Ethiopia's Climate Resilient Green Economy

CLIMATE RESILIENCE STRATEGY
AGRICULTURE AND FORESTRY

FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

CONTENTS

FOREWORD

Ethiopia's food crops and livestock upon which the livelihoods of millions depend are underpinned by its natural resources – land, water and forests. In the face of growing climate change threats, such as temperature rise, frequent droughts and flooding, Ethiopia is working to address vulnerability and food insecurity as a development priority. In the past two decades, significant efforts and major public investments have been made to boost the contribution of the agriculture and forestry sectors. For example, in 2012/2013, 1.23 million quintals of improved seeds and 9.23 million quintals of fertilizer were used to increase the productivity of major crops (254 million quintals) and about 13.7 million hectares of degraded watersheds were treated with sustainable land management techniques. The last three years have also seen large-scale tree planting (16.8 billion seedlings with an average survival rate of 70%) to improve the forest cover of the country. These steps are not only to prevent disasters but also to enhance our people's quality of life and prosperity for generations to come.

Launched in 2011, the Climate Resilient Green Economy (CRGE) strategy sets that by 2025 Ethiopia will be a middle-income country, resilient to climate change impacts and with no net increase in greenhouse gas emissions from 2010 levels. This resilience strategy for agriculture and forestry has been developed as part of the CRGE strategy. It shows that economic growth must be protected against the impacts of current and future climate change. The agriculture and forestry sectors are key to both national income and household livelihoods. Combined, the sectors make up over two-fifths of the national economy (43% of our Gross Domestic Product (GDP)) and employ the vast majority (around 80%) of the country's population. Due to reliance on rain-fed techniques, agriculture is highly vulnerable to weather and thus to future impacts of climate change. Also, future climate change is expected to pose significant impacts on the productivity of our forests.

The analysis in this document shows the scale of the challenge: agriculture and the livelihoods that depend on it are vulnerable, and future climate change poses an even greater threat (for example, with increased incidences of droughts, the negative impacts on GDP could be 10% or more by 2050). However, interventions that can reduce this vulnerability have also been identified. Indeed the analysis shows that a lot of work is already being undertaken to reduce the vulnerability in the agriculture and forestry sectors, yet more needs to be done to ensure the future resilience of our economy and our people, and more financing is required.

Finally, combatting the negative impacts of climate change and building resilience requires collective responsibility of all stakeholders at different levels. The sectors have to assume the leadership at the national level while working together with international efforts. To ensure success, it requires the involvement of local communities in the overall process. Further, the private sector has an important role to play in investments to build community resilience. Similarly, development partners can contribute significantly to ensure climate resilience by providing technical assistance, building capacity and supporting implementation. Therefore, we urge all concerned stakeholders to shoulder their responsibilities to bring about climate resilience in the agriculture and forestry sectors.

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LIST OF ABBREVIATIONS

APZ	Adaptation Planning Zone
BAU	Business As Usual
CR	Climate Resilience
CRGE	Climate Resilient Green Economy
CSA	Central Statistics Agency
CSO	Civil Society Organisations
DFID	Department for International Development
EDRI	Ethiopian Development Research Institute
EIAR	Ethiopian Institute of Agricultural Research
EIB	Ethiopian Institute of Biodiversity
EPACC	Ethiopian Programme of Adaptation to Climate Change
GCAP	Global Climate Adaptation Partnership
GDP	Gross Domestic Product
GE	Green Economy
GGGI	Global Green Growth Institute
GHG	Green House Gas
GTP	Growth and Transformation Plan
Ha	Hectares
IFF	Investment Financial Flow
IPCC	Intergovernmental Panel on Climate Change
IRM	Iterative Risk Management
ITCZ	Inter Tropical Convergence Zone
M&E	Monitoring and Evaluation
MAA	Multi Attribute Analysis
MEF	Ministry of Environment and Forest
MOA	Ministry of Agriculture
MOFED	Ministry of Finance and Economic Development
MSC	Ministerial Steering Committee
NMA	National Meteorological Agency
NRM	Natural Resource Management
R&D	Research and Development
RBF	Results Based Finance
SNNPR	Southern Nations Nationalities and Peoples Region
SREX	Special Report on Extreme Events
SRM	Sectoral Reduction Mechanism
STC	Sub Technical Committee
TC	Technical Committee
UK	United Kingdom

EXECUTIVE SUMMARY

In November 2011 we launched our 'vision' to build a Climate Resilient Green Economy (CRGE) by 2025. This economy would be middle-income, resilient to the negative impacts of climate change and achieved with no net increase in greenhouse gas emissions. The vision is supported by two strategy documents: the Green Economy Strategy, completed in 2011, and the Climate Resilience Strategy for agriculture presented here, as well as Ethiopia's Programme of Adaptation to Climate Change (EPACC).

This Climate Resilience Strategy focuses on the agriculture and forestry sectors due to their importance to national income and livelihoods. The sectors make up 43% of our GDP, produces nine of the ten largest export commodities, and employs around 80% of the Ethiopian people. Other sectors will also face climate change challenges, as such, this strategy will act as a starting point for subsequent climate resilience analysis across the remaining sectors of the economy.

Since this strategy's focus is on the challenges faced in the agriculture and forestry sectors related to current and future climate, the options to cope with these challenges as well as identifying the financial sources to fund these options, three tranches of work have been undertaken:

- Identified the impact of current weather variability and projected future climate change on Ethiopia. This is the **challenge to growth and wellbeing.**

- Identified and cost options to build climate resilience and reduce the impact of current weather variability and climate change. This is the **response to build climate resilient growth.**

- Mapped the steps necessary to finance and implement efforts to build climate resilience. This is **the funding and institutions to deliver climate resilient options.**

The key conclusions of the strategy are:

- **Our economic growth and the livelihoods of our people are already being negatively impacted by current weather variability. These impacts could get worse with climate change.** Ethiopia already feels the impacts of hazards related to current weather variability and extremes, and by 2050, the negative impacts of climate change, under an extreme scenario of higher temperatures and increased intensity and frequency of extreme events, could cost Ethiopia 10% or more of its GDP. The key hazards brought on by this potential extreme volatility are droughts, floods and soil erosion. The worst impacts are caused by droughts, with recent droughts having negatively impacted GDP by between 1% and 4%.

- **The impacts of current weather variability and future climate change will not be uniform across all of Ethiopia.** Some regions and sectors are more vulnerable and more susceptible to volatility than others. The current key hazards will depend on the current climatic features of particular regions and sectors, current exposure to key risks, future climate change and livelihood types.

- **We are already engaged in activities that build climate resilience but we need to do more.** As one of the fastest growing economies in the world, with a rapidly expanding population, we are undertaking significant development efforts. These efforts are intertwined with actions designed to build climate resilience. The analysis shows that mainstreaming climate resilience into the planned investment in the agriculture and forestry sectors will cost $600m per year by 2030. Total resilience expenditure will be around $3.5 billion a year by 2030 with a shifting emphasis on private sector investment.

- **We are putting the instruments in place to deliver the CRGE.** The financing to deliver a CRGE will come from a variety of sources but we will target international public finance to leverage other types of finance (domestic and private). Our aim is to move away from project-based finance to ensure funding is pooled and deployed strategically. We have already established the CRGE facility that will pool finance and match it to strategic and transformative actions that will deliver the CRGE. This will be delivered through its implementing instrument, the Sectoral Reduction Mechanism (SRM). Implementation of the SRM will rely on the sectors and regions but will also include a diverse array of agents with stakes in effective economic development.

A full overview of our conclusions and implications of our analysis of the agriculture and forestry sectors presented in this report is set out in the following three sections, the challenge, the response and making it happen.

i. THE CHALLENGE

To follow an economic growth path in agriculture that is resilient to current weather variability and future climate change.

Our climate is varied and complex. The biophysical characteristics within Ethiopia are highly varied. The terrain spans from the hot arid desert of the Danakil lowland to the mountainous ranges of the Simien. Overlaid on this terrain, agriculture and land-use activities are extremely diverse. This reflects the variation in climate, soil type and cultural practices across the country. This variation complicates policy planning, particularly since responses to build resilience must be grounded in local contexts.

There has been evidence of climate change in Ethiopia over the last 50 years. At the national level, temperatures have increased by an average of around 1°C since the 1960s. This increase has been felt across all regions. Rainfall nationally is subject to high variability between years, seasons and regions. Yearly variation around mean rainfall levels is 25% and can increase to 50% in some regions. Despite this complexity, there is evidence of a 20% decrease in rainfall in the south central region of the country.

Weather variability leads to extreme events and hazards. Within Ethiopia extreme weather events are common, especially droughts and floods. Alongside the evidence of a changing climate, there is a suggestion that the incidence of droughts and floods may have increased in the last 10 years relative to the decade before. Soil erosion is a key hazard for agriculture with up to 6% of the country at risk.

Historic weather variability, extreme events and hazards have resulted in a substantial negative impact on economic growth in agriculture. Floods and droughts have resulted in severe loss to agricultural crops and livestock resulting in food security implications. The economic impact depends on the extent of the variability and extreme events but droughts alone can reduce total GDP by 1% to 4%. Soil erosion has been estimated to reduce agricultural GDP by 2% to 3% (around 1% of total GDP). Even excluding these major extremes, the sensitivity of agricultural output to weather variability means we must aggressively address the costs of current vulnerability.

In addition to economic impacts, agricultural livelihoods are also vulnerable to weather variability and stresses. By mapping Ethiopian agricultural livelihoods we assessed how the different types of livelihoods are vulnerable to ongoing weather variability and extreme events. The impacts to agricultural livelihoods depend on the livelihood type and region of Ethiopia, underscoring the need for responses appropriate to the local context. Consecutive droughts are the most prominent of these hazards, as they impact all livelihood types.

Future climate change in Ethiopia is uncertain, although scenarios of change show the range of possible outcomes. There is a high degree of uncertainty in projections of how global climate change will affect temperature and rainfall patterns in Ethiopia. While projections clearly show temperatures increasing, there is disagreement on the exact level, with a range of projections indicating between 0.5°C to 2°C by the 2050s relative to today. Due to the complexity of our climate, the projections of future rainfall are uncertain. However, the models project that current rainfall variability will continue (projections of the change in future annual rainfall range from -25% to +30% by the 2050s). Given the outputs of the climate models, the scenarios of projections for our climate range from a slightly warmer and wetter scenario to a much hotter and drier scenario, along with potential changes in the intensity and frequency of extreme events.

The future impacts and costs of climate change on agriculture and forestry are potentially very significant, which could put our ambition of reaching middle-income status by 2025 at risk. In a hotter drier scenario, with increased incidences of droughts, the negative impact on GDP could be 10% or more by 2050. This is particularly worrying not only for our middle-income ambition but also because the impacts will fall on the most vulnerable in society. Our analysis has highlighted that climate change poses a particular threat to one of our key exports, Arabica coffee (worth around 2% of GDP to our economy today but the total income is set to double under the first phase of the Growth and Transformation Plan (GTP)), as it can only be grown within tight temperature thresholds. We must therefore prepare for these specific effects of climate change.

ii. THE RESPONSE

To identify options that will build climate resilience and reduce the impacts of current climate variability and future climate change.

To address the negative impact of current weather variability and future climate change in agriculture and forestry, 41 key options were identified. We undertook a review of all the responses that could feasibly be used to build climate resilient growth. We identified 350 distinct options that were appraised and refined them down to the 41 most promising options using a number of criteria. These criteria included: feasibility; contribution to economic growth; contribution to equity and distributional issues; and extent to which they address the current weather variability and future impacts of climate change.

To take into account the uncertainty associated with future climate change we adopted a flexible, robust approach to planning. As recommended by the Intergovernmental Panel on Climate Change we have used an 'iterative risk management approach' to design implementation. This approach highlights when to implement the relevant options, in an iterative, flexible, yet robust way. Acting now to build our capacity and improve our monitoring of climate change, while mainstreaming climate resilience into our development plans, will allow us to respond to climate change when it intensifies. We have highlighted climate resilient coffee as one immediate example of where action is needed to build resilience to future climate change.

Current investment and action is already building climate resilience in the agriculture and forestry sectors. An appraisal of the current investment in agriculture from the federal budget has shown that there is substantial overlap between development investment and spending on resilience options. Analysis of the 41 options showed that 38 were currently covered to some extent by the Ministry of Agriculture's federal programmes and many activities that build resilience are ongoing. Between 2007 and 2013 total investment in agriculture was around $1.1bn of which around 40% ($0.4bn) was from within the federal budget of the Ministry of Agriculture. 60% of the federal budget ($0.3bn) was spent on resilience activities related to addressing key climate risks. Around 80% of current resilience spending ($0.2bn) is on protecting the most vulnerable people in society through a programme of safety nets which provide income supplementation and social aid.

Current programmes in the Ministry of Agriculture do not go far enough to build the required level of resilience. We have assessed all of the options being delivered within the Ministry of Agriculture and whether the current programmes and the level of spending on each option are sufficient to adequately build climate resilience. Our analysis has shown the additional investment needed to deliver the 41 options, over what will be delivered under a baseline scenario, is around $236m in 2030. This represents a budget uplift of 18%. This uplift should be seen in the context of an assumed increased spending on resilience options of 200% by 2030 under a baseline scenario (rising from $0.3bn to $0.8bn); total expenditure on resilience by the federal Ministry of Agriculture will be around $1 billion in 2030.

Appraisal of investment from the non-federal budget shows the private sector has an important role to play in delivering resilience options. We also undertook analysis of current and projected investment in agriculture from other sources (regional budgets, donor finance and the private sector). This currently makes up 60% of all investment. We projected future investment flows from these sources and have estimated that additional spending to build resilience will be $367m in 2030. Therefore total additional spending to build resilience from all investment sources is $600m, on top of the $2.9 billion investment already assumed under the baseline scenario to build resilience. Our analysis has shown that the private sector share of total investment will rise from around 20% today to 40% in 2030 driven by the commercialisation of land for agriculture.

iii. MAKING IT HAPPEN

Setting the foundations for the implementation of climate resilient activities

We have prioritized a number of activities for early action. In assessing the current risks, as well as gaps in our current climate resilient implementation and planned policies, we have identified 15 areas for early action. These activities span from capacity building, thus enabling a fast and informed response to climate change, to technological options. We have divided these into three scales: macro (primarily to enhance GDP), households (to ensure protection of small scale farmers) and biodiversity options (recognizing the interlinkages with the agricultural systems).

We will put in place the instruments for integrating agricultural development and climate change. The SRM will deliver strategic and transformative change to help achieve a middle-income Climate Resilient Green Economy. This will not be easy; a major shift is needed to ensure that climate resilient actions in agriculture and forestry are implemented. However failing to act will negatively impact our growth ambitions. The responsibility lies with the whole of our society from Government institutions, development partners, civil society, to research organisations. Only with a coordinated and concerted effort can we achieve our vision.

This strategy will be supplemented with climate resilience analysis in other sectors. The SRM is about transforming the whole economy and not just the agriculture and forestry sectors. Therefore the work undertaken in this strategy will now be extended to the other sectors of our economy so that we can ensure resilience to our whole economy.

CHAPTER 1
THE VISION

For Ethiopia to become a middle-income country by 2025, and to achieve this through economic growth that is resilient to climate change and results in no net greenhouse gas emissions

KEY MESSAGES

Climate Resilient Green Economy (CRGE)

Ethiopia's ambition is to build a middle-income economy by 2025. Our Climate Resilient Green Economy (CRGE) Vision, launched in 2011, sets out a goal to achieve this in a way that is both resilient to the negative impacts of climate change and does not result in net greenhouse gas emission.

Alongside the CRGE Vision, we also launched the Green Economy (GE) Strategy. This provided detailed analysis of the pathway for low-carbon development.

Climate Resilience Strategy

This document sets out our strategy for ensuring that Ethiopia's economic growth in agriculture is climate resilient. It focuses on the sectors of responsibility covered by the Ministry of Agriculture (including crops, livestock and forestry). These sectors are the most vulnerable to the impacts of climate change, and play a major role in Ethiopia's economy, contributing 43% of GDP, around 80% of employment and approximately 75% of export commodity value.

The strategy aims to identify the impact of both current weather variability and future climate change on Ethiopia ('challenge'), to highlight options for building climate resilience ('response') and to understand how these options can be delivered ('making it happen').

1.1 THE CRGE

1.1.1 Introducing the CRGE

Ethiopia is committed to increasing the average annual per capita income of its citizens so that it reaches over $1,000 by 2025; the level of a lower middle-income country. Our Growth and Transformation Plan (GTP), spanning three five-year planning periods between 2010 and 2025, lays out the basis for building this economy. Our vision is to enable an average annual economic growth rate of around 10% and to meet the millennium development goals through building a modern and productive agriculture sector, strengthening the industrial base and growing exports.

To help realise this vision, by ensuring that economic growth is both resilient to the impacts of climate change and is in line with the global shift towards a carbon neutral society, we launched the **Climate Resilient Green Economy (CRGE)** Initiative.

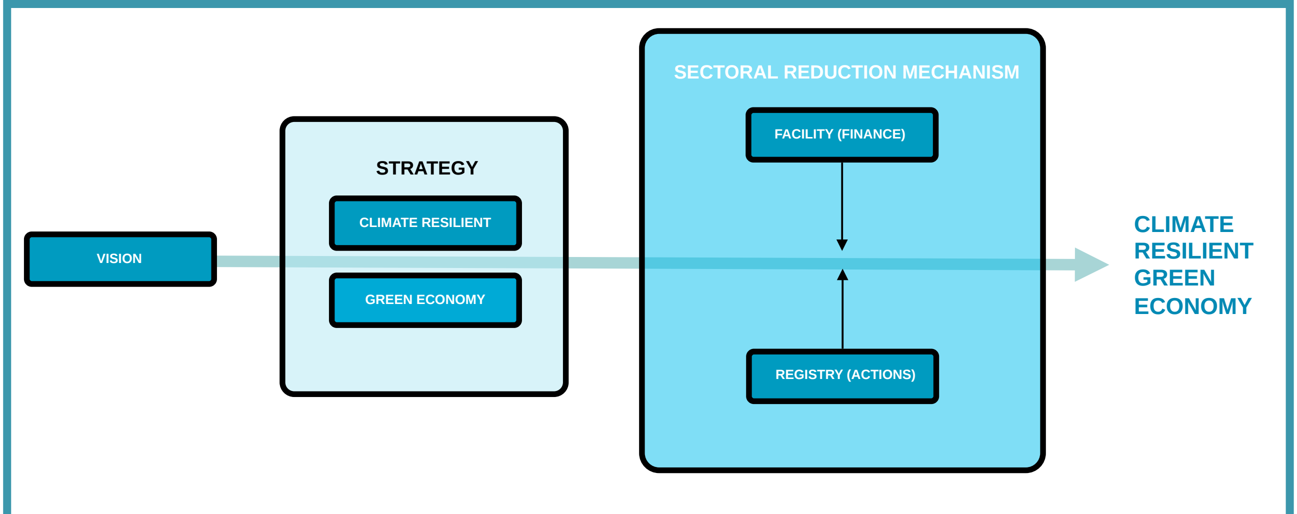
1.1.2 Rationale for the CRGE

Ethiopia will be one of the countries most vulnerable to the impacts of climate change. Current weather variability leads to hazards such as floods, droughts and soil erosion. These impacts are felt by the most vulnerable in society. Furthermore, climate change will exacerbate these current impacts of weather variability on the physical environment, economic growth, and the livelihoods of the most vulnerable. Unless we create an economy that is *'climate resilient'*, these impacts will stand in the way of Ethiopia becoming a middle-income country by 2025.

Ethiopia will also ensure that growth creates a carbon neutral *'green economy'*. This is for four distinct reasons. The first is to contribute towards the global mitigation of greenhouse gases (GHG) to avoid dangerous climate change. The second is to avoid over-exploitation of natural resources such as forests and croplands and ensure their long-run economic contribution. The third is to reduce the fiscal burden from importing fossil fuels (which already amounts to 4% of GDP), and the fourth is to ensure inclusive benefits of growth, especially to improve the resilience of poorer communities that are most vulnerable to the impacts of climate change.

1.1.3. Elements of the CRGE Initiative

FIGURE 1 : **CRGE INITIATIVE**



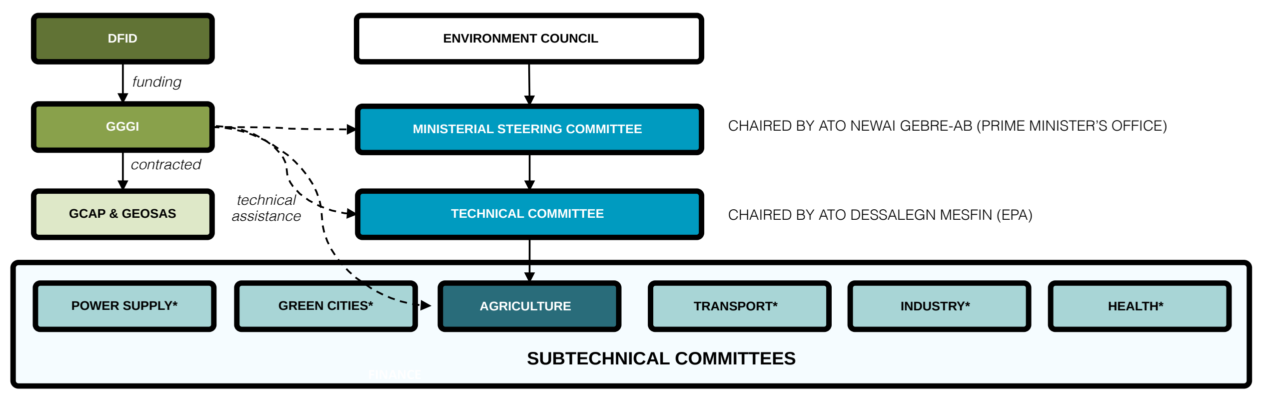
The CRGE Initiative consists of four elements to achieve a climate resilient green economy (see figure 1); the Climate Resilient Green Economy **Vision** was developed through a process led by the Ministry of Environment and Forest (MEF) with support from the Prime Minister's Office and the Ethiopian Development Research Institute. The late Ethiopian Prime Minister, His Excellency Meles Zenawi, presented the CRGE Vision to the international community at the UN International Climate Change Conference in Durban in December 2011.

The CRGE Vision is supported by two national strategies. The **Green Economy (GE) Strategy** was developed with support from the Global Green Growth Institute (GGGI) and was launched in parallel with the CRGE Vision in November 2011. The **Climate Resilience (CR) Strategy** for agriculture is presented in this document, which builds on the EPACC.

Finally, the **Sectoral Reduction Mechanism** (SRM) aims to enable action on the priorities identified in the CRGE Strategies. The SRM will compile a CRGE registry of actions to deliver the CRGE and will match them with funding from a pool of finance termed the CRGE Facility. Coupled with new systems for measuring, reporting and verifying impacts, and a proactive approach to knowledge management, the SRM represents a mechanism for responding to climate change.

MEF is the lead agency for the coordination of Ethiopia's response to climate change. In developing the GE and CR Strategies it has worked together with a series of committees involving officials and experts from across government (see figure 2). The Global Green Growth Institute (GGGI), through funding from the UK's Department for International Development (DFID) with support from international and local expert partners, the Global Climate Adaptation Partnership (GCAP), Geosas and Vivid Economics, helped the process technically.

FIGURE 2 : **INSTITUTIONS INVOLVED IN CR STRATEGY**

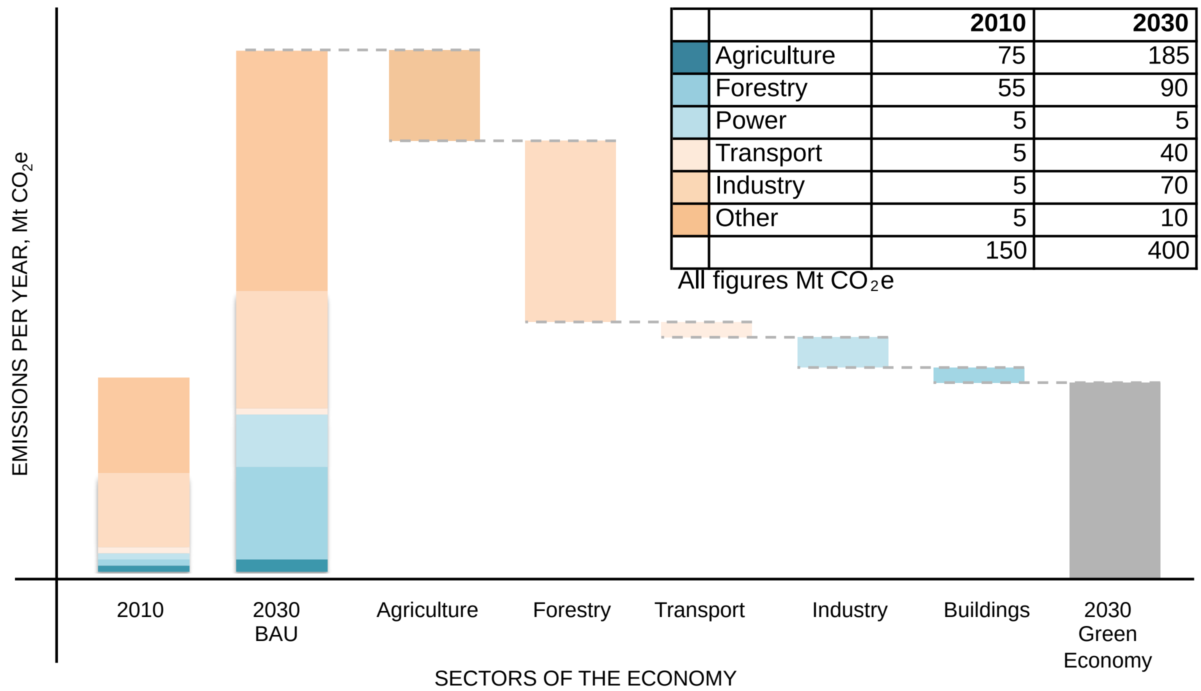


The Green Economy (GE) Strategy sets out the plans for developing a low carbon economy in Ethiopia. Detailed analysis showed that GHG emissions in Ethiopia would rise from 150 $MtCO_2e$ per year in 2010 to 400 $MtCO_2e$ in 2030 under a conventional development path ('business as usual'). The GE Strategy identified and prioritised more than 60 initiatives, which together enable us to achieve our development goals while limiting GHG emissions in 2030 to today's levels. These initiatives would save 250 $MtCO_2e$ per year with around 90% of low-carbon development opportunities coming from the Agriculture and Forestry sectors (see figure 3). For more than 80% of the options, the 'abatement cost' was less than $15 t/$CO_2e$. These options can be seen as 'no and low regrets' offering positive return on investments and therefore directly enhancing economic growth. Continued planning and implementation will make Ethiopia's middle-income economy carbon neutral.

The GE Strategy is built on four pillars, these are:

1. Improving crop and livestock production practices for higher food security and farmer income while reducing emissions (agricultural and land use efficiency measures).
2. Protecting and re-establishing forests for their economic and ecosystem services, including as carbon stocks (increased GHG sequestration in forestry).
3. Expanding electricity generation from renewable sources of energy for domestic and regional markets.
4. Leapfrogging to modern and energy-efficient technologies in transport, industry, and buildings.

FIGURE 3 **ETHIOPIA'S GREEN ECONOMY**



		2010	2030
	Agriculture	75	185
	Forestry	55	90
	Power	5	5
	Transport	5	40
	Industry	5	70
	Other	5	10
		150	400

All figures Mt CO_2e

DEFINITION OF KEY TERMS

All references are from IPCC SREX (2012).

Vulnerability. The propensity or predisposition to be adversely affected.

Resilience. The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions.

Disaster Risk. The likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.

Hazards. The potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources.

Exposure. The presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected.

Adaptive capacity. The combination of the strengths, attributes, and resources available to an individual, community, society, or organisation that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities

Livelihoods. The means by which households obtain and maintain access to essential resources to ensure their immediate and long-term survival (Livelihood Integration Unit).

1.2. THE CLIMATE RESILIENCE STRATEGY

1.2.1. Aims of the strategy

The CR Strategy has three objectives, reflected in the three main chapters of this document (see figure 5, next page):

- To identify the impact of current weather variability and projected future climate change on Ethiopia (**'challenge'**).
- To identify ways to build climate resilience and reduce the impact of current weather variability and future climate change, and estimate their cost (**'response'**).
- To map the steps necessary to finance and implement efforts to build climate resilience (**'making it happen'**).

The CR Strategy supplements the GE strategy by enhancing its key recommendations in terms of climate resilience. As such, both the CR and GE Strategies together form a single overarching strategy. This strategy is also supported by a number of technical reports related to the analytical work produced.

1.2.2. Focus on agriculture

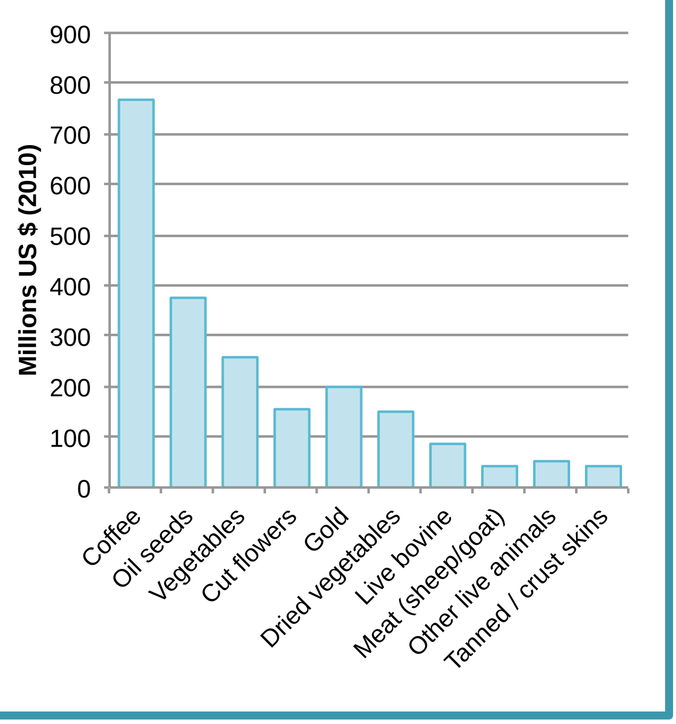
Developing climate resilience is particularly crucial in agriculture, as it is a sector that is climate dependent, and therefore vulnerable to the future impacts of climate change. Agriculture plays a major part in our economy, contributing 43% of GDP, around 80% of all employment and nine of the top ten export commodities by value (see figure 4).

Furthermore, agricultural development will continue to be the basis for economic growth (albeit with a lower overall share of the economy) with a targeted growth rate in the sector of around 10% (see figure 6). This will see increases in the production of major crops, with substantial increases in coffee production and livestock over coming years.

Phase 1 of the CR Strategy therefore focuses on the agriculture sector (which includes agricultural crops, livestock, forestry, food security and disaster prevention). Other sectors will also face climate change challenges, and the Phase 1 strategy will act as a starting point for subsequent climate resilience analysis across the remaining sectors of the economy.

The CR Strategy is aligned with the sectoral activities covered by Ethiopia's Ministry of Agriculture (MoA). Grounding the work and recommendations into existing governance structures and responsibilities helps to ensure the relevance for policymakers. The MoA is split into these sectors: Disaster Risk Management and Food Security, Agricultural

FIGURE 4 : **EXPORT COMMODITIES**



Development, Livestock, Natural Resources Management and Extension. The agriculture sector is made up of three sub-sectors, agricultural crops, livestock and forestry (see Box 1).

BOX 1 : **AGRICULTURE SUB-SECTORS**

Agricultural crops. Ethiopia has a land area of 1.1m km^2 and a diverse agricultural sector. Agricultural crops currently make up 67% of agricultural GDP (27% of total GDP). The main crops are cereals, pulses, coffee, oil seeds, spices, herbs, vegetables, flowers, fruits, sugar cane and fibre. Small-scale subsistence farming based on rain-fed agriculture and traditional farming techniques predominates. This involves around 8 million households accounting for 95% of the total area under crops and more than 90% of the total agricultural output.

Agricultural crops are a major source of GHG emissions through the use of fertilizer and through N_2O emissions from crop residues, producing 12 $MtCO_2e$ a year in 2010. The GE Strategy estimates this will increase to 60 $MtCO_{2e}$ a year by 2030 under a business as usual scenario. This will be combated through avoiding deforestation and adopting higher yielding techniques.

Livestock contributes 21% of agricultural GDP in 2012/13 (around 9% of total GDP). Ethiopia has the largest livestock population in Africa mainly made up of cattle (53m), sheep (26m), goats (23m) and poultry (50m). Like agricultural cropping, livestock production is mainly based on traditional techniques, whether mixed farming or pastoralism. A large proportion of livestock holders own just a few animals.

Livestock, especially cattle, are the largest important source of GHG emissions in Ethiopia and currently account for 65 $MtCO_2e$ a year, which is around 40% of total current national emissions. Further, the population of cattle is expected to increase by almost 30% by 2030 under business as usual, resulting in increased emissions. To combat this rise the main abatement options are to improve the efficiency of beef production, and to switch from beef to poultry.

Forestry makes up 9% of agricultural GDP (4% of total GDP). Forest and woodlands contribute to the national economy and to livelihoods. This is through the provision of timber, fuel-wood and non-timber forest products. Informal forest based activities may contribute more than 30% of per capita income in some areas.

Forests also provide benefits for food security, health, employment and support wider ecosystem services (such as rain water filtration, flood control, and soil retention), which in turn provide economic benefits. For example, honey production (much of which occurs in forests) was reported as 42,000t in 2010/11. Although it provides a low proportion of agricultural GDP (<1%) and exports, it is a valuable source of additional income for rural households in some regions. The forest sector is the second largest source of GHGs, currently accounting for 55 $MtCO_2e$ a year, and is estimated to increase to 90 $MtCO_2e$ by 2030 under a business as usual scenario. The main driver for this is deforestation caused by pressure for agricultural land and fuelwood and charcoal demand. However, a number of priorities will help to tackle this, such as reforestation programmes and programmes to reduce demand for fuelwood (such as through efficient cookstoves).

FIGURE 5 : LOGICAL PROCESS FOR THE CR STRATEGY

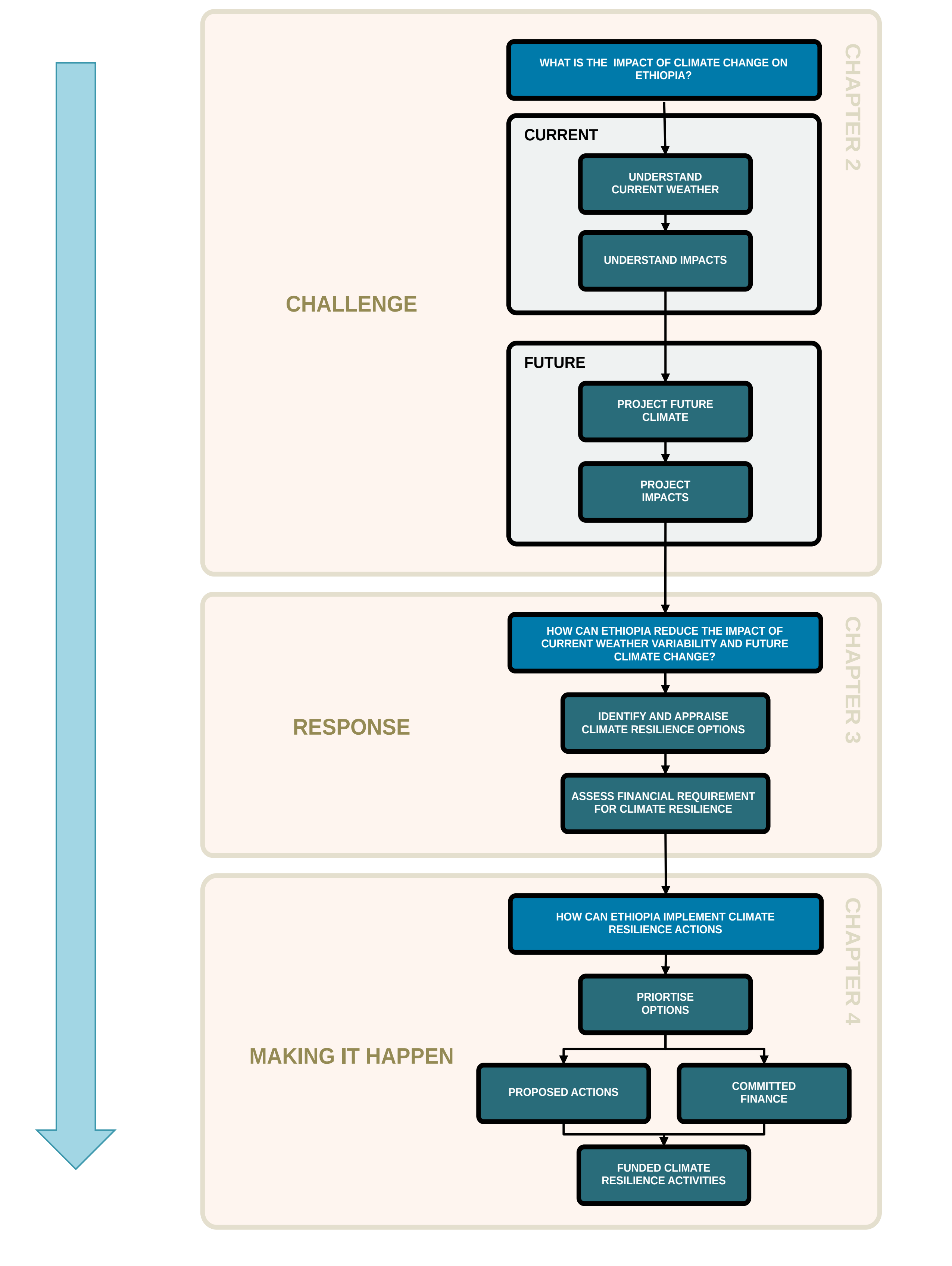
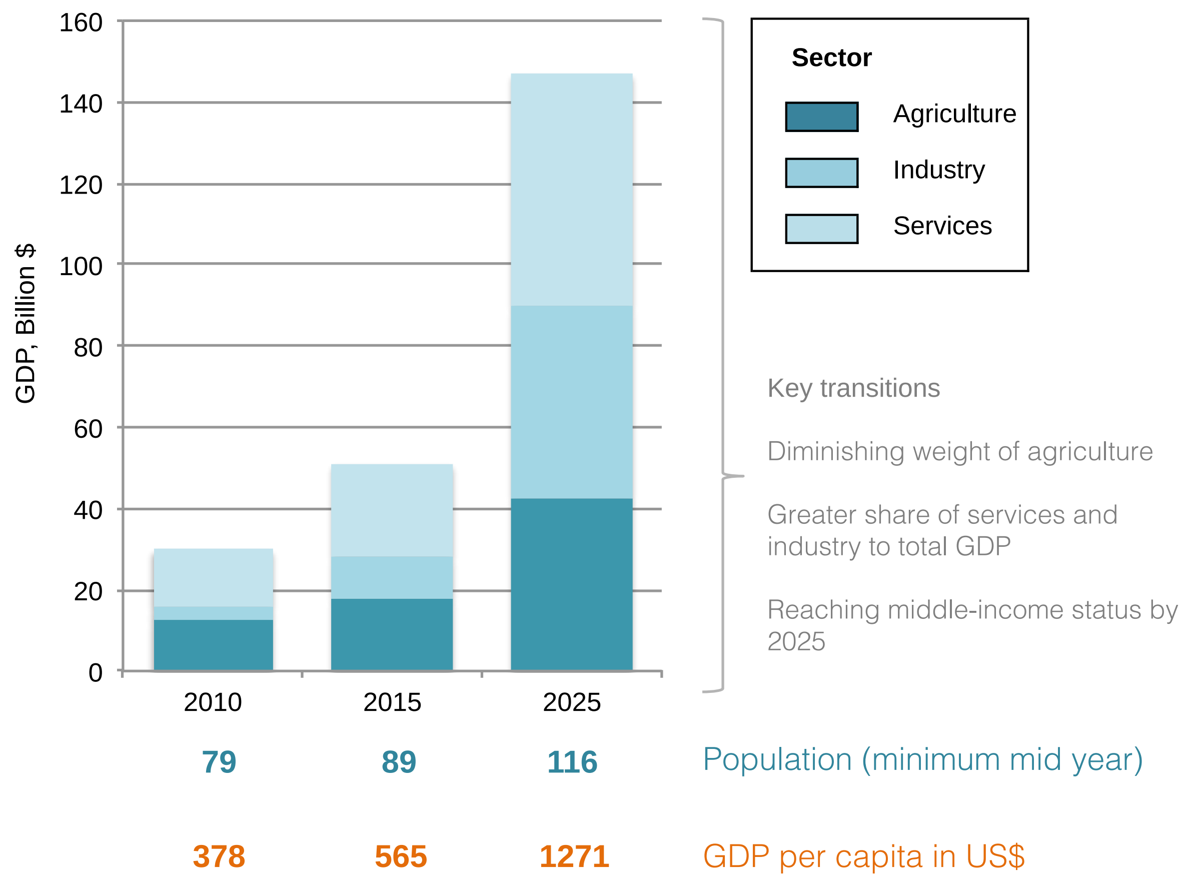


FIGURE 6 : **ETHIOPIA'S FUTURE ECONOMY**



CHAPTER 2
CHALLENGE

To follow an economic growth path in agriculture that is resilient to current weather variability and future climate change

KEY MESSAGES

This chapter analyses the current and future impacts of climate.

Current and historic climate

- Temperatures have increased by an average of around 1°C since the 1960s. Rainfall is very variable which makes identifying trends difficult, though there has been a 20% decrease in the south-central region of the country.

- Current weather variability leads to droughts, floods and soil erosion. There are indications that the incidence of floods and droughts may have been increasing over recent years.

Current vulnerability to weather variability

- The economic impact of climate depends on the extent of annual weather variability and extremes, but recent major droughts have reduced GDP by 1% - 4%. Rain induced soil erosion has been estimated to reduce GDP by around 1%.

- The impacts to agricultural livelihoods depend on the livelihood type and region of Ethiopia. This underscores the need for resilience responses that are grounded in the local context.

Future climate change

- There is a high degree of uncertainty in the future projections of temperature and rainfall arising from climate change in Ethiopia. While temperatures will rise, the future level is uncertain, with the projections indicating a 0.5°C to 2°C increase by the 2050s relative to today. There is greater uncertainty as to whether rainfall will increase or decrease and the projections indicate a change in national annual average rainfall from -25% to +30% by the 2050s.

Future impacts and costs of climate change

- Future climate change could have significant economic impacts. Under some extreme scenarios the impact of climate change on all sectors could reduce 10% or more of GDP by 2050. This potential decrease in GDP could impact of our ambition to reach middle-income status by 2025.

2.1. METHOD

To analyse the impacts of today's climate and future climate change on the agriculture sector, the following steps have been undertaken (see figure 7):

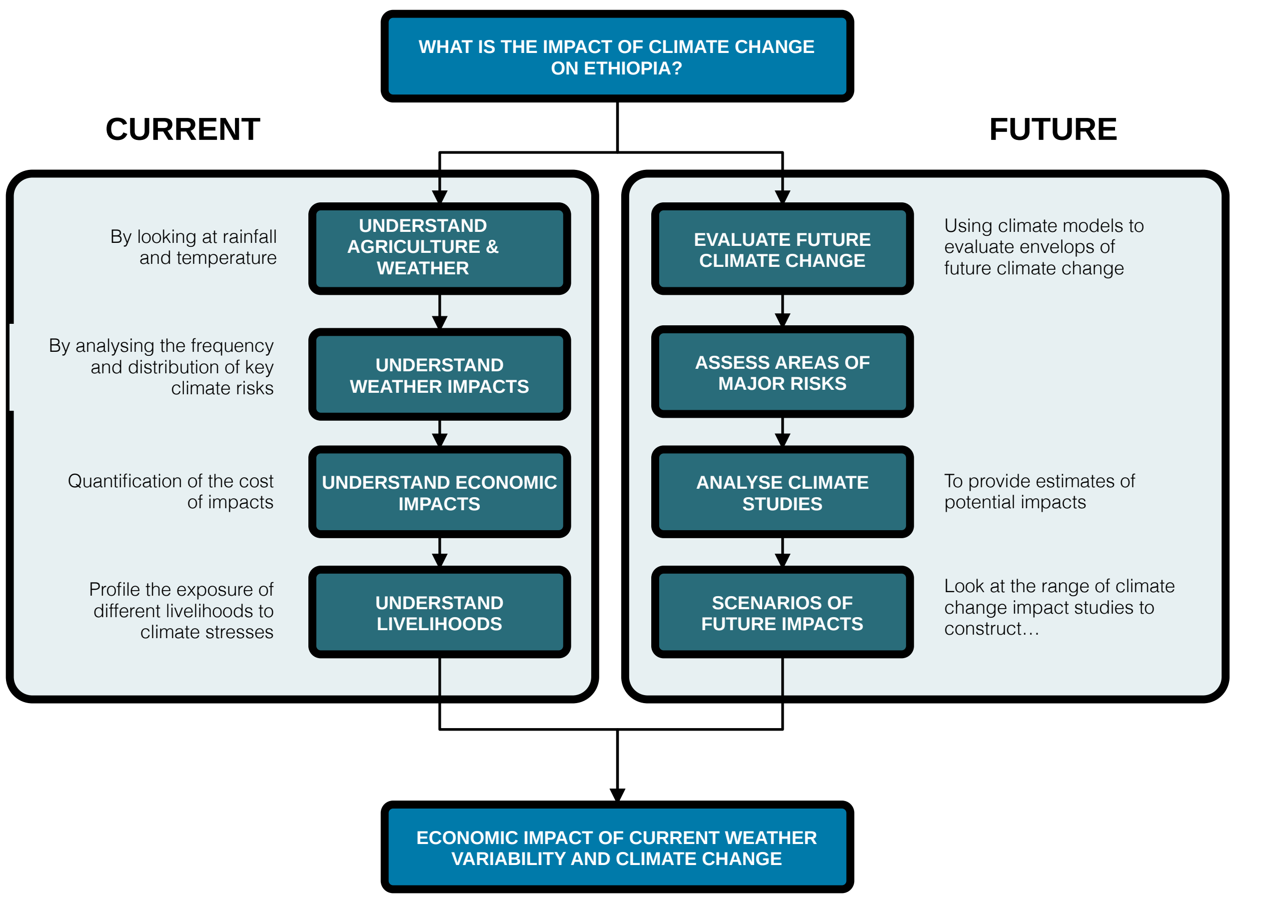
Step 1. Current and historic climate (section 2.2). First analysed current and historical trends in rainfall, temperature, and major climate related hazards at a national and regional levels.

Step 2. Current vulnerability to climate (section 2.3). Secondly undertook an assessment of the vulnerability of the agriculture sector to current weather variability.

Step 3. Future climate (section 2.4). Thirdly used climate model outputs to outline a range of scenarios for future rainfall, temperature and other climate variables.

Step 4. Future impacts and costs of climate change (section 2.5). Finally undertook an assessment of the risks and impacts of the range of possible future climates in Ethiopia.

FIGURE 7 : LOGICAL PROCESS FOR CHAPTER 2



2.2. CURRENT CLIMATE

Weather variability and historic change in temperature and rainfall is already having physical impacts in Ethiopia through the incidence of major hazards (droughts, floods and soil erosion).

2.2.1 Ethiopia's current climate

Ethiopia has a complex and varied climate. This is driven by the interaction between global climate systems and Ethiopia's varied terrain. Within a few hundred kilometres, there are areas of hot arid desert, cool wet highlands and wet humid lowlands. Elevations vary from 100m below sea level to 4,000m above sea level, and this results in wide variations in temperature. The pattern of elevation, temperature and rainfall across the country is shown in figure 8.

Agriculture and land-use activities are extremely diverse. This reflects the variation in climate, soil type and cultural practices across the country. These different agro-ecological contexts have been addressed through the creation of 14 Adaptation Planning Zones (see Box 2). This disaggregation is essential to understanding the local climate contexts for the purposes of designing responses to build climate resilient economic growth.

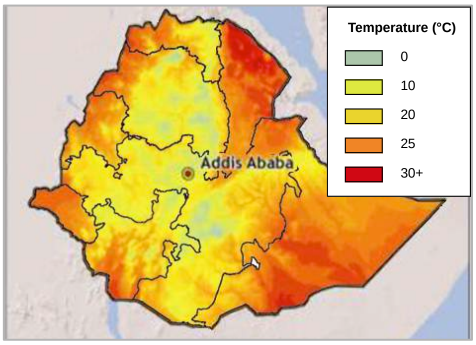
2.2.2 Temperature

Temperature variability is an important factor in agriculture, livestock and forest productivity. Higher temperatures reduce productivity, farm revenues, economic activity and growth rates.

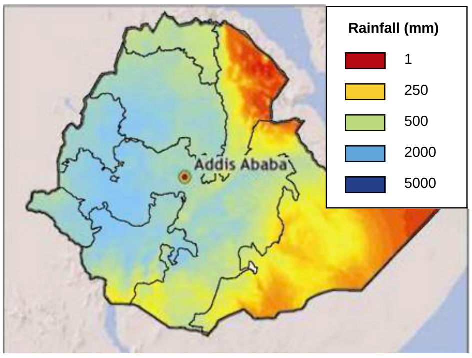
Ethiopia shows a broadly consistent trend of increasing temperature across the country over the last 50 years. Regional analysis of average temperature in the two major agricultural growing seasons shows increases over the entire country, especially in the Nile valley. The estimates of temperature increase range from 0.1°C to 0.4°C per decade, resulting in an approximate average temperature increase of around 1°C since the 1960s (see figure 9). The temperature observations have been supported by other indications of a warming climate, such as increasing minimum and maximum temperatures, increased frequency of hot days and hot nights, and decreases in the frequency of cold days and nights.

FIG 8 : **CURRENT CLIMATE**

Annual average temperature



Annual average rainfall



Elevation profile

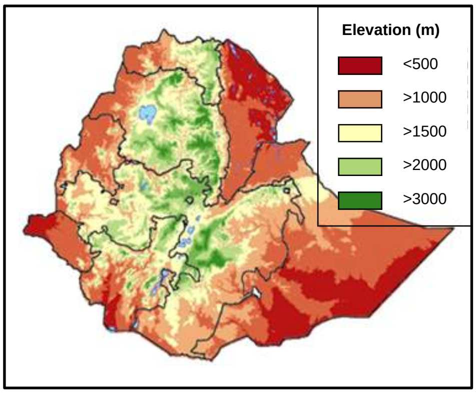
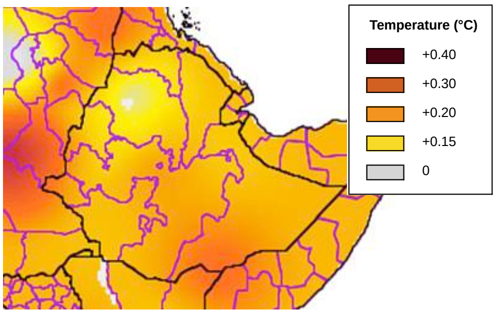
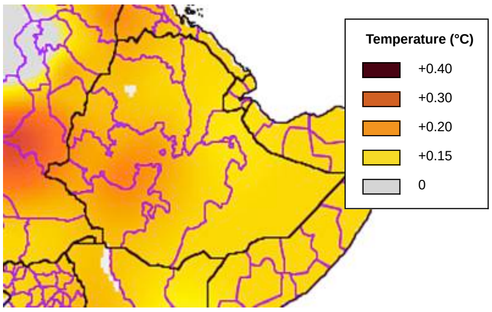


FIG 9 : **TEMP. TRENDS**

Temperature trends for March - June



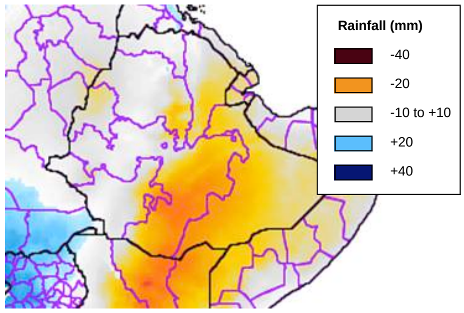
Temperature trends for June to Sept.



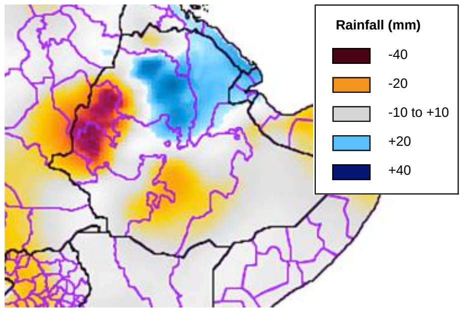
Note figures are °C per decade relative to 1960s average.

FIG 10 : **RAINFALL TRENDS**

Rainfall trends for March - June



Rainfall trends for June to Sept.



Note figures are mm per decade relative to 1960s average.

2.2.3 Rainfall

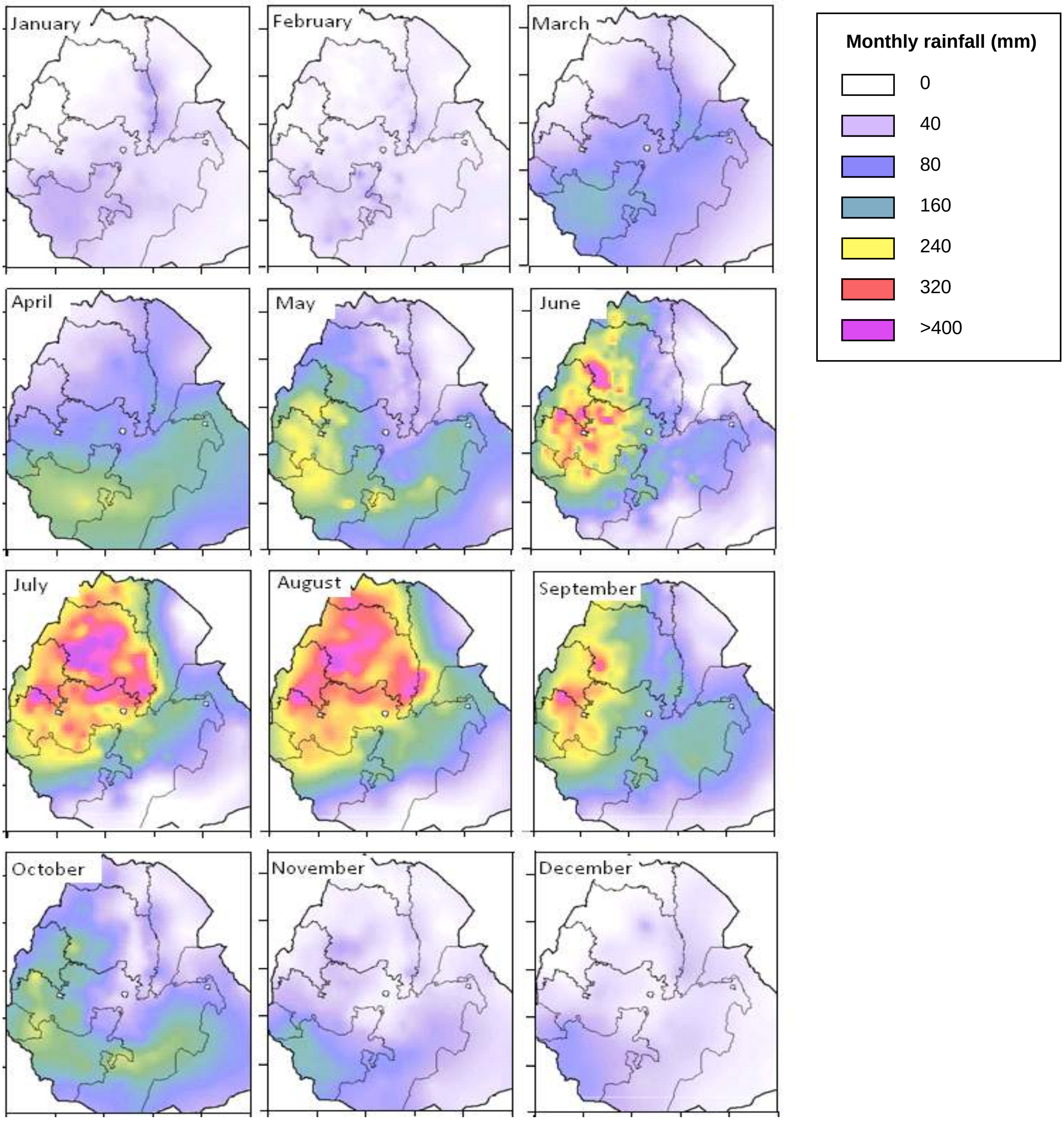
Rainfall is a key variable in agriculture, livestock and forestry output. Variability in annual, seasonal, and even daily rainfall leads to significant fluctuations in agricultural production.

Ethiopia's rainfall patterns are complex, ranging from arid regions to those that experience rainfall of 2,000mm per year, with the west of the country experiencing greatest rainfall. Ethiopia's rainfall is determined mainly by seasonal changes in large-scale global circulation systems, particularly the seasonal north–south movement of the Inter Tropical Convergence Zone (ITCZ). Movements of this zone create distinct rainy seasons in different regions of the country which are either bimodal (twice a year) or unimodal (once a year). The eastern highlands and the south and south-east of Ethiopia experience a bimodal system and the north, east and west experience a unimodal pattern (see figure 11).

At the national level rainfall is subject to high inter-annual, inter-decadal and seasonal variability. When it comes to inter-annual variability, historic data shows national variability of approximately 25% around the mean across the time period 1960 to today. Regional and local variability is often much more extreme. For example in Mekele, Tigray, annual rainfall can vary by over plus or minus 50% of the 1971-2000 mean. There are also clear decadal cycles at the national level and in some areas such as Dire Dawa.

Some trends in changes in rainfall start to emerge when specific regions and seasons are considered. At the regional level, there are some indications of a fall in annual rainfall in the south (see figure 10). This shows a large decline in the summer and particularly spring rains, by as much as 20%, in some heavily populated areas (e.g. in south-central Ethiopia). The high warming across the entire country has exacerbated this dryness.

FIGURE 11 : ANNUAL RAINFALL PATTERNS IN ETHIOPIA



2.2.4 Climate-related hazards

Our weather variability results in major impacts through extreme weather events and hazards, the most prominent of which have been droughts, floods and soil erosion. There are also other weather hazards that affect agriculture, such as forest fires and pests and diseases.

Drought frequently occurs and is an extreme weather event. 60% of the country is dryland and in these parts of the country annual rainfall is low and seasonal and inter-annual variability is high. These areas are highly vulnerable with desertification and droughts having been persistent throughout history.

Periodic major droughts have occurred over the last twenty years in most parts of the country. Droughts have been especially prevalent in the central and northern highlands (from northern Shewa to Wello and Tigray) and low-lying agro pastoral lands (see figure 12). Historic data suggest that the incidence of droughts may have been increasing over recent years.

FIGURE 12 : **FREQUENCY OF DROUGHTS BY WOREDA**

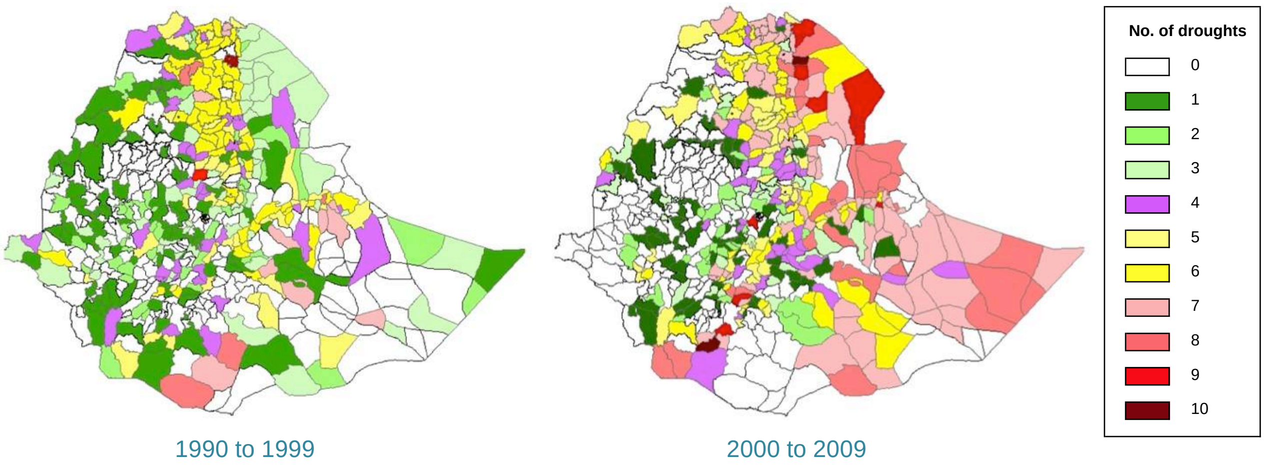
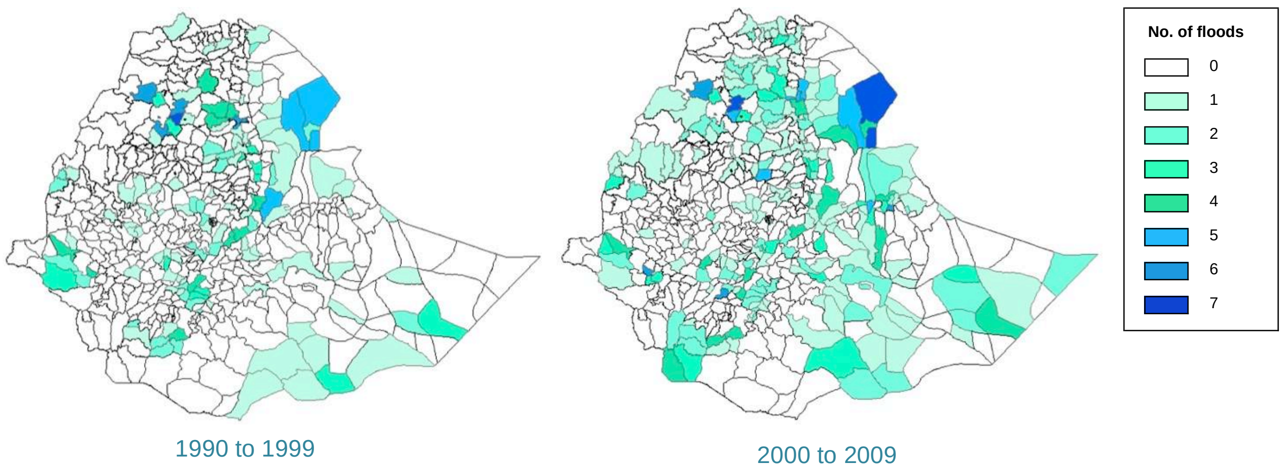


FIGURE 13 : **FREQUENCY OF FLOODS BY WOREDA**

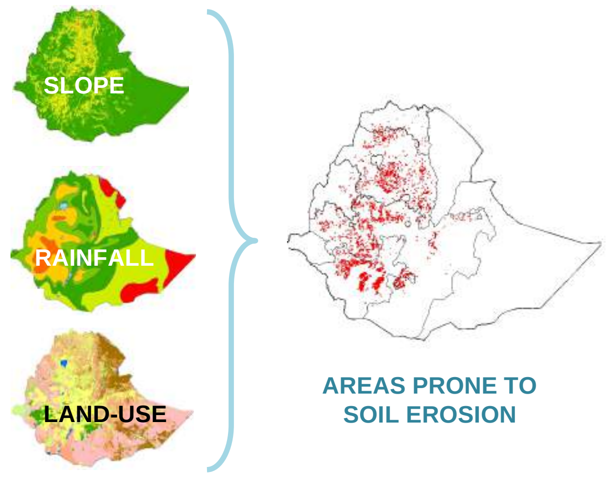


Floods are a frequent occurrence and are an extreme weather event. Major floods have occurred in 1988, 1993, 1994, 1995, 1996 and 2006. In addition to these major events there are localised flash floods, especially in cities, which cause significant damage. Like droughts, there are some suggestions that floods have increased over recent years (see figure 13).

Soil erosion is defined as the physical processes which cause land degradation, impacting negatively on soil productivity. This reduction in soil productivity is caused through a loss of fertile topsoil and water holding capacity, reduction in rooting depth and removal of nutrients.

Although considered a climate-related hazard, soil erosion is caused by a mix of socio-economic and climate factors. The variables are slope (steepness), rainfall and run-off, land use and wind. Changing farming practices and increasing demand for basic natural resources can result in land-use changes that increase soil erosion (e.g. by reducing vegetation cover). Strong winds also disturb dry soil causing soil erosion, an issue in the drylands.

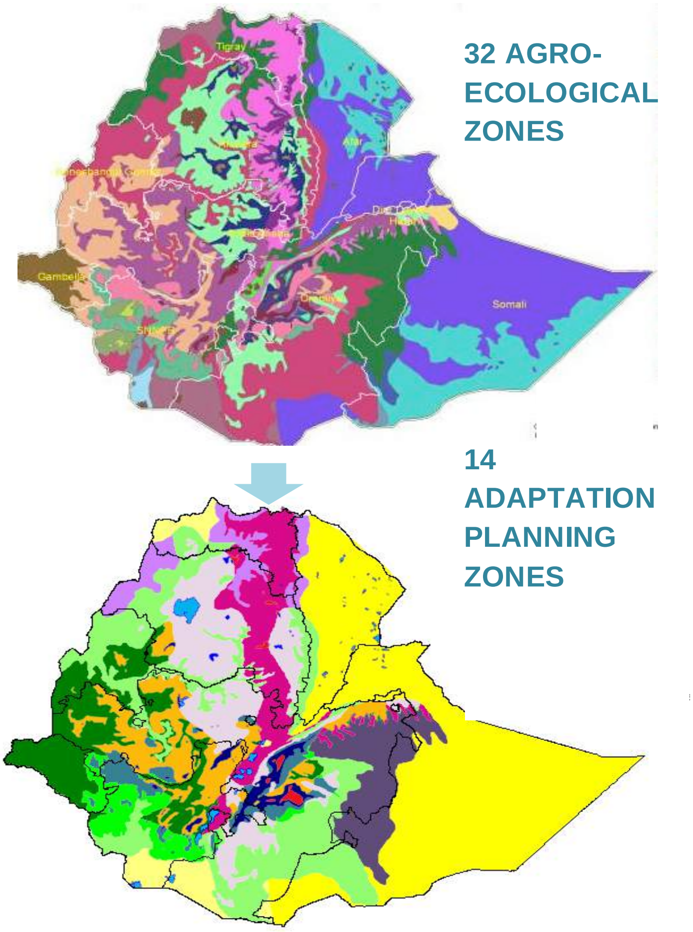
FIGURE 14 : SOIL EROSION



The areas at potential risk from current soil erosion have been estimated by analysing slope, rainfall and land use, (see figure 14). Our analysis suggests 6% of Ethiopia is at high risk of soil erosion, particularly areas to the west of the country, including, Tigray, Amhara, Oromia and SNNPR.

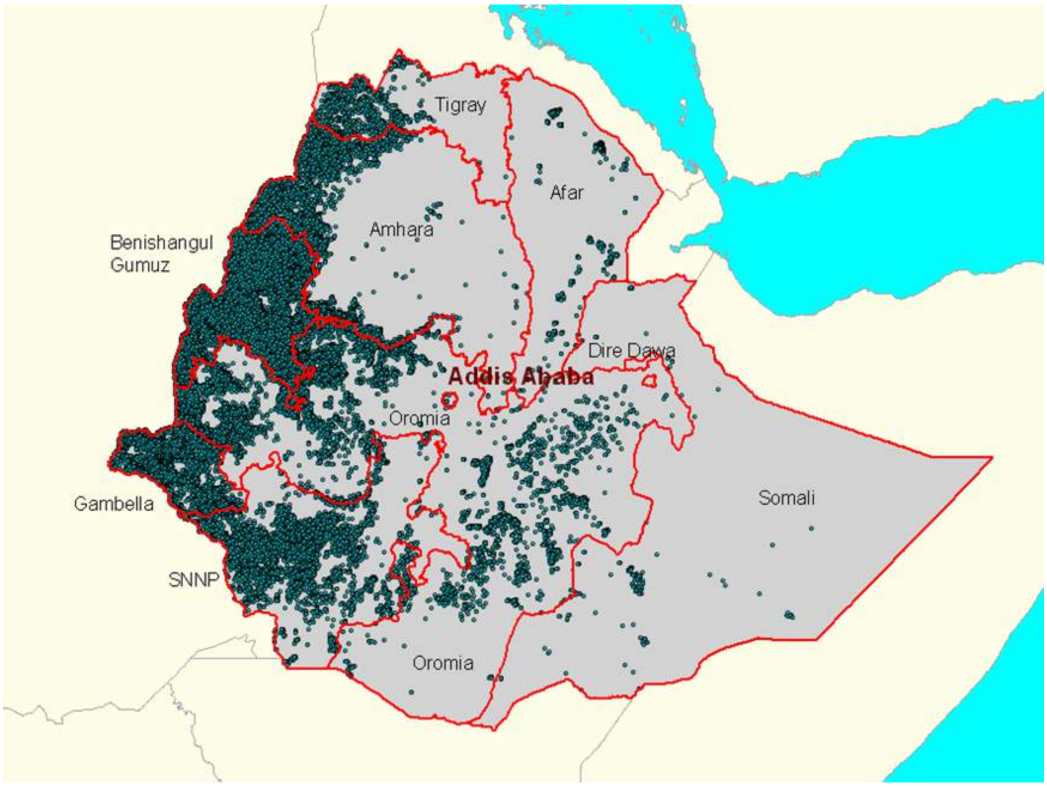
BOX 2 : MANAGING ETHIOPIA'S CLIMATIC DIVERSITY

To capture the variation in Ethiopia's biophysical conditions (i.e. elevation, climate, terrain, soil type, vegetation and fauna) the MoA has previously split the country into 32 Agro-Ecological Zones (AEZs). For assessment in this strategy, the AEZs have been clustered to create 14 Adaptation Planning Zones (APZs). This is in order to simplify the analysis while reflecting the diversity within Ethiopia's climate.



Forests fires are strongly linked to climate, with periods of drought increasing their prevalence and potential damage. The incidence map of recent events is shown below (see figure 15). There are reports that fire has affected more than 200,000 ha every year in recent decades.

FIGURE 15: **FOREST FIRE INCIDENCE IN 2008**



Pests and diseases will increase as temperature, relative humidity and moisture availability change in both magnitude and variability with the intensification of climate change. The main strategy to counter crop diseases effetively will continue to be crop breeding. Ethiopia should, therefore, give an increasing attention to crop breeding capacity. This should be reflected in both scientific training and in the acquisition of the needed equipment and supplies.

2.3. CURRENT VULNERABILTY

Our analysis has shown that Ethiopia is exposed to a variety of climate hazards, spread across different areas, in particular related to the variability of rainfall. We have experienced temperature increases over the last 50 years, and there are indications that droughts and floods may have become more frequent.

The current weather variability and related hazards result in the current level of vulnerability to weather extremes in agriculture. To understand this vulnerability, two steps have been undertaken. The first was to examine the estimates of historic impacts of extreme weather events primarily in terms of negative effects on economic output. This provides an overall picture of the scale of impacts, and solidifies the overall case for action. However, it does not give a good sense of specific vulnerability characteristics. Therefore, the second step was to map out the livelihood systems of different types of farmers and pastoralists across the country, and identify their exposure to 'climate stresses'. This latter step allows us to create 'risk profiles' for the 14 APZ regions to show how climate change results to risks in different regions.

Other non-climatic drivers are inextricably linked to vulnerability but have not been explicitly included here in order to distinguish between largely "exogenous" drivers (determined by climate change), and largely "endogenous" drivers, which economic policy can strongly influence. The non-climatic drivers include general agricultural development, degradation and loss of natural resources and ecosystem services, land use change, institutional issues and governance. Any response to vulnerability will be grounded in the need to influence both sets of drivers.

2.3.1. Framing the impacts of climate from an economic perspective

Our GDP is already negatively impacted by weather variability (especially temperature and rainfall) and related hazards (especially drought, floods, soil erosion). The negative impact means our future economic growth ambitions will be hampered unless current impacts related to climate change are addressed.

BIG PICTURE

At the national level the weather variability and related hazards have a clear negative impact on economic output in agriculture. This is due to lost agricultural output, lower export earnings and reduced foreign direct investment. Different studies produce different estimates that cannot be seen as independent and mutually exclusive. Therefore some broad estimates of the loss to the economy caused by current weather variability and related hazards have been presented. Although extremely approximate, these estimates give a sense of the extent to which our economy has already been hurt by its lack of sufficient climate resilience. The largest impacts come from droughts with the cost to the economy being between 1%-4% of total GDP depending on the scale and duration of drought events.

TEMPERATURE

Analysis has shown that higher temperatures in African countries have a negative impact on agricultural output. At the African scale, analysis at the farm level shows that higher annual or seasonal temperatures have a significant impact on annual crop revenues per hectare. For example a 1% increase in temperature is estimated to lead to a 1.3% decline in farm revenues. Unsurprisingly, farms in hotter and drier regions were found to be the most sensitive (resulting in a 1.6% decline for a 1% increase in temperature).

The relationship between temperature and livestock is uncertain. Some studies report that an increase in annual or seasonal temperature negatively impact revenue from livestock while others report the opposite (with difference by season and region).

RAINFALL VARIABILITY

There is also a clear relationship between economic growth and rainfall variability. It is generally reported that lower rainfall is damaging to agricultural crops, and increasing rainfall is beneficial. However some studies suggest there are differences between seasons and farming systems. The relationship is more complex for livestock, because of the interaction with feed availability and pests and diseases.

As reported earlier, there is a high variability in the current levels of annual rainfall in Ethiopia which makes these effects very important. The effects of ongoing variability show some overlap with flood and drought impacts (discussed below), but studies show that high seasonal variability can have a detrimental impact on agricultural productivity and on farm level revenues.

HAZARDS

Furthermore, hazards from extreme weather events also have negative impacts on economic output and growth.

Droughts have high human health and economic impacts, and are a major challenge to the agriculture sector both in terms of income but also food security. Droughts can have wider effects through lost energy and industrial production, through the linkages with hydroelectricity.

The periodic droughts affect millions of people in ways that cannot be evaluated in simple outputs terms alone. The largest human impact in recent years was in 2003 where 12m people were affected with an estimated 0.3m fatalities. The long-term health and human development impacts of such extreme events are considerable, although difficult to quantify.

Droughts have a well-documented impact on agricultural production. The 2002/03 drought was the most severe in recent history and led to a 4% decline in GDP, a 12% reduction in agricultural output and a 15% inflation rate. Coffee was particularly impacted with a 30% decline in harvest in coffee producing areas of the western, south-western and eastern parts of the country. The severe drought of 1984 is estimated to have reduced GDP by 10%, which highlights the potential catastrophic impact of weather variability.

Floods lead to potential damage to land, agricultural crops, buildings and infrastructure. Moreover, there are indirect impacts from the contamination of water supplies, disruption to electric energy systems and transport. The cost of recent major floods (in 1994, 1995, 1999, 2005 and 2006) range from $3.5m-$6m per event, though these only capture direct costs.

Floods also impact people, but not on the same scale as droughts, in terms of numbers affected. The most catastrophic floods were in the 2006 rainy season, when floods in DireDawa, South Omo and West Shewa led to high infrastructure damage, around 650 deaths, and the displacement of 35,000 people.

The total humanitarian assistance requirements over the last decade have been typically in the range of $350 to $400m per year. However in severe drought years this rose to approximately $600m.

Soil erosion is a key hazard as it reduces agricultural productivity and therefore farm incomes and agricultural livelihoods. Although it does not have the catastrophic and prominent immediate impact of floods or drought, the negative impact of soil erosion has been estimated to be of the order 2% to 3% of agricultural GDP per year (around 1% of total GDP).

2.3.2. Understanding vulnerability to climate stress

To understand the specific characteristics of vulnerability the exposure of different livelihoods to climate stresses has been mapped

It is possible to map agricultural livelihoods. The previous work of the Atlas of Ethiopian Livelihoods that identifies three agricultural livelihood systems has been used. These are pastoral, agro-pastoral and cropping. Additionally, further disaggregation of the three livelihood systems is possible based on the extensive catalogue within the livelihood atlas.

These livelihoods are vulnerable to weather events. Our analysis has identified 18 climate stresses common to Ethiopia based on observed trends in climate change and possible futures. These stresses relate to temperature (climate stresses 1-3), rainfall and related hazards (4-9), seasonal variation (10-17) and cloudiness/humidity (18). Each stress results in different key impacts within agricultural systems (see table 1). Many of these stresses are already experienced, but future changes may make them more frequent, or more intense.

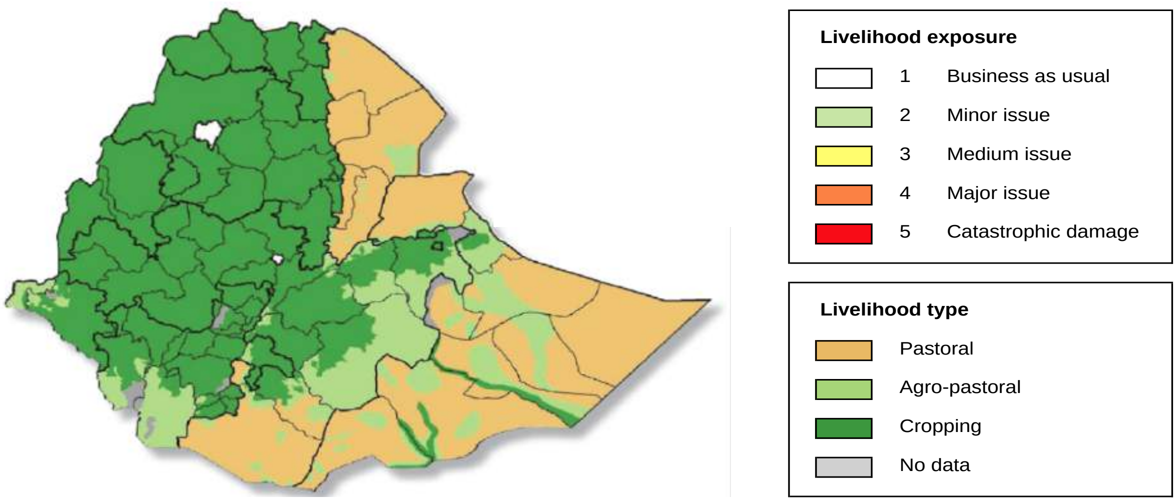
TABLE 1 : **CLIMATE STRESSES AND KEY IMPACTS**

	Climate stresses	Key impacts (stylised)
1	High mean temperature	Shifting agro-ecological zones;
2	Days with a max temperature above 35 °C	Heat stress for some crops
3	Days with a max temperature above 40 °C	Leads to heat stress on people and livestock
4	Lower mean rainfall	Shifts in agro-ecological zones; plus drought impacts
5	Higher mean rainfall	Landslides, damage to crops and livestock
6	Large scale floods	Damage to crops, livestock, infrastructure and people
7	Flash floods	Local damages to crops, livestock, infrastructure, people
8	High 1-hour rainfall intensity	Soil erosion and landslides, some local damages to crops
9	Heavy hail events	Crop damage at certain times in the growing season
10	Rainfall distribution (variability) within season	Significant impact on some crops
11	10-day dry spells	Significant impact on some crops
12	Seasonal droughts	Significant impact on most crops
13	Consecutive seasonal droughts	Significant impact on livelihoods and economic growth
14	Later onset of rainfall season	Shortens growing period - impacts on crops, fodder
15	Earlier end date of the rainfall season	Shortens growing period - impacts on crops, fodder
16	Decreased predictability of the rainfall season	Less reliable forecasts affect some enterprises
17	Increased uncertainty in rainfall distributions	Increases risk, important for some enterprises
18	Increases in cloudiness and humidity	Reduces radiation, increases thermal stress for people

Each type of livelihood has different exposure to the identified climate stresses. The different exposure profiles across the three main livelihood systems are determined by mapping climate stresses against different livelihoods (see figure 16). The exposure and related vulnerability is assessed along a qualitative five-point scale ranging from 1 (climate stress has no impact on livelihood) to 5 (climate stress will have a catastrophic impact on livelihood).

It is important to note within these livelihood systems that there will be differing distributional impacts with respect to weather. The impacts of weather extremes will be more severe for vulnerable groups such as children, the elderly, the disabled and women. For example women tend to be more dependent on natural resources than men, and have less financial resources and fewer alternative income opportunities making them more exposed and sensitive to climate stressors.

FIGURE 16 : **LIVELIHOOD EXPOSURE MAPS**



HIGHLAND CROPPING SYSTEM		TEMPERATURE			PRECIPITATION						SEASONAL CHANGES								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Pastoralists		1	1	1	3	2	2	2	1	2	2	2	4	4	3	3	1	1	1
Smallholder dryland farming	Coffee/ Cereal	1	1	1	2	1	3	3	1	2	2	2	3	4	3	3	2	2	1
	Cereal /Pulse	1	2	2	3	1	3	4	3	4	2	3	3	4	3	3	2	2	2
Commercial farming		1	1	2	1	1	3	4	4	4	3	3	3	3	2	2	3	3	1

AGROPASTORAL / TRANSITION ZONE		TEMPERATURE			PRECIPITATION						SEASONAL CHANGES								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Agro-pastoral		1	1	3	4	2	2	1	1	1	2	3	3	4	3	3	1	1	1
Small-holder dryland farming	Coffee/ chat/cereal & livestock	1	1	3	3	1	3	3	2	1	2	2	3	5	2	3	2	2	2
	Cereal/ pulse/teff & livestock	1	2	3	4	1	3	4	3	3	4	4	4	5	3	3	2	3	2
	Horticulture/enset	1	3	2	3	1	3	4	3	3	3	3	3	5	3	3	2	3	2
Trade networks		1	2	2	1	1	3	4	3	2	1	1	4	4	1	1	1	1	1

PASTORAL LOWLANDS	TEMPERATURE			PRECIPITATION						SEASONAL CHANGES								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Pastoralists	1	2	4	4	1	NA	1	1	NA	1	1	4	5	1	1	1	1	2
Agro-pastoralists	2	2	4	3	1	NA	2	2	NA	2	3	2	4	2	2	1	2	1
Smallholder irrigated cropping	2	3	4	2	1	NA	2	2	NA	1	1	1	3	1	1	2	2	1
Commercial (Sugar cane)	1	2	3	2	1	NA	1	3	NA	2	3	2	3	3	2	2	2	2
Traders	1	1	4	2	1	NA	2	2	NA	1	1	2	3	1	1	2	1	1

Our analysis reveals important differences in exposure to extreme weather events between different livelihoods. It confirms the four key climatic risks as floods (climate stress 7), droughts (climate stresses 12 and 13), soil erosion (climate stress 8) and certain aspects of variability in both temperature and rainfall (climate stresses 3, 4, 10 and 11). Consecutive droughts are the most prominent of these hazards and are a cause for concern for all livelihood types, but especially for cropping and agro-pastoral livelihoods.

2.3.3 Understanding risks and economic impacts: risk profiles

Our analysis of the exposure of livelihoods to different climate stresses has shown which livelihoods are at risk and what they are at risk to. As the exposure will be context specific depending on the local climate, 'risk profiles' for each APZ have been developed (see table 2). This shows which livelihoods and hazards are present in each individual APZ. For example the humid central highlands are at risk from floods and contain the livelihood of mixed agriculture.

Our policy planning is not undertaken across the distinct areas of the APZs, but rather across 11 administrative regions. Therefore the risk profile also maps each APZ by administrative region. This makes it possible to see within each administrative region the different climate zones, weather event hazards and livelihoods that are contained within it. For example, the humid central highlands span three administrative regions: Oromiya, SNNPR and Addis Ababa. The table shows that the administrative regions contain many different climates (e.g. Oromiya and SNNPR), which will require different responses, depending on the climatic challenges faced in that particular region.

TABLE 2 : **RISK PROFILES BY APZ AND REGION**

ADAPTATION PLANNING ZONES	CLIMATE RISKS				LIVELIHOODS						REGIONAL DISTRIBUTION OF ADAPTATION ZONES										
	DROUGHT	FLOODS	VARIABILITY (RAINFALL)	VARIABILITY (TEMP)	PASTORAL	AGROPASTORAL	CROPPING	HORTICULTURE	MIXED	NOTES	Oromiya	Amhara	Gambella	Somali	SNNPR	B-G	Afar	Addis	Dire Dawa	Harari	Tigray
ARID	✓	✓	✓		✓	✓					2%			83%			84%			84%	
SEMI-ARID	✓	✓			✓					Some mixed sesame cropping	5%				10%						17%
SEMI-ARID HIGHLANDS			✓	✓			✓				6%	23%			2%		1%		28%		44%
SUB-MOIST NORTH	✓		✓						✓	Cereal, pulse and sesame		12%				1%	6%				26%
SUB-MOIST WEST	✓						✓		✓	Transition	13%			9%							
SUB-HUMID LOWLANDS		✓	✓				✓		✓	Coffee & maize	10%	2%	84%		14%	44%					
MOIST LOWLANDS	✓		✓		✓					Mixed and transitional cropping	22%	20%		7%	12%	53%	7%		4%	7%	12%
MOIST HIGHLANDS		✓	✓					✓	✓	Teff, cereal-pulse	14%	37%			4%			19%	68%	7%	2%
TEPID SUB-HUMID MID-HIGHLANDS		✓	✓	✓				✓	✓	Teff, chat-sorghum, coffee-maize	16%	3%			17%	3%		13%		2%	
TEPID HUMID MID-HIGHLANDS			✓					✓	✓		5%		1%		12%			60%			
HUMID CENTRAL HIGHLANDS		✓						✓	✓		4%				3%			8%			
PER HUMID			✓		✓					Coffee-maize	1%		15%		25%						

Note: The APZs of the extreme highlands (<1% of both Oromiya and Amhara), extreme moist highlands (<1% of Amhara) and water bodies have been excluded. Only land areas higher than 1% are shown and therefore numbers may not sum to 100%.

2.4. FUTURE CLIMATE

Based on the understanding of current vulnerability and key weather event risks, the next step in our analysis is to understand the potential implications for future climate change.

2.4.1 Approach to estimating future climate and its impacts

The starting point for our analysis was the modelled projections of future climate change. Our analysis presented focuses on understanding the range of possible outcomes from future scenarios and alternative models, rather than seeking to establish a central estimate. The focus away from central projections to consideration of the range recognises future climate change projections are uncertain. This arises because of the uncertainty in the future emissions scenarios. It also arises because of the uncertainty and lack of agreement for given scenarios between the climate models, which can be examined by comparing different model outputs.

To analyse future climate change three steps have been taken. Firstly, a review of previous studies and literature on projections of climate change in Ethiopia. Secondly, compilation of the most recent global climate model projections from the global dataset. Finally, 'downscaled' climate model information was used to look at detailed patterns at the APZ and regional levels.

2.4.2 Temperature

Historic analysis shows that temperature has risen by around 1°C between 1960 and today. Climate models can be used to estimate what will happen to future temperature at both the national and regional levels.

Earlier studies reported that Ethiopia's annual average temperature would continue to rise in the future, although the range of possible futures is large. The National Meteorological Agency (NMA) reported a central projection of approximately 1°C increase by 2020s, 2°C by the 2050s and 3°C by the 2080s over Ethiopia (for a medium-high emission scenarios, relative to the baseline period of 1961-1990). However, the range around these central projections is large: with warming of 0.5 to 1.5°C by the 2020s and 1.5 to 3°Cs by the 2050s).

The most recent climate projections from the global datasets support the previous conclusion that future temperatures will rise in Ethiopia, within a fairly large range (see figure 17). Projected warming is between 0.5 to 1.5 °C by the 2020s (2011-2040) and 1.5 to 3 °C by the 2050s (2041-2070) (see figure 17), relative to the period 1961-1990.

Our analysis has taken downscaled climate information to look in more detail across regional levels. The results show similar temperature findings to those reported at the national scale, with a rise across every APZ in Ethiopia in every season and region when a high global emissions scenario is projected (see figure 19). When different emissions scenarios are considered there remains a wide range in terms of the exact level of temperature increase. This range of temperature increase at the regional level are similar to the range reported at the national level, though they occur on very different climatic zones.

2.4.3. Rainfall

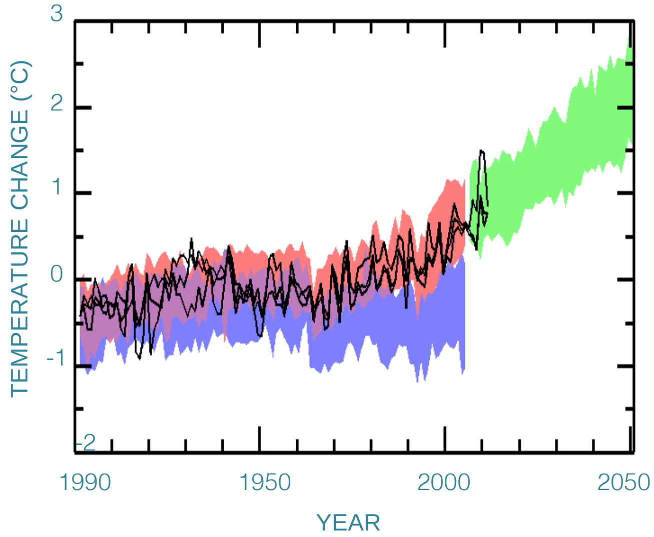
Rainfall is a more difficult climate parameter to model and Ethiopian climatology is more complex and challenging than for most countries. Historical analysis shows there has been no rainfall trend at the national level (unlike temperature) - indeed there is a pronounced annual and decadal variability.

Previous modelling of the future changes in rainfall in Ethiopia has reported a large range, typically reporting projections of between -20% and +40% by mid century relative to the baseline. This is similar to the current high levels of variability in Ethiopia's current rainfall.

The most recent climate projections from the global datasets continue to show little consensus on the future rainfall trend. The variations across scenarios and model projections indicate changes of -25% to +30% in annual rainfall by the 2050s, relative to the 1961-1990 period (see figure 18). This is similar to the levels of historic variability, making the analysis of trends extremely challenging.

The large range in the rainfall projections is mirrored at the regional and seasonal scale. Unlike temperature, the downscaled results for rainfall do not show similar patterns, with very wide ranges both by region and by month of the year. For most APZs the uncertainty across the range of model projections includes both wetter and drier scenarios (see figure 20). The downscaled results appear to suggest some regions could become wetter (i.e. the per humid and tepid humid mid highland APZs). Furthermore, in the far south of the country, there is some indication that there might be more rainfall by 2050 during October, November and December (this is at the very end of the dry season and there is no indication that it counteracts the drying trend reported in the current rainy seasons in the regions). However, the overriding message is one of uncertainty, with a wide envelope of potential change, and current levels of variability will continue.

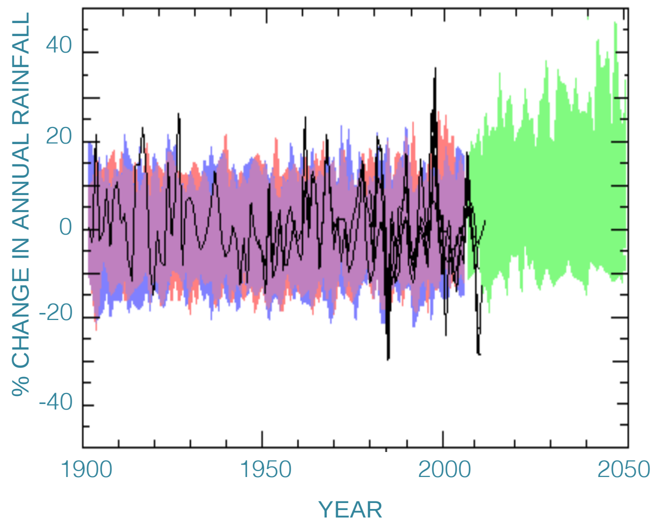
FIGURE 17 : **HISTORIC & FUTURE TEMPERATURE SIMULATIONS**



Key

- Observed annual average temperature relative to long-term 1961 to 1990 average
- Historical model runs without greenhouse gas forcing
- Historical model runs with greenhouse gas forcing
- Model projections from 2006 for two emissions scenario (IPCC A1B / RCP4.5) across the 10th to 90th percentile. Uses 32 model simulations from 12 climate models.

FIGURE 18: **HISTORIC & FUTURE RAINFALL SIMULATIONS**



Key

- Observed % change in annual average rainfall relative to long-term 1961-1990 average
- Historical model runs without greenhouse gas forcing
- Historical model runs with greenhouse gas forcing
- Model projections from 2006 for two emissions scenario (IPCC A1B / RCP4.5) across the 10th to 90th percentile. Uses 32 model simulations from 12 climate models.

2.4.4. Scenarios of climate change

The scenarios of change in both temperature and rainfall from the climate models for 2050 vary greatly and there is much uncertainty (see figure 21).

TEMPERATURE AND RAINFALL (AVERAGE)

Two broad scenarios for future climate change were constructed. These scenarios represent the range of outcomes projected by the climate models for average temperature and rainfall. The first (envelope A) is a slightly warmer, slightly wetter scenario. These would have more modest effects on agriculture over the next few decades. The second (envelope B) project hotter, drier outcomes that would lead to much larger negative impacts. These alternative scenarios are used to examine the potential future impacts and risks from a changing climate, noting there are, of course, a large number of intermediate outcomes that fall between these.

VARIABILITY AND EXTREMES

Our analysis has also assessed the possible scenarios for the frequency and intensity of rainfall. The scenarios range from where these variables stay at similar levels (frequency and intensity) to today's levels, through to scenarios where the intensity and frequency increase (with heavy rainfall days raising by 20% and rainfall intensity increasing by 10%).

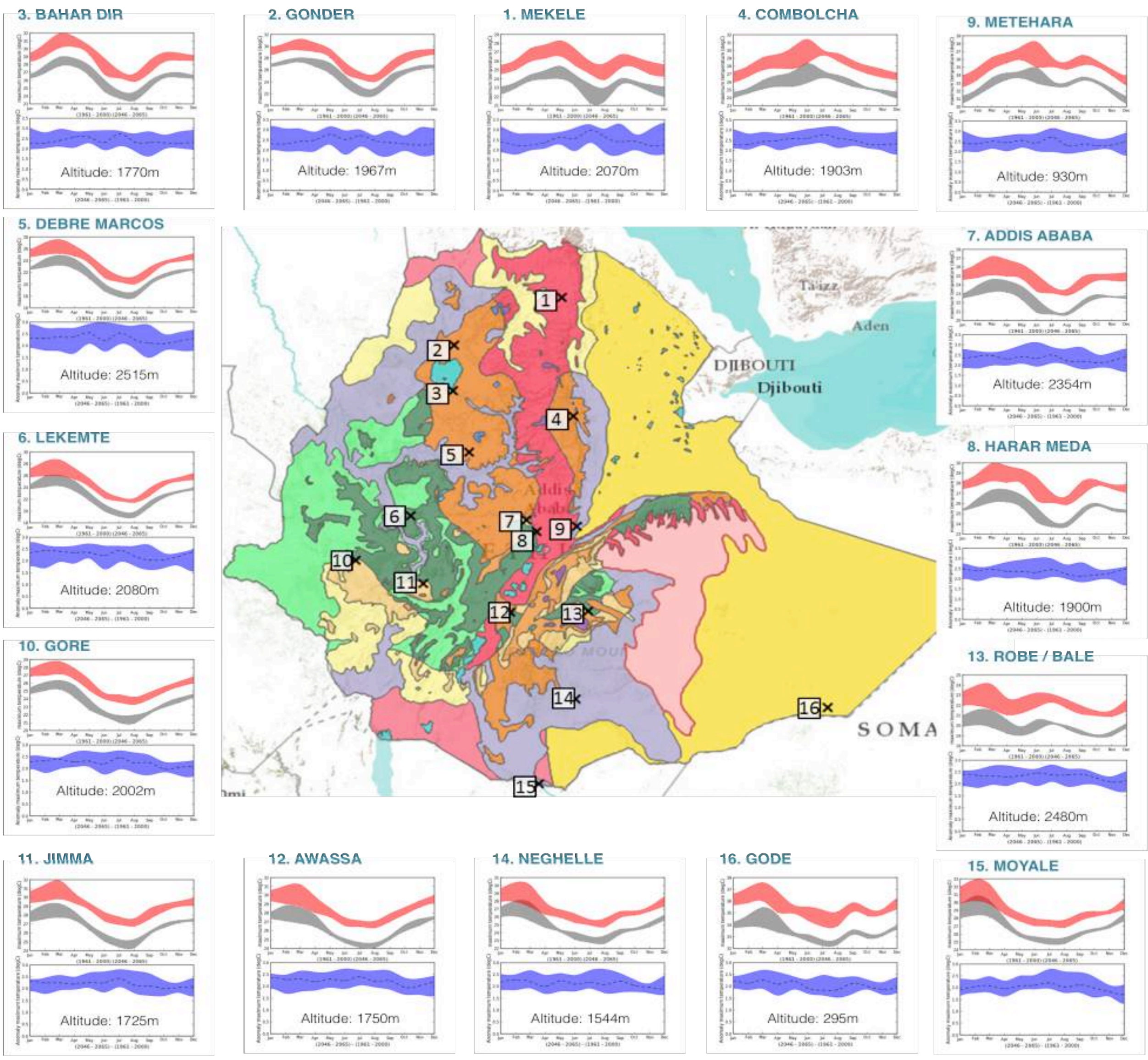
2.4.5. Key hazards

The scenarios of change will impact on the key hazards of droughts, floods and soil erosion in different ways. As climate models cannot fully capture the change in average rainfall, it is still not possible to determine with confidence what is likely to happen to season start and end dates, rainfall frequency and rainfall intensity. However using the scenarios of change it is possible to comment qualitatively on future scenarios of droughts, floods and soil erosion.

For the trends in **average** temperature and precipitation, two alternative scenarios are considered. These capture the range of model projections in the 2050s, shown in Figure 21, and highlight the difference between a hotter, drier Ethiopia, which generally leads to negative impacts, versus a slightly warmer, wetter set of projections, which have more modest effects.

For changes in **variability and extremes**, a number of alternative scenarios are also considered, associated with specific climatic risks. These outcomes are based on analysis of the range of climate model projections. For heavy rainfall, one scenario includes increases in rainfall intensity and/or the frequency of heavy rainfall events, leading to higher risks of floods and soil erosion. These events remain similar to today or decrease in the alternative scenario. Similarly for drought risks, one scenario projects increasing intensity or frequency of meteorological droughts, while the other sees little change or reductions in these events. Note that strong differentiated signals might arise across Ethiopia for these changes in variability and extremes.

FIGURE 19 : **MONTHLY TEMPERATURES FOR CURRENT AND 2050***



KEY & EXPLANATION OF CHARTS

Location	Map	Adaptation planning zone
Makale	1	Semi-arid highlands
Gondar	2	Moist highlands
Bahar Dar	3	Moist highlands
Combolcha	4	Moist highlands
Debre Marcos	5	Moist highlands
Lekemte	6	Tepid sub humid mid highlands
Addis Ababa-Bole	7	Tepid humid mid highlands
Harar Meda	8	Tepid sub humid mid highlands
Metehara	9	Moist lowlands
Gore	10	Tepid humid mid highlands
Jimma	11	Tepid humid mid highlands
Awassa	12	Moist highlands
Robe/Bale	13	Tepid sub humid mid highlands
Neghelle	14	Moist lowlands
Moyale	15	Moist lowlands
Gode	16	Arid

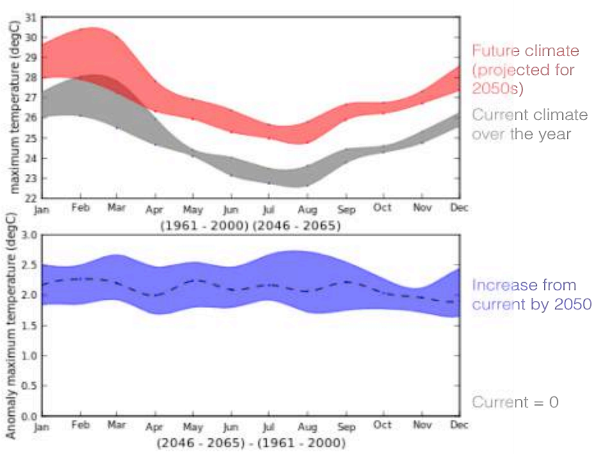
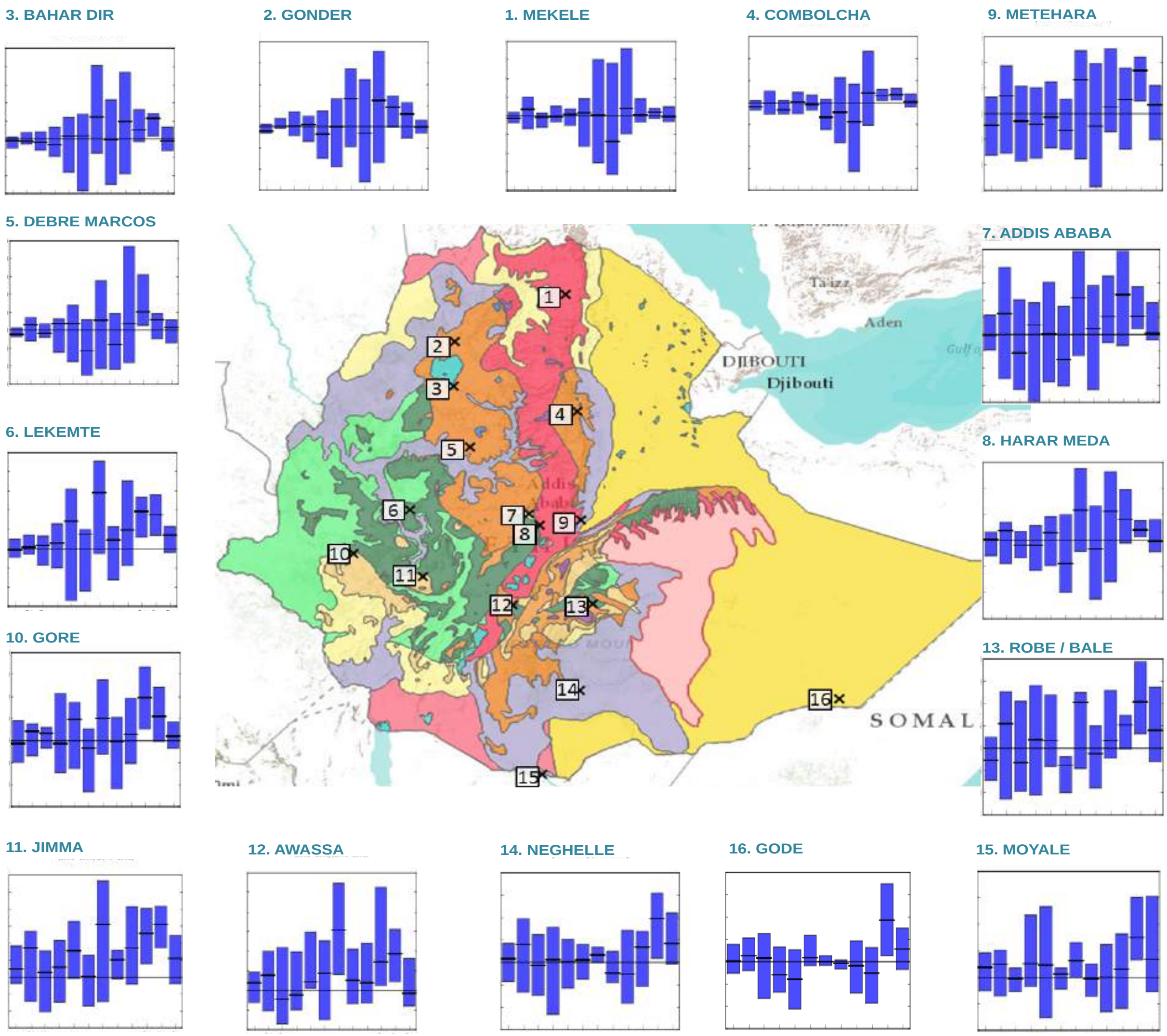


FIGURE 20 : **MONTHLY RAINFALL FOR CURRENT AND 2050***



KEY & EXPLANATION OF CHARTS

Location	Map	Adaptation planning zone
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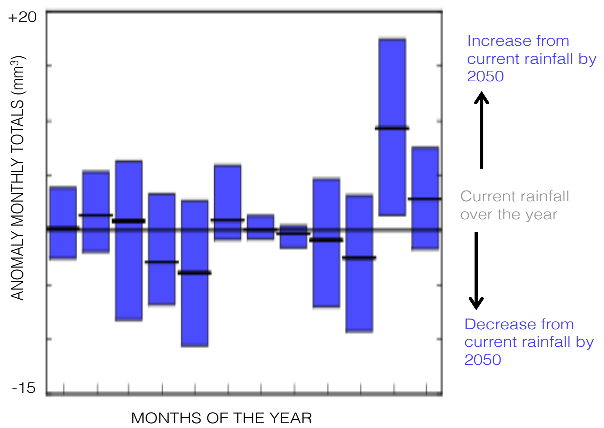
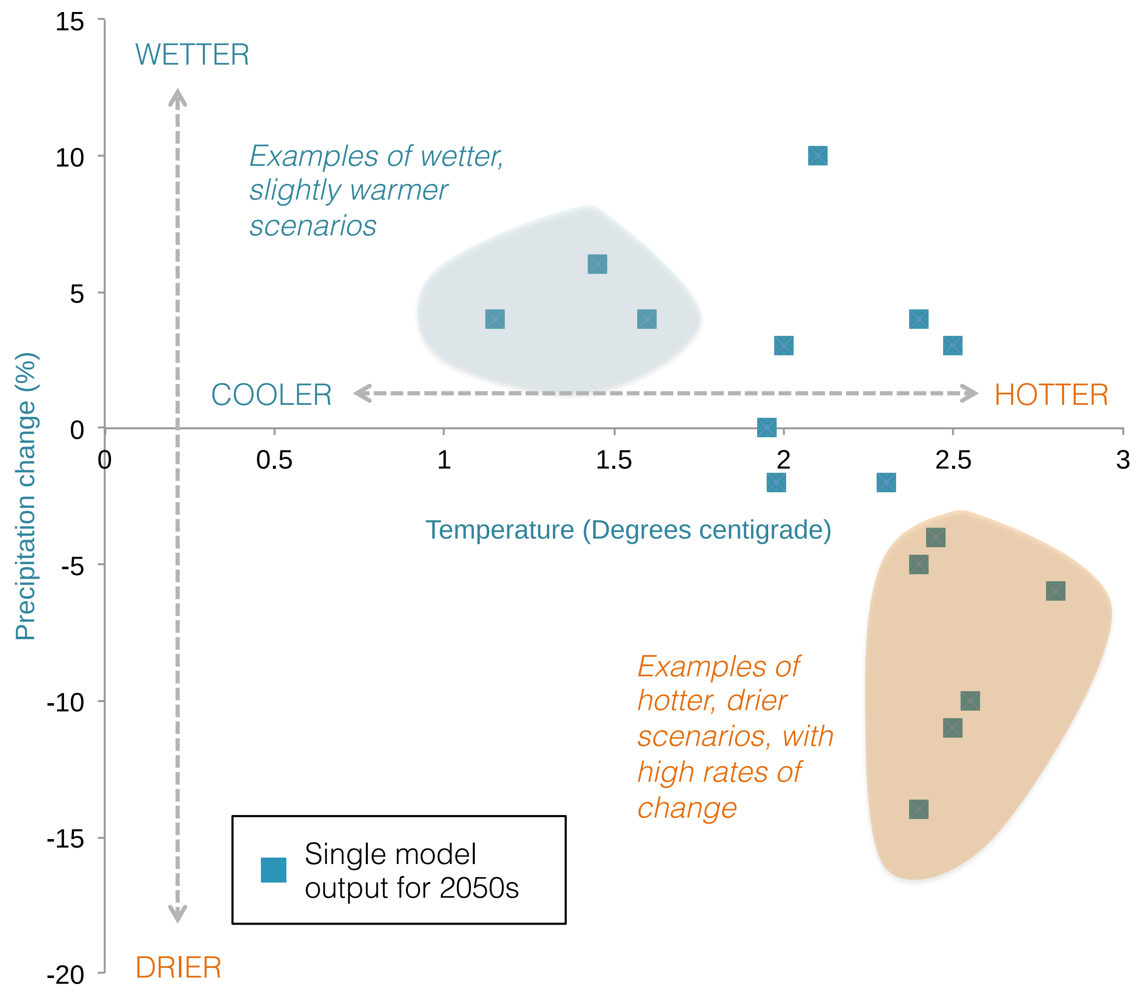


**NOTE : Plots are envelopes across 10 global climate models of monthly rainfall changes for 2040 – 2060 time period and A2 emissions scenario. The range captures model uncertainty: a tall bar in the rainfall charts for a given month indicates a wide range across the models*

FIGURE 21 : **2050 PROJECTIONS FOR ETHIOPIA**



2.4.6. Future socio-economic development

Alongside the future changes in climate, it is also necessary to consider future socio-economic trends. Our country is changing rapidly and population and wealth will affect future vulnerability. Indeed, previous studies show that these non-climate drivers are as important as climate change.

The most important trends relate to future population and economic growth. The population of Ethiopia is expected to increase from 84 million in 2013 to 100 million by 2020, 120 million by 2030 and 145 million by 2050, though growth rates fall in later years. Economic growth, anticipated in the GTP, will also serve to build resilience.

2.5. FUTURE IMPACTS AND RISKS

This section sets out the scenarios of key risks, the range of potential long-term outcomes and any key thresholds, given the scenarios of climate projections for Ethiopia.

2.5.1. Areas of risk and range of impacts

Based on the current and future weather variability we have highlighted key risks in three sectors (agricultural crops, livestock and forestry). We have also highlighted the impacts and costs arising from the cross cutting hazards of droughts, floods and soil erosion.

At the national level the cost of climate change could range from outcomes where impacts are very modest (or even beneficial) to aggregate impacts across all sectors that could be equivalent to 10% of GDP in 2050, based on the scenarios above. This is not to say that 10% is the maximum as this is not a comprehensive aggregation of all impacts. The key drivers for the higher costs relate to the severity and frequency of hazards caused by extreme events. The impacts will also depend on non-climatic drivers such as population growth, wider socioeconomic development and improved infrastructure. We have not undertaken detailed analysis mapping the impact of the climate scenarios to our ambition to reach middle-income status by 2025, although the impacts under the more extreme scenarios will make this ambition more difficult to achieve.

2.5.2. Impacts and costs to agricultural crops

Within agricultural crops there is a clear relationship between decreasing output and higher temperatures and lower rainfall. Future climate change has the potential to increase these impacts, acting through a large number of possible effects on the sector, including CO_2 fertilisation, changes in average trends, changes in variability and extremes. This vulnerability is related to the high proportion of rain fed agriculture compounded by other factors. Key thresholds that will negatively impact GDP will vary by individual crop and APZ.

Within warmer wetter average scenarios, the negative changes will be modest or even beneficial in agricultural productivity and agricultural GDP. This is due to more (average) rainfall, although current variability will continue. The benefits are estimated at 1% of GDP.

Within average hotter and drier scenarios there are high reductions in agricultural productivity. The effects of changes in weather variability and extremes exacerbate these impacts. Different estimates suggest reduction of per capita agricultural GDP of 3% to 30% in 2050 (estimate also includes livestock).

COFFEE AND IRRIGATED CROPS

Two key risks from future climate change within agricultural crops relate to coffee and irrigated crops, which are both linked to future economic growth.

Coffee is a temperature sensitive crop and it will be affected by future climate change. With increased temperature there could be reductions in production and quality, with potential major shifts such that current coffee growing areas become unsuitable for production. This is because coffee has narrow temperature thresholds for growing. Here reductions in areas suitable for wild coffee could reduce by 40%-90% by the 2080s based on the broad scenarios of climate change. If similar impacts occurred for commercial coffee, this could translate to a 30% reduction in export value equivalent to $0.5bn per year by 2030 with potential for total GDP losses from the crop in the long term.

Impacts on irrigated crops (e.g. sugar) are linked to changes in rainfall and related water availability. This water availability should be seen in the context of rising water demand (e.g. from an increase in population, with rising incomes, industrial demand, etc.) and reduced supply linked to lower rainfall (water gap). The future hotter, drier scenarios would lead to an increasing water gap and reduced crop yields. The reduction in crop yield could be 9%.

2.5.3. Impacts and costs to livestock

As with crops, livestock production and net revenues are affected by temperature and rainfall variability. Future climate change will impact on animal health, growth, quality, reproduction and value. There are also the possible changes in incidence and prevalence of some pests and diseases (indeed pests are currently estimated to reduce livestock income by 40%), with increases in rainfall associated with higher incidence of certain animal diseases.

Under higher scenarios of average future temperature, there are generally large impacts on livestock production and net revenues, with some studies reporting a decline of approximately 50% or more in livestock revenues by 2050. Such scenarios would also have major impacts on pastoralist livelihoods. High temperature scenarios also lead to high risks to housed poultry, which could be a concern if poultry numbers increase as projected under the GE strategy.

2.5.4. Impacts and costs to forestry

Current weather variability has existing impacts on forest health. Future climate change is expected to have a significant impact on forest productivity and health, compounded by the slow rate of natural forest adaptation and the limits on natural redistribution due to land constraints. These potential impacts are due to changes in temperature and rainfall, affecting the suitability of current areas (though some of these adverse effects may be partially countered by increased productivity due to the CO_2 fertilisation effect) and from changes in weather extremes. Over time, changes in climate will lead to changes in forest composition and forest cover. There are a limited number of quantitative studies in Ethiopia on the specific impacts of climate change, but hazards such as outbreaks of pests and diseases and forest fires that are already affecting forest areas are likely to increase in frequency and intensity.

Under modest average scenarios, there will be limited change in current impacts although slight warming may change some forest species. Under hotter, drier scenarios, there will be major shifts in climatic zone suitability for current forests. The scenario will result in projected reductions in the areas of forest coverage, fragmentation of forest life zones, the disappearance of certain types of forest (e.g. montane and lower montane wet forest and subtropical desert scrub). These will be offset with the appearance of other types of forest that are suitable to the changing condition. The changing climate will impact the species that can survive there and species with narrow ecological range (e.g. highland bamboo, alpine species) are likely to be threatened. This has the potential to affect timber and non-timber forest products, wider ecosystem services (water and soil catchment management and flood protection) and rural livelihoods, which depend on forests for a large proportion of their income, and as a coping strategy during times of drought.

2.5.5. Impacts and costs of key hazards

The key hazards of drought, floods and soil erosion could potentially cause large changes into the future. With respect to drought increased frequency and severity will lead to direct effects on all sectors and will be a continued drag on economic growth. These droughts will impact current livelihood zones and cause cascading effects to food security and socially contingent effects (e.g. famine, migration, conflict).

Assuming an increase in the frequency and intensity of rainfall, droughts may not increase, though the existing adaptation deficit will remain. Estimates suggest that in this scenario an overall average reduction in aid requiring numbers will reduce to 11% by the 2020s (average numbers over the last 20 years has been around 2m people per year). However in scenarios where these events increase (assuming a decrease in the frequency and intensity of rainfall) aid requiring numbers increase by around 30% with government expenditure expected to reach $1.2bn in the 2030s to counter the impacts of droughts (around 1% of GDP).

For heavy rainfall events, leading to increased risks of soil erosion and flooding, scenarios of increased intensity of rainfall and severity could have large impacts. Soil erosion could reduce agricultural GDP by a further 1% (on top of the 2% to 3% currently) from reduced agricultural productivity. The increases in flood risks and damages could be even larger and could reduce GDP by 8% by 2050.

CHAPTER 3
RESPONSE

To identify options that will build climate resilience and reduce the impacts of current weather variability and future climate change

KEY MESSAGES

Identifying options

- To build resilience against the risks from current weather variability and future climate change, 350 unique options were filtered down to 41 promising options using a number of criteria. These criteria were feasibility; contribution to economic growth; contribution to equity and distributional issues; and extent to which they address the current weather variability and future impacts of climate change.
- Analysis of the 41 options showed that 38 were currently covered to some extent by the Ministry of Agriculture's federal programmes. This demonstrates deep commitment at the federal level to deliver activities to build resilience.

Appraising options

- An appraisal of the 41 options using a multi-attribute analysis was conducted with Ethiopian experts. This exercise validated the options, identified the relative characteristics of the options (crucial, given that resilience happens in the local context with local objectives) and provided an assessment of the urgency of each option.
- An iterative risk management approach was adopted to highlight when to implement the relevant options, in an iterative, flexible way that promotes robustness. It identified three types of actions; no and low regret, climate justified and climate proofing.

Costing options

- Total investment in agriculture is around $1bn of which around 40% is from within the MoA. Between 2007-2013, 60% of the MoA's budget was spent on activities relevant to resilience activities.
- Private sector investment currently stands at 20% and is expected to rise to over 40% in 2030; it is crucial that this investment is resilient to future climate change.
- The additional investment required over what is projected under the MoA budget to implement all 41 options is around $200m today, rising to around $600m in 2030. Total expenditure on resilience activities by the federal MoA will be $1 billion in 2030, around $3 billion when all expenditure across regions, accountable institutions and the private sector is considered.

3.1. METHOD

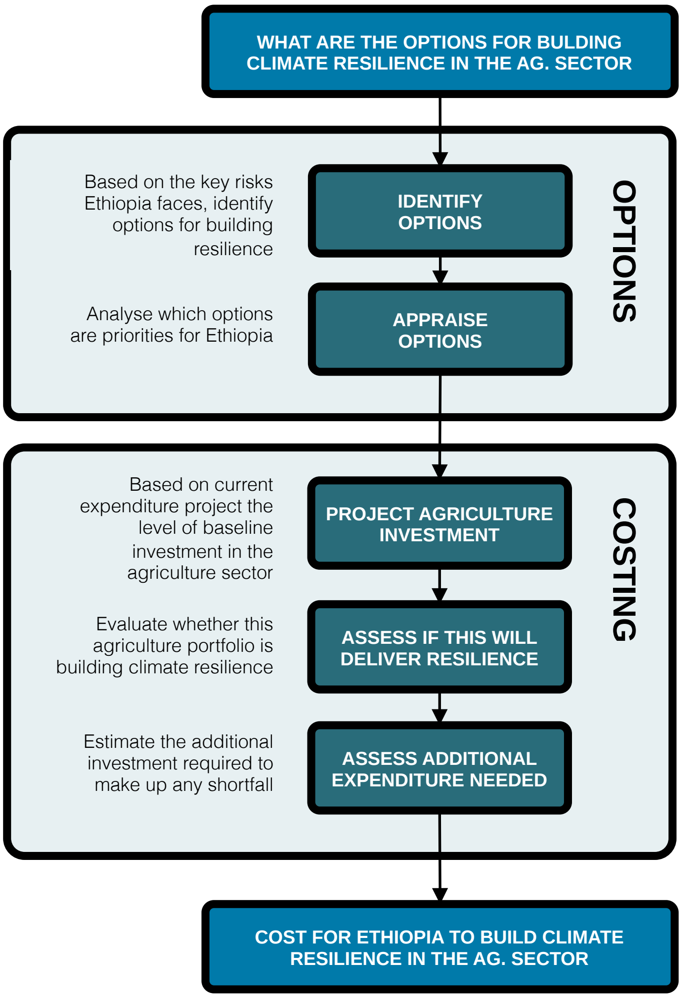
The previous chapter outlined the key risks that the climate poses for Ethiopia today as well as into the future. Our analysis showed that future impacts could cost up to 10% of GDP by 2050, which could hamper our economic growth ambitions, and disproportionately affect our most vulnerable populations. To analyse the response to these impacts, and related cost of delivering them, the following steps were undertaken (see figure 22).

Step 1. Identification of options (section 3.2). Options were identified and analysed that could build climate resilience and matched them to the key climate risks faced in Ethiopia, selecting the most promising programmatic options.

Step 2. Appraising options (section 3.3). Options were validated, appraised and sequenced the promising options through a multi attribute analysis and iterative risk management approach. This looked at the optimal sequencing given the uncertainty in the risk posed by future climate change

Step 3. Costing options (section 3.4). The cost of building climate resilience options into the current and future policy portfolio of the MoA and other sources of investment was estimated.

FIG. 22 : **LOGICAL PROCESS FOR CH. 3**



3.1.1. Understanding the need for action

Identifying actions to build climate resilient growth needs to take into account two things. First, some climate resilience will be delivered in the absence of government intervention, so called 'autonomous adaptation'. In adapting to historic climate change, farmers already undertake autonomous adaptation responses even without large-scale government intervention. This includes switching crop varieties, soil conservation techniques, early and late planting and irrigation. Further the 'business as usual' of resilience response may also include coping methods that are often detrimental in the long-term (such as selling livestock during a drought which depletes farmers assets). These actions may be mal-adaptations that increase the vulnerability of households and communities to the impacts of weather events.

The second is why government intervention is required at all if the economic case to undertake action is strong; this is due to the unique nature of climate change, captured by understanding the 'barriers to implementation'. This is due to a number of barriers including market failures (e.g. public good nature of resources) and other barriers such as transaction costs, liquidity constraints, lack of access to credit, complex decisions based on the uncertainty of future impacts, habitual behaviour and inertia, lack of information, increased risk from using new technologies, and a lack of capacity. It is vital to address these barriers in the design of a policy framework to ensure the successful delivery of resilience.

3.2. IDENTIFICATION OF OPTIONS

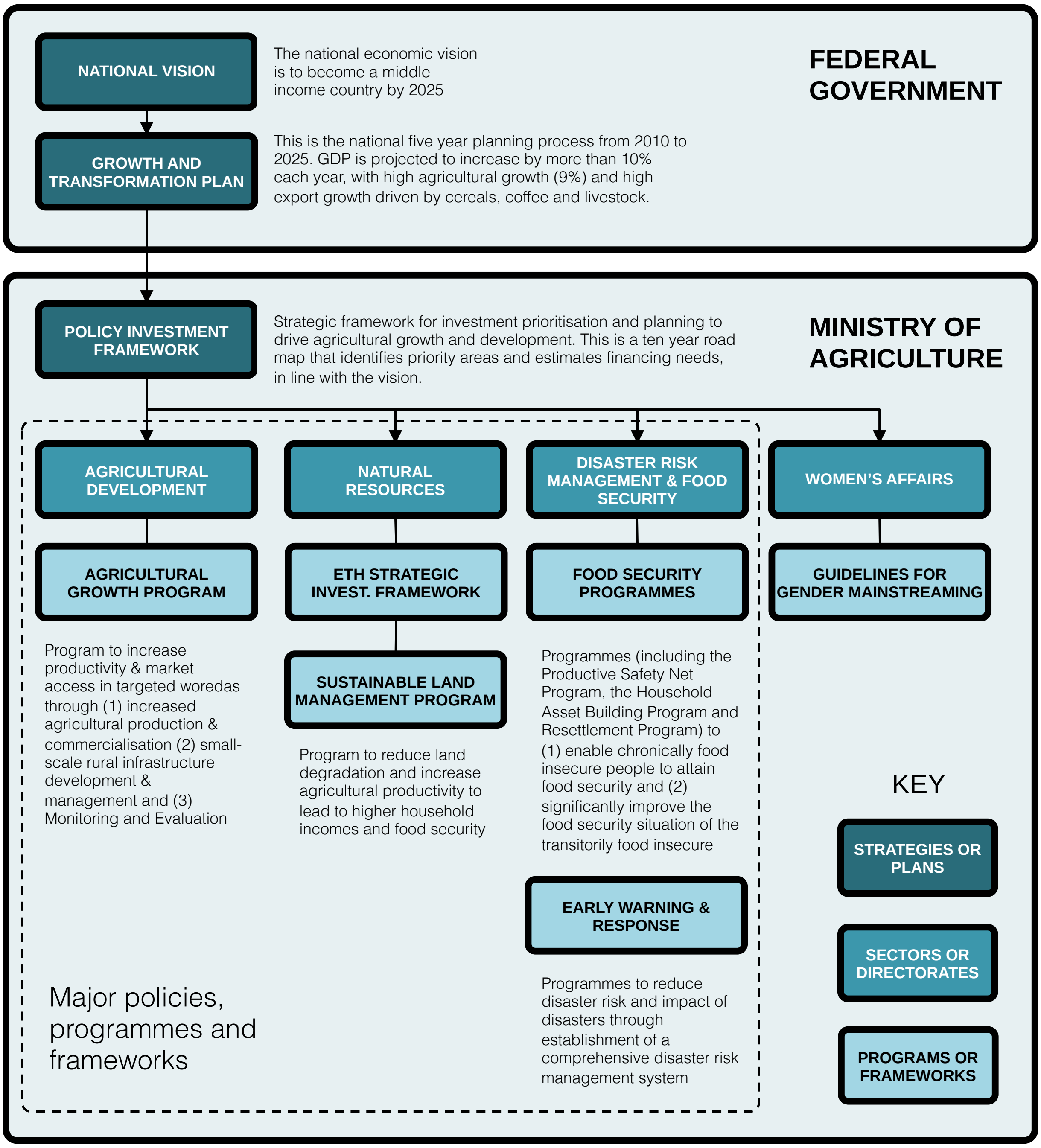
The previous chapter set out the key impacts of current weather variability and future climate change. We will now look at the key options that can build climate resilience to these hazards.

3.2.1. Identification of promising options

There is a very large number of possible resilience building 'options'. Resilience can be planned or autonomous, anticipatory or reactive, and with different sources of finance. It can range from capacity building and creating an enabling environment through to technical interventions at a local or national level. Governance and institutional structures, and policies to address key barriers, are as important as the specific technical interventions themselves.

Investment in agricultural development can come from federal or regional government budgets, donor financing or the private sector. At the federal level, the MoA is responsible for the implementation of actions related to agriculture. The MoA is currently engaged in a number of activities that build resilience, linked to national policy priorities and to its institutional framework (see figure 23). A high level stocktaking of these activities to inform the identification of 'promising' options has been undertaken. These promising options are strategic priorities to build resilience and were identified in three steps.

FIGURE 23 : **MAJOR AGRICULTURE PROGRAMMES AND PLANS**



3.2.2. Shortlisting process

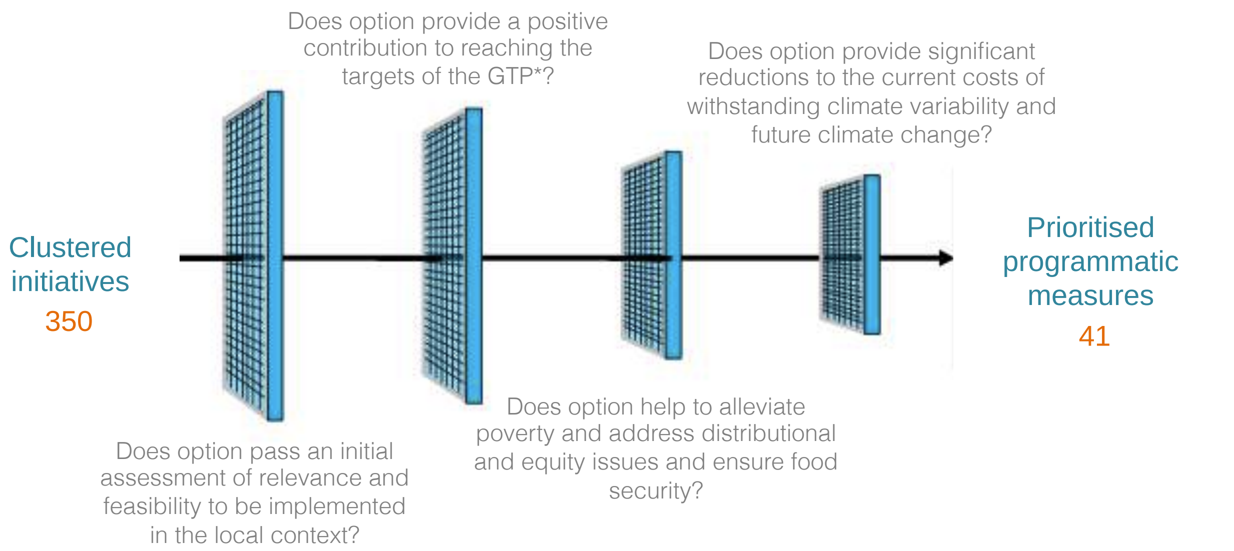
The first step was to identify a long-list of options to build resilience in agriculture. The adaptation plans reviewed were the EPACC, Ministry of Agriculture Adaptation Plan and the Regional Adaptation Plans. This analysis identified almost 1,000 potential adaptation options for building resilience within agriculture

The second step was to categorise the 1000 options: this resulted in a list of 350 unique options.

The third step was to filter the 350 options down to the promising programmatic options. They are programmatic in that each option could include multiple sub-options (e.g. crop switching would have multiple types of different sub-options). The options were filtered according to a number of criteria (see figure 24):

- **First criterion**. Does the option pass an initial assessment of relevance and feasibility to be implemented in the local context?
- **Second criterion**. Does the option provide a positive contribution to reaching the targets of the GTP?
- **Third criterion**. Does the option help to alleviate poverty, and address distributional and equity issues (women, children, people with disabilities), and ensure food security?
- **Fourth criterion**. Does the option provide significant reductions to the current costs of withstanding weather variability and future climate change?

FIGURE 24 : **FILTERING STEPS TO SHORTLIST RESILIENCE OPTIONS**



BOX 3 : **CONSISTENCY WITH THE GE STRATEGY**

The GE Strategy identified options for low-carbon growth in agricultural crop, livestock and forestry sectors. Of the four main pillars of the strategy, three are related to the sectors in the CR Strategy; (1) improving crop and livestock production practices for higher food security and farmer income while reducing emissions (agricultural and land use efficiency measures), (2) protecting and re-establishing forests for their economic and ecosystem services, including as carbon stocks (increased GHG sequestration in forestry) and (3) improving livestock management and productivity.

The GE Strategy makes a number of recommendations in agricultural crop, livestock and forestry sectors that have been reviewed with respect to climate resilience to ensure robustness. As an example the GE Strategy considered options to increase the productivity and resource efficiency of the livestock sector. It recommended to:

- Increase animal value chain efficiency to improve productivity, i.e., output per head of cattle via higher production per animal and an increased off-take rate, led by better health and marketing,
- Support consumption of lower-emitting sources of protein, e.g., poultry.
- Mechanise draft power, i.e., introduce mechanical equipment for ploughing/tillage that could substitute around 50% of animal draft power.
- Manage rangeland to increase its carbon content and improve the productivity of the land.

In looking at the potential linkages with climate resilience the following challenges and opportunities have been identified:

- Animal mix diversification has the potential to increase or decrease the vulnerability of the herd, depending on the species chosen.
- If poultry is to be house reared there is a need to ensure resilience to future temperature increases, i.e. sufficient ventilation.
- Mechanisation can reduce vulnerability through moving away from reliance on animals as well as increasing productivity.
- Finally, rangeland and pastureland management has resilience benefits by reducing soil erosion and increasing water infiltration.

This underscores the need to appraise options with both low-carbon and climate resilient growth as combined considerations.

TABLE 3 : **SHORTLISTED ADAPTATION OPTIONS**

THEME	PRIORITIZED OPTIONS (41)	EXAMPLE INTERVENTIONS	KEY RISK	SUB-SECTOR
Capacity building and institutional coordination	Climate information, research and enhanced co-ordination	Training and the use of networks to co-ordinate resilience responses between community's and delivery agencies. Also, research on climate, future climate change and responses.	Cross cutting	Cross cutting
	Institutional strengthening and building	Ensuring the correct institutions are strengthened and built to influence the uptake of resilience measures. A key area is land security.		
Information and awareness	Meteorological and agro-metrological data	Ensuring the collection and communication of data to farmers and communities.	Cross cutting	Cross cutting
	Agricultural research and development	Research programs to develop new seed varieties, test promising options, to monitor changes.		
	Enhanced extension services	Ensuring the dissemination of information to promote effective climate resilience so that options can be implemented in the local context.		
Crop and water management on-farm	Crop switching and new varieties	More heat resistant and drought tolerant crop varieties in addition to changing planting dates.	Climate variability	Natural Resources Management
	Fertilizer use	Additional fertiliser to increase productivity including the use organic manure and residues.		
	Farm management and technology	Improved farm practice including increased use of labour, diversified crop rotation and mechanisation.		
	Pests and disease (including post-harvest losses)	Monitoring of crop disease, improved storage facilities.		
	Irrigation	Different irrigation techniques including drip, communal, small-scale, home, and rain water harvesting.		
	Water infrastructure, allocation and transfers	Water allocation through market based systems, increased water use efficiency, dams, reservoirs, wells.		
Livestock	General animal and value chain improvements	Co-operatives, improved feeding systems, management techniques, improved extension services.	Climate variability, Pests and diseases	AGD
	Herd diversification	Changing species that are more resilient to climate change such as a move from cattle to sheep, goat and camel.		
	Breeding programmes	Breeding of climate resistant livestock		
	Improved animal health	Veterinary services, vaccines, changing practices		
	Fodder and feed improvement and resilience	Addressing food shortage, forage development, natural pasture improvement, changing feeding practices		
	Rangeland rehabilitation and management	Rotation of grazing, promotion of stall feeding, natural pasture improvement		
	Resilient animal housing	Shading and cooling, suitable housing for poultry farming		
Value chain and market development	Coffee	Monitoring temperature increases and pests and diseases, R&D, shade trees, conservation, store areas, future planned zones	Cross cutting	AGD
	Irrigated sugar plantations	Improved irrigation practice, river basin management, climate risk screening for new development		
	Roads	New roads, paving, design standards, drainage		
Sustainable agriculture and land management	Conservation agriculture	Zero or low tillage, cover crops, crop residues for mulching and soil cover	Soil erosion	Natural Resources Management
	Soil and water conservation (SWC) structures	Bunds, trees, grass strips, contour levelling, terraces, shade trees, waterways.		
	SWC cover crops and wild plants	Perennial grasses and legumes		
	SWC water harvesting	River basin planning, improved land managements		
	Soil management	Residue and manure crop fertilisation, agro-forestry, efficient use of fertilisers.		
	Agroforestry	Integration of forage legumes into agro-forestry systems.		
Natural Resources Conservation and Management	Using forests for adaptation	Supporting and encouraging forest growing, remove incentives for deforestation, create integrated land use planning.	Cross cutting	Natural Resources Management
	Resilience measures for forests	Support R&D, develop a national monitoring system for forests, ensure forest and species are resilient to changing climate.		
	Conservation and rehabilitation	Improving biodiversity		
	Promoting biodiversity in agriculture	Control and management of pest and diseases, institutions for biodiversity promotion, regional level monitoring systems		
	Payment for ecosystem services	Develop policy with a focus on watersheds		
Disaster risk reduction	Early warning systems	Enhancing drought and flood warning systems, flood forecasting and drought monitoring system, proper use of climate information	Floods & droughts	Disaster Risk Management and Food Security
	Disaster risk management planning	Information, risk profiling, risk screening		
	Insurance	Micro insurance, weather index insurance		
	Structural protection	Natural and manmade approaches to stop floods (e.g. river dikes)		
Social protection for high priority groups including women and children	Safety nets	Income supplementation, social support	Floods & droughts	Disaster Risk Management and Food Security
	Asset creation and protection	Community assets, restoration of homes, food storage facilities		
	Access to credit	Micro finance, improved information		
	Livelihood diversification	Income diversification both on-farm and off-farm		
	Resettlement/migration	Relocation of vulnerable communities from areas of high climatic risk		

This led to the identification of 41 promising programmatic options. As Table 3 shows, these 41 options have different characteristics in terms of the climate hazards they address, the sectors in the MoA and MEF that are critical to their delivery, and the APZs and political regions where they are most relevant.

Of these 41 options 38 are part of existing areas identified as potential resilience measures in federal, sectoral or regional adaptation or green economy plans. The 3 options not included previously were climate smart coffee, irrigated sugar plantations and payments for ecosystem services. The 41 options actually go further than previous studies and highlight more options (31 were present in the Regional Programme of Adaptation to Climate Change, 22 were present in the MoA Programme of Adaptation to Climate Change, 13 in the GE Strategy and 12 in the EPACC.

While the CR Strategy is a federal level strategy, resilience activities are relevant at the local scale related to unique climatic and socioeconomic characteristics. Our analysis shows that the 41 promising options are applicable to most APZs, and also to most regions. However, the level of relative priority will vary, and individual sub-options will differ in response to the specific local nature of risks.

3.3. APPRAISAL OF OPTIONS

The identification of the 41 promising options were identified at a high level using expert elicitation. However there is a need to understand how to appraise these options in more detail to inform where (based on their specific characteristics) and when they should be implemented. The answer to where is informed by a multi-attribute analysis (MAA) and when is informed by an iterative risk management (IRM) approach.

3.3.1. Multi attribute analysis

A MAA recognises the uncertainty and difficulty in attempting to undertake a narrow cost benefit analysis of options. A MAA looks at the 'attributes' of different options. This includes an appraisal of costs and benefits but also a number of other criteria to identify specific characteristics of options. This helps policymakers identify the appropriateness of the options in different local contexts. This appraisal was undertaken through a stakeholder workshop with experts from across Ethiopia.

Each option has been assessed against 5 criteria, made up of specific attributes (see figure 25). Each option was scored qualitatively from 1-4 with 1 performing weakly against the given attribute up to four that performs strongly (e.g. a 1 scored against the attribute urgency would mean it was not urgent, a 4 would mean very urgent). The MAA also linked the resilience measures to which livelihood group they were most applicable to and to which APZ. An example for soil and water conservation structures is shown in Table 4.

FIGURE 25 : **CRITERIA FOR MULTI ATTRIBUTE ANALYSIS**

ECONOMIC COSTS AND BENEFITS	CLIMATE RESILIENCE AND ROBUSTNESS	SYNERGIES AND CO-BENEFITS	URGENCY	DISTRIBUTIONAL EFFECTS & GENDER	INSTITUTIONAL FEASIBILITY / PHASING
UNIT COSTS	INCREASED TEMPS AND RELATED HAZARDS	ECOSYSTEM SERVICES & SUSTAINABLE LAND	COSTS	POVERTY & EQUITY	LEAD STAKEHOLDER
PROGRAM COSTS	DROUGHT	CONSERVATION & BIODIVERSITY PROT.	BENEFITS	GENDER	PRACTICALITY
UNIT BENEFITS	FLOOD & INTENSE RAINFALL	ECONOMIC GROWTH / AG. TRANSFORMATION	NO. OF BENEFICIARIES		SCALE OF EFFORT*
TOTAL BENEFIT	RESILIENCE*	LOW CARBON FUTURES	FINANCE		
NO. OF BENEFICIARIES					

* Both in the near term and in the face of long term climate change

* From federal to impacts at the local level

The MAA did not assign weights to the criteria and attributes, therefore it does not say whether a 4 score in biodiversity is equal to or yields a greater benefit to society than a 4 in economic growth. Therefore the output of this analysis is not a prioritised list from 1 to 41 but a qualitative assessment of the relative merits of the options.

An output of the MAA provides three things. First, it validates the options identified. The outcome of the MAA showed that all promising options were validated. Second, it displays the different characteristics of options to inform what options should be prioritised. For example if the policy focus was on resilience to floods and gender equity, then options that performed strongly in those areas could be sequenced first. Third, the criterion of urgency is informed by the perception and scoring of the other criteria.

TABLE 4 : **MAA EXAMPLE**

Example of multi attribute analysis – here applied to the soil and water conservation option.

ATTRIBUTE		A	B
Institutional feasibility	Leadership	3	3
	Practicality	3	4
	Scale	3	3
Climate risk and opportunities	Temperature	3	2
	Drought	3	3
	Floods	3	3
	Resilience	4	3
Synergies & co-benefits	Poverty & equity	3	2
	Gender	2	3
	Ecosystem services	3	3
	Biodiversity	3	3
	Economic growth	3	3
	Low-carbon futures	3	2
Economic cost and finance	Cost per person or per hectare	2	2
	Economic cost for project/program	2	3
	Benefits per person/hectare	2	2
	Number of beneficiaries	3	2
	Nature of economic benefits	3	2
Urgency		3	4
Adaptation zones	Arid and semi-arid	✓	
	Transition, sub-humid	✓	✓
	Highlands, sub-humid to humid	✓	✓
	Urban aras and market		
Livelihood	Pastoral		
	Agro-pastoral	✓	✓
	Cropping	✓	✓
	Commercial		

A = ranking through the literature review
B = ranking at the priotization workshop

Note: SWC structures are part of sustainable agriculture and land management. Measures include structure bunds, trees, grass strips, contour levelling, terraces, shade trees, and waterways.

3.3.2. Iterative risk management

Following from the MAA, we have undertaken an IRM approach to sequence resilience options. This takes account of the uncertainty in future climate change. This approach builds on the latest recommendations of the Inter-Governmental Panel on Climate Change (IPCC), and their special report on extreme events, which recommends the use of IRM approaches.

The IRM looks at how to implement options over time, based on current impacts (and the adaptation deficit) and projected future climate change, against a background of uncertainty (see figure 26). The IRM looks at three time periods to analyse when to sequence options based on these key climate risks: the short term (now), the medium term (2025) and the long term (2050+). It looks at how to implement options based on current and projected future climate and the associated risks. Options should be sequenced in a robust and flexible manner given this uncertainty and should be matched to risk areas and key decision thresholds.

In the short term, the focus should be on three types of resilience building actions to undertake IRM:

- First, are **low- and no-regret** actions. These options result in social and economic benefit irrespective of the envelope of future climate change, and thus provide immediate benefits for economic growth, as well as enhancing long-term resilience. In practice this involves general levels of capacity building that should be strengthened to ensure the institutional frameworks and an enabling environment are created to allow subsequent resilience mainstreaming and integration. This involves the information for decisions, and the research for future options. This should include the planning capacity required to undertake IRM itself.
- Second, are **climate proofing** actions. These should be implemented and integrated into development immediately to make development more effective and 'climate smart'.
- Third, are **climate-justified** actions. These actions are proactive investigations of certain long-term issues that need to start immediately. These include early monitoring and research into responses, and for areas where decisions with long life-times (e.g. infrastructure, forest planting) with risks of locking Ethiopia into a non-resilient development path.

The options by theme are shown in Table 5. Our analysis of the options shows that all should be implemented in some form immediately, though some of the long-term areas might only require initial investigation.

TABLE 5 : **RESILIENCE OPTIONS BY IRM THEME**

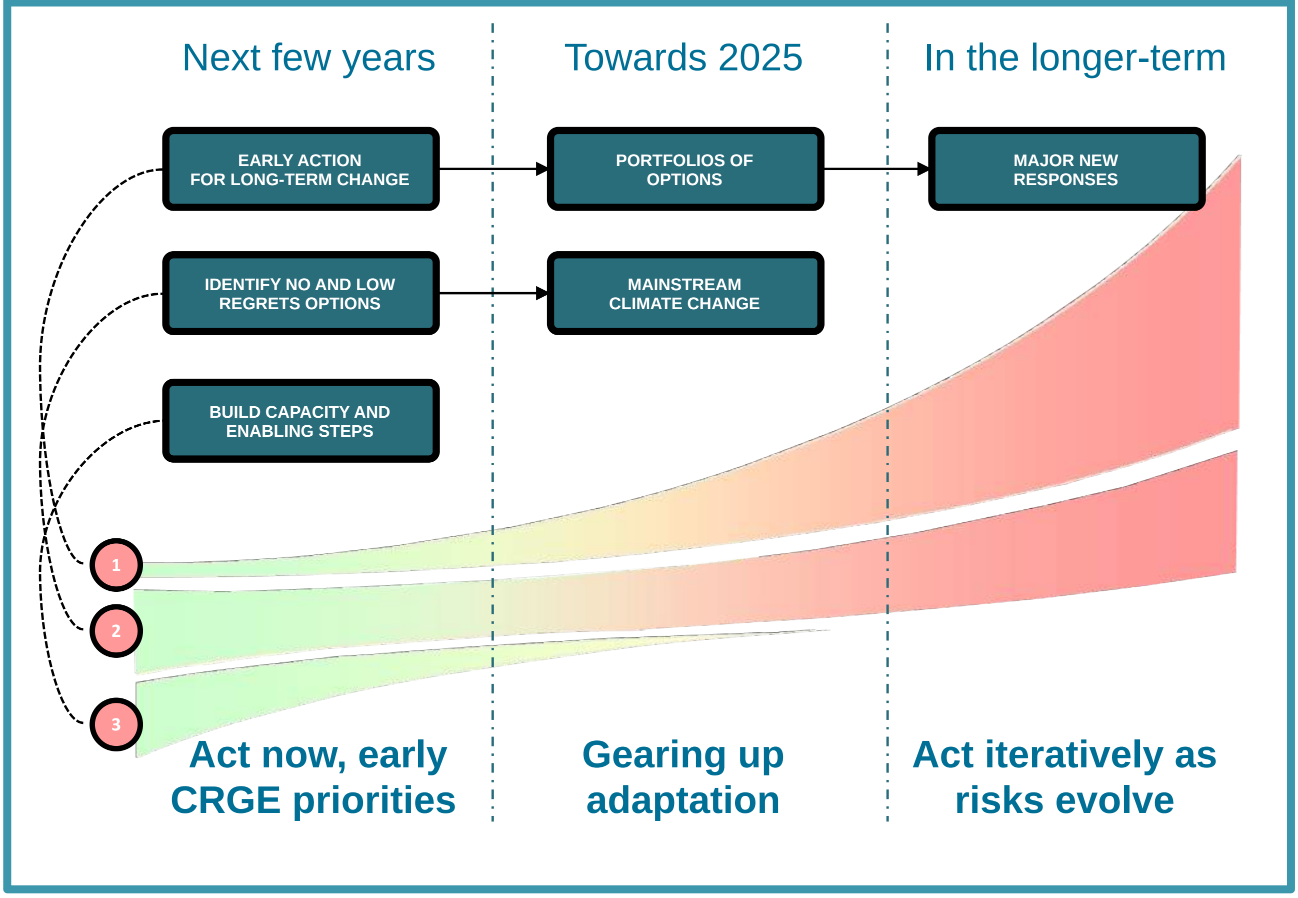
Capacity building	Low and no regret options	Long term options
Climate information, research and enhanced co-ordination	All other options	Irrigated sugar plantations
Institutional strengthening and building		Roads
Meteorological and agro-metrological data		Animal housing resilient to increased temperatures
Agricultural research and development		Structural protection
		Resettlement/migration

In the period to 2025, consistent with the GTP objectives, the low and no regret options will have been delivered and Ethiopia will have the institutional and technical capacity to deliver climate resilient growth. The focus will be on on-going delivery of climate proofing actions that build resilience, fully integrating these into the delivery of development activities to ensure climate resilient growth (i.e. all development investment is screened for its compatibility with climate resilience). At the same time, the development of portfolios of climate justified options to deal with possible future risks should be assessed in detail, building on the information, emerging monitoring information, and early research taken in the first period.

In the long term (post 2025) these portfolios of options will need to be implemented, noting that the specific activities will vary according to the evolution of climate risks, and how these match to the scenarios outlined in chapter 2. Under scenarios that lead to more negative impacts of climate change the portfolios of options will need to be significantly scaled up, and brought forward.

The key advantages of such an approach is that it seeks to exploit quick wins, by addressing the existing adaptation deficit at the same time as building future resilience. It also makes sure irreversible decisions are not taken now, which may or may not be needed depending on the level of climate change that arises. By doing so it encourages decision makers to ask "what if" and develop a flexible approach, where decisions are reviewed over time, and plans adjusted as the evidence emerges. This builds in flexibility, reduces the risk of lock-in or stranded assets, and aims to keep future options open (see box 4).

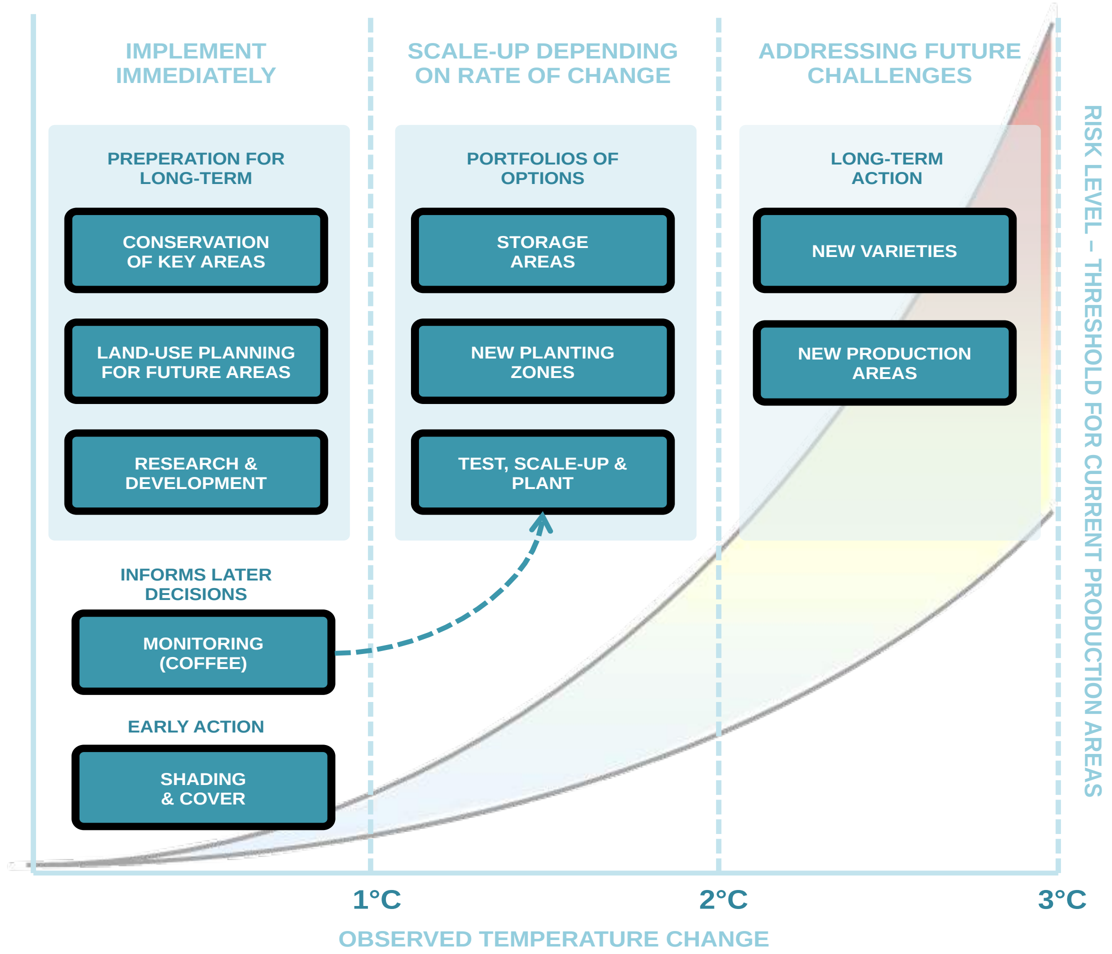
FIGURE 26 : **ITERATIVE SEQUENCING OF RESILIENCE OPTIONS**



BOX 4 : **ITERATIVE RISK MANAGEMENT AND COFFEE**

To give an example of the IRM, consider the crucial cash crop, coffee. Our coffee exports currently earn around $800m a year, which is set to double by 2015 under the GTP. Research shows the current species of export coffee (Arabica) will be affected if temperatures increase by more than around 2°C from today, shifting many current coffee production areas out of their optimal range, and reducing quality and yield. Projections as to when this might happen range from 2030 to beyond 2050, according to whether temperature increases are at the higher or lower range of the model projections.

The IRM approach recognizes that addressing this risk involves a number of short- and long-term responses, which are inter-linked. There is an immediate need to develop a monitoring, awareness and capacity building programme, to provide the baseline and early signs of changes in yield and quality. A second set of early responses is to investigate and promote early adaptation options, which can help current plantations cope, such as through the use of shade trees. Finally, a third set of actions is needed to start planning for future temperature rises, which includes a number of options, such as (i) to develop an R&D program to develop or adopt new strains of Arabica that are resilient to the potential increase in temperatures – noting this would take up to 25 years and there is not time to wait for the temperature change to occur before starting this strategy (ii) to identify potential new areas for production under future climate envelopes, and investigate the potential for production shifts. If the temperature is rising on a rapid trajectory, then these options can be rolled out more quickly. If the rise is slower, then lower cost options can be implemented.



3.4. COSTING

The multi attribute analysis has identified that all options to build resilience are suitable, that options have specific characteristics and highlighted which ones are urgent. The IRM has shown that options need to be sequenced and the ability to implement options in the medium and long term are path dependant on decisions and actions made in the short and medium terms respectively.

Our analysis of promising options identified which options will build resilience and if they are being delivered by current programmes and plans aligned to the MoA. Within the MoA many existing programmes are already seeking to address the existing impacts of weather variability identified in Chapter 2. By building on existing activities it grounds the implementation of future resilience options within the existing institutional and governance structure in government. This gives rise to two questions.

(1) Are the promising options identified currently being delivered in agriculture and forestry at the scale that is required to deliver climate resilient growth and where are the major gaps?
(2) What is the financial requirement to improve or develop programmes to build climate resilient growth?

In order to answer these questions we have estimated the total investment needed to build resilience using an investment and financial flow (IFF) analysis.

3.4.1. Investment and financial flows analysis

To address the questions above, the following steps have been undertaken:

Step 1. Historic investment. The first step was to compile a historic assessment of agriculture and forestry sector investment across expenditure from various sources.

Step 2. Future baseline. The next step was to assess future investment profiles, based on the continuation of current policies and plans, under a future where no new measures are taken to address climate change.

Step 3. Future resilience investment. The final step was to assess the additional resilience investment needs, estimating the uplift on existing activities and the development of new programmes to build climate resilience.

3.4.2. Historic investment

Historic investment has been estimated in three steps.

First, the spending and investment on agricultural and forestry activities during the period 2007-2013 was assessed with respect to expenditure profiles (i.e. what money is spent on) and source of finance (i.e. where money comes from). The expenditure profile makes the distinction between capital investments, capacity building costs and operation costs. The source of finance is disaggregated by budget expenditure (in the MoA and regional budgets), foreign grants, foreign loans, other internal funds and private sector.

Second, the budget expenditure within the MoA was analysed in detail. A detailed review of Federal MoA programming was undertaken for the period 2007-2013 to identify which of the 41 resilience options are already part of existing programmes. If programmes are delivering resilience, the proportion of the programme devoted to the resilience options has been estimated.

Third, an assessment of other agriculture sector investment was made for the period 2007-2013. There has not been an assessment of other sources of finance due to the lack of detailed programme data (i.e. regional budgets, foreign grants, foreign loans, other internal funds and the private sector).

Our analysis reveals there is substantial overlap between activities currently financed under the Federal MoA budget and the 41 resilience options identified. Our analysis indicates that over the period 2007-2013, more than 60% of the MoA budget was spent on resilience-oriented activities (see figure 27). Most of this relates to social protection for vulnerable groups through food security and income diversification programmes. Vulnerable groups are particularly exposed to climatic impacts, and such programmes both protect them from shocks as well as supporting graduation to more productive and growth-oriented activities.

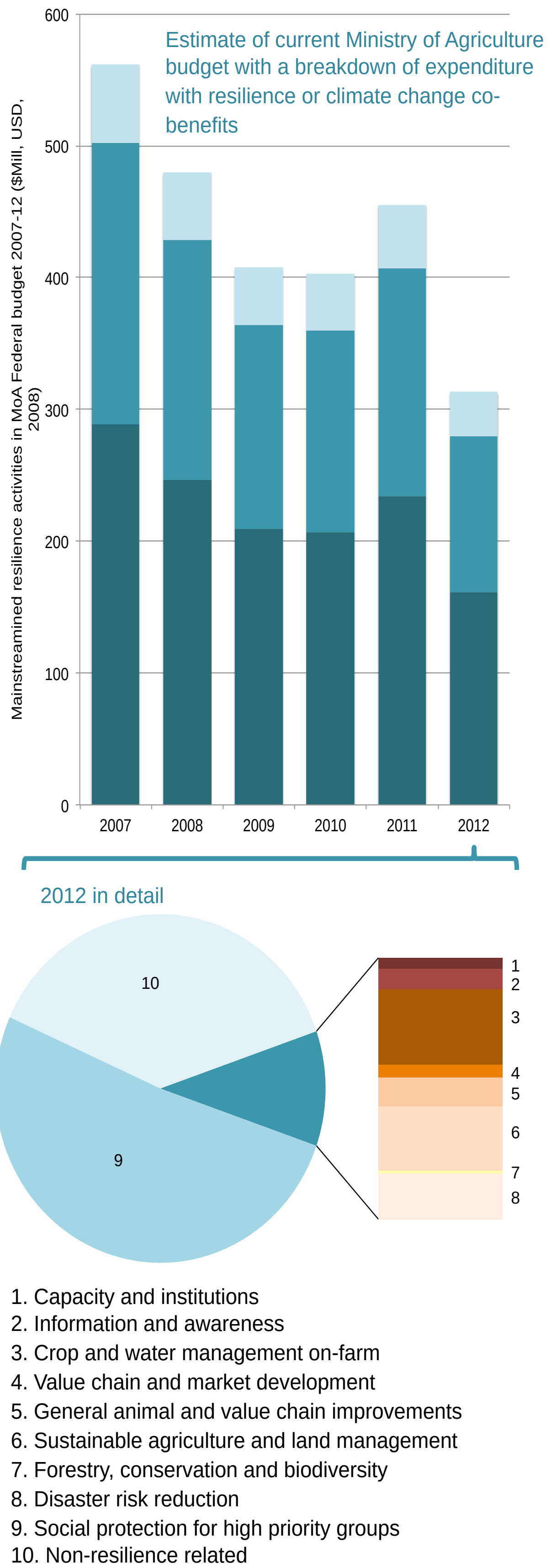
3.4.3. Future baseline

Our analysis of 2007-2013 was used to project the baseline expenditure profile, source of finance and (for the MoA) resilient relevant expenditure to 2030 (see figure 28). This projection is based on a number of assumptions including a steady growth in agricultural budgets and the investment required by the private sector to convert commercial land at the rate outlined in the GTP.

There will be an increasing role for the private sector in delivering a resilient agriculture sector. Over the period 2007-2013, more than 80% of agricultural investment was within a government budget, with the private sector accounting for only 20%. However, private sector financing is projected to double by 2030, making up 40% of the projected $5bn of total investment per annum in 2030. This reflects plans to substantially increase the rate of agricultural land commercialisation under the GTP. There is a clear role for government in ensuring that the enabling framework to support private sector investment in resilience is strengthened.

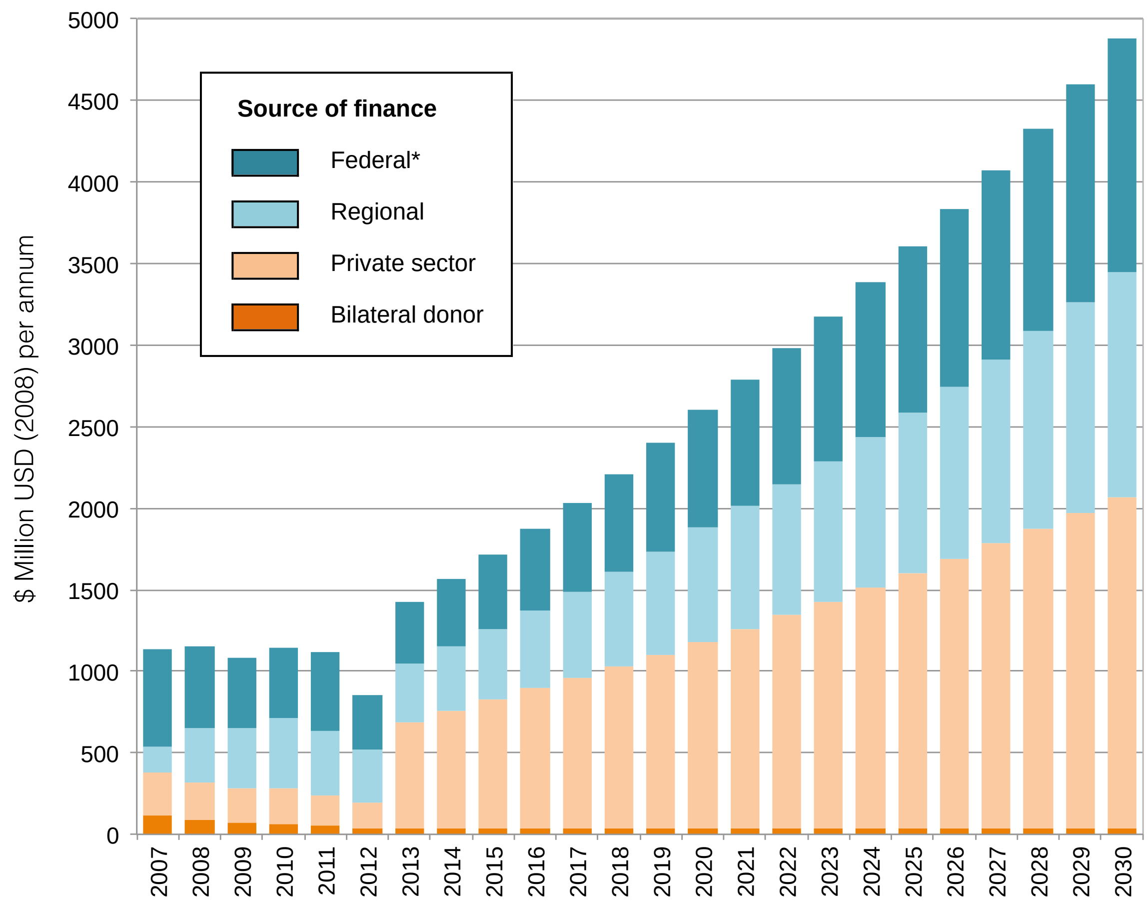
It is important to note that the growth rates of investment in the baseline are subject to uncertainty. This has implications for resilience activities delivered through the baseline, as if growth rates are not achieved this will result in a

FIGURE 27 : **AGRICULTURE EXPENDITURE**



reduction in baseline resilience expenditure.

FIGURE 28 : **PREDICTED AGRICULTURE INVESTMENT BY SOURCE**



3.4.3. Future resilience investment

To ascertain how much additional finance is required to build resilience, an assessment was made of the volume of climate relevant activities already mainstreamed into existing and future federal budgets within the MoA. For each option that was present, a *resilience action requirement rating* was assigned to the programme delivering the option (see Table 6). Based on this assessment, an additional programmatic budget was assigned to each option, ranging from no additional investment to $2.5m per annum. The second criterion was the extent to which relevant activities are already being financed through MoA projects irrespective of the presence of a programme. Based on this assessment, a percentage uplift of the existing budget was assigned, ranging from 0% to 100% per annum. For other types of investment broad assumptions were made to the uplift required to deliver resilience activities.

Our analysis has also sequenced the options within the MoA as informed by the IRM. For example programmatic investment in capacity building will need to take place earlier, while those options that only have long-term characteristics will need lower initial funding but will need to scale up with portfolios of options in the medium term.

TABLE 6 : CALCULATING ADDITIONAL FUNDING REQUIREMENTS

Rating	New program investment	(US$ millions)	Uplift of current activity spend for a given priority area	
High	$2.5m	There is no current or planned programme addressing the issue	100%	There is only limited budget targeted at this area, and a substantial increase is warranted
Medium	$1m	Some limited elements are covered in existing programmes, but not in a coordinated way	50%	There is a moderate budget targeted at this area, and it should be increased
Low	$0.5m	There is a dedicated programmatic element, but further strengthening is required	10%	There is substantial budget in this area, but it could benefit from additional funds for regional coverage
None	$0m	There is strong dedicated programme activity and no additional programme frameworks are required	0%	The existing budget is already substantial and further expansion of budget is not required

TABLE 7 : ADDITIONAL FUNDING REQUIREMENTS

	2015	2020	2025	2030
MoA Federal Budget	77	113	152	236
MoA Regional Budget	6	9	11	18
MoA Accountable Institutions	80	118	158	245
Donor bilateral	2	2	2	2
Total GoE and donor	**165**	**242**	**323**	**501**
Private sector	39	57	78	101
Grand total	**205**	**299**	**401**	**603**

All figures are in US$ million using 2008 prices

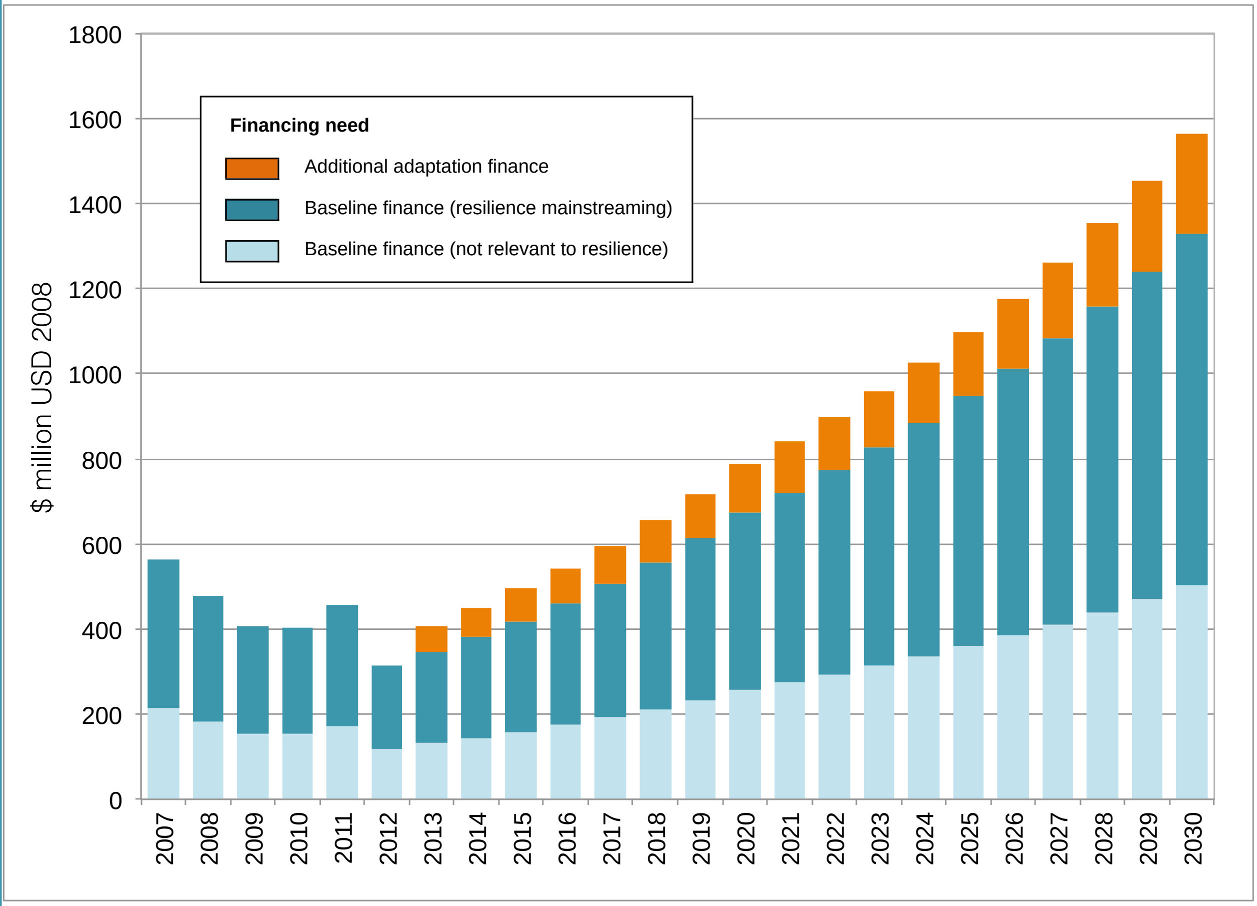
3.4.4. Conclusions on the financing need

The programmatic investment and budget uplifts are indicative guidelines to give an indication of the scale of investment required. These are order of magnitudes only as they have not been matched back in detail to the cost incurred because of future climate change set out in Chapter 2. More detailed and robust investment requirements will become apparent in future phases of planning.

The analysis of investment flows in the agriculture sector leads to four conclusions. First, the requirement to build resilience is approximately 11% per year over and above baseline investment (see figure 30). The additional financing costs for the public sector (covering federal and regional programmes, and MoA Accountable Institutions) are estimated to be more than $130 million per year in 2013-14, rising to $240 million per year by 2020 and more than $500m per year by 2030. When private sector costs are included, additional financing requirements increase to around $300m per year in 2020 and $600m per year by 2030. It is estimated that 80% of the additional costs will fall on the public sector budget ($1.8bn total discounted over the period 2013-30). These costs are shared equally between the Federal and Regional agricultural budgets. The private sector bears 20% of the additional costs (see table 7).

Second, the additional financing costs of resilience remain relatively small in comparison to the scale of existing resilience mainstreaming in current baseline projections (figure 29). Activities in 2030 will need to be uplifted by 18% to build climate resilience in the public sector and by 5% in the private sector. This underscores the risk of any shortfall of any resilience expenditure projected to be delivered in the baseline. Any shortfall of resilience expenditure in the baseline will increase the need for additional investment to build resilience. This can be seen in figure 31 where the total resilience expenditure for the federal MoA in 2030 is around $1 billion (noting that part of this expenditure will no rest with MEF). This rises to around $3.5 billion when all agriculture expenditures are considered: regional, MoA accountable institutions and the private sector.

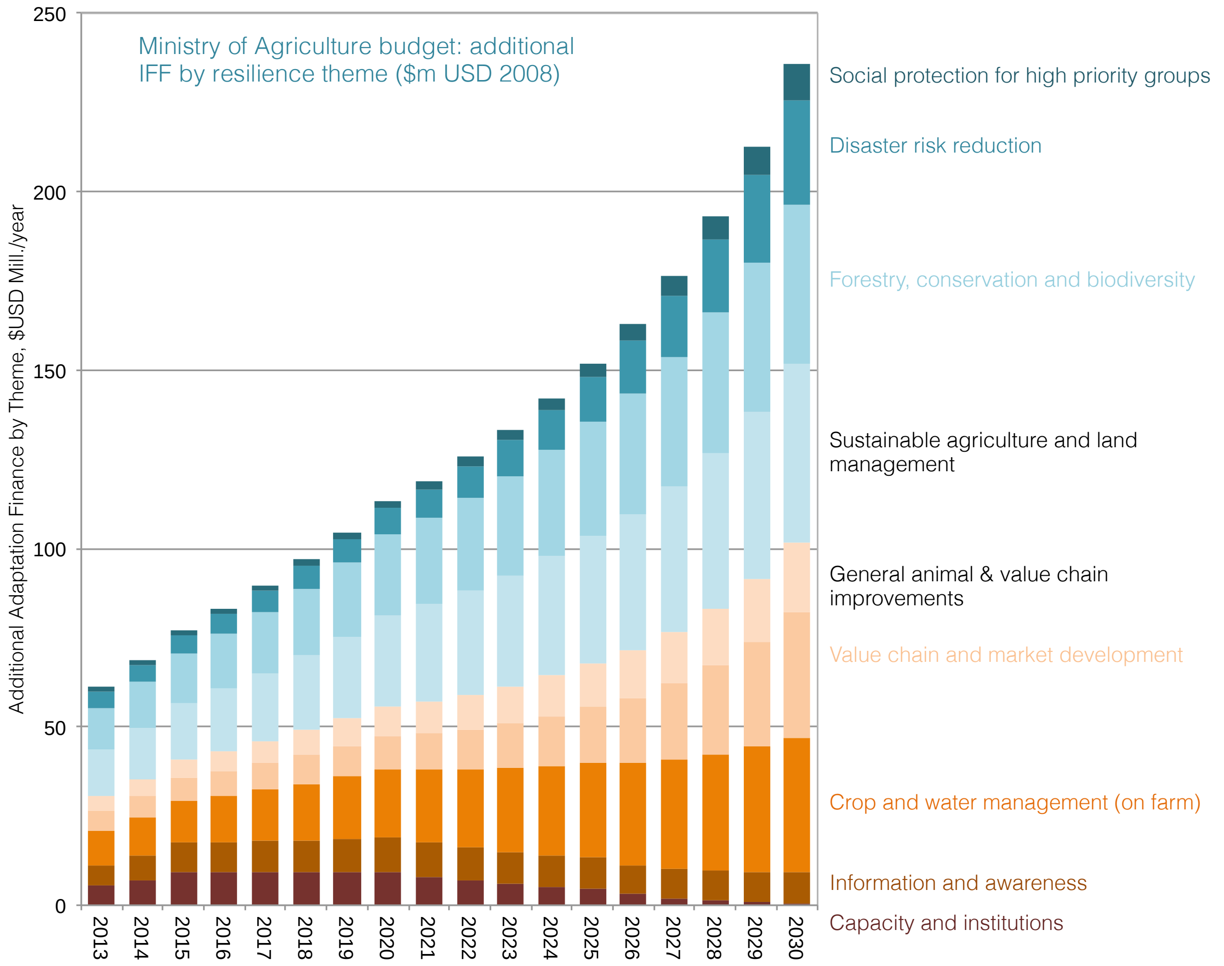
FIGURE 29 : **ADDITIONAL ADAPTATION FINANCING NEEDED**



Thirdly, our analysis highlights which specific areas of the MoA budget need uplift over the baseline (see figure 30). Social protection makes up a large proportion of the MoA budget in the baseline but represents only 12% of additional resilience expenditure. This is because the current programme structure are addressing climate vulnerability among exposed populations and the issue is being effectively mainstreamed. Our analysis shows that the majority of additional expenditure will be required in Natural Resource Management and Agricultural Development pillars.

Finally, the exact costs of resilience activities will depend to some extent on future climate change and the scale and level of autonomous adaptation. Our analysis considers the two scenarios of climate change outlined in chapter two to estimate additional resilience expenditure required under these scenarios. Under scenarios of average modest warming and increased rainfall, the level of risk is lower, and less of the additional future portfolios will be needed. Under hotter, drier scenario the existing mainstreaming of resilience and the additional investment in resilience would need to be scaled up, to make sure that existing resilience gains (against the adaptation deficit) are protected, and most importantly, to scale up the portfolio of resilience measures so as to address likely future major risks in the period 2030 onwards.

FIGURE 30 : **ADDITIONAL FINANCE REQUIRED BY RESILIENCE THEME**



CHAPTER 4
MAKING IT HAPPEN

Setting the foundations for the implementation of climate resilient activities

KEY MESSAGES

Macroeconomics

- The delivery of the CRGE will span the entire national economy, therefore it is necessary to consider the macroeconomic aspects of building climate resilience. The five key factors for building resilience are:

  1. Human capital accumulation
  2. Sound management of natural capital
  3. Strengthening physical capital
  4. Building market institutions
  5. Macroeconomic stability

Prioritisation

- We have identified 15 priorities for implementation that cover macro level responses (focusing on benefit to GDP), household level (to protect vulnerable groups) and biodiversity (recognizing its importance for resilience).
- The total cost of implementation of these 15 options is $97 million for the federal budget ($132 million including regions and accountable institutions).

Implementation

- We have identified three approaches for managing and implementing climate resilience: federal, basinwide and regional. These are not exhaustive but we have attempted to show some of the key considerations to be incorporated in the implementation of resilience activities.

- Flooding impacts across a number of river basins and regions, therefore it will be crucial for the River Basins Authority and the MEPF to coordinate an effective response to this key climate risk. Risks and response measures have been mapped to regions and through extensive consultation, coordination and capacity building, the relevant priorities for implementation will be identified.

Way forward

- The foundations for implementation have been laid, the CRGE facility has been launched and we have outlined our economy wide plan for implementation, the Sectoral Reduction Mechanism.

4.1 REALISING CLIMATE RESILIENCE

The previous chapters have charted the scale of the challenge and our options for responding. This chapter outlines the next steps for building climate resilience. It first assesses climate change and macroeconomics, recognising the role that macro economic policies play in ensuring resilience. It then identifies the options to prioritise in light of financial and capacity constraints. It then turns to possible resources to help finance an effort to build resilience.

4.2 MACRO ECONOMICS

The previous chapter discussed individual resilience options to build climate resilient growth. However climate resilient growth will be delivered in the context of broader macroeconomic factors whose policy reach extends beyond the MoA and MEF. In addition climate change will have an impact on these factors and therefore wider macroeconomic planning needs to take this into account. We have identified five macroeconomic factors important for growth.

4.2.1. Human capital accumulation

Human capital is the ability of a workforce to produce valuable goods and services. The core components are health and education. Climate change will have a detrimental impact on human capital, largely due to the impact of increased natural disasters and diseases.

Climate change will necessitate additional training and knowledge particularly for farmers. This could require coordination of educational and skills training that go beyond MoA and MEF to ensure that skills in resilience planning are integrated into different organisations and institutions. This could include the use of educational institutions but also NGOs.

4.2.2. Sound management of natural capital

Natural capital is defined as the natural resources available to a country that can either be used in the production of goods, or can directly provide valuable services. Markets do not capture all of the services provided by natural capital. Goods like timber and food have a market value, but many cultural and environmental services do not. These services are therefore undervalued and the ecosystem that provide the services are insufficiently protected.

In the context of climate change hazards, greater natural capital protection is needed in water, land, soil and other components of natural ecosystems management. Explicit attention should be given to natural resource management and ecosystem services in the GTP. This could be achieved by considering including natural capital measurement in national accounts in order to provide a view of its importance for future management, and to allow the value that can be created from it to be incorporated into our growth strategy.

4.2.3. Physical capital

Access to markets

Market access operates at a number of levels. First, it works through access to domestic markets, such as farmers gaining access to urban markets for produce through better transport. Second, market access functions through access to international markets through the removal of trade barriers and improvements in access to air and seaport infrastructures. This market access increases income and creates the potential for greater economic specialisation, which can provide increases in efficiency that lead to greater economic growth.

In relation to climate change at a domestic level, rural farmers are linked to the market through institutional and physical infrastructures. The latter is particularly susceptible to disasters and maintaining functioning infrastructure is vital to ensuring market access. This can be overcome by considering the susceptibility of key infrastructures and how to address key risks. The same is true of infrastructures that link Ethiopia with neighbouring ports. Climate change may alter demand, temporarily or even permanently, at the domestic level, but also for Ethiopian exports and supply of critical imports. Policymakers should also be mindful of the substitutability and specialisation risks in considering diversification of crop types, crop uses and export destinations.

Infrastructures

Infrastructures, such as transport, telecommunications and electric power, are of central importance for the efficient production of goods and services. Unreliable infrastructure discourages firms from investing in a country, limiting expansion of the private sector, and will increase costs for domestic firms. Without reliable infrastructure, it is impossible to adopt many of the efficiency improving innovations of recent years, such as just-in-time supply chain management. Finally, poor infrastructure creates unnecessary fragilities and increases uncertainty and risk. Improvements in infrastructure will therefore feed through into greater macroeconomic growth.

Roads and dams are two types of infrastructure where climate change impacts are likely to be particularly important for agriculture. This is for both market access and to provide water for irrigation. Investment appraisal of infrastructure planning should incorporate climate risks. For example dams should be situated in optimal locations to meet demand for water for both hydropower and agriculture.

4.2.4. Market institutions

Access to credit

Credit access is important to enable businesses to make long-term investments, which will, eventually, lead to increases in productivity. This is a key barrier to funding resilience options especially where there are high upfront costs or where resilient options have higher costs than alternative technologies that would not build resilience. The next chapter covers how problems of financing and access to credit can be overcome to build climate resilience.

Productivity, performance, institutions

These would be delivered through the delivery of the resilience options highlighted in this chapter where there are specific options to deal with these factors. However, the role of cross cutting policy and institutions should be additionally considered, especially where there are large interdependencies between sectors (e.g. when considering water access for agriculture, domestic use and large scale energy generation).

4.2.5. Macroeconomic stability

These factors are widely considered good for economic growth. Competition can stimulate economic growth by promoting efficiency and innovation, while macroeconomic stability is important for incentivising foreign direct investment, stability of government revenues and maintaining full employment. Both of these factors also have an impact on agricultural output, will be influenced by climate change and can build climate resilience.

4.3. PRIORITISATION AND FINANCE

The previous chapters have charted the scale of the challenge and our options for responding. This chapter outlines the next steps for building climate resilience. It first identifies the options to prioritise in light of financial and capacity constraints. It then turns to possible resources to help finance an effort to build resilience.

4.3.1 Prioritisation

The additional cost of implementing all 41 resilience options is an additional amount of $600 million per year by 2030. This is on top of substantial increase in investment in resilience activities expected under the baseline; total expenditure on resilience will be around $3.5 billion. Our analysis has also suggested that all options should start being implemented immediately to some extent. However, it is likely that there could be financial and capacity constraints and therefore there is a need to prioritise the options in light of these constraints. Through stakeholder consultation, examining current gaps in programmes and policies as well as priorities for development, three categories for priority actions have been identified: These are: those that build resilience at the macro scale, with the greatest benefit on GDP, those that will build resilience at the household scale, protecting the most vulnerable in society, and options to build resilience in biodiversity, recognising the importance and multiple benefits that biodiversity plays for resilience. These top 15 priorities with a validation for their urgency are listed below. The total immediate financial requirement from the MoA budget only for these 15 options is $97m per year (with total investment including the baseline of $132m).

TABLE 8 : **MACRO LEVEL RESPONSES**

Option	Discussion
Climate information, research and enhanced co-operation	Early priority as early capacity building step.
	Particularly important as provides information base for later decisions; as needed for coffee, and need for sufficient data and research information in future periods.
Institutional strengthening and building	Early priority as early capacity building step.
Meteorological data	Early priority as early capacity building step.
	Particularly important as provides information base for later decisions, and need for sufficient data periods.
Agricultural research and development	Early priority as early capacity building step. Particularly important because of time period for R&D and testing prior to scale-up (e.g. for developing new varieties).
Climate smart irrigation (i.e. sugar)	Major programme identified by the Investment Financial Flow (IFF) analysis.
Crop switching and new varieties	High existing adaptation deficit. Priority for early research given need to match emerging trends, and long time-scale for development programmes. Subject of existing programmes (as part of MoA accountable institutions) but still need for further investment.
Coffee (monitoring (yield, quality, pests), capacity building, new varieties, shade trees, conservation, new plantations).	Relative low temperature tolerance levels for current varieties and areas. Potential scale of medium-term effects very large.

TABLE 9 : **HOUSEHOLD LEVEL RESPONSES**

Option	Discussion
Conservation agriculture (zero or low tillage, cover crops, crop residue)	Significant opportunity for benefit, has co-benefits with mitigation and provides immediate benefits for resilience
Soil and water conservation (SWC) structures (bunds, trees, grass strips, contour leveling, terraces, shade trees, waterways).	High existing adaptation deficit and thus provides immediate benefit.
Soil management (residue and manure crop fertilisation, agro-forestry, efficient use of fertilisers, etc.)	High existing adaptation deficit and thus provides immediate benefit.

TABLE 10 : **BIODIVERSITY RESPONSES**

Option	Discussion
Using forests for adaptation	Major programmatic gap identified in IFF. Also provides an overlap with the GE Strategy. Improving conservation and management of remnant forests a priority.
Resilience measures for forests (support R&D, develop a national monitoring system for forests, ensure forest and species are resilient to changing climate).	Major programmatic gap identified in IFF. Identified as stakeholder priority because of long-life times.
	Key for supporting the emissions reductions
Payment for Ecosystem Services	Major programmatic gap identified in IFF
Sugar plantations (irrigation)	Major programmatic gap identified in IFF
Conservation and rehabilitation	Major programmatic gap identified in IFF
Promoting biodiversity in agriculture	Major programmatic gap identified in IFF

4.3.2. Types of finance

We view building climate resilience as a domestic priority requiring domestic finance. For this reason, we will continue to target national funds to government programmes that tackle food security, environmental management and other activities that build climate resilience. However, the international community also has a role to play in supporting resilience efforts in developing countries. A common concern is that the many different initiatives from different partners make it difficult to 'navigate' the landscape and match resilience priorities with funding sources. In addition, the potential role that the private sector (both domestic and international) can play in supporting resilience activities needs to be more clearly demarcated.

We have to address these challenges in the context of our priority resilience options, looking at both the type of financial resource that might be used to support a particular project or programme (in other words, grants, loans and so on) and the ultimate sources for that finance (public or private, domestic or international). Of course, there are inevitable overlaps between these layers.

At the project level, there are three main instruments that might be used: loans and grants, and, in the case of grants, these can be given either upfront or upon the delivery of results.

In order to assess the type of financial resources appropriate for any given project or programme two main dimensions are relevant:

1. **Revenue**. Some interventions will be able to generate revenues that allow for the repayment of capital (permitting instruments like loans, equity or other financial instruments) while other projects and programmes will require grant finance. This is determined by the economic characteristics of the project or programme at hand. Further, the need of the Ethiopian population

for the product or service, as well as the population's ability to pay for them, needs to be taken into account. While these considerations will often point to the use of grant finance, the provision of capital requiring repayment should be adopted where possible as it will allow for scarce funds to be recycled.

2. **Risks**. Grants can be provided either conventionally on an upfront basis or made contingent on the satisfactory delivery of particular results (results-based finance or RBF). The choice between these two is driven by the extent to which the grant recipient can control the additional risk placed on them by the results-based approach, as well as there being satisfactory access to capital to bridge the gap until receipt of the results-based payment. The advantage of results-based finance is that it places the decision-making on how to deliver the results into the hands of the executing agency, rather than the more distant funder. Where feasible, this is likely to result in more effective use of the resources.

Grants are likely to be particularly important in financing many of the priority themes. This reflects the focus of the options identified on capacity building and reducing vulnerability. More than half of the resilience options identified in Chapter 3 are likely to require upfront grants.

Amongst those themes most suitable for results based (grant) finance are (1) the construction of roads and other infrastructure (2) the roll-out of enhanced extension services (3) incentives for livelihood diversification (4) asset creation and protection schemes; and (5) payments for ecosystem services.

4.3.3. Sources of finance

The ultimate source of any finance can come from one of four categories:

1. **International public resources** have received particular attention as they mostly fulfil the obligation of developed countries under the UNFCCC to 'provide such financial resources, including for the transfer of technology, needed by the developing country parties to meet the agreed full incremental costs of implementing measures' such as 'preparing for adaptation to climate change'.

2. **Domestic public resources** complement the role of international public resources. Despite their relative scarcity, they have a role to play in supporting activities that would be in the interests of our development and are made more urgent by the need to adapt to climate change.

3. **International private resources** are the largest absolute source of finance, in terms of potential, although they can often only be accessed at less generous terms than other sources of finance.

4. **Domestic private resources** (domestic savings, intermediated through the financial system) also currently play a significant role in our economy – with domestic credit to the private sector accounting for just under 20% of GDP in the period to 2008 – and so should also be expected to play an important role in enhancing climate resilience in the country.

The focus on grants at the project level means that international and domestic public sources of finance will be particularly important, as domestic and international private sources will not provide such financial instruments.

More than thirty different sources of international public sources that can support options highlighted in chapter 3 have been identified. For each source, we considered the geographic and sectoral focus, the types of financing instruments that are provided (grants, loans etc.), and whether the fund has previously supported projects in Ethiopia and, where available, the amount of currently unused resources for each. This inventory covers both funds explicitly targeting resilience activities as well as some more conventional sources of development finance. It is not intended to be exhaustive, in particular current and future initiatives by bilateral development partners need to be added, but it is intended to identify the vast majority of the dedicated funds and institutions that may be relevant to financing resilience options and which can complement the role played by the CRGE Facility (which is intended to harness support from bilateral development partners). Many of these public sources of funding are open to, or actively encourage, results-based approaches.

In addition to public funds, there will be an important complementary role for the private sector, both domestic and international. This is particularly relevant in the area of cereal and livestock farming, where themes like asset creation, new crop varieties, animal housing that is resilient to increased temperatures and herd diversification could attract private funding, and in the area of value chain and market development, particularly in relation to commercial-scale crops such as coffee and sugar.

4.3.4 The role of policy

Actions to deliver resilience building will be complemented by the role of public policy. There are a range of policy instruments that can be designed which include insurance schemes, the use of market based mechanisms, public private partnerships, micro financing, regulatory incentives and research and development incentives. The next phase of work on the CRGE will explore the role of policy instruments comprehensively to deliver the needed actions.

4.4 IMPLEMENTING RESILIENCE

The impacts of climate change happen within the local context. However, through our analysis we have identified three potential levels of institutions that could lead on developing the investment plans as well as managing the implementation of resilience. This is not exhaustive, in reality there will be a myriad of actors who will both plan and implement responses. However, we wish to highlight the types of factors that will be needed when considering resilience options and the relative roles and responsibilities of institutions.

4.4.1. Federal

The federal government will have a key role to play in coordinating the national level response to climate change. This will include, but not be limited to, those options that display macro level characteristics. For example a number of the capacity building activities suggested in this document will need to be coordinated at the national level. However, all federal level institutions will be required to work closely with and supporting the regional governments to respond to climate change. This is a key consideration of the design of the SRM.

4.4.2. Basins

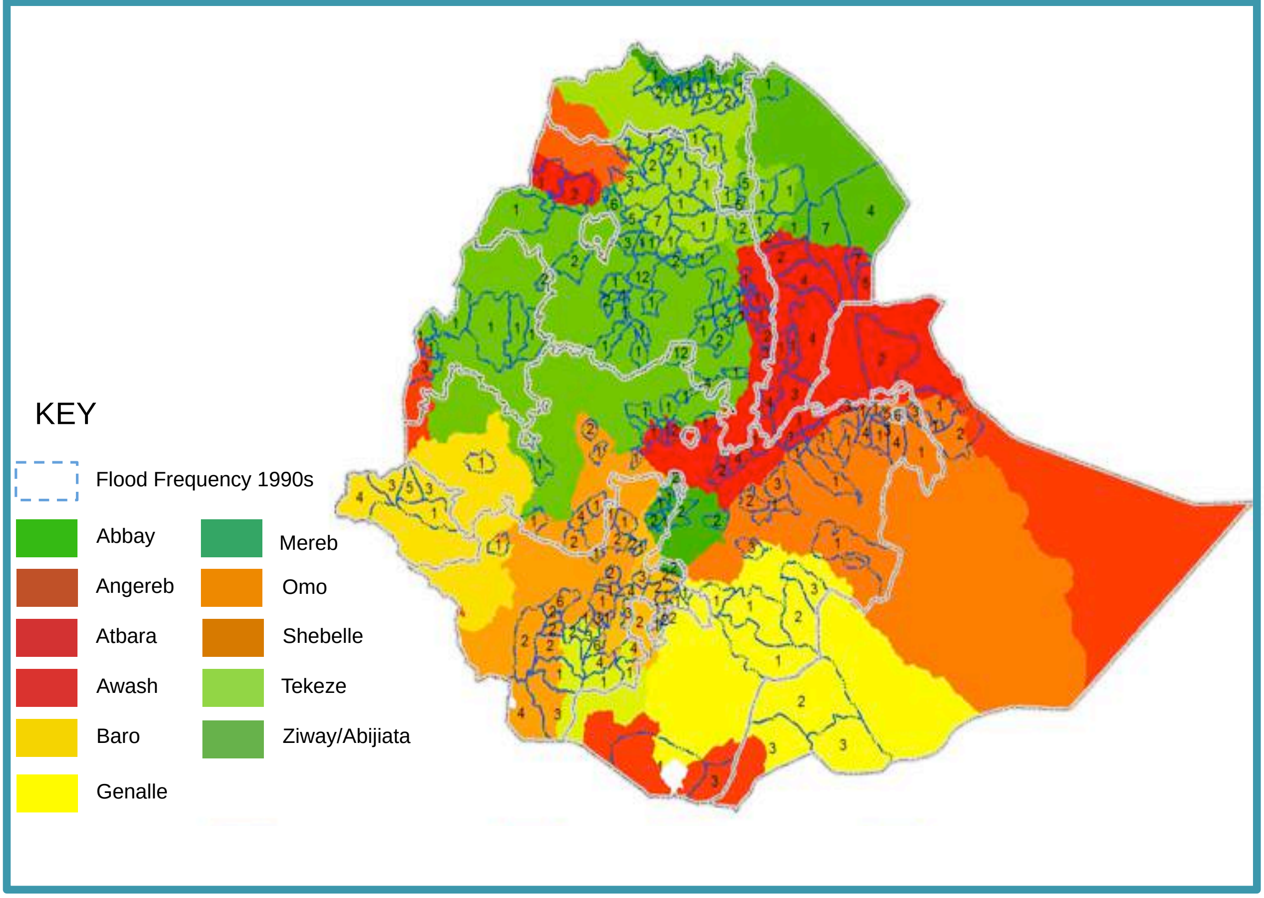
Ethiopia is often referred to as the “water tower” of East Africa, holding significant but distributed water reserves. It receives an estimated 980 billion cubic meters of rain annually. 14 major rivers rise in the Ethiopian highlands, shown in the major river basins in figure 31, and this provides an important potential resource for hydropower and irrigation. Estimates of the potential irrigable land are 3.7m hectares from gravity-fed surface water, 1.1m hectares from groundwater and 0.5m hectares from rainwater harvesting.

This map highlights the complexity that arises when responding to the impacts of current weather variability and future climate change. There are a number of flood prone areas that cut across not only a number of river basins but also regional administrations. It will be crucial for the River Basins Authority, with the coordinated support of the MEF, to work closely with the respective regional governments and federal sectoral ministries to plan and respond effectively to the risk posed by flooding. The key next step in the process will be to map out exactly which implementing entity is responsible for the development of investment plans, as well as providing the correct forums and engagement for all relevant state and non-state actors.

4.4.3. Regional

Regional governments will be crucial actors in responding to climate change. Each regional government will have its own unique characteristics that will determine its prioritisation of response measures; our analysis has not attempted to prescribe what those priorities are, however in chapter 2 we have highlighted, using the APZ's linked to regions, what particular climate risks each region faces. By reviewing table 2 in chapter 2, each regional government can clearly see the key climate risks it faces. Further by reviewing table 3, in chapter 3, those risks have been linked to particular response measures.

FIGURE 31 : **FLOODING IN ETHIOPIA BY RIVER BASIN**



Through the support and coordination of MEF, working closely with the MoA, capacity building and guidance will be provided to the regional government institutions to develop appropriate investment plans to respond to current weather variability and future climate change.

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The CRGE represents a major shift away from the conventional development path. The Green Economy Strategy outlined how we could develop with a zero net increase in greenhouse gas emissions. This Climate Resilience Strategy has outlined how the agriculture sector can ensure resilience to climate change. It will now be important to ensure that all sectors of the economy build resilience to climate change. As we have done in the agriculture sector, this will involve recognising the important work the sectors are already engaged in, building on this, and incorporating those actions in the SRM process. The realisation of the CRGE will bring lasting sustainable development to us all.