supply side interventions do not build capacity of poor groups as they are land and labour constrained and cannot make use of water	(?) Access to benefits is location specific. Equity aspects might become an issue	(?) Costs of investment, including, recurrent investment and payment for release of upstream water, need to be taken into account
Rangeland management Management of invasive alien species; introduction of fodder species; Strengthening of local management practices	Yes Focus on local management can enhance social and human capital assets that pastoral communities rely on	Yes Management of invasive alien species and introduction of fodder species *can* create assets. *Further discussion needed on composition of fodder species;* *Needs coordinated intervention with access to water*	Not assessed	Not assessed
Multiple use services/systems Investment in water taps, washing basins and cattle trough Training on water and sanitation management	Yes Creation of assets (multiple water use points) enhances existing coping capacity. *Interventions need to be climate proofed as they fail in providing benefits under water stress*	Yes Health and sanitation training has reduced incidence of water borne disease	(?) Horizontal coordination (between sectoral institutions) and vertical coordination (between political and administrative scales) needs to be addressed	(?) Predictability and sustainability of financial flows is lacking as there is no government financing available
Productive Safety Net Programme Supply and demand side WRM interventions; Wage/food for labour Access to credit	Yes Protection oriented interventions (check dams and afforestation) have reduced exposure to CC	Yes Asset creation and enhancement interventions (wage/food for labour and access to credit) have built coping capacity	(?) Corruption and nepotism need to be addressed	(?) Interventions capitalise on local skills and resources Budget cuts and delays undermine effectiveness

4.3.1 Small scale irrigation schemes

In its NAPA the Government of Ethiopia has identified small scale irrigation as a priority adaptation project. The government aims to invest in small scale irrigation and river diversion schemes, ponds and boreholes as a means to ensure greater agricultural productivity and access to water resources.

Role in enhancing adaptive capacity

Having assessed the role of small scale irrigation in Billa, the study findings confirm that small scale irrigation does enhance agricultural productivity. It thus enhances the asset base of some households. However, it is a supply side intervention, and study findings indicate that it is primarily the better off households that have access to such interventions.

Secondly, the findings also indicate that the source of water that the irrigation scheme relies upon plays an important role in determining the effectiveness of the intervention. For instance, local perceptions and CC literature highlight that the length of the dry season is increasing and the belg rainfall is becoming increasingly unpredictable in terms of timing and intensity. Due to this, irrigation schemes that rely on surface water (including ponds and rivers) are highly vulnerable to the impacts of CC. In this context, small scale irrigation that relies on boreholes (in areas where groundwater is available and accessible) has been assessed as a better investment option.

Political feasibility

In terms the political feasibility of such schemes, the study finds that access to the benefits of irrigation is very location specific. This includes location in terms of up-stream and down-stream users (e.g. between communities) as well as location in terms of distance of land from the irrigation channel (e.g. within the community). Therefore, mechanisms that facilitate equitable access are essential. In the current study it was found that villagers have resorted to an informal system of payment for environmental services. For instance, residents in Billa, which is located downstream, collect money and send their village elders to negotiate the release of water from the upstream village in times of water scarcity. Government officials in the Oromia and Somali regions are also trying to negotiate some form of equitable access between up-stream and down-stream villages using the irrigation scheme.

Financial feasibility

The study did not assess the financial sustainability of the intervention.

4.3.2 Rangeland management

The Government of Ethiopia has identified rangeland management as a priority adaptation project in its NAPA. It identifies CC as exacerbating ongoing rangeland degradation. Intervention activities include the introduction of fodder species and the management of invasive alien species and bush encroachment. The government also plans on promoting local management practices.

Currently, no rangeland management interventions have been implemented in the study area. As a result the team was unable to assess the effectiveness of the proposed activities in facilitating adaptation. However, during the impact and adaptation assessment, pastoral communities highlighted that a number of fodder species and water points have been adversely impacted due to increased climate variability and extreme weather events. It was assessed that pastoral communities are able to cope better with climate variability via migration and the use of donkeys to collect water as compared to coping with extreme weather events. In relation to extreme weather events, coping

capacity was assessed as being undermined, as increased climate-induced stress results in a breakdown of social systems such as traditional conflict management practices and reliance on neighbours, thereby undermining the robustness of migration as an adaptive strategy.

Role in enhancing adaptive capacity

Planned adaptation interventions under rangeland management could build on existing coping capacity and fill gaps where this capacity is being undermined. For instance, a focus on strengthening local management practices is likely to strengthen local conflict management mechanisms and thus strengthen the social asset base that supports pastoral migration. Similarly, the introduction of fodder species and the management of invasive alien species also have the potential of securing the asset base of pastoral communities.

Political feasibility

This was not assessed in the study site

Financial feasibility

This was not assessed in the study site.

4.3.3 Productive Safety Net Programme (PSNP)

Social protection (SP) like CC adaptation, aims to reduce vulnerability and increase resilience amongst local communities. It includes protective (e.g. safety nets - food aid or cash transfers), preventive (e.g. social insurance), and promotive (e.g. micro-credit) components. Thus, like the framework used in this paper, it has the potential to create, enhance and protect assets and is increasingly being promoted as an effective adaptation strategy in countries where a 'development deficit' is cited as one of the main drivers of climate-induced vulnerability. SP is seen as being able to respond to the multiple risks and short and long-term stresses and shocks associated with CC (Davies, et al., 2008).

The PSNP is being implemented by the government of Ethiopia and its development partners. Its expected outcomes include:

1. Food consumption assured and asset depletion prevented for chronically food insecure households.
2. Markets stimulated and access to services and natural resources enhanced for PSNP participants and other households.
3. Natural environment rehabilitated and enhanced (Draft review of the food security programme for the PSNP, 2008).

In the study site a number of supply and demand side interventions have been implemented under the PSNP. Supply side interventions include: micro basin and community pond construction, afforestation, and soil and water conservation (SWC) structures. Demand side investments include the creation of local institutions like water management institutions. The programme also provides wage/food labour and access to credit schemes.

Role in enhancing adaptive capacity

The PSNP is an effective intervention in terms of creating, protecting and enhancing the asset base of local communities. The study identified it as being effective in building local capacity and in filling the gap where it does not exist.

For instance, the construction of check dams and afforestation has reduced the exposure of lowland areas to floods. Soil and water conservation programmes have increased the percolation rate of water, thereby enhancing the asset base (e.g. increased soil moisture content). The food for labour scheme, under which food insecure households receive 15 kg grains/month, has reduced labour migration. Access to credit schemes has allowed villagers to invest in their assets. For instance, villagers can now engage in petty trading, livestock fattening and dairy production. 90 percent of credit beneficiaries are women.

Literature also highlights that the PSNP could play a role in enhancing adaptive capacity. For instance, the design of the cash transfer scheme in Ethiopia enables households to access and utilise other development interventions more effectively and has the potential to result in graduation and stimulate growth. Other assessments have also found that *'households participating in the Productive Safety Nets Programme make greater use of credit facilities, health, education and water services (Slater et al., 2006). This happens as the result of two processes: increased demand for services by those receiving the cash transfer and the improvement of service supply as the result of the public works component of the PSNP)'* (Slater, 2009).

Political feasibility

In terms of political feasibility, respondents indicated that implemented activities are simple and capitalise on local skills and thus enhance ownership of the interventions. However, they also outlined that nepotism and corruption has resulted in targeting better off farmers. Secondly, activities are at times implemented during peak agricultural seasons (e.g. sowing), thus disrupting agricultural productivity.

Financial feasibility

In terms of financial feasibility, respondents indicated that activities capitalise on local resources and knowledge base. However, they also outlined that budget delays and budget cuts by donors have been a problem. As outlined by Slater (2009) unpredictable cash transfers often lock households into debt payments due to which they lose a proportion of their transfer when it eventually arrives. Similarly, budget cuts have a direct impact on the scale of the programme and the size of the transfer. Both these aspects are essential for stimulating growth.

4.3.4 Multiple Use Water Services (MUS)

MUS are defined as 'water supply services that incorporate both domestic and productive uses in their design and delivery'. MUS works within an integrated water resource management (IWRM) framework to provide water services that meet the multiple needs of users and thus helps planners move beyond the conventional sectoral barriers of the domestic and productive sectors (Faal, et al., 2009; van Koppen, et al. 2006).

As such, MUS can be viewed as an effective tool for adaptation planning as it has the potential to facilitate coordinated planning of water resources between different users and uses. Integrated

planning and delivery that aims at delivering productive and domestic benefits is also likely to help communities diversify their income and improve their livelihoods.

The MUS intervention selected for this study is located in Bekelcha Oromia *kebele* and is being implemented by the Haraghe Catholic Secretariat (HCS). Interventions under the project include investments in three water taps and washing basins, two cattle troughs and training on sanitation and water management. Though the project has not invested in the construction of an irrigation scheme, farmers use the overflow to grow vegetables around water points.

Role in enhancing adaptive capacity

Interventions like the construction of multiple systems (water taps, washing basins and cattle trough) have created and enhanced the asset base of households. These have in turn reduced exposure to CC induced hazards and increased existing capacity to cope with impacts. For instance, the construction of a water reservoir has enabled night time irrigation, thereby building on existing coping capacity.

Interventions related to training on health and sanitation have also filled coping/adaptive capacity gaps related to the health induced dimensions of CC.

However, the study team also found that due to the lack of complementary investments in interventions like natural resource management, MUS interventions are unable to withstand climate related shocks like droughts. Thus in times of water stress, MUS is unable to provide multiple services and is thus unlikely to achieve its objective of facilitating income diversification and improved livelihoods.

Political feasibility

In terms of political feasibility, the team found that due to the existing institutional set up, there is little coordination between different planning departments. For instance, currently domestic water supply and water supply for economic use is managed by different ministries and expert interviews revealed that staff from the Bureau of Agriculture and Rural Development were not involved in the project design. Thus, in order to achieve its potential in facilitating coordinated planning, MUS requires an enabling environment that promotes inter-sectoral working and participatory planning (Faal, et al., 2009). Respondents also stated that it is essential to ensure political buy-in from different administrative levels.

Financial feasibility

In terms of financial feasibility, the team found that the government does not have the finances to construct and implement its own MUS projects. Under the current water policy, the government provides technical support to CBOs and NGOs engaged in the implementation of MUS projects, but does not provide any guidance for work shared between government and non-government bodies. Such an arrangement could undermine effective adaptive planning as it brings into question the predictability of financial flows.

5 Conclusion

This section concludes with a summary of research findings and proposed policy recommendations.

5.1 Research findings

In summarising the research findings, we have used the concept of net vulnerability to CC. Net vulnerability to CC for the purpose of this study has been defined as the level of household vulnerability after the role of local coping capacity and planned adaptation interventions has been assessed in reducing the impacts of CC. Figures 5-1, 5-2, 5-3, and 5-4 depict net vulnerability in the three livelihoods assessed.

Net vulnerability in all figures highlights that:

5. Local communities do perceive a change in climate, in terms of: increases in temperature, changes in humidity, soil moisture content and wind direction and, above all, changes in precipitation patterns;
6. In terms of impacts, climate-induced changes are likely to impact the economic and domestic use of water. These impacts are likely to be greater in the context of extreme weather events as compared to climate variability as there is greater capacity to cope with variability.
7. Local coping capacity to deal with climate variability exists. However, under increased uncertainty posed by climate change, this capacity is undermined. Local capacity to cope with extreme weather events is insufficient;
8. The assessed planned adaptation interventions build on coping capacity and fill gaps in coping capacity in many cases. However, a number of interventions will need to be climate proofed and will need to take into account aspects of equity to ensure continued effectiveness in the face of CC. Planned adaptation interventions will also need to address dimensions of political and financial feasibility.

Figure 5-1: Net vulnerability in pastoral livelihoods (Rangeland management).

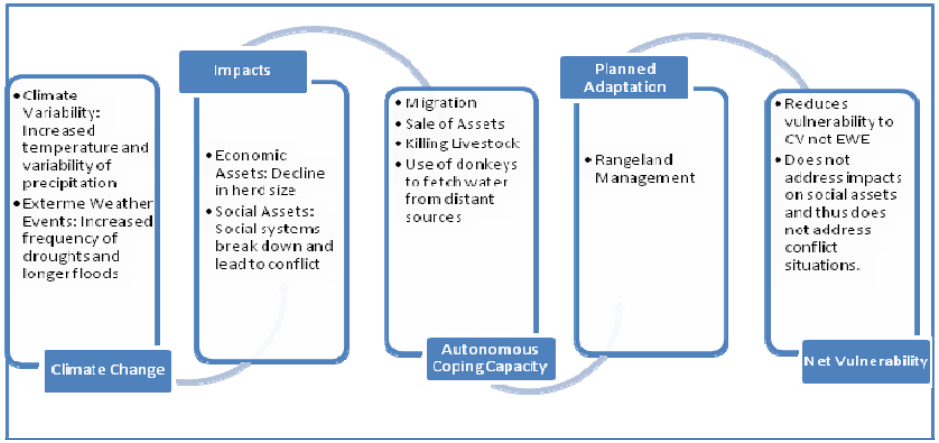


Figure 5-2: Net vulnerability in agricultural livelihoods (PSNP).

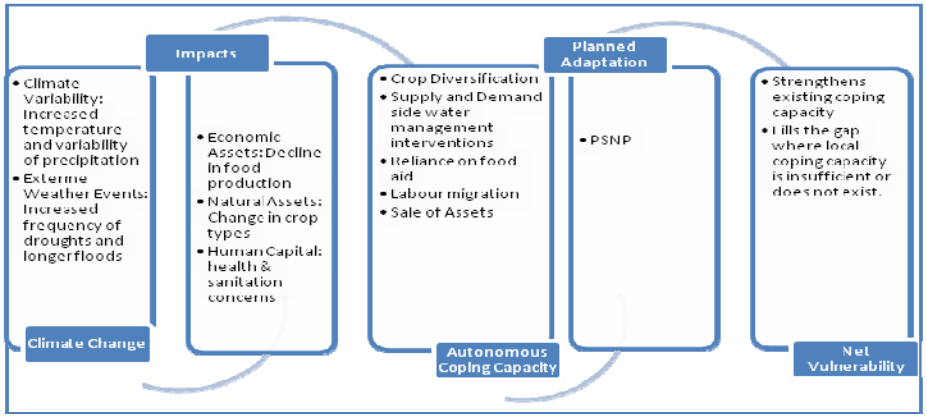


Figure 5-3: Net vulnerability in agro-pastoral systems (small-scale irrigation).

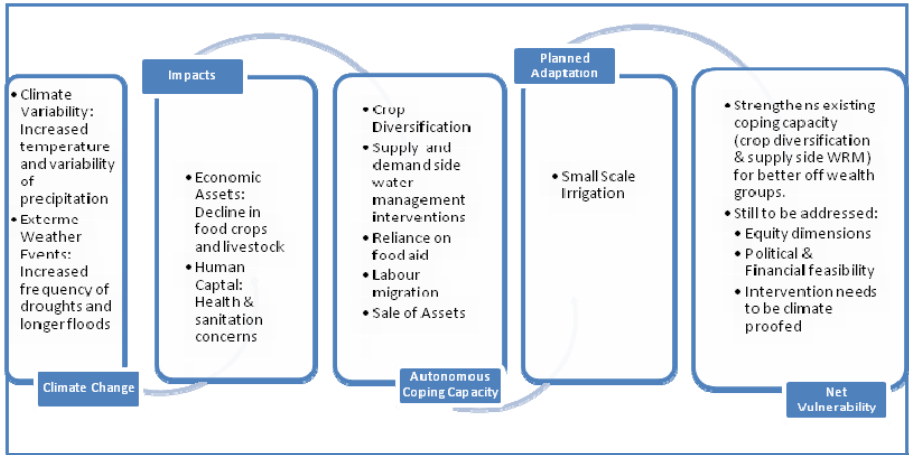
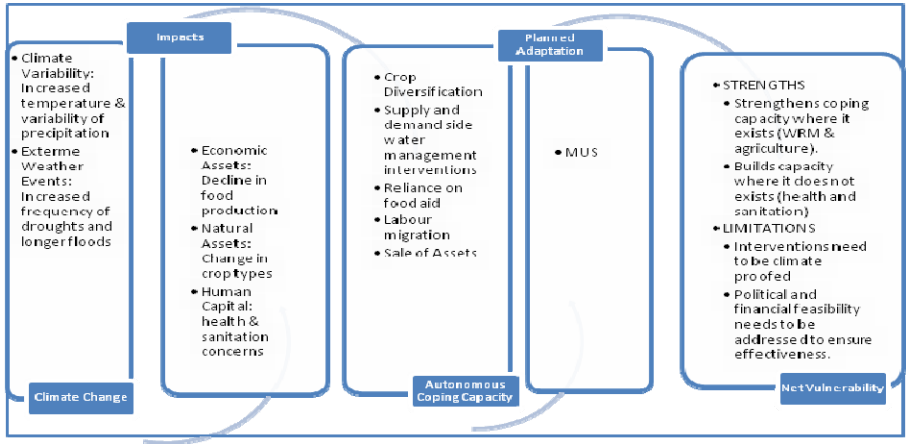


Figure 5-4: Net vulnerability in agricultural livelihoods (MUS).



5.2 Policy recommendations

In terms of policy recommendations, the study provides conclusions with respect to the overall research question and it provides specific recommendations for each of the assessed interventions.

5.2.1 Role of planned adaptation interventions in addressing CC induced vulnerability

As outlined in the introduction, a number of planned adaptation interventions (within the NAPA process and outside it) have been criticised as having 'repackaged development interventions in the guise of CC adaptation projects'. In this context, it is perceived that planned adaptation interventions will not be effective in addressing the specific challenges posed by CC.

Of the four interventions assessed, small-scale irrigation and rangeland management have been formulated explicitly in the context of CC. The other two, social protection and MUS, have been identified in literature as having a role to play in addressing climate-induced vulnerability. A number of activities in each of these interventions are development related activities.

The research findings conclude that the assessed adaptation interventions do 'create, enhance and protect' HH and community assets, and this in turn, does reduce exposure to climate-induced impacts and/or build capacity to cope with the impacts.

However, the research also finds that such interventions will need to be strengthened to face the specific challenges posed by CC. These include: increased uncertainty related to existing climate variability; an increase in the intensity and frequency of extreme weather events; and an increase in the gap between wealth groups due to the disproportionate impacts of CC and the potential of these impacts in undermining ongoing poverty reduction efforts.

It is thus suggested that planned adaptation interventions address climate-related challenges explicitly by ensuring that interventions are 'climate proofed' (responsive to changes in weather related events) and are able to ensure equitable access to the benefits that are delivered. Interventions will also need to address aspects related to political and financial feasibility if they are to be sustainable.

Some of the specific policy recommendations for each of the assessed planned adaptation interventions are outlined below.

5.2.2 Recommendations for each of the assessed interventions

Small-scale irrigation

Small scale irrigation schemes do enhance the coping capacity of some wealth groups. However, if they are to be effective in addressing the specific challenges of CC, such interventions should take into account the following:

- Irrigation schemes based on exposed sources of water are vulnerable to increased uncertainty related to climate variability and to extreme weather events and long term CC. In this context, where possible, irrigation schemes should be developed with the use of water resources that are less exposed to CC (example groundwater sources, night-time irrigation schemes, etc.);
- Small scale irrigation is a supply side intervention that is location specific. Supply side options are accessible only to better off wealth groups. Issues of equitable access must be taken into account when promoting this option.

Rangeland management

Rangeland management has the potential to enhance the coping capacity of pastoral communities and fill gaps where it does not exist. Interventions should strengthen this potential and include further measures to ensure effectiveness. These include:

- Initiatives aimed at promoting local management practices should build on aspects related to social and human capital in order to address conflict situations that are exacerbated by climate-induced impacts.
- Interventions aimed at the management of rangeland should focus on identifying suitable fodder species that are responsive to changes in herd composition, which is changing due to a number of factors including the impacts of CC.
- Water availability plays a key role in facilitating adaptation amongst pastoral communities. Currently none of the interventions targeted at pastoral communities address this factor, it is suggested that interventions that enhance access to water resources will have to complement the identified planned adaptation interventions under rangeland management.

Social protection (Productive Safety Net Programme)

Social protection programmes like the PSNP have been assessed to play a significant role in enhancing adaptive capacity. Interventions under such programmes need to be climate proofed:

- Social protection programmes need to be 'climate proofed'. For instance investments in water services under the public works component should draw water from groundwater sources in order to deal with increased variability in rainfall and temperature patterns.
- Secondly, under different CC scenarios, the chronically poor may be subject to more than six months of food deficit and a number of previously secure groups may become food insecure. The PSNP should be able to respond to such changing needs.

Multiple Use Systems (MUS)

MUS play a role in enhancing adaptive capacity as they enhance the economic and domestic use of water. They also have the potential to initiate coordinated planning to address the cross-cutting challenges posed by CC. When investing in MUS the following issues should be considered:

- MUS require inter-sectoral integration and as such their planning and implementation requires buy-in from a number of stakeholders at different administrative levels, including local politicians and planning officials from different line departments.
- MUS require a well coordinated management system and hence the organisation and training of beneficiaries and stakeholders is essential.
- MUS can only achieve their objective of providing multiple services if there is sufficient water to support multiple uses. The impacts of CC are likely to bring water resource management back to being a central component of water planning. This planning under MUS must focus on assessment of available water resources and invest in water resource management to enhance the availability of water

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Annex 1: Methods

A range of methods, including participatory rural assessment (PRA), Household (HH) survey, secondary data were used for data collection and triangulation.

Participatory rural assessment

A number of PRA tools were used to assess local perceptions pertaining to climate change, its impacts, local coping capacity and the perceived effectiveness of planned adaptation interventions. These include wealth group ranking, focus group discussions (FGD), key person interviews, time line surveys, resource mapping, root cause analysis and the use of the adaptation decision matrix.

Wealth group ranking

Given that wealth is an indicator of asset holdings at a HH level, which in turn determines the level of exposure to climate change impacts and the capacity of individuals, households and communities to cope with these impacts – a wealth group ranking exercise was carried out in all the village sites. Wealth group ranking also allows for a more disaggregated assessment of climate-induced vulnerability. As depicted in table A-1 levels of food security and livestock and landholding are key indicators of wealth groups.

Table A-1: Wealth group ranking.

Wealth group	Defining characteristics			
	Bukelcha Oromia	Chefe-aneni	Billa	Ayidora
Rich	4 oxen; 2 cows; >1 ha of land; year round food security.	>2oxen; >2cows; >1 donkey; 5 sheep; >1 hectare of land.	3-4 oxen; 2 cows; 20 camel; >50 goats; >1.8 hectare of land.	>20 cows; >10 camel; 120 goat and sheep; 2 donkey.
Middle	1 ox; 1 cow; 0.25-1 ha of farmland; food secure for 6 months.	1 ox; 1 cow; 1 donkey; 05-1 hectare of land	1 ox; 1 cow; 10 camel; 30-50 goat; 1-1.8 ha of land.	3-20 cows; 10 camel; up to 40 goat
Poor	No livestock; <0.25 ha of land; year round food insecurity.	No livestock; <0.5 hectare of land.	No ox or cow; 5 camel; <5 goat; <1 ha of land	No cows and camels; up to 8 goat.

Focus group discussion and expert interview

The FGD was based on purposive sampling from different wealth, gender and age groups. Accordingly, in each village, the FGD was conducted with five respondents from each wealth group and five women respondents.

Expert interviews were conducted to gather information on each of the identified adaptation interventions. Interviews were carried out, among others, with development agents (DA) from the District Agricultural and Rural Development Office, the District Water Office, and the Disaster Prevention and Preparedness Commission (DPCC).

Household survey

A HH survey was carried out in all four study sites. It is based on a sample size of 15 respondents per site representing the different wealth groups and women respondents.

Secondary data collection and analysis

Second generation vulnerability and adaptation assessment tools take into account weather, population, technology and livelihood trends in order to arrive at a more comprehensive assessment of climate change induced vulnerability and adaptation options. In light of this requirement, the study team attempted to assess technology and livelihood trends in the study area, but was unable to do so due to a lack of data. Secondary data has been collected on population and weather trends. In general, meteorological data for most of the stations in Ethiopia is very scant and incomplete. Nonetheless, an attempt has been made to decipher the long-term climatic patterns based on available rainfall and temperature data from three weather stations within the study area that have relatively long term records. These include, Kulubi, Deder and Hurso weather stations for Meta, Gorogutu and Erer districts respectively.

A literature review of climate change studies carried out in Ethiopia and the region has also been undertaken.

Triangulation

As mentioned above, the climate change study is one of the four studies that have been carried out under the Growth LARS. An attempt has been made to triangulate the findings with those of the other studies, particularly with the WELS study.

RiPPLE

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