



REPUBLIC OF ZIMBABWE

BASELINE REPORT ON ECONOMIC DEVELOPMENT AND CLIMATE CHANGE

Towards sustainable inclusive growth,
human centred development,
transformation and poverty reduction

Ministry of Economic Planning and Investment Promotion





REPUBLIC OF ZIMBABWE

Ministry of Economic Planning
and Investment Promotion

**BASELINE REPORT ON
CLIMATE CHANGE
AND DEVELOPMENT**

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Foreword

Climate change poses new risks to the existing challenges of tackling poverty and promoting economic growth and human development in Zimbabwe. To simultaneously address these challenges, Zimbabwe is developing a coordinated National Climate Change Response Strategy that cuts across the different sectors of the economy and society. The development of such a policy and institutional framework must be based on sound analysis of existing evidence of the effects of climate change on key economic sectors. This will in turn guide the design and implementation of climate compatible policies that contribute to sustainable economic growth and poverty eradication in Zimbabwe.

This Baseline Report sets out the foundation for contributing to the development of a coordinated national climate change and development strategy that is in line with Zimbabwe's broad policy objectives on economic growth and poverty reduction, outlined in the Medium Term Plan (MTP) 2011–2015. One of the key objectives of the MTP is to promote climate change adaptation and mitigation strategies in social and economic development at national and sectoral levels. This Baseline Report is an important first step in contributing to the achievement of this objective, at both practical and policy levels.

The priorities for technical assistance, research and policy implementation identified in this Report should form a basis for further discussion among key stakeholders, with the view of obtaining broad-based participation in the prioritisation and implementation of agreed policy objectives and programmes. Government will use this Report to develop and implement relevant policies and programmes on climate change and development.

A handwritten signature in black ink, appearing to read 'Dan', with a long, sweeping underline that extends to the right.

Honourable T. Mashakada (MP)
Minister of Economic Planning and Investment Promotion



Acknowledgements

I would like to express my heartfelt appreciation to a number of stakeholders who were instrumental to the production of this Baseline Report on Climate Change and Development. This report seeks to contribute to Zimbabwe's strategic response to climate change, by providing a preliminary analysis of the likely effects of climate change on various sectors of the economy. It provides an analysis of the challenges that climate change poses to Zimbabwe's socio-economic development trajectory, and also the opportunities for climate change mitigation and adaptation in all sectors.

Thus the complexity of the task required competent and committed officials to ensure that this report presents a comprehensive baseline which draws upon the most relevant evidence base on climate change and development in Zimbabwe. I would like to specifically mention the following Government Ministries for their support during the production of the Baseline Report: the Ministry of Environment and Natural Resources Management, Ministry of Agriculture, Mechanisation and Irrigation Development, Ministry of Energy and Power Development, Ministry of Finance and the Ministry of Water Resources and Development and other cooperating partners, civic society and the private sector.

The completion of this Baseline Report owes much to the technical support from the Institute of Environmental Studies (IES), University of Zimbabwe. Much appreciation goes to Climate and Development Knowledge Network (CDKN) for the technical and financial assistance which made the study possible.

A handwritten signature in blue ink, appearing to read 'D.M. Sibanda', written in a cursive style.

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Acronyms and abbreviations

AfDB	African Development Bank
AGRITEX	Agricultural Extension Services
AusAid	Australian Agency for International Development
CDKN	Climate and Development Knowledge Network
CDM	Clean Development Mechanism
CIMMYT	International Maize and Wheat Improvement Center
CO ₂	Carbon Dioxide
CSO	Central Statistical Office
DANIDA	Danish International Development Agency
DfID	UK Department for International Development
EIA	Environmental Impact Assessment
EMDAT	World Health Organization's Emergency Events Database
ENDA	Environment and Development Action in the Third World
FAO	Food and Agriculture Organization of the United Nations
FEWSNet	Famine Early Warning Systems Network
GDP	Gross Domestic Product
GEF	Global Environment Facility
GISS	Goddard Institute of Space Studies
GMO	Genetically Modified Organism
GTZ (now GIZ)	Gesellschaft für Technische Zusammenarbeit
GW	Gigawatt
GWh	Gigawatt hour

Ha	Hectare
Ibid	ibidem, meaning 'in the same place'
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Centre
INTRAC	International NGO Training and Research Centre
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Private Producer
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
KNMI	Koninklijk Nederlands Meteorologisch Instituut (Royal Netherlands Meteorological Institute)
Kw	Kilowatt
LEAD International	Leadership for Environment and Development
mn MT	Million Metric Tonnes
MP	Member of Parliament
MW	Megawatt
NGO	Non-Governmental Organisation
NOCZIM	National Oil Company of Zimbabwe
OECD	Organisation for Economic Cooperation and Development
SADC	Southern African Development Community
SADC-HYCOS	SADC Hydrological Cycle Observing System
SMHI	Sweden's Meteorological and Hydrological Institute
START	Global Change SySTem for Analysis, Research and Training

TW	Terrawatt
TWh	Terrawatt hour
UK	United Kingdom of Great Britain and Northern Ireland
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
UN-REDD	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
US	United States of America
ZERO	Zimbabwe Energy Research Organisation
ZESA	Zimbabwe Electricity Supply Authority
ZIMSTAT	Zimbabwe National Statistics Agency
ZINWA	Zimbabwe National Water Authority

1. Executive summary

1.1 Introduction

Zimbabwe faces a major challenge: adapting to the effects of climate change while alleviating poverty and developing its economy. Addressing this will require an integrated climate and development strategy, based on sound data and rigorous analysis, and the ability to translate scientific findings into policies. These policies will in turn need institutional support, adequate financing and rapid implementation.

The Baseline Report on Economic Development and Climate Change in Zimbabwe presents a preliminary analysis of the country's current state of preparedness for climate change, both for adaptation and mitigation. The Report:

- provides a brief overview of Zimbabwe's economy
- examines how climate change is affecting key economic sectors, and how the sectors are contributing to greenhouse gas emissions
- assesses the current policy and institutional framework in each sector, and considers the legislative framework to which policy responses must align
- identifies the challenges and opportunities for climate change adaptation and mitigation
- provides recommendations for specific research and technical assistance activities to inform and implement mitigation and adaptation measures, which should be part of Zimbabwe's national climate change and development strategy.

It is the first step towards the development of a national climate change and development strategy, which will be formed within the context of Zimbabwe's Medium Term Plan 2011–2015.

1.2 Zimbabwe's economy

The structure of the economy has undergone radical transformation and change in recent decades, from strong state intervention in the 1980s, to the adoption of structural adjustment programmes in the 1990s, followed by a decade-long economic crisis from 1998 to 2008. Since establishing the Government of National Unity in 2009, Zimbabwe's economy has experienced strong growth. This is mainly due to political stability attributed to the formation of the Government of National Unity, and economic reforms implemented since then. Gross domestic product (GDP) growth has increased from 5.4% in 2009 to 10.6% in 2011 (Ministry of Economic Planning and Investment Promotion, 2011), mainly due to the significant growth in mining and agricultural production.

However, 72% of the population still lives below the national poverty line and an estimated 80% are not formally employed, with a significant proportion employed in the informal sector. The high rate of unemployment in the formal sector is largely due to the adverse impacts of the economic structural adjustment programme in the 1990s, and the drastic post-2000 decline in economic performance and well being associated with the political and economic challenges of the past decade.

Zimbabwe's economy is currently based on agriculture, mining, manufacturing, tourism, and a large informal sector. Each sector will be affected by climate change in different ways. In turn, stakeholders in each sector will need to find specific ways to adapt to these changes. There are potential measures to mitigate the effects of climate change in each sector, and in some instances changes in the climate may create opportunities for people.

1.3 Climate change in Zimbabwe

Zimbabwe is prone to droughts, periodic floods and shifting rainfall patterns. These are likely to increase in intensity and frequency as the global climate changes. The effects of climate change are already apparent across Zimbabwe's economic sectors. Severe droughts, floods and extreme weather events in recent years have contributed to existing food shortages, damaged infrastructure and degraded the natural resources on which people's livelihoods and the national economy is based.

The often unpredictable and potentially violent effects of a changing climate are influenced by, and deeply affect, how food is produced, land is used, and forests and water resources are managed. Management of natural disasters must also encompass uncertain and increasing climate change impacts. All of these sectors present opportunities for climate change mitigation and adaptation.

The political and economic challenges Zimbabwe now faces are exacerbated by the threats posed by climate change, particularly on agricultural systems. Severe droughts (in 2002, 2005 and 2007) struck when the country was already suffering from considerable political and economic challenges. Climate change is undermining past development gains and jeopardising the development objectives outlined in the Medium Term Plan. While the country has taken some steps to address this, these have focused mainly on mitigation. This has left its economic sectors vulnerable to the potentially devastating climate impacts in the short and long term.

1.4 The impacts of climate change on Zimbabwe's economic sectors

The next section of this Summary considers the impacts of climate change on different sectors of the economy and natural and urban environment, as well as the opportunities for adaptation and mitigation strategies.

1.4.1 Agriculture

Increases in temperature, more frequent extreme weather events, and greater rainfall variability will affect agriculture in several ways. These impacts are expected to increase the occurrence of crop failures, pests, crop disease, and the degradation of land and water resources. These will adversely affect Zimbabwe's agricultural sector – a critical issue at a time when the country is trying to increase agricultural production to support a growing population and maintain economic growth.

Agriculture employs over 70% of Zimbabwe's formally employed population and currently contributes about 17% of export earnings (Ministry of Economic Planning and Investment Promotion, 2012). Despite a diversified economy, the agricultural sector is deeply intermeshed with the rest of the economy; disruption to agriculture from climatic shocks could lead to overall economic decline.

Existing studies on climate change and agriculture in Zimbabwe are inadequate, and the few studies that have been done only consider a few crops. Yet adaptation to climate change requires a diversified cropping system. Given that the country's agro-ecological regions have been shifting over the years, largely as a result of climate change, there is need to re-analyse existing regions and assess their suitability for growing different crops.

Another key adaptation strategy is the development of irrigation schemes. With only about 2,000 of the country's 119,000 hectares (ha) of irrigated land under smallholder control (Rukuni et al, 2006), communal and resettlement agriculture remain the most vulnerable to drought.

Agriculture is also a major greenhouse gas emitter, for example through the clearing of forests to create new cropland and the use of fossil fuels in farm operations. As such, it has a key role to play in Zimbabwe's mitigation strategies. Important strategies for mitigation include improving crop and grazing land management, restoration of degraded lands, improved water management, agro-forestry, and improved livestock and manure management.

Key areas for improvement to the agricultural sector include: budgetary support; increased collaboration in the collection, analysis and dissemination of weather information; improved seed varieties; expanded irrigation development; re-classification of Zimbabwe's agro ecological regions; and linking agricultural policy and climate change.

1.4.2 Forestry

Forestry plays a critical role in climate change mitigation, as forests sequester carbon from the atmosphere and act as carbon sinks. It also plays a role in adaptation to climate change, for example acting as a buffer against extreme weather events and providing resources during and after disasters.

But Zimbabwe's forests are under tremendous pressure due to increased demand for new agricultural land, increased tobacco production among resettled farmers, and fuel demands in both urban and rural areas. This has been exacerbated by an absence of policy and institutional coordination across the different sectors that affect forestry.

Zimbabwe urgently needs an inter-sectoral platform to guide forestry policy – one that bring together stakeholders expertise around land use, agriculture, finance, environment, national parks and climate change. The role of forests as carbon sinks is less well articulated.

Zimbabwe needs to assess, quantify and monitor existing carbon stocks in the country's forests. One way to achieve this is to become a partner country in the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD) programme. This will ensure that the country obtains UN support and assistance to develop analyses and guidelines on measurement, reporting and verification of carbon emissions and flows. More importantly, it will ensure that forests continue to provide multiple benefits for livelihoods, economic growth and the environment.

1.4.3 Land use

Land use patterns in Zimbabwe are being transformed through the land reform programme. Although changing land uses have a direct impact on climate change, the nature and extent of the change is not well understood. Also, other parameters have changed as a result of the land reform programme, including types of beneficiaries (or farmers), farm size, tenure arrangements and productivity. The nature of the relationship between such attributes and climate change is also not clear.

Some land use policy, especially forest-based land reform policies, has a direct impact on adaptation and mitigation. However, while the role of forests as carbon sinks is well known, current land policy neither acknowledges this nor highlights any strategies to capitalise on opportunities.

Zimbabwe needs a coordinated system to track land uses changes that emphasises both the clearing of forests and afforestation initiatives at the farm level. Policy guidelines should also balance crop-based and forest-based land uses, as these both affect, and are affected by, climate change.

1.4.4 Water

Climate change projections for Zimbabwe provide ample evidence that water resources will be significantly affected, with serious consequences for social and economic development.

Observed changes in the country's climate include: changes in the intensity and timing of rainfall; extreme weather events such as flooding; higher temperatures, which affect soil moisture content; and higher rates of evapotranspiration. These changes will alter not only the supply and demand of water resources, but also the quality.

Zimbabwe's existing Water Policy provides a basis for the water sector's response to climate change. This could be improved by including mitigation and adaptation strategies, for example improving irrigation systems, more research on the country's groundwater resources, and investing in micro hydropower schemes. There is also a need to revise the Water Act and the Zimbabwe National Water Authority Act, both created in 1998, so that they take into account the changing water use in the country, and the likely impacts of climate change on water resources.

1.4.5 Mining

The mining sector accounts for 44% of Zimbabwe's foreign exchange earnings (Ministry of Economic Planning and Investment Promotion, 2012). Recent years have seen resurgence in the sector, with increased production in key minerals, such as gold, coal, platinum and diamonds. Mining is less vulnerable to the impacts of climate change than other economic sectors, and could be an economic buffer against the adverse effects of climate change, particularly on the agricultural sector.

Future policy for the sector can reduce the contribution of mining to climate change. One important way to reduce emissions is to increase the energy efficiency of mining operations, so it emits fewer greenhouse gases. The Government must provide a regulatory framework that encourages the mining sector to use clean technologies, particularly in coal mining.

Research and capacity building activities for technical colleges and universities need to be funded, to build the critical skills required to develop efficient technologies, monitor and assess greenhouse gas emissions, enforce government regulations, and foster a transition to low-carbon mining. In terms of adaptation, a proportion of funds contributed by mining firms to community trust funds should be used to support community-wide adaptation activities.

1.4.6 Energy

Zimbabwe has a wide range of energy resources, including coal, coal bed methane and hydropower. Current energy use is dominated by fossil fuels, mostly coal, and unsustainable firewood harvesting.

As the economy expands and the population increases, Zimbabwe's energy demands are set to grow. Much of this increased demand will be met by coal, with the country's reserves estimated at approximately 10.6–26 billion tonnes (AfDB, 2011). However, energy projections in Zimbabwe indicate an increasing diversity of sources, with ethanol biofuel and thermal power gaining prominence in the country's energy mix. Hydropower is projected to continue growing, and solar energy is also viewed as a potential energy resource. Solar water heaters and wind power have potential too.

While Zimbabwe has significant experience in renewable energy for household use, the market has not grown to contribute significantly to the national energy balance. One significant renewable is biofuels, which have a long history in Zimbabwe. Ethanol production from sugarcane accounted for 20% of motor fuel before production ceased in 1992. With rising oil prices and fuel shortages, ethanol production resumed in 2008.

A 1994 greenhouse gas inventory found the energy sector to be responsible for 80% of the greenhouse gases emitted by the country. The energy sector has the potential to contribute significantly to reducing carbon dioxide (CO₂) emissions, given the dominance of firewood and thermal energy as well as the continued use of inefficient technology. The National Energy Policy of 2009 and the Medium Term Plan together provide an effective policy and institutional framework for Zimbabwe's energy sector to provide low carbon energy, as both emphasise renewable energy sources and energy efficiency in domestic and industrial processes.

However, funding and technical capacity to support the transition to low carbon energy generation and supply is lacking. There has been little investment in low carbon and renewable energy sources from the private sector, or public and donor agencies.

And the Ministry of Energy and Power Development has limited technical and research capacity to develop effective policy responses that focus on energy and climate change. But the sector is undergoing significant development and rehabilitation. This is an opportunity to embed climate compatible energy policy and programmes in Zimbabwe.

1.4.7 Transport

Zimbabwe's transport sector consists of road, rail and air networks, and a small ferry service on Lake Kariba. The sector relies on fossil fuels and, as the economy grows, transport activity will also increase. With increasing incomes associated with economic growth, there is likely to be an increase in vehicle ownership. This will ultimately lead to increased greenhouse gas emissions.

While the road network is the most extensive transport infrastructure in Zimbabwe, the rail network will play a key role in mitigating climate change, given the lower emissions from this form of transport. Encouragingly, there are plans to extend the rail network by another 1340 km.

The priorities for the transport sector are detailed research into the sector's contribution to greenhouse emissions and realising opportunities for climate change mitigation and adaptation such as promoting alternative fuels such as biofuels, promoting fuel-efficient transmission technologies, and developing an efficient public transport system.

1.4.8 Disaster risk management

It is critical that disaster risk management plays a central role in all national climate change adaptation strategies. But disaster risk management and climate change adaptation currently fall within different ministries, and are addressed at the national level under different policy frameworks. Consequently they are managed through different line departments that rarely have any coordination across them. There are persistent gaps between the production of climate risk information and the ability of the decision-makers and vulnerable stakeholders to interpret and react to such information.

The drafting of the Disaster Preparedness and Management Policy provides an important step in providing a coordinated framework for Zimbabwe to respond and effectively plan for extreme climate events and disasters.

Zimbabwe also needs technical assistance from regional and international disaster reduction agencies to support education and training, including public awareness programmes. For example, mainstreaming disaster risk management training and capacity building in schools, colleges, universities and other technical and professional training institutions will increase people's awareness of the issues. An effective disaster database is also long overdue; currently Zimbabwe relies on international organisations for its disaster statistics.

1.4.9 Urban infrastructure

More than 50% of Zimbabwe's 13 million people live in urban areas. Zimbabwe's urban areas are vulnerable to a number of climate change hazards. The main risks include storms, localised flooding and water logging, drought-induced water scarcity and urban warming from the urban heat island effect. But there is inadequate information on the specific impacts of climate change on the country's urban infrastructure.

Zimbabwe's urban planning regime does not sufficiently address the challenges for climate planning, engineering, environmental health and the financial architecture for urban infrastructure in the coming decades. There are concerns about the quality and inclusiveness of local governance, as well as the extent of community participation and preparedness.

It is important to support well-funded research to analyse the potential impacts of climate change on urban infrastructure. Key areas include institutional preparedness, policy adequacy and performance management. This will guide the development of relevant guidelines and policies that ensure the country's urban infrastructure can survive the impacts of floods, droughts and other extreme weather events.

1.5 Existing climate change legislation

The Baseline Report analyses the links between climate change and the various sectors of the economy, and identifies the opportunities for adaptation and mitigations for each sector. But it is also important to consider the legislative framework, which provides a legal basis for mainstreaming policy options in national development framework and programmes.

The Baseline Report reviews the key legislation governing various sectors and assesses their relevance to climate change. The majority of laws do not specifically mention climate change, although there are many instances in which issues relating to climate change are inferred. The provisions for climate change-related legislation are scattered in various legal provisions; these must now be integrated to form overarching and coordinated climate legislation.

1.6 Conclusion

There is unequivocal evidence that Zimbabwe is experiencing the effects of changing climate. These threaten to undermine economic recovery, threatening efforts to reduce poverty and achieve the Millennium Development Goals. However, there is considerable scope for responding to these challenges. The following actions are priorities in Zimbabwe:

- Develop a National Climate Change Strategy that aims to increase the integration of adaptation and mitigation initiatives into economic and development activities, including efforts to implement the suggestions and recommendations for research, policy and technical assistance highlighted in the Baseline Report.
- Develop a National Adaptation Programme of Action and address priorities for adaptation research and technical assistance within each economic sector, so that they can continue to expand while preparing for a changing climate.
- Seize opportunities for mitigation research and technical assistance, for example those provided by the UN-REDD+ process.
- Access international climate financing opportunities. This will help to ensure that climate change does not undermine poverty reduction and Zimbabwe's future prosperity.
- Complete the Second Communication on Climate Change by the Climate Change Office, and provide the Office with recurrent funding so that it can fulfil its mandate, expand, and decentralise to provincial levels.
- Clarify roles and improve coordination between government agencies on the one hand, and non-governmental organisations (NGOs), researchers and international agencies on the other.

2. Introduction

In Zimbabwe, there is an increasing realisation that climate change threatens social and economic development. Climate change will exacerbate droughts, floods and extreme weather events, which could contribute to food shortages, damage infrastructure, and degrade the natural resources on which local livelihoods and the national economy is based. Consequently, climate change can undermine past development gains and make it more difficult to attain the development objectives outlined in the Medium Term Plan 2011–2015.

Responding to the impacts of climate change is critical. One way of doing this is to ensure that climate change risks and impacts are considered systematically in national development policies and programmes, with the view to making social and economic development resilient to a changing climate. 'Development as usual', without consideration of climate risks and opportunities, will not allow national development strategies to confront climate challenges.

To develop informed policy responses, it is imperative for Zimbabwe to develop an evidence-based understanding of climate change risks and impacts on key sectors of the economy. Such policy responses should enable Zimbabwe to adapt to the effects of, and mitigate her contributions to, climate change and move to a low-carbon economy, while maintaining the growth rates needed for sustained poverty reduction and economic growth. A delicate balance is crucial; robust national development planning for the short and long term should acknowledge the uncertainty associated with climate change and embed adaptation and mitigation strategies in policy frameworks. Climate policy and strategy must go beyond an environmental focus to include social, political and economic dimensions.

2.1 Purpose of the Baseline Report

This Baseline Report presents a preliminary analysis of climate change and development in Zimbabwe. It was written in response to a request to the Climate and Development Knowledge Network (CDKN) from the Government of Zimbabwe, through the Ministry of Economic Planning and Investment Promotion, for technical assistance in the development of a National Climate Change and Development Strategy within the context of the Medium Term Plan.

The Report provides a baseline for future policy development. It examines climate change vulnerabilities and impacts on key sectors of the economy, the current policy and institutional framework governing a particular sector, and the challenges and opportunities for climate change adaptation and mitigation.

The Report aims to contribute to the design and implementation of climate compatible development and an economic growth strategy across all sectors, through a coordinated policy and institutional framework. It seeks to achieve this through an evidence-based approach to policy and programming.

The Report aims to identify policy and institutional challenges within a sector and suggest adaptation and mitigation strategies that can be integrated into a coherent national policy. It also explores the legislative framework governing different sectors. At present, climate legislation and policy is uncoordinated and sometimes unenforceable. But if the various pieces of legislation and policy can be brought into a coherent framework, they can constitute a basis for an effective legislative framework.

2.2 Methodology

The Report is based on a review of primary and secondary literature combined with interviews with key stakeholders in Harare. Data used in this Report were the most recently available; the use of older data sets in some places indicates a lack of current data for such topic. In some cases the only available statistics are from studies conducted more than ten years ago.

The report is not intended to provide a detailed and nuanced picture of local-level climate change impacts or adaptation and mitigation activities. It does, however, provide a coherent summary of the national and sector level, and should be used to foster a useful and constructive debate on climate and development.

2.3 Report structure

This Baseline Report is organised as follows:

- Part A provides an overview Zimbabwe's economy and natural resources.
- Part B summarises the evidence of climate variability and change, and the institutional and policy frameworks.
- Part C provides a sectoral analysis of agriculture land use, forestry, water and disaster management.
- Part D provides a sectoral analysis of mining, energy, urban infrastructure and transport.
- Part E details the legislative framework governing most of the above sectors.

Part A – Zimbabwe's Economy and Natural Resources

3. Zimbabwe's economy

3.1 Introduction

Zimbabwe's economy is based on agriculture, mining, manufacturing and tourism, with a large informal sector in rural and urban areas. From 1980 to the present day, the structure of Zimbabwe's economy has undergone four distinct phases of radical change. The first phase (1980–1990) was characterised by strong state intervention. The second phase (1990–1998) was defined by the adoption of structural adjustment programmes. The economic crisis from 1998 to 2008 represents the third phase. The fourth phase, from 2009 to the present, is marked by economic recovery, reconstruction and growth, associated with political stability and the establishment of the Government of National Unity.

The current phase 2009 to present, has witnessed a marked growth in the economy, mainly due to political stability attributed to the formation of the Government of National Unity and economic reforms implemented since then. Real GDP growth has increased from 5.4% in 2009 to 10.6% in 2011 (Ministry of Economic Planning and Investment Promotion, 2011). This is impressive given that real GDP growth was minus 3.7% in 2007 and minus 17.7% in 2008.

The increase in real GDP growth is based on the significant expansion in mining and agricultural production over the past three years. Table 1 shows real GDP and sector growth for 2009 onwards.

Mining grew by 47% due to rising mineral and metal prices on the world market (African Development Bank/AfDB, 2011:4). Agricultural output increased by 34% due to higher outputs of tobacco, sugar, maize and cotton (ibid) supported by firm prices for these commodities. Locally, the increased use of sugarcane for biofuel production partly explains the increase in sugar prices. Globally, the demand for grain, especially maize, in biofuel production can be attributed to increased

maize production in response to better prices offered for maize. It is important to note that the agricultural sector was adversely affected by Zimbabwe's Fast Track Land Reform Programme,¹ poor rainfall patterns, delays in the distribution of inputs, and late payments to farmers for deliveries. The sector's current growth, particularly improved agricultural production among some beneficiaries of the land reform programme, suggests a long-awaited recovery.

Table 1. GDP growth by sector 2009–2012

GDP by sector (%)	2009	2010	2011
Real GDP	5.4	9.6	10.6
Agriculture, hunting and fishing	21	34.8	5.1
Mining and quarrying	33.3	60.1	25.1
Electricity and water	1.9	19.1	7.8
Construction	2.1	5.4	6.2
Finance and insurance	4.5	5.6	2
Real estate	2	5.4	3.1
Distribution and hotels	6.5	8.8	3.3
Transportation	2.2	20.5	18.7

Source: MOF, MEPIP, 2011

Table 1 shows that real GDP growth increased from 5.4% in 2009 to an estimated 10.6% in 2011. A further indication of continued recovery is the decline in inflation from 238% in 2006 to 6% at the end of 2009, mainly as a result of adopting foreign currencies (US dollars and South African Rand) in business and trade.

An increase in the use of manufacturing capacity, from 25% in January 2009 to 40–50% in 2011, suggests a considerable rebound. However, the manufacturing sector has yet to fully recover as it is adversely affected by lack of credit, power shortages, and uncertainty in some key policies that concern investors, such as the indigenisation policy. The latter has led to little external investment in the manufacturing sector.

This economic progress largely rests on the settlement between Zimbabwe's two main political parties, marking an end to political violence and a concerted effort to embark on economic recovery. Two policy documents, the Short Term Economic Recovery Programme and the Medium Term Economic Recovery Programme, detail the programmes that the Government of National Unity put in place to ensure stability, growth, reconstruction and recovery. Improved revenue collection by the Zimbabwe Revenue Authority and cash budgeting by the Ministry of Finance improved government finances. Total revenue increased from \$933.6 million in 2009 to \$2.34 billion in 2010 (AfDB, 2011) and an estimated \$2.75 billion in 2011 (Ministry of Finance, 2011). The major sources of government revenue are value-added tax (32%), Pay as You Earn contributions (20%), customs (12%), excise duty (10%) and corporate taxes (10%) (ibid). However, employment costs consume approximately 63% of government revenue, resulting in little to fund social and development programmes, including climate change and development.

Two key points are evident from the above. First is the link between agricultural production and economic growth in Zimbabwe. Despite a diversified economy, the substantial forward and backward linkages between the agricultural sector and the rest of the economy ensure that disruption to agriculture by climatic shocks may lead to economic decline. As such, the likely effects of climate change on agriculture must be curtailed to sustain the sector's contribution to GDP. The prominent contribution of mining, which is less vulnerable to climate change, could act as a buffer against the adverse effects of climate change on agriculture and its contribution to the national economy. Second, despite a tumultuous recent past, Zimbabwe's economic future once again looks bright.

3.2 Key economic sectors

3.2.1 Agriculture

Zimbabwe's agricultural sector provides a livelihood to over 70% of the population, and currently contributes about 17% of export earnings (Ministry of Economic Planning and Investment Promotion, 2012). From 1980 to 1998,

agriculture contributed more than 60% of the country's foreign exchange earnings, and 15–19% of GDP. Between 1998 and 2008, the sector contracted rapidly due to rainfall variability (e.g. the drought from 2000 to 2002), foreign exchange shortages, and the political crisis associated with the Fast Track Land Reform Programme, which adversely affected agricultural production in the commercial farming sector (AfDB/OECD 2003: 356).

Despite the significant decline in the agricultural sector in the past decade, agriculture continues to play an important role in Zimbabwe's development. It provided employment for the majority of the population during the current economic recovery. The allocation of land to a significant number of small- and medium-scale farmers under the land resettlement programme, coupled with the envisaged irrigation development programme aimed at creating 240,000 ha of irrigated land by 2015, suggests substantial future growth – especially if agricultural prices remain favourable. Furthermore, the agricultural sector has strong links with the manufacturing sector.

3.2.2 Mining

The mining sector accounts for around 4% of GDP, 5% of formal sector employment, and at least 50% of foreign exchange earnings (Ministry of Economic Planning and Investment Promotion, 2012). Major products include gold, platinum, nickel, diamonds, ferro-alloys and coal, the majority of which are exported as semi-processed products. The anticipated growth in the mining sector has important implications for climate change; mining contributes to climate change due greenhouse gas emissions from the sector (it is dependent on thermal power), while climate change can affect mining operations. For example, extreme weather events may disrupt power supplies, and changes in water availability may threaten water-reliant production and processing techniques.

3.2.3 Manufacturing

Zimbabwe's manufacturing sector, both formal and informal, is highly diversified and absorbs much of the agricultural and mining output. The main sub-sectors are agro-processing, beverages, metal products, chemicals and petroleum products, and textiles. Manufactured exports, including semi-processed minerals such as ferrochrome and agricultural products such as cotton, were estimated to account for 33% of merchandise exports in the 1990s.

Manufacturing contributes a significant share of Zimbabwe's GDP, export earnings and employment. Its share of GDP averaged 25% in the 1980s but fell to less than 14% in the 1990s, partly due to deindustrialisation associated with structural adjustment programmes, and also an influx of cheap imported goods. The decline continued into the 2000s and its contribution fell from about 19% of GDP in 2001 to an estimated 15% by 2006.

From 2009 onwards, the manufacturing sector started to grow due to improved capacity utilisation, partly as a result of the introduction of US dollars. This resolved the acute foreign currency shortages and inflation of the Zimbabwean dollar. The manufacturing sector is estimated to have grown by 5.7% in 2011, due to improved credit support and a more reliable energy supply. As current capacity utilisation is only around 50%, it is likely the sector will grow rapidly in coming years through the measures Government has proposed through the Medium Term Plan and the Industrial Development Policy.

As manufacturing grows, it is important that any potential climate change and development policy examines the sector's demands for energy and water, and its contribution to greenhouse gas emissions, as well as impacts of changing climatic conditions on industry. Such policy should balance embarking on a low-carbon trajectory for the sector with its contribution to national economic growth and poverty reduction. In other words, the challenge for the Zimbabwean Government is to ensure that the sector is assessed for greenhouse gas emissions and energy efficiency. Further, the Government should ensure a regulatory framework is put in place to enforce policy and allows the sector to be efficient and competitive at the regional and global level.

3.2.4 Energy

Energy in Zimbabwe is drawn from different sources. Wood used by households accounts for 47%, coal and coke 21%, motor fuels 20% and electricity 12% (AfDB, 2011). The residential sector consumes 47%, followed by industry (19%), transport (15%), agriculture (11%), commerce (4%), mining (3%) and others

(1%). There is a paucity of data on future energy consumption by sector, but it is fair to say that as the population increases and key economic sectors continue to recover and grow, energy demand will also increase. Also, the success of the Rural Electrification Programme has led to increased consumption of electricity in rural areas (see Box 1).

Box 1. Rural Electrification Programme

The Rural Electrification Programme was launched in 2001 with the aim of providing electricity to 10,000 rural public institutions such as schools, rural health centres, extension offices and farming communities. The programme promoted the economic use of electricity in rural areas by developing energy-intensive irrigation schemes, and cottage and agro-industries. By October 2010, the Rural Electrification Agency, which ran the programme, provided electricity to 608 rural centres across Zimbabwe, including 39% of rural primary schools, 70% of rural secondary schools, and 65% of rural health centres. In addition, 222 mini-grid solar systems had been installed at remote schools and clinics.

Source: AfDB, 2011:14

<http://dailynews.co.zw/index.php/business/35-business/2315-zim-manufacturing-sector-to-grow-6.html>

Zimbabwe's energy sector is dominated by coal, hydropower, petroleum, biomass, ethanol and liquid gas. The country relies mainly on coal, and this is set to continue, with proven reserves of half a billion tonnes and possible reserves of up to 30 billion tonnes (Government of Zimbabwe, 2008). Both technology transfer within coal-fired power stations, and hydroelectric and renewable energy sources, offer potential for generating offset credits for Zimbabwe through the Clean Development Mechanism (CDM) and other international carbon markets.

For hydroelectric power, the country depends on the Kariba Hydropower Station, but the country has significant potential for hydropower generation along the Zambezi River and in the Eastern Highlands. According to Mungwena (2002), eight further dams have the potential to generate hydropower in Zimbabwe. Small hydroplants can also be installed on smaller dams, provided there is sufficient flow.

Biomass is a major energy source, especially for rural and low-income urban populations. Of the country's total land area of 39 million ha, 20.5 million ha are under indigenous forest while 140,000 ha are under commercial forest plantations. For energy purposes, only the indigenous forests in communal areas can be considered as major resource. Loss of natural forest continues, especially near urban centres and some rural districts. Both afforestation and reduced deforestation hold potential for carbon offset schemes (the former through both the CDM and voluntary markets, and the latter through voluntary markets).

Zimbabwe has had significant experience with renewable energy for household use. Solar water heaters, solar photovoltaic power for lighting, efficient wood stoves, and solar cookers have all had government, NGO and private sector support since the early 1980s. However, the market has not grown to contribute significantly to the national energy balance. The solar photovoltaic market continues to be small, as most people can only buy small panels to power radios and some lights. Large systems are still rare.

Biofuels have a long history in Zimbabwe. Ethanol production from sugarcane was conducted at Triangle Limited producing 20% of motor fuel requirements. However, production ceased in 1992 as unblended petrol became cheaper than blended fuel. Due to high oil prices and fuel shortages, ethanol production resumed in 2008. More significantly, a new ethanol plant has been constructed at Chisumbanje by Government in partnership with Green Fuel. Sugarcane ethanol production has important implications for climate change and development policy. It has some potential to reduce emissions of greenhouse gases (dependent on the input intensity of feedstock production, and land-use changes). If sugarcane production involves small-scale farmers, including A1 and A2 farmers, and focuses partly on local consumption of energy and other related products, then there could be considerable poverty co-benefits. These objectives need to be integrated into national policy frameworks on climate change and development.

3.2.5 Services

The services sector played a vital economic role during the 1990s, contributing more than 58% of GDP in 1998. This was mostly a result of increased spending on education and health, and an expansion of tourism.

However, the contribution of services to GDP has fallen rapidly since 2002. For example, the value added from social services dropped from 10.8% of GDP in 2001 to an estimated 7% in 2006. The tourism sector, which was the fastest growing sector during the 1990s, has experienced a profound decline since 2000 due to the deepening economic crisis, limited air traffic and the unstable political climate. Visitor arrivals in the first half of 2002 were just 739,000 compared with 1.45 million during the same period of 2001 (AfDB/OECD, 2004). However, tourist arrivals have increased since 2003. Total tourist arrivals in the first quarter of 2003, at just over 1 million, were 47% higher than in the first quarter of 2002 (ibid).

Although the services sector is not a heavy greenhouse gas emitter, the sector can contribute to climate mitigation through changes in energy use, building equipment, appliances, and fuel use for transportation. Further, climate change can adversely affect service industries and enterprises. Extreme weather-related events may cause damage to property and energy infrastructure, and lead to the loss of revenue and higher insurance premiums. Adverse climate change impacts on water resources and biodiversity may particularly affect tourism.

3.3 Social and economic conditions

3.3.1 Poverty and employment

Currently, the Poverty Headcount Ratio at the national poverty line is estimated at 72%. This significant proportion of people living in poverty is largely due to the adverse impacts of the economic structural adjustment programme implemented in the 1990s, and the drastic post-2000 decline in economic performance and wellbeing associated with the political and economic crisis of the past decade. People living in poverty in Zimbabwe are predominantly rural and female, reflecting in part the unproductive nature of land in many communal areas, and the powerlessness of women in accessing productive resources for their livelihoods.

Employment rates deteriorated sharply from 1998 to the present. In 2003, structural unemployment was recorded at 63%, with current rates estimated at over 80% (Government of Zimbabwe and UNDP, 2011). However, these figures do not include the informal sector, which is mainly comprised of informal trading, informal manufacturing, carpentry, motor mechanics, and the informal transport sector.

3.3.2 Population

Zimbabwe's population has increased from 7.5 million in 1982 (CSO, 1982) to 12.6 million in 2010 (World Bank, 2012). It is projected to increase to 15.5 million by 2020. Despite the increase in total population, the average rate of population growth was only 0.6% between 2000 and 2005, which is a significant decrease from the 3% experienced in the 1980s. This can be partly explained by outmigration during the period of economic contraction. In 2003, approximately 3% of the population was over 65 and 44% was under 15. According to the Zimbabwe Demographic and Health Survey, the proportion of people living in urban areas increased from 33% in 1998 to 34.5% in 2002, then fell to 31.6% in 2006/07 (CSO and Macro International, 2007).

3.4 Natural resources

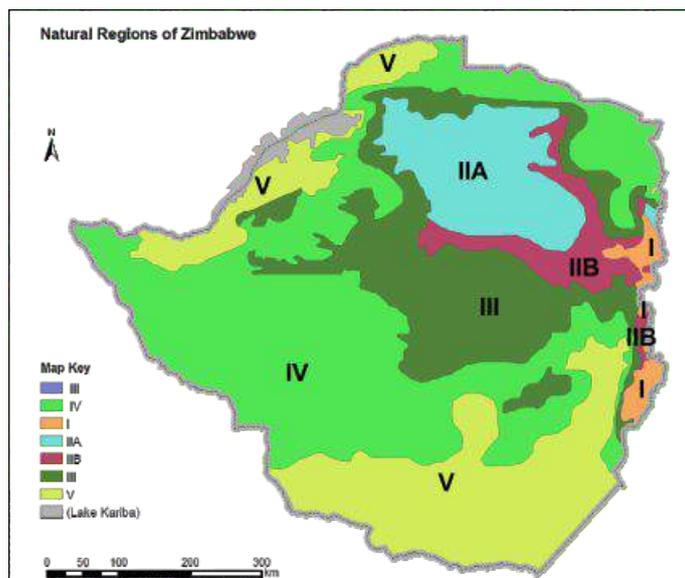
Zimbabwe is divided into five agro-ecological regions on the basis of climatic conditions, farming potential and, to certain extent water resources (see Figure 1 and Table 2).

Surface water contributes over 90% of the country's water supply. Most of the rivers and streams, especially those in drier areas, are seasonal. Zimbabwe has 140 large dams with a capacity greater than 1 million cubic metres and nearly 11,000 small dams, but high siltation rates are a major problem, reducing the life span of small dams (ENDA-ZERO, 1992). Because of recurrent droughts, over-exploitation, poor management and ecological degradation, freshwater is becoming increasingly scarce.

Zimbabwe has many wetlands (vleis), including dambos, which are grass-covered, treeless valleys that are periodically inundated with water.

Dambos are used intensely for cattle grazing, dry season agriculture and domestic water supply. Unfortunately, many dambos have been severely degraded by inappropriate and excessive use (Chenje et al, 1998). Groundwater is also used via wells and boreholes, and is particularly important in the drier parts of the country.

Figure 1. Natural regions in Zimbabwe



Source: Mtisi, 2008

Zimbabwe has rich biological diversity, which provides ecosystem services such as food, medicine, energy sources, building and craft materials, as well as spiritual, cultural and aesthetic services (Millennium Assessment, 2005). Vegetation is mainly savannah woodland interspersed with open grassed drainage lines or dambos (wetlands) (Government of Zimbabwe, 1987). Human activities and fires have altered the climax ecosystem, displacing much of the indigenous woodland (Moyo et al, 1991). In communal areas, most indigenous vegetation has been cleared for arable farming, especially in higher rainfall regions with high population densities. Apart from providing commercial timber, forests contribute resources to meet the subsistence needs of rural people (Nhira et al, 1998). Many indigenous species have medicinal properties and contribute to indigenous knowledge systems. Introduced flora includes pines, eucalyptus and wattle. Many food plants, notably maize, which is the staple crop, are also introduced.

Table 2. Agro-ecological Regions in Zimbabwe

Agro-ecological Zone	Key characteristics
Natural Region I	Annual rainfall of more than 1,050 mm. It is suitable for a broad range of agricultural activities such as dairying, tea, coffee and intensive
Natural Region III	Annual rainfall of 500–700 mm. It is subject to periodic seasonal droughts and prolonged mid-season dry spells. Agriculturally, it is a semi-intensive farming region where maize and drought-resistant
Natural Region IV	Annual rainfall of 450–600 mm. This region is suitable for cattle ranching (rain-fed agriculture is risky). Drought-resistant crops such
Natural Region V	This region has few water resources. Rainfall is normally less than 450 mm per year and largely erratic. It is too dry for successful crop

Zimbabwe has abundant and diverse fauna (Chenje et al., 1998). Wildlife is a lucrative renewable resource and contributes to the economy through tourism, hunting safaris, hide processing and ivory carving (Government of Zimbabwe, 1992). Organised sustainable wildlife management extends beyond protected areas and national parks to community-based programmes. Many of these activities occur in drier agro-ecological regions, where wildlife is more profitable than cattle ranching (Moyo et al, 1991).

The main problem is loss of biodiversity, particularly in non-protected areas such as communal and resettlement areas. The recurrent droughts affecting Zimbabwe have also resulted in population declines of several plant and animal species (Ministry of Environment and Tourism, 2008).

3.5 Summary

Zimbabwe faces many challenges in reducing poverty and promoting sustainable social and economic development. The political and economic challenges of the decade between 1998 and 2008 led to a significant decline in social and economic progress. Such challenges are exacerbated by the threats posed by climate change, particularly on agricultural systems. Severe droughts in 2002, 2005 and 2007 occurred when the country was already suffering from considerable political and economic challenges.

The recent resurgence of agriculture and mining, and the important contributions that the two sectors make to GDP, employment and poverty reduction, must be noted. However, Zimbabwe needs to respond to the challenges posed by climate change and, at the same time, devise policies that ensure economic recovery, social development and poverty reduction while considering the effects of climate change.

Part B – Climate science, institutions and policy

4. Climate variability and change in Zimbabwe

4.1 Introduction

Zimbabwe is a tropical country, but enjoys subtropical conditions because of its high average elevation. The whole country is within the Inter Tropical Convergence Zone, the influence of which peaks in January. When the Inter Tropical Convergence Zone is poorly defined, there is a tendency towards below-average rainfall and a likelihood of serious drought in the country. When the Inter Tropical Convergence Zone is well defined, rainfall is average or above average. Zimbabwe's average annual rainfall ranges from 500–750 mm, and diurnal average surface temperature varies from 15°C in July to 22°C in January.

There is growing evidence that the country's climate has been undergone dramatic changes in recent years. Zimbabwe is affected by large fluctuations in rainfall. An improvement in the water balance as a result of climate change would be a great benefit; increased water stress would be a development challenge.

Zimbabwe faces a number of risks related to climate variability and change. The country is prone to droughts, periodic floods and shifting rainfall patterns. The primary and secondary industries, as well as urban centres, face ongoing water constraints. Widespread and severe climate change impacts are likely to worsen these challenges.

Minimising the potential economic, environmental and social dislocation caused by climate variability and change – and capturing new opportunities for productivity growth inherent in emissions reduction and adaptation – will require greater scientific understanding. Policy-makers and development practitioners must know how and why the climate has been changing in the past, how and why it will change in the future, and how those changes are likely to affect the country's socio-economic status and various economic sectors.

This section presents the evidence on climate change in Zimbabwe, the status of climate modelling and research (including the availability of relevant scientific data), the management of climate change information, and the national framework for climate sciences. It also identifies priority areas for research and technical assistance.

4.2 Historic changes in temperature and precipitation

4.2.1 Temperature

Zimbabwe's temperature records began in 1897 at Harare and Bulawayo. Reliable surface temperature records for the whole country go back to July 1923, when conventional Stevenson's screen replaced thermometer shelters. A number of research reports show that Zimbabwe is experiencing more hot and fewer cold days than earlier last century (Aguilar et al, 2009). The country's annual mean surface temperature has warmed by about 0.4°C from 1900 to 2000 (Figure 2). National average maximum temperature has increased by about 1°C over the same period. The period from 1980 to date has been the warmest on record.

4.2.2 Projected changes in temperature

Several models have produced future climate scenarios for Zimbabwe and the southern Africa region (KNMI, 2006; Engelbrecht et al, 2009) for periods up to 2100. All cited studies conclude that Zimbabwe's climate will be warmer than the 1961–1990 baseline. More specifically, warming rates of 0.5–2°C by 2030, 1–3.5°C by 2070, and 3–4°C by 2100 (all over the baseline) are projected assuming an A2 greenhouse gas emissions pathway (see Figure 3). These scenarios suggest a warming rate of just below 0.2°C per decade to over 0.5°C per decade.

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) indicates that climate models for the period between 2001 and 2100 suggest an increase in global average surface temperature of between 1.1°C and 6.4°C. The range depends largely on the scale of fossil fuel burning within the period and on the different assumptions within the models.

Since the first IPCC report in 1990, assessed projections have suggested global average temperature increases between about 0.15°C and 0.3°C per decade for 1990 to 2005. This can now be compared with observed values of about 0.2°C per decade, strengthening confidence in near-term projections (IPCC, 2007).

Figure 2. Changes in mean annual temperature for Zimbabwe 1900–1998 and early temperature trends across southern Africa 1901–2002

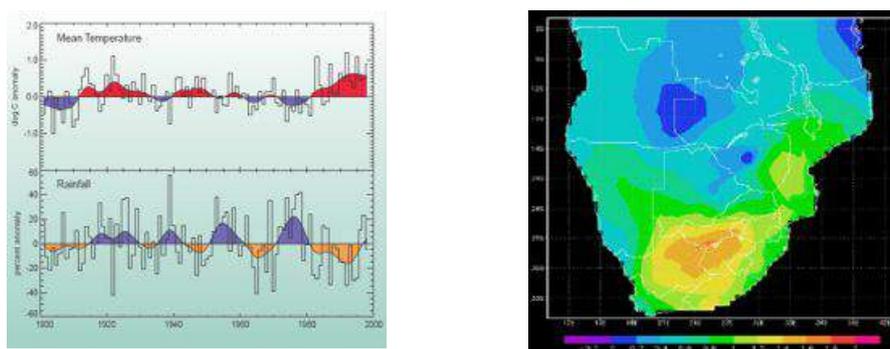
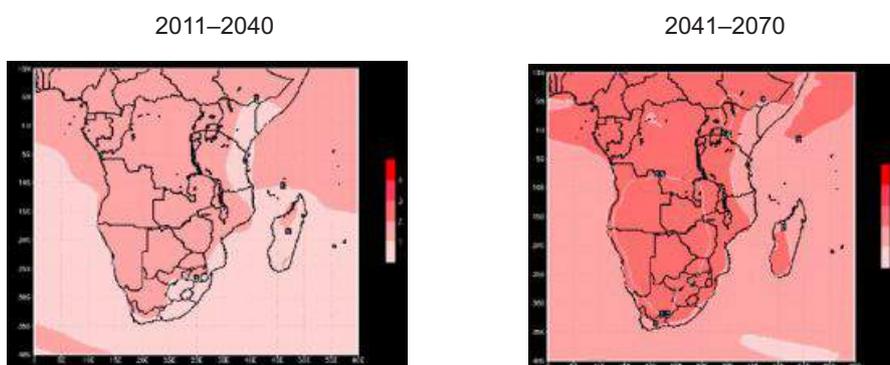
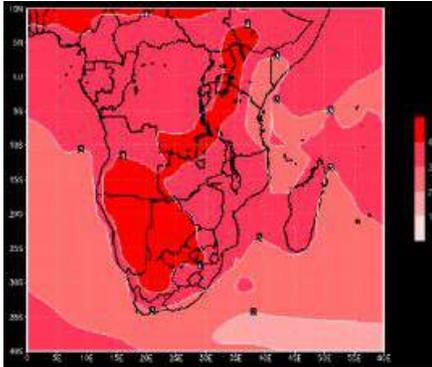


Figure 3. Projected changes in annual average temperature from the 1961–1990 baseline



2071-2100



Source: Engelbrecht et al, 2009

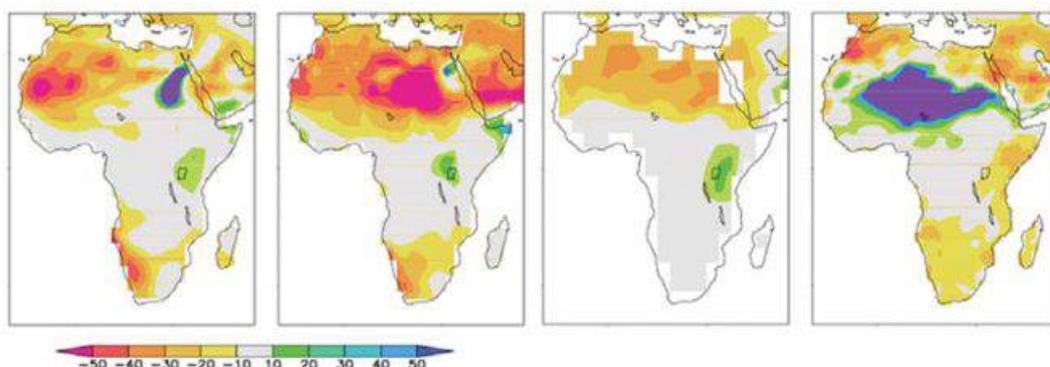
4.2.3 Rainfall

Zimbabwe does not show any aggregate long-term trends in levels of rainfall (see Figure 4). However, it appears that the timing and amount of rainfall received in any given season are becoming increasingly uncertain. In addition, from 1950 to 2010, the length and frequency of dry spells during the rainfall season has been increasing while the frequency of rain days has been reducing (Tadross et al, 2009). It has been generally observed that competing responses (such as an increasing number of dry days, coupled with increases in rainfall intensity), working at different timescales, tend to mask climate change signals in time-averaged total rainfall across the country.

4.2.4 Projected changes in precipitation

There is considerable uncertainty relating to precipitation changes simulated by global climate models for Zimbabwe and Africa. Some global climate models suggest increased precipitation while others suggest drying by as much as 10–20% of the baseline (Figure 4). Downscaled model outputs for selected river basins in Zimbabwe also show little evidence of significant changes in total precipitation across the country, but do show substantial temperature increases, leading to greater evapotranspiration and possible water stress (Boxes 2 and 3).

Figure 4. Percentage change in annual mean precipitation around 2050 compared with 1971–2000 in selected climate models



From left to right: Geophysical Fluid Dynamics Laboratory (GFDL) Coupled Model (CM) 2.0 and 2.1; Canadian Centre for Climate Modelling and Analysis (CCCMA); Third Generation Coupled Global Climate Model (CGCM) Output 3.1; Hadley Centre Global Environmental Model (HadGEM), version 3

Source: KNMI, 2006

Box 2. Save River Basin climate change scenarios

The Coping with Drought and Climate Change project, managed by the Environmental Management Agency, UNDP, and the Global Environment Facility (GEF) used data from ten global climate models to produce downscaled future climate change scenarios for the Save River Basin in southeast Zimbabwe for the periods 2046–2065 and 2081–2100. The downscaled data predict a temperature increase of 1.5–3.5°C across the basin by 2046–2065 for the A2 (high emissions combined with high sensitivity) greenhouse gas emissions pathway. Rainfall predictions for the same period, from the median model output, do not show significant changes in total rainfall amount, except for some slight decrease during February. Scenarios of rising temperatures across the Save River Basin imply increased water loss through evapotranspiration, which could lead to some water balance problems if water supply and management practices do not change.

Source: Government of Zimbabwe/UNDP/GEF Coping with Drought and Climate Change project, 2009

4.2.5 Weather extremes

Extreme weather events include spells of very high or low temperature, torrential rains, and droughts. Changes in extreme events may be the first indication that the climate is changing. Change can occur in both mean climate parameters and the frequency of extreme weather events.

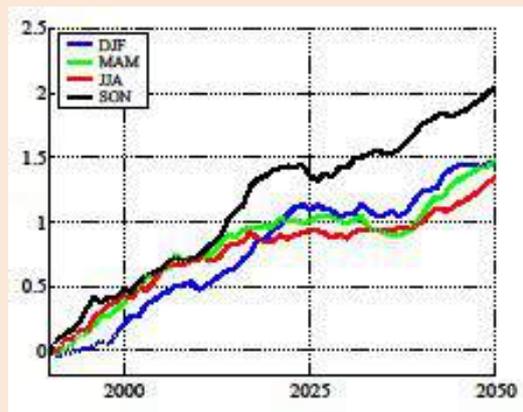
Global trends in temperature and precipitation extremes indicate that, between 1955 and 2003:

- the occurrence of extreme cold days and nights decreased by 3.7 and 6.0 days per decade respectively
- the occurrence of extreme hot days and nights increased by 8.2 and 8.6 days per decade respectively
- the average duration of warm days increased by 2.4 days per decade
- the Diurnal Temperature Range showed consistent increases
- there was a significant increase in regionally averaged daily rainfall intensity and dry spell duration; however these trends were not mirrored in Zimbabwe
- there was an increase in regionally averaged rainfall in maximum annual 5-day and 1-day rainfall.

Box 3. Pungwe river basin climate change scenarios

Sweden's Meteorological and Hydrological Institute used a regional climate model in 2006 to simulate temperature and rainfall over the Pungwe River Basin for two periods: 1991–2020 and 2021–2050, assuming the A2 greenhouse gas emissions pathway. A general feature of the scenario simulations is a significant increase in temperature in all seasons. Taken as an average, the increase is between 1.5 and 2.2°C for all seasons (see Figure 5). For precipitation, none of the simulations gave changes larger than $\pm 5\%$ in total precipitation for the period December to May, while they give decreases of 10–20% between June and November. Models also show a clear delay in the onset of the rains for the Pungwe River Basin. The climate change signal is stronger in the second period 2021–2050 than in 1991–2020.

Figure 5. 30-year running means of simulated seasonal temperatures in the Pungwe river basin



DJF = December, January, February; MAM = March, April, May; JJA = June, July, August; SON = September, October, November

Trends in synoptic systems (e.g. tropical cyclones) are more difficult to assess, because of difficulties in monitoring these consistently over several decades and in modelling and understanding them. The strongest evidence that extremes are changing is the significant difference in the frequency of climatic shocks between the 1980s and the late 1990s and early 2000s.

Prolonged periods of extreme weather – such as the five years of El Niño conditions during 1990–1995 – can affect agriculture. Changing weather patterns can increase the vulnerability of crops to infection and weed/pest infestations. Sequential extremes, along with altered timings of seasons,

can also decouple relationships among species (e.g. predator/prey) essential for controlling pests, pathogens and populations of plant pollinators (Rosenzweig et al, 2001).

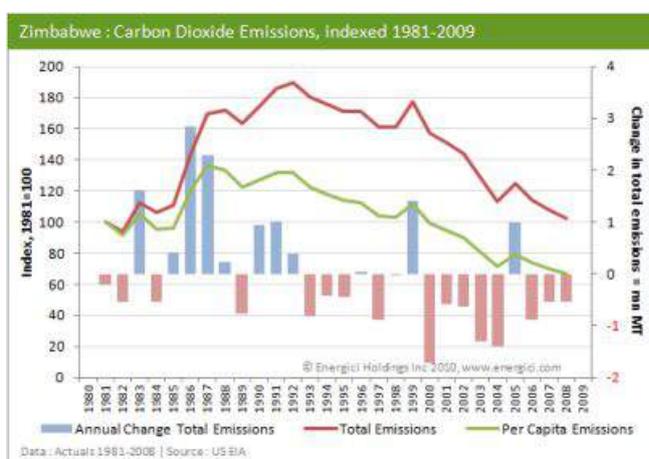
4.2.6 Carbon Dioxide Emissions

Current CO₂ emissions from anthropogenic sources (mainly fossil fuel burning and land use change), and their resultant concentration in the atmosphere, are central to future climate change. Projected CO₂ emissions shape policy options for climate change mitigation.

Figure 6 shows CO₂ emissions in Zimbabwe from 1980 to 2009. It is important to note emissions have been decreasing in the last decade of that period. In 2008, total CO₂ emissions were 8.96 million metric tonnes (mn MT), a compound decrease of 2.04% from 2003 (Energici Holdings, 2010).

Zimbabwe's total emissions are 0.78% of total regional emissions in Africa and 0.03% of total world emissions. On a per capita basis, Zimbabwe was ranked at 154 worldwide in 2007, with per capita emissions of 8.17 mn MT (ibid). With the economic recovery of the past three years and increased agricultural production, it is expected that CO₂ emissions will increase. But this is from a very low base, so the increase will not significantly alter the country's contribution to regional and global emissions.

Figure 6. Zimbabwe's CO₂ emissions, indexed 1981–2009



4.3 Climate science in Zimbabwe

The climate system can only be understood if it is analysed on a global scale. But Zimbabwe's climate has some unique characteristics, influenced by a distinct set of climate drivers. There is a need to promote local climate research to produce the information needed to understand climate change relevant to local needs, and to inform effective policy responses. In the 1990s, Zimbabwe contributed to climate science through a wide range of peer-reviewed papers in international journals and high-level climate change impact assessments provided to the Government via the National Climate Change Office. During the same period, Zimbabwe was an active participant in IPCC Working Groups, the International Geosphere-Biosphere Programme and the World Climate Research Programme. But current climate science does not maintain this quality and is mostly based on empirical studies rather than modelling.

The country is yet to develop world-class climate change science capabilities. A skills shortage in science agencies is developing, and better career opportunities for scientists are needed to address this. Part of the solution must be to improve cooperation between Zimbabwe's research institutions and international climate change experts. Zimbabwean universities also need to increase their climate science capacity. The Government needs to consider targeted investment to provide the necessary capability in infrastructure, people and climate science capacity.

4.4 Knowledge management of climate data

User communities including climate scientists, farmer groups and government ministries, are seeking efficient and effective mechanisms to access climate change information to underpin their policies and decision-making processes. Using climate data to manage climate change is an essential component of any mitigation and adaptation effort. Improving our ability to collect, aggregate and make accurate data broadly accessible would significantly improve our capabilities for responding to climate change.

The Meteorological Services Department currently manages a central database of historic climate data but has nothing on future climate impacts. A national node for knowledge management on climate change, and the vulnerability of systems and sectors at various spatial and temporal scales, is necessary to support mitigation and adaptation programmes.

4.5 National framework for climate change science

This sub-section assesses some of the challenges for Zimbabwe's climate change science agenda in terms of capability, people and institutions, and research. It also identifies areas where climate change science will need to deliver information over the next decade.

4.5.1 Capability

Climate observations

Long-term, consistent records of the climate system underpin climate change detection and attribution. They provide vital information with which to test models and support the development of adaptation and mitigation responses.

The Meteorological Services Department is Zimbabwe's primary institution for gathering meteorological data and producing weather forecasts. The network coverage is about 65 meteorological sites and around 400 rainfall stations (a decline from 1400 in 2001). Priority data streams include:

- annual assessments of temperature and precipitation change
- records of greenhouse gas emissions, particularly CO₂
- observed changes in extreme weather events, such as the frequency and intensity of tropical cyclones, dry spells, heat waves, thunderstorms, heavy rain and hail.

Climate process studies

Process studies lead directly to improvements in climate system information and predictability. Elements of Zimbabwe's climate system that require process studies include cloud dynamics and feedbacks, aerosol (air pollution, dust and smoke) effects, tropical convection, ocean interaction, land surface–atmosphere exchange, and the dynamic interactions of vegetation with the changing climate. Currently there is no evidence of local capacity to undertake such studies.

Predicting future climate scenarios

Zimbabwe needs climate information at time scales of days, months, years, and decades, and across a range of spatial scales. The country currently has the capacity to provide daily forecasts and some limited information about seasonal climate (3–9 month forecasts) with moderate accuracy. The country's capacity to provide information on the 10–30 year time scale, which is of interest to many decision-makers for adaptation programming, is almost non-existent.

Linking the climate with social and economic systems

While there are some joint activities to enhance risk reduction activities, there is still little active engagement between communities researching similar themes. There is a need to enhance efforts on the coupling of disaster risk reduction activities, vulnerability assessments, and climate change and variability assessments. There is also a need to improve and continue to assess the means (including the institutional design and requirements) by which scientific knowledge and advanced technological products (e.g. early warning systems, seasonal forecasts) could enhance the resilience of vulnerable communities.

4.5.2 People and infrastructure

Appropriate skills, infrastructure and communication mechanisms are fundamental to efforts to deliver the information needed by the adaptation and mitigation communities. Skilled Zimbabwe scientists are distributed across several local and foreign institutions, including academic and research organisations, and some government agencies. The challenge is to develop an effective mechanism to coordinate climate science work across these institutions and:

- harness the best available scientists to work on national climate change science priorities
- use scarce resources, large-scale infrastructure and data more efficiently
- develop new scientific talent.

Much of the research on climate has been driven by the atmospheric sciences community, including greater interaction with biophysical scientists in recent years. However, there is much to be gained from an approach that includes those working in the social sciences and public policy. Moreover, the growing interest in partnerships, both public and private, as well as the inclusion of large corporations, formal and informal business, and wider civic society, requires more inclusive processes and activities. More creative interactions will be required, for example greater interactions between users and producers of science, as well as policy-makers and development agencies.

4.5.3 Future research directions

The IPCC Fourth Assessment Report has identified a number of knowledge gaps for Africa, most of which are relevant for Zimbabwe. There has been considerable progress in recent years, particularly with model assessments, but the climate in many areas of Zimbabwe is still not fully understood. Climate scenarios developed from global climate models are very general and do not adequately capture important local variations. There is a need to develop regional and sub-regional climate models, at a scale that is meaningful to decision-makers and that includes stakeholders in framing some of the issues.

A further need is an improved understanding of climate variability, including an adequate representation of the climate system and the role of regional oceans. Improved seasonal forecast systems are expected to play an increasingly important role in strengthening adaptation strategies in the country.

Research on agro-ecological zones has so far been conducted on the assumption that these zones are stable. But agro-ecological zones are by definition a function of climate, and their geographical extent or characteristics may change as the climate changes. Future research should estimate the impact of climate change on Zimbabwe's agro-ecological zones. If there are any shifts in agro-ecological regions, these need to be carefully understood and their implications for local economies and livelihoods mapped out. Knowing more about these potential aspects of climate change is essential to social and economic policy in Zimbabwe.

5. Institutional and policy framework for climate change

Several formal and informal institutions deal with climate change issues in Zimbabwe, including public institutions (mainly, government agencies), civil society organisations, NGOs, community-based organisations, private sector organisations, and informal institutions (e.g. traditional authorities).

This section analyses the current institutions and policies that govern climate issues, examining the strengths and limitations. More importantly, the analysis explores the extent to which prevailing institutional arrangements and policy frameworks can serve as a basis for a coordinated approach to the development of national adaptation and mitigation strategies.

5.1. Public institutions

5.1.1 Ministry of Environment and Natural Resources Management

The most important public institution working on climate change is the Ministry of Environment and Natural Resource Management, which provides administrative coordination for climate change policy and programmes. It is the leading ministry for the development and implementation of environmental policy, and coordinates with all other ministries and agencies on environmental matters. The Ministry derives its mandate from one key piece of legislation, namely the Environmental Management Act (Chapter 20:27) of 2002, which is executed via the Environmental Management Agency, the National Parks and Wildlife Management Authority, and the Forestry Commission. The Climate Change Office deals with climate change issues.

The Ministry manages multilateral environmental agreements in Zimbabwe. Zimbabwe was one of more than 150 countries that signed and ratified the three Rio Conventions, including the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. In 1997 Zimbabwe signed the Kyoto Protocol, and both houses of the Zimbabwe Parliament ratified this in 2008.

5.1.2 Climate Change Office

The Climate Change Office was established in the Ministry of Environment and Tourism, in 1996 to implement the UNFCCC and the Kyoto Protocol. It hosts a UNDP/GEF project on capacity building in sub-Saharan Africa, which is commissioning studies to update greenhouse gas inventories.

Staff includes a coordinator and a secretary. An officer from the Environment Division of the Ministry is also assigned to the Office. It is mainly externally funded, with the Government providing office space, furniture and recurrent costs. The coordinator participates in international climate change negotiations and UNFCCC conferences. The Climate Change Office's work is guided by a multi-sectoral National Climate Change Steering Committee.

5.1.3 National Climate Change Steering Committee

The multi-sectoral National Climate Change Steering Committee supports the administration and implementation of the UNFCCC (Ministry of Environment and Tourism, 2008). The Committee was originally established under the United Nations Institute for Training and Research project, with national institutions, universities, research organisations, industry associations and NGOs providing technical input. The Committee meets annually and its primary function is sharing information about UNFCCC negotiations with all relevant stakeholders.

The Committee consists of:

- the Permanent Secretary of Ministry of Environment and Natural Resources Management
- the Climate Change Office, which is the Secretariat
- members of line ministries and parastatals: Agriculture, Health, Science and Technology, Foreign Affairs, Water, Industry and Commerce, Finance, Labour and Social Services, Transport (which includes the Meteorology Department), the Attorney General's Office, Environmental Management Agency, Forestry Commission
- the leader of the Coping with Drought and Climate Change project
- the Standards Association of Zimbabwe
- UNDP, Harare Office
- GEF Small Grants Programme

- the Ozone Office
- Zimbabwe Energy Research Organisation (ZERO), a regional NGO
- Southern Centre for Energy and Environment, a regional NGO
- WWF (formerly the World Wide Fund for Nature), an international NGO.

5.1.4 National Designated Authority Board

Under the Kyoto Protocol, developing countries have access to funds for investment in environmentally sound technologies under the CDM. Zimbabwe is establishing a National Designated Authority, the mechanism required to examine project proposals and access CDM funding. The framework for the National Designated Authority is under review at the Attorney General's Office and is expected to consist of line ministries and be chaired by the Ministry of Environment. A Statutory Instrument is being developed, with terms of reference to guide the operations of the National Designated Authority.

5.1.5 National Task Team on Climate Change

The National Task Team on Climate Change is located in the Office of the President and Cabinet, and led by a Secretary of Special Affairs. The Task Team is charged with responsibility for providing overall policy guidance on climate change issues in the country and assists in mobilising all relevant Ministries and other stakeholders to participate in the development of policy and programmes on climate change in Zimbabwe, and coordinating and spearheading the development of a national climate change strategy. The Task Team would be able to instruct institutions to provide data and information on climate change. Furthermore, the multi-sector Task Team will ensure that decisions taken regarding climate change and development by various sectors are compatible and comply with the overall national development policy.

5.1.6 Department of Meteorological Services

Climate monitoring falls under the responsibility of the Department of Meteorological Services, in the Ministry of Transport. Although the Department does not have any climate change programmes, it participates in climate change initiatives. For example, the Department has a Memorandum of Understanding with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) on a climate change programme, which involves providing data for a weather insurance index.

5.1.7 Zimbabwe National Statistics Agency

The Zimbabwe National Statistics Agency (ZIMSTAT, formerly the Central Statistics Office) compiles national Environmental Statistics Reports, produced in 1994, 2000, 2004 and 2010. The reports identify national environmental concerns and gaps. The 2010 Report contained a section on climate change, including a historical overview of drought and rainfall patterns in southern Africa from 1800 to 2007 (ZIMSTAT, 2010). The Report also contains information on rainfall, water resources and deforestation.

5.1.8 Environmental Management Agency

The Environmental Management Agency, a parastatal under the Ministry of Environment and Natural Resource Management, is responsible for promoting standards for environmental quality, including air quality, and providing environmental information. It oversees implementation of the United Nations Convention to Combat Desertification, which involves a National Action Plan and implements pilot projects dealing with adaptation by vulnerable communities.

5.1.9 Forestry Commission

The Forestry Commission, a parastatal under the Ministry of Environment and Natural Resource Management, monitors the extent of forests and deforestation in the country, and promotes rural afforestation. It carries out studies for the Climate Change Office on the Land Use Change and Forestry initiative.

5.1.10 Ministry of Water Resources, Development and Management

Hydrological observations fall under the responsibility of the Zimbabwe National Water Authority (ZINWA), a parastatal in the Ministry of Water Resources, Development and Management. The Authority is central in the production of water statistics and has the mandate to collect data on river flows and dam levels, run-off in selected rivers, groundwater levels, siltation of water bodies, and rainfall and evaporation (CSO, 2009).

5.1.11 Ministry of Agriculture, Mechanisation and Irrigation Development

This Ministry, in collaboration with research institutions including the University of Zimbabwe and Chinhoyi University of Technology, is carrying out research with smallholder farmers on adaptation to climate change and piloting best practices.

5.1.12 Department of Disaster Management and Resettlement

Natural disasters in Zimbabwe are predominantly climatic or meteorological in origin, namely droughts and floods, but include wild bush fires that are primarily anthropogenic in origin. Zimbabwe has a Disaster Risk Reduction Policy, which provides local structures for disaster and risk management. The Policy is being revised in view of climate change. Policy implementation is coordinated by the Department of Disaster Management and Resettlement (formerly Department of Civil Protection), under the Ministry of Local Government, which is responsible for coordinating and handling natural disasters.

The Department of Disaster Management and Resettlement collates data on natural disasters, including incidence of droughts, landslides and floods, runoff, and disease outbreaks. The Department of Disaster Management and Resettlement has structures at national, provincial and district levels. At the national level, the Climate Change Coordinator is a member of the Disaster Management Committee.

5.1.13 Local Authorities

There are approximately 52 local authorities in Zimbabwe, which are mandated to monitor air quality, but they have little capacity and equipment. Harare City Council carries out air pollution monitoring, but not on a regular basis.

5.2 Non-governmental Organisations

Many national and international NGOs are involved in climate change activities, including mitigation, adaptation, capacity building and awareness raising. According to the National Association of NGOs, over 180 organisations work on climate change and the environment, mainly on resource management in communal areas. ZERO and the Southern Centre for Energy and Environment are members of the National Steering Committee for Climate Change.

5.2.1 The Climate Change Working Group

The Climate Change Working Group consists of organisations interested in climate change in Zimbabwe. The Working Group is chaired by ZERO, which also provides the secretariat.

The Working Group implements programmes that aim to influence government policy. There are a number of thematic sub-committees dealing with a wide range of climate change issues, including:

- advocacy for climate change policy
- facilitating and promoting research
- strengthening education, awareness and capacity development
- promoting climate change adaptations and mitigation strategies
- developing communication strategies.

5.2.2 Community-based institutions

Communities have formed several ad hoc institutions to deal with climate change, primarily adaptation. Largely uncoordinated and formed around a specific issue, they mainly promote an important local concern that is not adequately represented in policy process. For instance, the Tongwe Community Group is addressing the loss of its irrigation infrastructure. To prepare for increased water shortages, the group decided to diversify income-generating activities and switched from growing maize to drought-tolerant and pest-resistant sorghum seed.

5.3 Academic and research institutions

Academic and research institutions are involved in climate issues across various disciplines. Table 3 provides an overview of the key institutions and their respective work.

Table 3. Academic and research institutions working on climate change in Zimbabwe

Institution	Activities
Centre for Social Studies (Trust)	<ul style="list-style-type: none"> • Conducts policy research on climate change and development, particularly effects on local livelihoods. • Works with the Ministry of Agriculture on nationwide vulnerability assessments funded by the Food and Agriculture Organization of the United Nations (FAO).

Chinhoyi University of Technology	<ul style="list-style-type: none"> • A project on climate change education and awareness, focusing on agricultural extension officers.
Department of Geography and Environmental Sciences, University of Zimbabwe	<ul style="list-style-type: none"> • Teaches a course on Climate Change and Development for undergraduate and post-graduate students. • Contributed vulnerability and adaptation studies to the Second National Communication.
Faculty of Agriculture, University of Zimbabwe	<ul style="list-style-type: none"> • A number of projects on the resilience of smallholder farmers to the effects of climate change.
ICRISAT	<ul style="list-style-type: none"> • ICRISAT conducts innovative agricultural research and capacity building programmes on sustainable development in Zimbabwe.
Institute of Development Studies, University of Zimbabwe	<ul style="list-style-type: none"> • Conducts research on development policy and practice in Zimbabwe.
Institute of Environmental Studies, University of Zimbabwe	<ul style="list-style-type: none"> • Conducts environmental research on ecological, social and economic consequences of environmental change. • Provides three services: research and development; education and training; information, consultancy and networking.
Midlands State University	<ul style="list-style-type: none"> • A project on building adaptive capacity to cope with increasing vulnerability due to climatic change with communities in southern Zimbabwe, funded by the UK Department for International Development (DFID) and the International Development Research Centre (IDRC).
Scientific and Industrial Research and Development Centre	<ul style="list-style-type: none"> • A component on climate change under the Cleaner Production Initiative.
Southern Centre for Energy and Environment	<ul style="list-style-type: none"> • Conducts policy and technical studies to support the introduction of sustainable environmental practices. • Provides support for renewable energy and cleaner production technologies, activities that are relevant to climate change.

5.4 International agencies

Over the past decade, several international agencies have stopped working in Zimbabwe. In this context, a significant amount of funding by international and donor agencies was channelled towards work on governance and humanitarian assistance. However, several organisations have supported work on climate change, including the following:

- The British Council and the United Nations Educational, Scientific and Cultural Organization (UNESCO) are implementing a project called 'Our Climate, our Future', which seeks to raise awareness on the effects of climate change in Zimbabwe.
- The British Council, together with the University of Zimbabwe's Institute of Environmental Studies and Department of Civil Engineering, is implementing a project to incorporate climate change into the integrated water resources management Master's Programme.
- In 2011, DfID funded ZERO to commission research under the 'Meeting Information and Advocacy Needs for Adaptation to Climate Change in Zimbabwe' initiative.
- The GEF Small Grants Programme has funded more than 20 small projects on climate change in Zimbabwe since 1993, which have supported activities that contribute to the reduction of greenhouse gases while contributing to local development.

Although this work is commendable, budgets allocated to climate change activities in Zimbabwe have been low. In some instances, climate change budgets were withdrawn or reduced (as with the British Council). These developments, coupled with the political crisis of the past decade, make it extremely challenging for international agencies to fund climate activities in Zimbabwe.

A thawing of the diplomatic tensions since 2009 has seen increased innovation in funding for climate change work, and a return of some international agencies, such as the Danish International Development Agency (Danida). The increasingly active role that the Australian Agency for International Development (AusAid) is expected to take in Zimbabwe, and sub-Saharan Africa generally, might also increase funding for climate change. This should increase budgets for climate change work, although the impact of global financial crisis on future flows of funding to climate change work in Zimbabwe is yet to emerge.

5.5 Links to research and policy

Preliminary analysis of the aforementioned climate change activities indicates there is limited coordination of research and practice to influence national policy processes. Although there is an emerging body of literature on various aspects of climate change, such studies are still to be translated and packaged into accessible, meaningful and practical recommendations that can be taken up by policy-makers and decision-makers. Political tensions of the past decade between researchers, NGOs and international agencies on the one hand, and policy-makers on the other, still characterise this relationship. Consequently, there is limited space for researchers and NGO staff to engage in constructive debates with policy-makers to develop a coordinated response to climate change and development. The use of research to inform a climate change policy will depend on an improvement in these relations.

The Climate Change Office has prepared proposals for, and conducted studies on, climate change and climate-related issues that have influenced the policy process. All these studies aim to help Zimbabwe identify and prioritise the climate change initiatives it should undertake.

The Climate Change Office is currently finalising the Second National Communication to the UNFCCC, coordinated by the Ministry of Environment and Natural Resource Management. This report highlights measures that could reduce greenhouse gas emissions: for example, catchment area rehabilitation through agro-forestry, industrial energy management, development of projects for the CDM, and wider use of renewable energy. The climate change coordinator is currently developing a proposal for the Third National Communication.

Although these reports are important, the project-by-project potential for emission reductions in Africa is generally small. Investors would therefore not achieve the short payback periods they require. The carbon market is a higher cost option for Zimbabwe than it would be if there was a flourishing African, or even Southern African, carbon market. Also, the CDM process is complex and there are limited skills in Africa to conceive, design, implement and certify a CDM project.

Some progress has been made linking the work done by the Climate Change Office to national policy-makers, as climate change is now being debated in Parliament. In 2010, the Parliamentary Committee for Environment and Natural Resources called the climate change coordinator to answer questions on climate change.

In addition, broad research on different aspects of climate change has been carried out in Zimbabwe recently (see Boxes 4 and 5). A key study on the impacts of climate change on agriculture is being conducted by the Environmental Management Agency, in collaboration with the UNDP and with funding from the GEF Special Climate Change Fund.

Box 4. Adaptation: coping with drought

The Environmental Management Agency, in collaboration with UNDP and with financial support from the GEF Special Climate Change Fund, has been implementing a five-year (2008–2012) 'Coping with drought and climate change' pilot project. The project's goal is to enhance the capacity of agricultural and pastoral systems in Zimbabwe to adapt to climate variability and change, with special reference to agro-pastoralists in semi-arid regions. The primary focus is Chiredzi District in Masvingo province.

The project is designed around four outcomes to address the barriers hampering long-term adaptation to climate change in the agriculture sector: (i) developing the capacity of national institutions to facilitate climate change adaptation by improving their knowledge base; (ii) promoting sustainable livelihoods for drylands; (iii) enhancing the use of early warning systems; (iv) up-scaling adaptation lessons, outwards to other areas and upwards to national policy-makers.

Box 5. Research on different aspects of climate change

The University of Zimbabwe is conducting research and field trials on various water harvesting technologies to improve crop yields in dry regions. For example, in the semi-arid districts of Mudzi, Chivi and Mutoko, dead-contour water management technology and *Fanya juus* are being used with appropriate soil-water management techniques and drought-tolerant seeds of crops such as rapoko, sorghum and finger millet. *Fanya juus* are the opposite of contour ridges; the soil is heaped down slope and the resultant ridge keeps water within the levelled field, facilitating infiltration for crops. Combined, the technologies have achieved yields of 3 tonnes per ha of drought-tolerant crops, compared to around 1 tonne per ha under dry farming (Feresu, 2010).

The IDRC's Climate Change Adaptation in Africa research and capacity development programme and the Global Change SySTem for Analysis, Research and Training's (START) African Climate Change Fellowship Programme support African countries in efforts to increase their knowledge, capabilities and experience for advancing climate change adaptation in Africa.

Box 5 (continued)

Several Zimbabwean researchers have produced research through these programmes. For example, the University of Zimbabwe is implementing the project 'The lack of resilience in African smallholder farming: exploring measures to enhance the adaptive capacity of local communities to pressures of climate change' in Rusape and Wedza. The project assesses the vulnerability of smallholder farming communities to the effects of climate change and variability on agricultural productivity and livelihoods. It also identifies opportunities to enhance the adaptive capacity of different households and communities, with a particular focus on integrated soil fertility management.

The **GEF** has been a key partner in supporting mitigation projects in Zimbabwe. For example, the country benefited from the pilot phase of a GEF photovoltaic project with a budget of \$7 million over five years. The project was designed to remove barriers to energy conservation and energy efficiency.

A UNEP/GEF-supported technology transfer needs assessment was conducted in 2004, covering the agriculture, industry, mining, and energy sectors. The assessment aimed to establish technology needs to reduce greenhouse gas emissions from those sectors, as an enabling activity for concrete technology transfer projects. A UNEP/GEF-supported capacity needs self-assessment for the implementation of the Multilateral Environmental Agreements was conducted in 2006.

Climate information can improve early warning systems, which can reduce vulnerability to climate change. Zimbabwe participates in the **Southern African Development Community's** (SADC) regional early warning systems and hosted the SADC Drought Monitoring Centre during from 1991 to 2008 (Feresu, 2010). The Centre monitors near real-time climatic trends and generates long-range climate outlook products on monthly and seasonal time-scales. These outlook products are disseminated to the regional community to help decision-makers develop strategic plans for adverse climatic conditions.

The country also participates in the SADC Regional Early Warning System and the Famine Early Warning System, which provide advisory services on food security. Zimbabwe is also a member of the Southern Africa Regional Climate Outlook Forum, a network that meets regularly to interpret global and regional climate signals and provide seasonal rainfall forecasts for the region.

5.6 Existing institutional architecture for climate change and development policy

Zimbabwe's political crisis created political tensions between Government and other stakeholders, such as civil society organisations, the NGO sector, and donor agencies. Consequently, there has been little coordination between Government and other stakeholders on climate change and development, and policy responses to climate change have been fragmented.

This is supported by findings from the National Capacity Self-Assessment process, which looked at Zimbabwe's ability to implement three United Nations Conference on Environment and Development conventions, including the UNFCCC. The study concluded that, although institutional arrangements exist for implementing the UNFCCC, more needs to be done to formalise institutions and improve mandates (Ministry of Environment and Tourism, 2008). The report further noted that the functions and responsibilities for climate change were not clearly allocated.

The report identified six key capacity constraints:

- Current legislation is based on 'command and control' rather than incentives and penalties. There is a need to enhance the capacity of institutions to formulate evidence-based policies.
- There is low awareness of the existence of climate change, its causes, and possible redress mechanisms, due to inadequate communication and dissemination of information.
- There are insufficient project proposals being developed on climate change for local situations. There is need to streamline the proposal process and provide technical assistance for proposal development.
- There is a lack of climate change-related research in Zimbabwe and a need to strengthen the research and development capacity of local scientists and research institutions.
- Environmental education is limited and needs to be promoted at all levels.
- There is a lack of capacity for systematic inventories of greenhouse gases, and obtaining reliable information is a problem.

A key reason for the lack of user uptake of climate knowledge has been that the Climate Change Office lacks long-term funding. This results in a significant amount of time spent trying to secure funding.

In addition, ZIMSTAT reviewed the capacities of institutions to deliver the information used to formulate climate change policy (CSO, 2009). This review found that the country is not collecting high quality or reliable data regarding air and climate indicators (ibid). The relevant institutions do not have the required equipment or skilled personnel to capture data on air pollution. There are also gaps in data on greenhouse gases in Zimbabwe.

Similarly, the Department of Meteorological Services has faced problems with respect to instruments for measuring climatic data. Over the past 10 years, many rain gauges have been vandalised, or information and returns have not been submitted, either through lack of commitment or lack of sufficient knowledge to make the required measurements (ibid). Animals have destroyed some evaporation pans in remote areas. Also, the automatic weather observing equipment is malfunctioning and obsolete (ibid). As a result the Meteorological Department is now failing to collect relevant climatic information to inform users, and more importantly, to make day-to-day decisions.

The reliability of air and climate statistics provided by the Meteorological Department is further compromised by gaps in geographical locations (ibid). Much of the data is not captured due to malfunctioning or absent equipment. The Department has a lack of computer capacity for climate modelling to create local scenarios. These problems need to be addressed if climate data is to be used to understand climate change and feed into national policy processes.

The Climate Change Office collects data on greenhouse gas emissions through commissioning studies by consultants. Under the obligations of the UNFCCC, Zimbabwe is required to collect data and report on greenhouse gas emissions every five years. The last report was in 1998 and the Climate Change Office is currently working on the latest National Communication Report. There is no systematic emissions inventory for the country, except that compiled on greenhouse gases as part of the Initial National Communication to the UNFCCC (Ministry of Environment and Tourism, 2008).

Although the Climate Change Office adheres to quality control techniques developed by the IPCC and its reports are subjected to external validation, it does not have the resources to verify data submitted (CSO, 2009). Verifying data would improve the quality of the statistics produced.

At present, the Climate Change Office is not able to deliver effectively because of its weak mandate, small size, limited structure and limited funding. It does not have statutory powers to enforce compliance in submission of returns. The Office only operates at national level; as such there are no lower level structures, meaning no vertical coordination.

5.7 Challenges and opportunities for institutional coordination on climate change and development

There are several potential challenges to effective institutional coordination, as well as opportunities to improve coordination of climate and development in Zimbabwe.

5.7.1 Climate Change Office

The major challenge is the limited capacity and mandate of the Climate Change Office, which is geared to serve the international agenda on climate change. The fact that the Climate Change Office is funded by UNEP might place emphasis on UN processes on climate change, which emphasise mitigation and carbon trading. One of the key activities of the Climate Change Office is compiling the national communication frameworks, such as the Second Communication. Although important, such policy documents are primarily for the UN. There is need for the Climate Change Office to focus more on the national agenda, specifically the effects of climate change on Zimbabwe's social and economic development. The Climate Change Office should pay more focus to climate change adaptation issues in Zimbabwe, which are the country's priority under the UNFCCC (Ministry of Environment and Tourism, 2008) and champion these at national and international levels.

The lack of a comprehensive climate change policy makes it difficult to mobilise funds. A welcome development in 2011 was the Government's decision to allocate funds to the Ministry of Environment and Natural Resource Management for climate change activities.

Zimbabwe has a well established, albeit small, Climate Change Office with an experienced coordinator, together with a high level of experienced technical expertise. This could lead to a vibrant and effective institution for leading all aspects of climate change and development in Zimbabwe. The Office has robust links with major stakeholders and institutions on climate change, both government and civil society, as well as with the private sector and academia. With more resources, the Office could be transformed into a fully-fledged department, with sections to deal with specific issues. The National Capacity Self-Assessment corroborates this as a priority need under the UNFCCC (Ministry of Environment and Tourism, 2008).

5.7.2 National Steering Committee on Climate Change

The multi-stakeholder National Steering Committee on Climate Change is an excellent opportunity to permeate all areas of development and coordinate across sectors. However, at present, the National Steering Committee is more of a platform for sharing information on international climate change events than for addressing national climate change issues. Meetings are infrequent and there is no mechanism to coordinate policies or implement climate change activities. This reduces its impact for driving sustainable development and climate change issues.

The national importance and crosscutting nature of climate change and development issues has been recognised, and the matter is currently being addressed by the Office of the President and Cabinet, through the National Task Team on Climate Change. The advantage of such a high level Task Team is that it has the authority to carry out its mandate and insist on compliance. The Task Team is able to instruct institutions to provide data and information on climate change. Furthermore, it can ensure that decisions taken regarding climate change and development by various sectors are compatible and comply with the overall national development policy. This will avoid conflicts between targets set for national appropriate mitigation actions under the multilateral agreements and national industrial development.

A strong multi-disciplinary institution would enable the country to plan in a coordinated manner for worst-case scenarios. It is envisaged that technical committees with operational mandates will be established under the National Task Team to handle the various issues.

There is a need for a coordination mechanism and structures to ensure the systematic identification, coordination and monitoring of climate change policies and activities in each sector. One solution could be a 'climate change desk' in each relevant ministry.

5.8 Vertical coordination: lack of downward and upward links

At present, there is a disjuncture in coordination between national and local levels. Although the Environmental Management Agency has officers at the district level, the Climate Change Office does not have any lower level structures. This makes the coordination of countrywide activities difficult. Institutions responsible for adaptation at the local level report to different line ministries. Accountability tends to be upwards, rather than downwards, resulting in very little coordination of policies and activities at the lower levels. There is an opportunity here, with a lot of activity at district and local levels that needs to be coordinated and streamlined. Strengthening local level institutions and structures will improve local level coordination. These in turn can then engage with institutions at higher levels.

5.9 Compliance on climate change policies

The absence of a distinct, overarching climate change policy makes it difficult for the Ministry of Environment and Natural Resource Management to insist on compliance or the submission of required data on climate change indicators, as it does not have the mandate or authority to be effective across sectors. There are also different priorities within industry. Climate change issues are not mainstreamed into sector policies, which are often contradictory and non-compliant. Furthermore, there are numerous climate change mitigation and adaptation activities that are not coordinated, instead implemented on an ad hoc basis. This results in overlaps and gaps. A variety of projects and research are being implemented on climate change issues, with various sources of funding and partnerships, but it is unclear how these relate to the national coordinating institutions.

There is need to harmonise climate change policy across sector policies, as well as harmonise climate change activities, and give the Ministry of Environment and Natural Resource Management a stronger mandate and greater authority to insist on compliance.

This can be ensured through legislation, such as developing regulations under the Environmental Management Act and as part of the domestic process to ratify the Kyoto Protocol.

This issue is being addressed through the formation of a comprehensive National Climate Change Strategy, initiated by the Ministry of Environment and Natural Resource Management with funding from UNDP. Zimbabwe's Medium Term Plan 2011–2015 sets a time frame for the development of the National Climate Change Strategy and Policy by the end of 2013 (Government of Zimbabwe, 2011).

5.9.1 Role of Civil Society

Civil society initiatives on climate change are not well organised or coordinated. They tend to run parallel systems, being supported by various sources of donor funding. The strength of the Civil Society Working Group, an umbrella group for civil society organisations, is that it comprises organisations with a diverse range of interests in climate change. However, the Climate Change Office is not represented in the Working Group, and consequently links with Government are weak. To forge stronger links with government actors and more effective coordination of climate activities, the Climate Change Office should be invited to join the Working Group, so that the civil society can benefit from national priorities, policy and practices.

5.10 Integration of climate change and development into national policy frameworks

The National Environmental Policy and Strategies is the framework policy that provides scope for an integrated approach to sustainable development in Zimbabwe (Government of Zimbabwe, 2009). The National Environmental Policy and Strategies provides for a number of objectives. One of the key principles of these objectives is sustainable development that promotes equitable access and sustainable use of natural and cultural resources, to satisfy basic needs, enhance food security, reduce poverty and satisfy basic needs.

National Environmental Policy Objective 2.3.6 calls for the promotion of national interests by cooperating in the drawing and implementation of international environmental agreements, such as the UNFCCC.

The main goal of the Environmental Policy is 'to avoid irreversible environmental damage, maintain essential environmental processes, and preserve the broad spectrum of biological diversity so as to sustain the long term ability of natural resources to meet the basic needs of people, enhance food security, reduce poverty, and improve the standard of living of Zimbabweans through long term economic growth and the creation of employment' (Ministry of Environment and Natural Resource Management, 2008:2).

Following international and regional trends in natural resources management, the Policy promotes principles of sustainable management: public participation and partnerships, access and benefit sharing, access to information, polluter pays principle and integrated approach. Box 6 lists these environmental rights and general principles.

Box 6. Environmental rights and general principles guiding environmental management in Zimbabwe

General environmental rights

Every person shall have a right to:

1. a clean environment that is not harmful to health
2. access to environmental information
3. protect the environment for the benefits of present and future generations and participate in implementation of legislation and policy that prevents pollution and environmental degradation and enhance ecologically sustainable management of natural resources whilst promoting economic and social development.

General principles

4. All elements of the environment are linked and inter-related, therefore environmental management must be integrated and the best practicable environmental management options must be pursued.
5. Environmental management must place people and their needs at the forefront of its concern.

Box 6 (continued)

6. The participation of all interested and affected parties in environmental governance must be promoted and all people must be given an opportunity to develop the understanding, skills and capacity necessary for achieving equitable and effective participation.
7. Environmental education, environmental awareness and the sharing of knowledge and experience must be promoted in order to increase the capacity of communities to address environmental issues and engender values, attitudes, skills and behaviour consistent with sustainable environmental management.
8. Development must be socially, environmentally and economically sustainable.
9. Anticipated negative impacts on the environment and on people's environmental rights shall be prevented, and where they cannot be altogether prevented be minimised and remedied.
10. Any person who causes pollution or environmental degradation shall meet the costs of preventing, controlling and minimising further pollution, environmental damage and adverse health effects.
11. Global and international responsibilities relating to the environment must be discharged in the national interest.
12. Sensitive, vulnerable and highly dynamic or stressed ecosystems require specific attention in management or planning procedures, especially where they are subject to significant human resource usage and development pressure.

The Zimbabwe Medium Term Plan 2011–2015 integrates climate change to all sectors of the economy. The overall goal is 'to transform the economy, reduce poverty, create jobs, maintain macro-economic stability and restore the economy's capacity to produce goods and services competitively, building upon the gains achieved since the launch of Short Term Economic Recovery Programme in March 2009' (Government of Zimbabwe, 2011:1). The Medium Term Plan also states that 'climate change poses a significant and complex challenge to Zimbabwe' (Government of Zimbabwe, 2011:165). To adequately deal with these challenges, the Medium Term Plan advocates for the development of a Climate Change Strategy and Policy with the objective of 'promoting climate change mitigation and adaptation strategies in social and economic development at national and sectoral level' (ibid.).

The Medium Term Plan's policy targets under climate change are:

- the development of National Climate Change Strategy and Policy by end of 2013
- the development of National Plan for Adaptation and Mitigation by end of 2012
- an increase in the integration of climate change adaptation and mitigation strategies in economic and development activities and policies at national and sectoral level by end of 2012.

The development of a comprehensive climate change strategy and policy is important in many ways. First and foremost, the policy will outline the Government of Zimbabwe's intention, vision and strategies with regard to climate change. Second, the policy and strategy will lead to a coordinated and harmonised approach. Currently, uncoordinated and fragmented approaches result in conflicts and overlaps between various laws, policies and government departments, which wastes human and financial resources. The need for a coordinated and harmonised approach to climate change cannot be overemphasised.

5.11 Research and technical assistance

Zimbabwe has limited capacity to address climate change at policy, research and implementation levels. Several studies have identified and prioritised the most pressing needs as greenhouse gases monitoring and the generation of accessible, policy-relevant environmental and climate information. Studies also indicate there is a need to strengthen capacity for policy formulation and analysis, and mainstream climate change in the country's sectoral policies.

This Baseline Report suggests key priority areas for research and technical assistance:

- Support for a National Climate Change and Development Policy and Strategy. This should be done through broad-based consultation and participation at all levels and with all sectors. Once the policy is in place, it will need support for its implementation. There is also a need to support the integration and implementation of climate change and adaptation strategies in economic and development activities at national and sectoral levels.

- Support for a fully staffed and resourced Climate Change Office. This is a prerequisite for implementing a climate change policy and strategy. At implementation level, there is need for better coordination of activities among different ministries and sectors, and for financial and human resources to be mobilised (Feresu, 2010).
- Enhanced capacity of local level institutions to adapt to climate change. Technical assistance and research should focus on building the capacity for adaptation and strengthening local institutions (Ministry of Environment and Tourism, 2008). Support needs to cascade from the Climate Change Office to the provinces. This could be done by extending the mandate of the District Environmental Committees, which are already involved with fire control, prevention of deforestation, and pollution.
- A policy-relevant research programme would help identify appropriate actions as the state of knowledge evolves. Research needs include understanding the mechanisms responsible for climate variability, such as El Niño events, and improving forecasting and early warning systems for extreme weather events.
- Of paramount importance is research to develop practical and technological innovations for adapting to the impacts of climate change. For example, there is a need for research on: crops and livestock that are more tolerant to disease and drought; short-season, high-yielding crop varieties and livestock breeds; effective storage systems for agricultural products; and water harvesting. Research into the cost-effectiveness of these options is needed, so that policy decisions are well informed.

5.12 Summary

There is an urgent need for a climate change policy to provide the framework in which development actors across all sectors can operate. At present, there are fragments of policies spread across various sectors; these need to be streamlined and harmonised into a comprehensive climate change policy, with strategies for implementation. The development of the policy should be informed by research findings and experiences of climate change in Zimbabwe.

Key institutions dealing with climate change issues are in place; these need strengthening to be fully functional. There is an urgent need to provide the necessary resources for the government structures involved in climate change to operate effectively. In particular, the Climate Change Office is the core of climate change activities in Zimbabwe and needs to be fully resourced to become a decentralised hub of climate activities in Zimbabwe.

Part C – Sectoral analysis

6. Agriculture

This section focuses on the threats and opportunities from climate change in the agriculture sector. Increases in temperature, more frequent extreme weather events, and greater rainfall variability are projected to increase the occurrence of crop failures, pests, crop disease, and the degradation of land and water resources. These impacts will adversely affect Zimbabwe's agricultural sector as the country seeks to increase agricultural production to support a growing population and national economy. Agriculture also contributes to anthropogenic emissions of greenhouse gases, so the sector has a key role to play in mitigation strategies.

6.1 Overview of the agricultural sector

Zimbabwe's agricultural sector is highly diversified, producing tobacco, wheat, tea, coffee, maize, cotton, beef, and dairy and horticultural products. Agriculture provides livelihoods to over 70% of the population and currently contributes 20.4% to the GDP (Ministry of Finance, 2011).

Between 1998 and 2008, the agricultural sector contracted rapidly due to a combination of factors, including frequent droughts, foreign exchange shortages, and the political crisis associated with the Fast Track Land Reform Programme (AfDB/OECD, 2003: 356). Some analysts point out that sanctions and restrictive measures on some of the political elite have limited lines of credits to the sector, contributing to the decline in production.

Despite the significant decline in the sector in the past decade, agriculture continues to play an important role in Zimbabwe's development. It is providing employment for the majority of the population during the current economic recovery. The allocation of land to a significant number of small- and medium-scale farmers under the land resettlement programme, coupled with the planned programme to put 240,000 ha of land under irrigation by 2015, suggests substantial future growth, especially if agricultural prices remain favourable.

The agricultural sector has strong forward and backward links with the manufacturing sector. At least 60% of agricultural produce finds its way into local manufacturing industries, while 20% of manufacturing output is absorbed by agriculture (AfDB/OECD, 2003).

For many decades, there was sustained public investment in maize, tobacco and cottonseed, leading to great improvements in yield. These crops are widely grown by smallholders.

6.1.1 Maize

Production of maize, Zimbabwe's staple crop, on communal land increased rapidly in the 1980s and 1990s, but declined between 2002 and 2008 (see Figure 7). Between 2009 and 2011, maize production increased across all farming sectors, with communal farmers accounting for the largest share (43%) while large commercial and A2 (commercial) farmers accounted for 4% and 20% respectively (Government of Zimbabwe, 2011). Table 4 shows that A1 (smallholder) farmers contributed 20% of the increase in maize production, while resettled farmers contributed 5%, small-scale commercial farmers 2%, and peri-urban farming 4% (ibid).

Although maize production increased between 2009 and 2011, the total output was still inadequate to meet the total national maize requirement of 1.8 million tonnes. The significant declines in old resettlement schemes and small-scale commercial farms need to be addressed as part of a broad strategy to produce sufficient maize to meet national requirements.

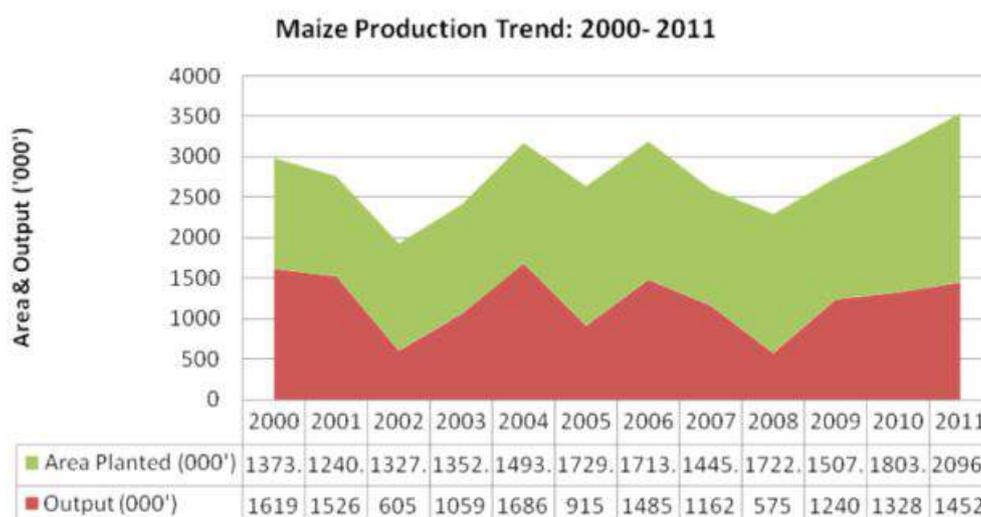
Communal areas play a pivotal role in maize production. Yet, invariably all communal areas are located on marginal lands in Natural Regions IV and V (see Section 3.4), regions that are prone to droughts. The predicted increase in the frequency and intensity of droughts associated with climate change is likely to adversely affect maize production in communal areas.

Table 4. Sector contribution to maize production 2009-2011

Sector	2009/2010 season	2010/2011 season	2011 proportion of contribution (%)	Yield change (%)
Communal areas	536 051	627 210	43	17.0
A1	296 964	357 408	24	20.4
A2	259 668	285 443	20	9.9
Old resettlement	133 740	69 603	5	-48.0
Small-scale commercial farming areas	40 454	29 909	2	-26.1
Peri-urban	60 695	56 704	4	6.6
Total	1 327 572	1 457 799	100	9.8

Source: Ministry of Finance, 2011

Figure 7. Maize production 2000–2011



Source: Ministry of Finance, 2011:19

6.1.2 Cotton

Cotton mirrors the development of maize production in Zimbabwe in many ways, with a highly successful local breeding programme and successful integrated pest management techniques. The cotton marketing system has been described as a 'single channel operation', ensuring high-quality produce and input provision, and paying highly competitive prices to growers (Tschirley et al, 2006). But cotton production has been declining, associated with the decrease in average yield per ha from 2009 to 2011. Average yield/ha declined from 0.7 tonnes per ha in 2010 to 0.58 tonnes per ha in 2011 (Ministry of Finance, 2011). Paradoxically, the decline in average yield was accompanied by an increase in the area under crop production, which increased from 338,270 ha in 2010 to 379,689 ha in 2011 (ibid).

6.1.3 Tobacco

Tobacco used to be Zimbabwe's main foreign exchange earner and main national industry, contributing 25–30% of total earnings, and at least 6% of national employment (Woelk et al, 2001). Since 2000 production has collapsed, mainly due to the implementation of the Fast Track Land Reform Programme, which led to the acquisition and redistribution of some of the large-scale commercial tobacco farms. Annual production decreased from over 200,000 tonnes to less than 50,000 tonnes in the early 2000s. However, in 2010 Zimbabwe produced over 118,000 tonnes of flue-cured tobacco, more than doubling the previous years' crop. This increase was not based on large-scale estate production, but smallholders, who grew around 70% of the crop.

Zimbabwe mainly grows and exports flue-cured Virginia tobacco. This is a capital-intensive crop, due mainly the curing requirements of heating the reaped tobacco leaf in large barns and ensuring that smoke does not impart any flavour into the leaf. The labour required for flue-cured tobacco is highly concentrated in a small period of time: not only are large quantities of fertiliser applied in a single dose, but leaves must be reaped quickly before they fully mature. These agronomic characteristics have contributed to flue-cured tobacco being grown using direct wage labour, and not estate tenants or out-growers.

6.1.4 Horticulture

The production and export of horticultural goods such as fresh vegetables, fruit and cut flowers expanded rapidly in the 1980s and 1990s. Zimbabwe was one of the few countries able to exploit international horticultural markets – mainly cut flowers, baby vegetables, mange tout, sweet corn and chillies. These crops were usually exported to the UK. By the middle of the 1990s, over 140 smallholder schemes were growing over 8,000 ha of horticultural crops. By the end of the decade, smallholder farms produced around 10% of fresh produce for export (Masakure and Henson, 2005).

6.1.5 Finger millet and groundnuts

The production of crops such as finger millet and groundnuts has significantly increased in the past three years. Table 5 shows the increased production of the two crops between 2009 and 2011.

Table 5. Production of finger millet and groundnuts 2009–2011

Crop	Production in tonnes		Percentage change
	2009/2010 season	2010/2011 season	
Finger millet	12,403	16,627	34
Groundnuts	186,214	230,475	24

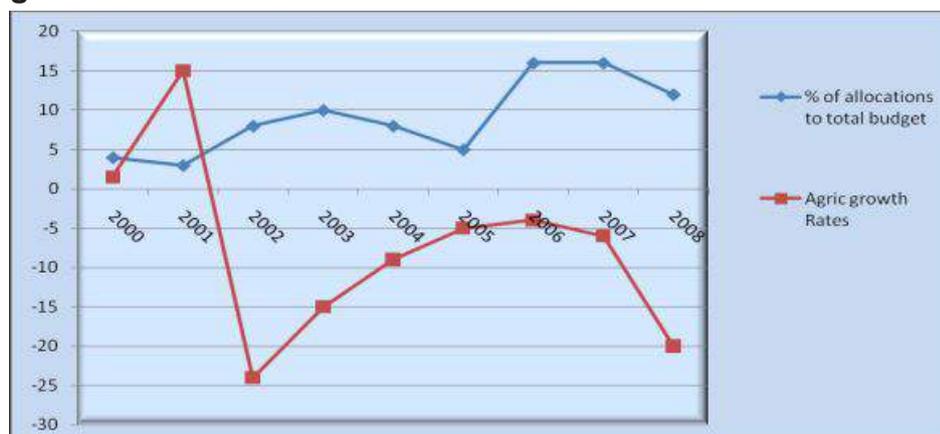
Source: Ministry of Finance, 2011

Despite the significance of agriculture to the national economy, Government support has been falling far short of the 10% of national budget recommended by the Africa Union Maputo Declaration of 2003. For the period 1995–2008, budgetary allocation has varied from 2% to 7.5%. Figure 8 shows the continued low trend in budgetary allocation to agriculture and agricultural growth rates from 2000 to 2008. However, between 2009 and 2011, international partners and private financiers provided \$1.4 billion to the agricultural sector, with the Government providing \$552.

In the Medium Term Plan, the agriculture sector is projected to grow by 14.8% in 2012, 8.8% in 2013, 7% in 2014 and 5.9% in 2015 (Government of Zimbabwe, 2011).

This is expected to ensure that agriculture plays its part in contributing to economic growth and poverty reduction as well as enabling the country to be food self-sufficient. This growth in agriculture is premised upon maize, sugarcane, tobacco, cotton and beef production, coupled with increase in irrigation development. This has implications on policy options for climate change adaptation and mitigation strategies.

Figure 8. Trends in budgetary allocations to agriculture and agricultural growth rates 2000–2008



Source: Ministry of Finance, 2011

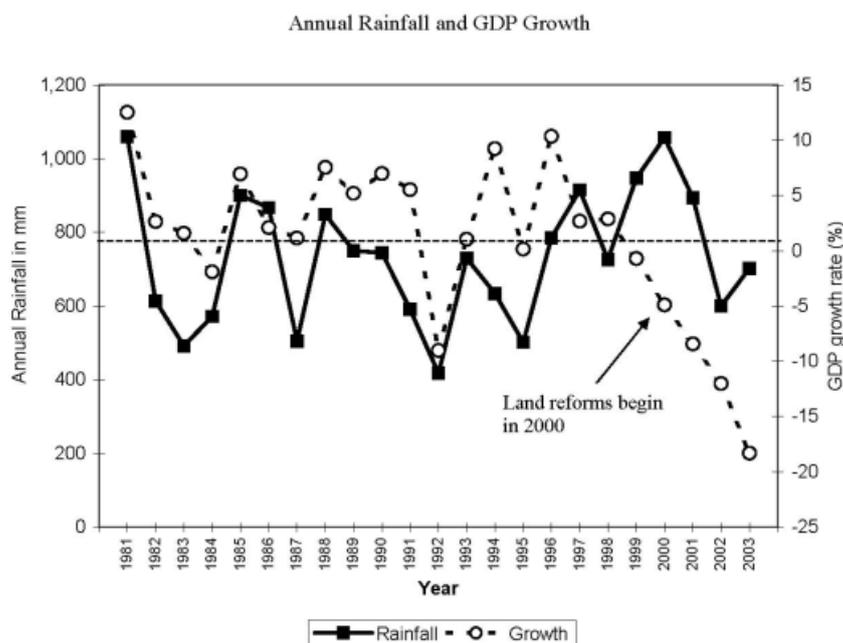
6.2 Climate change vulnerabilities and opportunities

Rainfall is the most important climatic factor affecting crop production in Zimbabwe (Rukuni et al, 2006). As Zimbabwe gets warmer and rainfall becomes more variable, the sector's output will be strongly influenced by weather patterns. Trends in economic performance are closely linked to rainfall variability (see Figure 9).

Vulnerabilities associated with climate change include changing seasonal characteristics, especially the onset and cessation of rainfall, and increasingly intense mid-season dry spells. There have also been notable shifts in the frequency of heavy rainfall events and tropical cyclones. It has been observed by farmers that the onset of the rainy season has shifted from the end of October to the end of November.

The sequence of rainfall events leading to the start of the rainy season, as understood by smallholders in communal and resettlement areas, has almost disappeared. This traditional pattern had guided local farmers on when to prepare their fields for the coming season. They used indigenous names according to the period in which they occurred: madzura chando (the winter rains in June), followed by the gukurahundi (the rain in August), the bumharutsva (the rain in September) and kutemera gwati in mid-November, which indicated the start of the actual rainy season. However, these defining characteristics are no longer seen in intra-seasonal rainfall patterns.

Figure 9. Influence of rainfall on GDP growth



Source: Richardson, 2005:9

Average temperature has also increased, impacting both negatively and positively on crop grain yields (Dimes et al, 2009). These changing rainfall and temperature patterns have affected the country's agro-ecological regions, classified in the 1960s (see Figure 3). Agro-ecological regions classified as high rainfall areas no longer experience rainfall to suit such classification. For example Chinhoyi, Chibero and the surrounding areas, which were formerly classified as Natural Region II with high rainfall, have assumed rainfall characteristics of Natural Region III, marked with low annual rainfall. Kwekwe, which was classified as Natural Region III, has acquired Natural Region IV characteristics.

Natural Region I, characterised by high rainfall, is reported to be shrinking fast. Thus, agro-ecological regions suitable for rain-fed farming are decreasing.

The changes in these key climatic variables will result in lower agricultural productivity and declines in crop yields, pasture growth and livestock production. These impacts are not going to be uniform throughout the country's agriculture systems, but differentiated by farming sector.

Agriculture in Zimbabwe can be broadly classified as smallholder agriculture in communal and A1 resettlement areas, and commercial agriculture in A2 schemes and old, large-scale commercial farms. Table 6 summarises the frequently observed vulnerabilities within the country's farming sectors.

Table 6. Climatic and non-climatic determinants of vulnerabilities to climate change across Zimbabwe's agricultural systems

Farming sector	Examples of vulnerability	Climatic drivers of vulnerability	Non-climatic drivers of vulnerability
Communal areas (smallholder farmers)	<ul style="list-style-type: none"> Poor soils Famine and chronic food shortages Increased poverty 	<ul style="list-style-type: none"> Increased incidence of climate extremes (droughts and floods) Increased aridity Changes in average climate and shifts in rain season 	<ul style="list-style-type: none"> Land degradation Poor rural infrastructure Limited off-farm livelihoods High dependence on a small number of crop varieties Less educated Lack of social safety nets Lack of access to credit
A1 resettlement (smallholder)	<ul style="list-style-type: none"> Declining incomes and increasing poverty 	<ul style="list-style-type: none"> Increased incidence of climate extremes Shifting seasons Deteriorating agro-ecological conditions 	<ul style="list-style-type: none"> Unstable cash prices, and rising input costs Insufficient agricultural management skills Poor infrastructure
A2 (commercial farmers)	<ul style="list-style-type: none"> Declining or more variable net income Decreased crop and livestock quality 	<ul style="list-style-type: none"> Increased incidence of climate extremes Shifting seasons Deteriorating agro-ecological conditions 	Non-climate factors buffered by: <ul style="list-style-type: none"> on-farm dams better farming infrastructure, good access to resources, credit and finance better quality farm products

Constructed from various sources

A2 and old large-scale commercial farmers are mostly located in areas with high rainfall and good soils, and rely on the intensive use of technologies such as improved seeds, fertilisers and mechanisation. As a result, this farming category obtains higher yields per ha for most crops (Mudhara, 2004). Commercial farmers, both A2 and old large-scale farmers, are highly literate and use information productively. Farming for this group is significantly shaped by the performance of commodity markets, access to finance and seasonal forecasts.

In contrast, smallholder farmers in communal and A1 resettlement schemes have a limited asset base compared to their A2 counterparts. Many smallholder farmers are poor and have limited literacy. Communal and resettlement farmers are located in regions that have low rainfall and poor soils. As such, they are more vulnerable and less equipped to understand the nature and extent of climate change. As climate change takes its toll on the agricultural sector, declining agricultural productivity, especially among smallholders, is a major cause of concern.

The categorisation of farmers as smallholders and large-scale farmers translates into varied agricultural productivity across communal, resettlement and large-scale commercial farms. At its peak in the 1980s, smallholder agriculture in Zimbabwe contributed to an increase in maize production. But Mudhara (2004) noted that there were low yields and agricultural productivity in the communal areas compared to large-scale farms. Thus, as an illustration, communal area farmers were achieving maize yields of 800 kg per ha compared to 4,000 kg per ha achieved by large-scale commercial farmers (ibid). Nationally, maize yields declined from a peak of 1,653 kg per ha in 1993 to 455 kg per ha in 2002, before rising to 659 kg per ha in 2007 (Government of Zimbabwe, Draft Agricultural Policy, no date). UNDP (2008) estimates that maize production in Zimbabwe currently averages about a third of 1998 levels.

Changing rainfall patterns have altered the character of the country's agro-ecological regions, but non-climatic factors have and will continue to play an important role as well. These include land and agricultural policies, institutional reforms, technical support, markets for agricultural produce and infrastructure.

6.3 Agriculture and mitigation

Agricultural systems contribute to carbon emissions in several ways:

- Cultivation of soils, resulting in the loss of soil organic matter.
- Clearing of forests to create new cropland.
- Direct use of fossil fuels in farm operations.
- Indirect use of embodied energy in manufacturing processes that are energy-intensive.

Agriculture releases significant amounts of greenhouse gases into the atmosphere, which include CO₂, methane and nitrous oxide (see Table 7).

Table 7. Main greenhouse gases emitted by agricultural practices

Greenhouse gas	Agricultural source
Carbon dioxide (CO ₂)	Released largely from microbial decay or burning of plant litter and soil organic matter
Methane (CH ₄)	Produced when organic materials decompose in oxygen-deprived conditions, for example fermentative digestion of ruminant livestock and stored manures
Nitrous oxide (N ₂ O)	Generated by microbial transformation of nitrogen in soils and manure, especially under wet conditions

Source: IPCC, 2007: 501

Greenhouse gas emissions from agriculture are expected to increase globally due to the greater area of land under agriculture, increasing use and manufacture of fertilisers, escalating demand for meat products, and the greater demand to for energy to power agricultural equipment.

A variety of options exist for mitigating greenhouse gas emissions in agriculture. Key options include improving crop and grazing land management, restoration of degraded lands, improved water management, agro-forestry, and improved livestock and manure management (IPCC, 2007). While Zimbabwe has low greenhouse gas emissions compared to high- and middle-income countries, it shares the common responsibility of all countries to reduce emissions. Mitigation efforts should be grounded in a strategy for developing viable offset projects through the CDM or other market channels.

Agriculture can sequester carbon when organic matter accumulates in the soil and in above-ground woody biomass, which is used in agro-forestry systems and for the production of biomass for energy sources to replace fossil fuels. Soil organic matter, and thus carbon, can be increased to a new higher equilibrium with sustainable management practices. The greatest dividend comes from converting annual crops to agro-forests systems, which accumulates carbon in woody biomass.

As Zimbabwe's economy recovers, it is likely to be accompanied by a growing demand for meat, which may result in further changes in land use from forest to grassland to provide pasture for livestock. This will lead to increased CO₂ emissions. In addition, larger herds of beef cattle will cause increased emissions of methane and livestock manure.

Grasslands within rotations, zero-tillage (or no-till) farming, green manures and cover crops, and high amendments of straw and manures to the soil, also lead to substantial carbon sequestration.

Zimbabwe has been one of the leading proponents of conservation and zero-tillage agriculture. These practices reduce energy use in the agricultural sector, and can increase carbon storage in soils. While such agricultural practices have the potential to form offset projects for voluntary carbon markets, no such projects have yet been proposed in Zimbabwe. The reasons for this according to the Climate Change Office (which is responsible for coordinating offset projects) are:

- a lack of domestic legal and institutional frameworks (e.g. a lack of title to emission rights)
- a lack of local and regional financing sources to execute offset projects
- limited capacity among stakeholders to formulate and develop offset projects, especially for the CDM
- limited understanding of the opportunities that offset projects represent.

Implementing mitigation measures in the sector should shape policy and practice of Zimbabwe's national development priorities. Balancing the trade-offs between mitigation, adaptation and poverty reduction measures in the sector is vital for a successful climate change and development policy.

6.4 Agriculture and adaptation

Table 8 shows potential adaptation options in the agricultural sector.

One major adaptation strategy is the development of irrigation schemes. With only about 2,000 ha of the country's 119,000 ha of irrigated land under smallholder control (Rukuni et al, 2006), communal and resettlement agriculture remains the most vulnerable to drought. Furthermore, some irrigation schemes are not functioning, for various reasons. Irrigation development provides an opportunity for the agricultural sector to adapt to increased rainfall variability.

Available data show that non-functioning irrigation schemes are widespread. For instance, in Kadoma District, four of the eight irrigation schemes are not functioning, while in Cheguto four out of seven are not working. In Bubi District (Matebeleland North), six out of nine are not functioning (Government records, July 2011). Reasons include pump breakdowns and inadequate water supply.

Table 8. Climate risks, effects on agriculture and potential adaptation options

Climatic risk	Effects on agriculture	Adaptation options
Decline in precipitation	Decrease in optimal farming conditions for some areas	<ul style="list-style-type: none"> • Livelihood diversification • Strengthen local farming capacity to reduce sensitivity to climate change • Changing cultivation practices • Increased irrigation of key crops
Increase in temperature	Crop area changes and decreased crop productivity	<ul style="list-style-type: none"> • Changes in crops and cropping patterns • Increased input of agro-chemicals to maintain yields • Advisory services for farmers on adapted farming practices and on new crops • Crop planting diversification • Agricultural insurance
	Loss of soil water retention capacity	<ul style="list-style-type: none"> • Irrigation • Create/restore wetlands • Water retention technologies
	Land abandonment	<ul style="list-style-type: none"> • Design regional adaptation plans • Livelihood diversification
	Increased erosion	<ul style="list-style-type: none"> • Better and new agricultural practices that reduce erosion • Change fallow and mulching practices to retain moisture and organic matter
Increase in extreme weather events	Droughts and floods	<ul style="list-style-type: none"> • Increase rainfall interception capacity • Reduce grazing pressures to protect against soil erosion from flash flooding • Contour ploughing • Increase drainage • Insurance for crop damage and farm infrastructure

Frequent droughts	Reduced water availability	<ul style="list-style-type: none"> • Invest in irrigation development • Improvements in irrigation technology – trickle irrigation, • New irrigation practices, for example irrigating during the night • Installation of small-scale reservoirs on farms • Improve field drainage and soil absorption capacity • Improved water management, for example water audits, water charging to promote efficient water use; recreate wetlands
	Deteriorating conditions for livestock	<ul style="list-style-type: none"> • Livestock breeding and introduction of heat tolerant breeds • Supplemental feeding • Match stocking densities to forage production

Agricultural research in Zimbabwe is quite advanced and the country has a long history of successfully adopting innovative approaches in agricultural production. For example, the Zimbabwe branch of the International Maize and Wheat Improvement Center (CIMMYT) developed, released and successfully tested productive maize varieties that mature early, or are tolerant to drought and other stresses such as nitrogen deficiency and pests. These may play a substantial role in responding to future climate change.

In addition, ICRISAT introduced conservation agriculture in 2008. FAO, the Gesellschaft für Technische Zusammenarbeit (GTZ, now GIZ), DfID and Practical Action have together run pilots in conservation farming and zero-tillage in many villages throughout the country.

The broad suite of adaptation measures contained in the National Communication of 1998 include:

- introduction of livestock and dairy production in areas where maize production becomes uneconomical
- promotion of drought-tolerant crops
- improvement of irrigation techniques
- promotion of agricultural diversification
- adjustment of the timing of farming operations and changing planting density
- installation of medium to large dams throughout the country for the irrigation projects
- shifting from a subsistence to a cash-crop economy to boost rural incomes.

Despite the seemingly progressive intentions, there is no clear evidence to suggest widespread adoption of such measures. The Government does not appear to have a clear strategy on climate adaptation in agriculture, so most work is being led by NGOs and development agencies, especially the UN. Ongoing initiatives that are contributing to adaptation, although originally conceived to address a range of productivity challenges, include rainwater harvesting and integrated water resource management.

6.5 Food security and climate change

Food security is a broad concept that encapsulates availability, access and utilisation of foodstuffs (Falco et al, 2011). As such, food security can be achieved through production or trade (local, regional and international). This section focuses exclusively on food availability through national production.

The impact of higher CO₂ levels, higher temperatures and more varied precipitation on staple food crops is mixed. Research suggests that increased CO₂ concentrations and higher temperatures can have positive effects on crop yields. Studies by the International Benchmark Sites Network for Agrotechnology Transfer and evidence from Hadley M2 General Circulation Models indicate that crop yields increase for several reasons:

- Increased CO₂ concentrations lead to increased photosynthetic rates and water-use efficiencies of vegetation and crops, which result in increased rates of plant growth. This increases organic matter supplies to soils, which are vital for plant growth.
- Minor increases in soil temperatures and extended periods in which soils are warm enough for microbial activity tend to increase the quantity of plant nutrients cycling through soil organisms. The increased production of root material tends to raise soil organic matter content, which also entails the temporary immobilisation and cycling of greater quantities of plant nutrients in the soil (Brinkman and Sobroek, 2001).
- They lead to longer growing seasons and the amelioration of cold temperature effects on plant growth. In Zimbabwe, increased temperatures will be conducive for crops affected by frost, especially in the Eastern Highlands, and provide regimes more conducive to greater crop productivity.

However, these positive effects are subject to a 'hill function': that the effects of higher temperatures and CO₂ levels on crop yields reach an inflection point, after which further increases in temperature reduce yields.

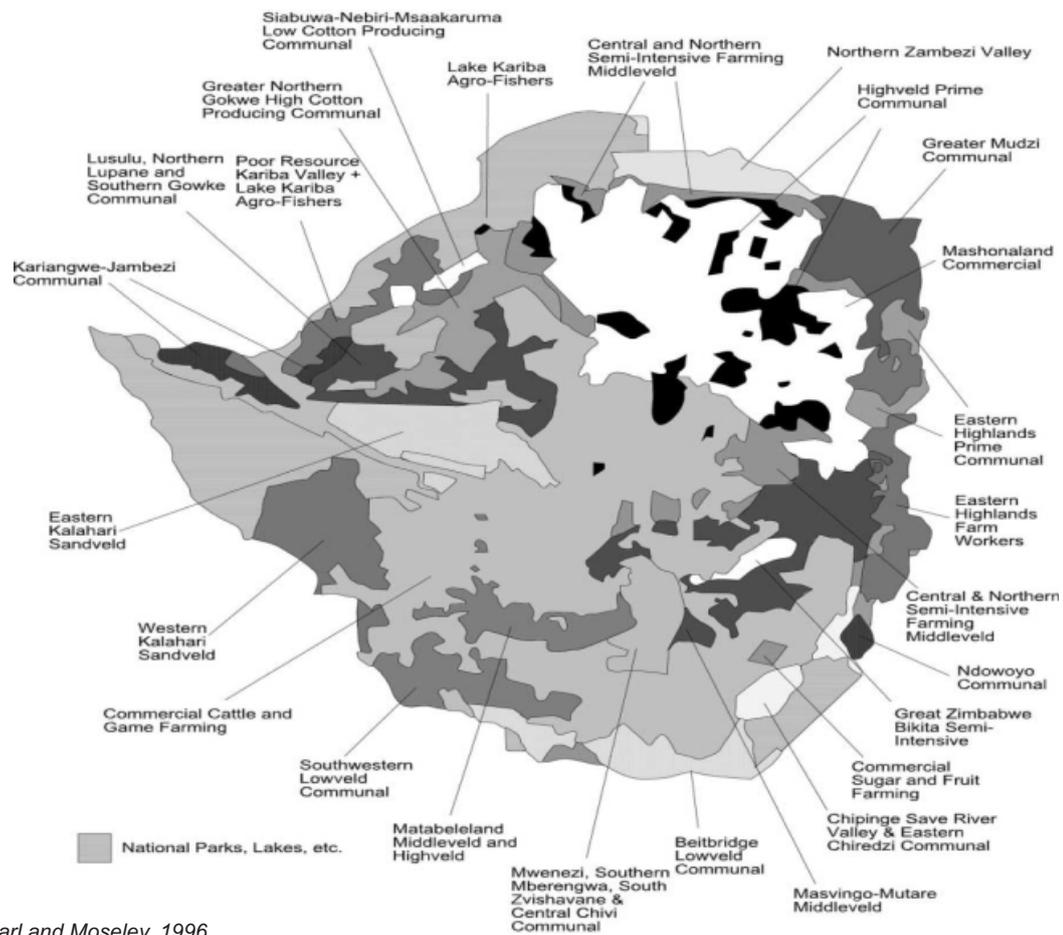
Such thresholds differ across species and landscapes. For example, maize yields are particularly sensitive to increases in temperature, because maize does not utilise higher CO₂ levels effectively. Livestock production could also be affected, as a scarcity of pasture and water results in the deterioration of livestock condition and a decline in market prices.

Climatic variations could lead to greater food insecurity for both farming households (especially subsistence farmers in communal and A1 resettlement schemes) and those employed in non-agricultural sector, due to declining agricultural production and lack of income or financial resources to buy food. Such changes could translate into a shift in livelihood zones. Earl and Moseley's (1996) 25 food economy zones have possibly moved in relation to the shifting agro-ecological zones (see Figure 10).

Food security issues in the country are region-specific and vary from one group of farmers to another. There is need for food security policy to recognise farmers are diverse and disaggregate the needs of different farmers in different agro-ecological regions. For example, the distribution of seed packs should take into account the suitability of the seeds to different agro-ecological regions.

At the national level, the Zimbabwe Vulnerability Assessments and the Early Warning Systems were put in place to enhance national preparedness to deal with food insecurity. Through the FAO-led Agriculture Coordination Working Group, appropriate national institutions like the Meteorological Services Department and the National Early Warning Unit have played a key role in generating appropriate information to make relevant decisions about the national food situation.

Figure 10. Food economy zones in Zimbabwe



Source: Earl and Moseley, 1996

However, the national early warning system tends to focus on cereal production and the impact of hazards, primarily drought. While this may be sufficient to warn of impending food shortages, in most cases the information and analysis is insufficient to actually guide planning (Mano and Nhemachena, 2007). Jayne et al (2009) also point out that the Early Warning Systems Unit needs to be empowered to the extent that politicians do not overrule their findings. Despite timely early warnings in Zimbabwe, the Government is generally slow to acknowledge impending production shortfalls and launch official appeals for assistance.

6.6 Research and technical assistance

Studies on climate change and agriculture in Zimbabwe remain grossly inadequate. Only a limited number of crops, mostly cereals, feature prominently in the few studies that have been done. Yet adaptation strategies require a diversified cropping system.

Given that the country's agro-ecological regions have been shifting over the years, there is need to re-analyse the suitability of existing regions for a range of crops. As such, the reconfigured agro-ecological regions need to be supported by new cropping regimes. While crop yields are sensitive to variations of climate (e.g. the onset of rainfall, temperature trends), there has been no systematic analysis of locally available information, in order to present empirical evidence to farming communities on the localised effects of climate change. In general, such information largely remains in its crude, unanalysed form in various offices.

More importantly, the information has not been used in any meaningful way to improve the adaptation strategies of farmers. There is need for more analytical work on adaptation strategies by individual households. Gwimbi (2009) makes reference to preferred adaptation strategies by farmers, but concluded that 'no evidence was found that supported the view that farmers were implementing any adaptation on the ground, despite the farmers highlighting their preferred coping strategies to climate change'.

Studies are required to establish the appropriate role of trade in ensuring food security. And there is a need for a comprehensive framework for collating statistics on food security, including production estimates, market prices, ratio of local 'ganyu' wages to food prices, incidences of coping strategies and nutritional indicators, building on the data provided by the Famine Early Warning Systems Network (FEWS-Net).

6.7 Summary

Several key recommendations emerge from the analysis above:

- **Prioritise budgetary support.** The Government will take the lead in supporting farmer adaptation strategies, as defined in the National Communication Strategy of 1998. This will require the National Budget to adhere to the Maputo Declaration, which stipulates that African governments need to increase the proportion of national budget to the agricultural sector to 10% of total budget. The Ministry of Finance needs to prioritise budget allocation to agriculture, particularly to support climate change adaptation.

- **Increase collaboration among local institutions, as well as with international and regional centres** (e.g. SADC Drought Monitoring Centre) in the collection, analysis and dissemination of weather information. This will guide farmers' agricultural practices. Close collaboration is needed between the Meteorological Department and Agricultural Extension Services (AGRITEX) for more effective use of climate information. AGRITEX needs human resources, funds and know-how to provide better services to farmers. There is also a need for enhanced collaboration between AGRITEX, NGOs and community-based organisations in using agricultural information to guide farmer practice.
- **Develop improved seed varieties.** There is a need to improve research, development and adoption of improved seed varieties that effectively respond to the challenges posed by climate change. For instance, drought-tolerant varieties of maize, millet and sorghum developed by CIMMYT and ICRISAT should be widely promoted.
- **Expand irrigation schemes** is advisable as an adaptation strategy, but should be placed within the context of increased competition for water with other sectors at a time when water availability is declining. This means that technologies that allow economical use of water should be given priority. An integrated approach which combines large and small water storage options, including water from natural wetlands, soil water, groundwater, and water collected in tanks and reservoirs, should be pursued for communal and A1 farmers.
- **Reclassify Zimbabwe's agro ecological regions.** There is a need to assess the emerging agro-ecological zones and suitability of particular crops. Traditional crop types for a particular region may already be unsuitable, as rainfall patterns have shifted.
- **Link agricultural policy and climate change.** Existing agriculture policies make no direct reference to climate change and do not clearly state the role of the agriculture sector in climate change. This needs to be addressed as a matter of urgency. More research on climate change and agriculture is required to guide interventions in the agricultural sector. The outputs of research work will also be critical in helping farmers to understand the impacts of climate change, as well as informing farmer adaptation strategies.

7. Land use and land use change

Land use and land cover are linked to climate change and weather in diverse and complex ways. These include:

- the exchange of greenhouse gases between the land surface and the atmosphere
- the radiation (both solar and long wave) balance of the land surface
- the exchange of sensible heat between the land surface and the atmosphere; and,
- the roughness of the land surface and its uptake of momentum from the atmosphere.

Because of these strong links, changes in land use and land cover can be important contributors to climate variability and change. Land cover characteristics are important inputs to climate models.

Land use change is often a driver of environmental and climatic changes. Land use change can be due to demographic factors, such as population size and distribution, expansion and growth of agriculture, and economic and technological development. At the same time, a changing climate can alter land use practices and land cover. As average annual temperatures increase and average rainfall declines, some areas may switch from particular crops.

This section focuses on land use changes brought about by land reform and seeks to establish how land reforms affect land use change, and the implications for climate change.

7.1 Land reform and land use change 1980–2010

Zimbabwe's land reform programme started at independence in 1980. The period 1980–2000 saw 3.5 million ha of large-scale commercial farms settled under the land reform programme – 9% of the total land area. Fast-track land reform, launched in 2000, distributed 4.1 million ha as smallholder plots (A1 model) and 3.5 million ha as small-, medium- and large-scale commercial farms. This represents 11% and 9% of the country's total area respectively (Moyo et al, 2009).

A new category of farmer has emerged from the land reform programme process. An estimated 76,000 households were allocated land in the first phase of land reform (1980–2000). In addition, 146,000 smallholder farmers (A1) and 16,000 commercial farmers (A2) have benefitted from post-2000 land reform. Fast Track Land Reform distributed over 80% of large-scale commercial farms. What has changed with land reform include: land use; farm size structures; tenure rights; management and use of land; access to and management of water resources; productivity and production technologies; and the character of beneficiaries. The task now is to establish the interface between land reform-induced changes and climate change.

The post-2000 land reform targeted all forms of land use for resettlement. Land under timber plantations and set aside for wildlife was also redistributed. New evidence shows that maize production is the dominant land use by new beneficiaries (Moyo et al, 2009). Maize production has expanded into new areas in the dry regions; this demonstrates changing land use patterns.

7.2 Land use, policy and climate change

Two important issues link Zimbabwe's land reform programme and land use policy with climate change. First, there is the changing agrarian structure, characterised by the conversion of large-scale commercial farms into smallholder plots and farms. Second, the distribution of land is accompanied by changing land use patterns, a process dominated by the clearing of vegetation, especially trees, to make way for crop-based production. This reduces the area of forest that acts as a carbon sink.

In 2000, the Government introduced a new policy, the Rural Land (Farm Sizes) Regulations S1 288. This set the parameters for subdividing rural land for distribution under the land reform programme. The regulations set maximum farm sizes for each of the country's agro-ecological regions across A1 and A2 farms (see Table 9). This led to the division of farms into small-scale, medium-scale, large-scale and peri-urban commercial farms. The subdivision of land for the different land-use patterns, including timber production, was expected to respect maximum farm sizes. The new farm size structure has implications on the type of land use that such plots can support.

Table 9: Policy determinants of the new agrarian structure

Agro-ecological zone	A1 plots (size in ha)			A2 farms (size in ha)			Peri-urban commercial farms (size in ha)
	Arable	Grazing	Total	Small-scale	Medium-scale	Large-scale	
I	5	7	12	20	100	250	2–50
IIa	5	10	15	30	200	350	
IIb	5	15	20	40	250	400	
III	10	20	30	60	300	500	
IV	10	30	40	120	700	1500	
V	10	60	70	240	1000	2000	

Source: Government of Zimbabwe, 2004

7.2.1 Tenure

Zimbabwe's land reform programme has changed the tenure arrangements governing the ownership of rural land. Existing tenure arrangements for resettled land range from permits (especially for A1 smallholder farmers), 'offer letters' and 99-year leases, which are not widely viewed as providing security of tenure for new farmers (Richardson, 2005; Marongwe, 2009). The processing of new tenure rights for land reform beneficiaries will take time, given the complexities of the process and the institutional constraints that confront land administration institutions. It remains to be seen how the tenure arrangements will evolve.

Zimbabwe's land reform programme has resulted in significant change in land use. The clearing of forests and other vegetation for crop production is accepted in policy and practice as an integral part of the programme. A significant proportion of the 8 million ha of land distributed in the post-2000 period has already been cleared. Moyo et al (2009) makes reference to land utilisation levels of ~80%. Scoones et al (2010) noted that the farmers in their study sample had used between 2.8% and 56% of their plot sizes. It is

apparent that land reform beneficiaries have been clearing forests and other vegetation for crop production.

7.2.2 Timber plantations

Traditionally, the exotic timber sector supplied most of the country's timber needs. Before Fast Track Land Reform, it was estimated that Zimbabwe's exotic timber plantations occupied 119,000 ha of the estimated 140,000 to 170 000 ha of forests in the country, with 90% located in Manicaland Province. The Rural Land (Farm Sizes) Regulations of 2001 stipulate that timber plantations should be subdivided into maximum farm sizes of 250 ha. This was criticised as being unresponsive to the uniqueness of the timber industry, forcing the creation of a specific technical team to deal with the settlement of timber plantations. The technical team recommended appropriate technicalities in the redistribution of timber plantations in Manicaland Province. The maximum farm sizes were to be 500 ha, supporting the recommendations of the influential Utete Report of 2003.

The growing cycles for the different types of timber range from 7–10 years for eucalyptus light poles and pulpwood, to 25 years for pine. Investment in timber production therefore does not yield immediate and seasonal benefits within the initial 7–10 years. New settlers who start timber production would not expect to make any money for at least seven years. This has important implications on the willingness of land reform beneficiaries to continue with timber plantations, directly affecting the functioning of forests as carbon sinks.

Ideally, beneficiaries should be well-resourced farmers who can rely on other sources of income before any profit is realised from timber ventures. The economic characteristics of new settlers who were allocated land with timber are a critical variable in the discussion on whether they will be in a position to continue with timber plantations as a land use. The important question is: how prepared – psychologically, technically and financially – are beneficiaries of timber plantations to continue with forest as a land use?

The forest-based land reform policy is anchored on the continuation of timber plantations as the main form of land use, while developing strategies to enhance the participation of indigenous populations in timber production. However, anecdotal data indicate that events on the ground have been contrary to this, making the policy intentions almost

inoperable in certain areas without major reversals and regularisation. Interviews with relevant officials show that some of the new farmers are replacing timber plantations with crop-based land use systems. This conversion of timber plantations has negative consequences on climate mitigation. The conflicting demands of land reform and the role of forests in a climate change mitigation strategy have to be negotiated.

Away from exotic timber plantations, trends elsewhere have confirmed the clearing of forests and other vegetation to make way for crops. Using Landsat satellite imagery, the Zimbabwe Environmental Assessment Report analysed land use or land cover changes in Chipinge, Goromonzi, Makoni, Marondera, Mazowe, Umguza and Zvimba Districts, as well as Harare Province (UNDP, 2003). Focusing on 1998–2002, the assessment found that there was a 3.2% increase in the area under cultivation in Marondera, linked to Fast Track resettlement. An increase in area under cultivation was also noticed in Mazowe, Makoni and Goromonzi. Minimal afforestation was recorded in Chipinge and Zvimba districts.

7.3 Land use and mitigation

A small range of mitigation options exist regarding land use change:

- Maintain and expand sinks by protecting and practicing agro-forestry and other plantation activities.
- Create a system of credits and debits wherein emission or sequestration of carbon in the biosphere is equated with emission of carbon fossil fuels.
- Restore degraded lands.
- Reduce emissions through positive changes in the agricultural system, such as increased cropping.
- Promote land use planning practices that reduce the demand for energy and transportation services.
- Change the crops grown for cattle feed to reduce methane emitted, and use methane produced for energy.

However, the scope for climate change mitigation is not that broad in the land reform and land use sector. The discussion is better placed in other subsectors, especially agriculture, forestry and water. Land policy provisions that call for the continuation of forest-based land uses represent the clearest examples that land reform and land use patterns are linked

to climate change mitigation strategies. The proposals outlined in the forest-based land reform policy should form the basis for implementing climate change mitigation strategies through the promotion of forests.

7.4 Land use and adaptation

Climate change adaptation strategies in the field of land use and land cover change are located in the land use planning and disaster management arena. This calls for the analysis of risk and vulnerability of places according to land use. Within the framework of existing land use practices and proposed land use changes, risk and vulnerability assessments can provide information on how land use practices are prone to climate change extremes. According to Environmental Management Agency (2002), the following climate change adaptation strategies are relevant to land use planning:

- Restrict or prohibit development in high-risk areas, through zoning and other forms of development control.
- Restrict or limit the types of development in high- to moderate-risk areas for recreation or other forms of public use, reducing the potential impacts of natural hazard events; and,
- Apply appropriate development controls in moderate and lower risk areas, such as minimum elevations, setbacks, plot sizes, and maximum densities and site coverage.

Other important strategies include the development of model household and community land use plans, which will guide how communities affect land use and land cover change. This will be supported by policies and standards that regulate the clearing of land. In addition, it is important to develop a data and knowledge base that assists households (as land users) to adapt to climate change in local contexts.

7.5 Research and technical assistance

The argument so far has been that land reform is an important contributor to anthropogenic climate change. Overall, there is need for the following actions:

- Analyse the effects of land reform on land use change and the implications these changes have on climate change. Such an analysis will inform national climate change adaptation and mitigation strategies
- Analyse the links between deforestation and tobacco production, especially the use of wood fuel in curing tobacco. This will guide the development of alternative methods of tobacco curing
- Study changes in the exotic timber plantations that were redistributed under the land reform programme. While policy provisions call for new farm size structures of not less than 500 ha, and that new beneficiaries should continue with forest-based land uses, research is yet to establish the consistency between policy prescriptions and policy implementation. Studies should identify key success and failure factors that determine the outcomes of forest-based land reform; and,
- Perform detailed studies on how land use changes associated with land reform affect processes such as soil erosion, desertification and deforestation. How the outcomes of such processes impact on household livelihoods is another important point.

Relevant government and academic institutions require technical assistance to track land uses changes and measure critical variables, such as the albedo of different land surfaces and changes in the water cycle. This should include access to satellite imagery equipment and equipment for measuring area at the farm level. The development of an information management system will assist in capturing and monitoring land use changes. A full set of indicators will need to be developed to guide data collection. Partnerships with appropriate universities will allow students to participate in data collection.

7.6 Summary

Land use patterns in Zimbabwe are transforming as a direct outcome of the land reform programme. While changing land uses have a direct impact on climate change, the nature and extent of the changes is less well understood. And there are other parameters that have changed as a result of the land reform programme, including types of beneficiaries (or farmers), farm size, tenure arrangements and even productivity.

The nature of the relationship between such attributes and climate change is not articulated in policy. Some policy provisions, especially forest-based land reform policies, have a direct impact on climate change adaptation and mitigation strategies. The existence of the forest-based land reform policy is important, as it provides the basis upon which other activities can build.

The conflict between land reform and the role of forests as carbon sinks is noted. Land policy has neither acknowledged this nor highlighted any strategies to resolve it. In addition, a system of tracking land use changes is required. Such monitoring work needs to emphasise both the clearing of forests and afforestation initiatives at the farm level. Policy guidelines are required to balance crop-based production and forest-based land uses.

8. Forestry

This chapter presents the results of an assessment of Zimbabwe's forest sector and climate change. It starts with an overview of the forestry sector in Zimbabwe, followed by climate change vulnerabilities and opportunities, mitigation options, and a discussion of REDD. The chapter ends by highlighting priority areas for research and technical assistance.

8.1 Overview of the forestry sector

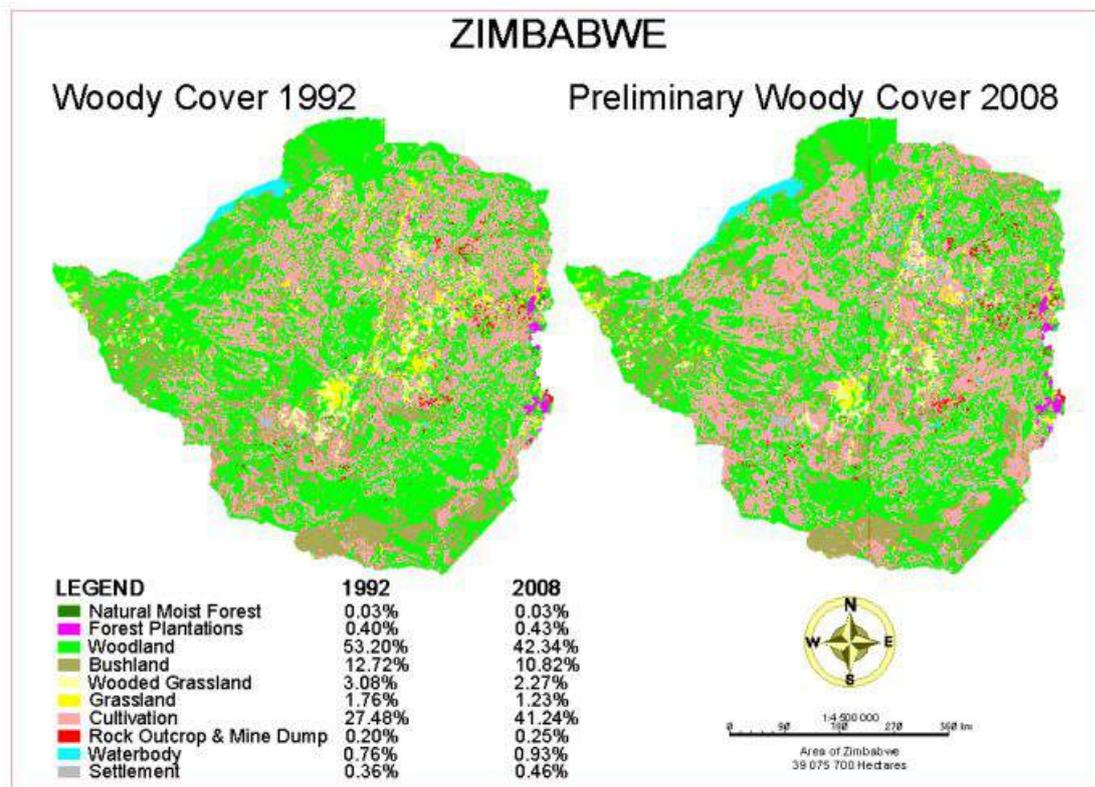
Forest covers approximately 56% of Zimbabwe's total land area of 218,295km² and generate a wide range of products (both timber and non-timber) and ecosystem services.

Products include: fuel wood (for various purposes including charcoal making and tobacco curing), sawn timber, pulpwood, building materials, wood for crafts, fodder, fruits, honey, mushrooms, bark for rope, medicines, leaf litter, bush meat, gum and resins. Ecosystem services include: watershed management, carbon sequestration, microclimate stabilisation, and the provision of windbreaks, shade, soil stability and wildlife habitat.

Zimbabwe's extensive forest has the potential to be a carbon sink, but current pressures for settlement, agricultural land and fuel wood make this unlikely (Shumba, 2001).

Forestry in Zimbabwe is divided into two sectors: indigenous (i.e. naturally occurring) forestry and plantation forestry. Indigenous forests consist of natural forests, woodlands, bush lands and wooded grasslands, and make up about 22 million ha according to 2008 Forestry Commission statistics (see Figure 11). Indigenous forests are divided into five woodland types: Miombo, Teak, Mopane, Acacia and Terminalia/Combretum. Woodland degradation has been triggered by the over-exploitation of open access common property, fires, disease, browsing by wildlife (especially elephants), and the opening up of forest land for agriculture expansion following the Fast Track Land Reform Programme in 2000.

Figure 11. Changes in forest cover 1992–2008*



* 2008 satellite data have not yet been verified through field sampling or inventory.

Source: Forestry Commission of Zimbabwe Mapping and Inventory, 2010

Table 10 shows the changes to Zimbabwe's forests. Results indicate that only the area of natural moist forests has not significantly changed since 1992; all other woodland types have decreased. This can be attributed to opening up forests for cultivation purposes. Forest plantations have increased by a very small margin.

Table 10. Percentage of the total area covered by various land uses in Zimbabwe

Class	Cover type	1992 (ha)	%	2008 (ha)	%
1	Natural moist forest	11 477	0.03	11 508	0.03
2	Forest plantation	155 297	0.40	168 581	0.43
3	Woodland	20 790 234	53.20	16 544 210	42.34
4	Bush land	4 972 071	12.72	4 228 547	10.82
5	Wooded grassland	1 204 666	3.08	888 463	2.27
6	Grassland	689 186	1.76	479 883	1.23
7	Cultivation	10 738 945	27.48	16 113 866	41.24
8	Rock	78 707	0.20	97 720	0.25
9	Water body	298 089	0.76	364 331	0.93
10	Settlement	139 341	0.36	180 904	0.46
	Total	39 078 013	100.00	39 078 013	100.00

Source: Forestry Commission of Zimbabwe Mapping and Inventory, 2010

8.1.1 Commercial plantations

Zimbabwe's plantation forests covered 89,862 ha in 2009 (Timber Producers Federation, 2009). However, when considering all small eucalyptus plantations in communal, resettlement areas and commercial farms, this covers a total of 168,581 ha. About 90% of the plantations are located in the Eastern Highlands, an area characterised by high altitudes (700–2,200 m) and high rainfall (average of 1,000 mm per year). Major plantation forest species include: Mexican weeping pine (*Pinus patula*), slash pine (*P. elliottii*), loblolly pine (*P. taeda*), rose gum (*Eucalyptus grandis*), red river gum (*E. camaldulensis*) and black wattle (*Acacia mearnsii*). Pine species are mainly used for structural timber, pulp and paper, and gum trees are used for poles, pulp and paper. Wattle is used to produce tannin and high-quality charcoal.

Between 2000 and 2009, there was a steady decrease in commercial forest plantation area, from 118,621 ha in 1999 to 89,862 ha in 2009 (see Table 11). This decrease can be attributed to resettlement losses, fire losses and clear felling without afforestation. This data, from the Timber Producers Federation (1999–2009) only covers plantations in the Mutare area, Eastern Zimbabwe, while the data in Table 11 covers the whole country, including small eucalyptus woodlots in communal and resettlement areas.

Table 11. Commercial forest plantation land area (ha)

Year	Pine	Eucalyptus	Wattle	Others*	Total area
1999	80 989	23 910	13 434	288	118 621
2000	79 082	29 036	11 789	275	120 182
2001	78 007	29 314	11 529	280	119 130
2006	68 550	26 010	10 039	106	104 705
2007	70 946	26 654	9 906	134	107 641
2008	69 140	19 350	9 782	46	98 318
2009	57 637	22 375	9 799	51	89 862

* These include *populus*, *auricaria* species, *acacia melunoxylon*, *crytomeria japonica* and *cuppressus* species.

Source: Timber Producers Federation, 1999–2009

Zimbabwe's Ministry of Environment and Natural Resources Management is a major player in forest biodiversity management, through the Forestry Commission and the Department of National Parks and Wildlife Management. Several other sectors, such as agriculture, construction and water, have direct and indirect impacts on forest resources. There is currently no formal cooperation mechanism between the institutions governing forestry and other sectors, however.

8.2 Climate change vulnerabilities and opportunities

Forests thrive in various climatic conditions globally, from wet tropical forests to the forests in dry boreal (high-latitude) regions (Sedjo and Sohngen, 1998). The type of vegetation, from deserts to grasslands to forests, depends on the prevailing moisture conditions. Changes in temperature and precipitation, brought about by climate variability and change, affect forests in different regions in varying ways.

Climate change will affect the physiology, structure, range, species composition and health of forests. Increased temperatures and drought will lead to more frequent pest outbreaks, more forest fires, and increasing alterations plant and animal species, severely affecting forest health and productivity. In some regions, climate change may bring about positive effects through increased forest productivity, but this will depend on the availability of precipitation and nutrients. In Zimbabwe, forests thrive under varying ecological conditions, ranging from very dry to very wet conditions, and with different mix of tree species in each eco-region different (see Table 12).

Forest ecosystems safeguard other ecosystems and provide physical buffers against desertification, drought, high temperatures, land degradation and flash floods, which are common climate impacts in Africa. Direct and indirect impacts of climate change on forests include:

- climate change, especially high temperatures and low rainfall, could directly affect the availability (positively or negatively, depending on the change) of forest products
- the majority of Zimbabwe's population live in rural areas and depend on agriculture. Climate change impacts on agricultural production is likely to increase the reliance of rural communities on forest ecosystems as alternative sources of food, medicine, fibre and income; and,
- other effects of environmental degradation indirectly resulting from climate change, such as drought and bushfires, can affect forests' ability to regenerate.

Studies using the Holdridge Life Zone and the Goddard Institute of Space Studies (GISS) methods have examined the impacts of future climate change scenarios on forest distribution in Zimbabwe. Under current climate conditions, Zimbabwe has five Holdridge Life Zones: subtropical dry forest, subtropical thorn woodland, tropical very dry forest, subtropical moist forest and the warm temperate moist forest (Matarira and Mwamuka, 1996). Subtropical dry forest covers the largest area in Zimbabwe (68.7%).

Table 12. Vegetation in Zimbabwe's Eco-regions

Eco-region	Corresponding natural region	Altitude (metres above sea level)	Mean annual rainfall (mm)	Dominant vegetation type
Central	II and III	1300	620	Msasa (<i>Brachystegia spiciformis</i>) and Mchenga (<i>Julbernardia globiflora</i>) woodlands
Eastern Highland	1	1500	740	<i>Themeda-exothea loudetia</i> grasslands; Msasa and Mchenga woodlands
Kalahari	IV and V	1030	560	Mopane (<i>Colophospermum mopane</i>) and <i>Baikieaa</i> woodlands
Save Limpopo	IV and V	687	400	Tree savanna, Acacia woodlands
Zambezi	IV	1080	650	Mopane woodlands

Source: Ministry of Environment and Natural Resources Management, 2010

Under the GISS climate scenario, there is a shift towards more variable annual precipitation (rainfall) and high ambient temperatures. According to Matarira and Mwamuka (1996), north-eastern Zimbabwe will become more suitable for vegetation found in the subtropical moist forest conditions in the GISS climate change scenario, instead of the warm temperate moist forest which currently exists (see Table 13).

Table 13. Selected holdridge life zone classes in Zimbabwe, comparing current climate conditions and under GISS climate change

Life zone class	Forest area (km ²) under current climate conditions	Forest area (km ²) under GISS climate change	Change (km ²)	Percentage change
Subtropical dry forest	264 056	175 179	-88 877	-33.66
Subtropical thorn woodland	83 725	9 016	-74 709	-89.23
Tropical very dry forest	21 253	157 790	+136 537	+642.44
Subtropical moist forest	10 304	1 223	-9 081	-88.13

Source: Matarira and Mwamuka, (1996)

8.3 Opportunities for mitigation

Forests act as carbon sinks, removing CO₂ from the atmosphere and sequestering carbon in biomass, woody stems and the soil. But when they are cleared or degraded, carbon is released as CO₂. The largest source of greenhouse gas emissions in most tropical countries is deforestation and degradation, which collectively account for nearly 20% of global greenhouse gas emissions.

Research to quantify the existing carbon stocks in Zimbabwe's forests has yet to be undertaken. This will be crucial if the country is to benefit from existing carbon markets and related mechanisms.

Many land-based opportunities to increase carbon stocks or avoid carbon emissions exist in Zimbabwe. For forests, this can be achieved by:

- protecting secondary and other degraded forests to allow them to regenerate naturally
- restoring native forests through assisted and natural regeneration
- maintaining existing forest-carbon stocks and sink processes by avoiding deforestation and forest degradation
- establishing plantations on non-forested lands; and,
- managing forests sustainably to provide services, such as biomass for energy.

8.3.1 Reducing Emissions from Deforestation and Degradation

Global climate initiatives to address greenhouse gas emissions are being developed, such as REDD. These enable developing countries to actively contribute to greenhouse gas mitigation and benefit from conservation, sustainable forest management and the enhancement of forest carbon stocks. The 13th Conference of the Parties to the UNFCCC in 2007 laid the foundations to develop a post-2012 climate change agreement that would include REDD in developing countries. Since then, the REDD mechanism has expanded to include conservation, sustainable forest management, and the enhancement of forest carbon stocks (REDD+). This mechanism, although still being negotiated, offers a unique opportunity for developing countries to benefit from activities, while contributing to global mitigation of greenhouse gas emissions.

REDD can be a relatively cost-effective climate change mitigation strategy, and can create additional socio-economic benefits to local communities by conserving forest biodiversity. A REDD mechanism with robust environmental and social safeguards could offer an effective climate mitigation strategy, provided it is linked to a post-2012 climate agreement with strong, binding CO₂ emission-reduction targets for industrialised nations. Zimbabwe's REDD policy process faces several key challenges:

- Zimbabwe has not yet joined other developing countries in participating in the UN-REDD programme (a multilateral initiative to support developing countries' readiness for a REDD+ mechanism). To participate, Zimbabwe needs to ask the UN-REDD Secretariat to participate as a partner country.
- There is currently no climate change policy or strategy in place.
- The country needs political will and commitment to manage forests sustainably, for example a process to tackle the practical challenges between forestry policy and the land-reform programmes.
- Communities may be unwilling to invest in managing forests and land for which they do not have tenure or land rights.
- If financial or policy incentives for sustainably managing forests are not sufficient, it will be difficult to convince communities to manage forests.
- Effective forest governance systems do not exist at the local level; without transparent, accountable local-level institutions, it will be difficult to avoid deforestation and benefit from REDD.

- There is currently no updated national forest inventory, which is necessary to establish a forest reference emissions level (a pre-requisite for entry into the REDD+ mechanism), and Zimbabwe lacks the technical capacity to develop such a system.

8.4 Research and technical assistance

Zimbabwe needs the following research and technical assistance;

- Research to understand the impacts of climate change on forests and the forestry sector
- Research to understand deforestation and microclimate in various areas. Results that show for instance a link between the amount of rainfall in the area and the forest area may help convince communities to take care of their forests
- Research to understand the links between hydrology, climate and forests
- Research to evaluate whether the current forestry policy and related legislations are in line with principles of sustainable management
- Technical and financial assistance to review these to ensure that they are in line with sustainable management principles and policies
- Research to understand local-level drivers of deforestation, especially tobacco production.
- Baseline surveys for areas where REDD+ projects could be implemented
- A detailed analysis of the specific financial and technical support needed to enable the Government to prepare to enter the REDD+ mechanism
- Feasibility studies on communities' willingness to conserve and sustainably manage forests, and the additional measures needed to avoid deforestation. Questions include: What is needed to address the drivers of deforestation, which is often poverty? How to enable and reward communities participating in REDD+ programmes? How best to ensure that environmental and social safeguards are met?
- Technical assistance to learn lessons from existing community-based natural resources management; and,
- Research and technical support to quantify carbon stock and community involvement in carbon markets.

8.5 Summary

Forestry plays a crucial role in climate change mitigation and adaptation. Yet Zimbabwe's forests are under tremendous pressure due to increased demand from for agricultural production, tobacco curing and fuel demands. This has been exacerbated by an absence of policy and institutional coordination across the different sectors that affect forestry. There is a need for inter-sectoral platforms to guide forestry policy, which bring together land, agriculture, finance, environment, national parks, and climate change.

The role of Zimbabwe's forests as a carbon sink and their potential role in carbon markets are poorly articulated. There is a need to assess, quantify and monitor existing carbon stocks in the country's forests. One way to achieve this is for Zimbabwe to apply to become a partner country in the UN-REDD programme. This will ensure that the country obtains UN support and assistance to develop analyses and guidelines on measurement, reporting and verification of carbon emissions and flows. More importantly, it will ensure that forests continue to provide multiple benefits for livelihoods, economic growth and the environment. Such membership can be used to develop local policies and programmes that consider the role of forestry in climate change mitigation and adaptation and links to land reform, agricultural production and ecosystems services, all within the context of national social and economic development.

9. Water Resources

Climate change and variability have a significant impact on water resources, mainly through changes in the amount and patterns of precipitation, and the occurrence of extreme hydrological events such as floods. These changes will affect the supply of, demand for and quality of water resources. This section reviews climate-related impacts on water resources in Zimbabwe and examines their likely effects on social and economic development. It concludes by suggesting mitigation and adaptation strategies for the water sector to ensure it continues to play a critical role in poverty reduction and national economic growth.

9.1 Overview of the water sector

There is considerable variation in the spatial and temporal distribution of water resources in Zimbabwe. Zimbabwe's rainfall pattern is best described as erratic, unreliable and insufficient; only 37% of the country receives adequate rainfall for agriculture.

The country has one rainy season (November to March), with an average annual rainfall of 657 mm. This varies from 1,000 mm per year in the Eastern Highlands to 400 mm per year in the low veld. Trends over the years have shown that the majority of Zimbabwe's wet seasons are punctuated by mid-season droughts, which result in poor harvests (Gumbo, 2006). Net annual pan evaporation ranges from 1,400 mm in high rainfall areas to 2,200 mm in low-lying areas.

The country has 12.26 km³ of water available per year. Zimbabwe's surface water resources are estimated to account for 90% of the country's water supply. There are seven internal river basins in Zimbabwe – Gwayi, Manyame, Mazowe, Mzingwane, Runde, Sanyati and Save – whose watersheds yield 11.26 km³ of freshwater per year. In addition, there are several reservoirs. Around 45% of these are government reservoirs, and the other 55% in around 5,700 reservoirs found in former large-scale commercial farming areas, mines, and plantation estates.

Groundwater currently contributes no more than 10% of Zimbabwe's total water use (Gumbo, 2006). The country uses 1–2 km³ of groundwater per year, located in four aquifers: Lomagundi dolomite, Nyamandhlovu forest sandstone, Kalahari sands and Save alluvial deposits. Groundwater is mainly tapped through boreholes. Records show that there are over 16,000 boreholes across the country but some experts believe there could be in excess of 50,000. Total annual groundwater abstraction for rural communities is estimated at 35x10⁶ m³ and 350 x 10⁶ m³ for the agricultural sector. Groundwater is also drawn for several Growth Points and rural service centres (e.g. Nyamandhlovu, Gokwe), urban centres (e.g. Bulawayo) and rural institutions (e.g. schools, health centres).

Zimbabwe's estimated exploitable freshwater resources are 8.5 km³ per year. Of this, 56% (4.8 km³) is committed, leaving 3.7 km³ per year for irrigation and other sectors. Close to 550,000 ha of land in Zimbabwe are irrigable using internal water resources, not including trans-boundary resources such as the Limpopo and Zambezi rivers. However, only 33.6% (200,000 ha) have been developed. Of the potential area, over 100,000 ha can be immediately developed using water from existing under-used dams, newly constructed dams, and dams currently under construction. The lack of funding and the high investment costs for irrigation have slowed the development of new irrigation facilities (National Investment Brief, 2008).

Of the total irrigated area in Zimbabwe in 1999, approximately 114,000 ha were under sprinkler irrigation (including centre pivots), 47,000 ha under surface irrigation, and 14,000 ha under localised irrigation (ibid). Of this, approximately 102,000 ha are operational and 73,000 ha (43%) are equipped but not operational, because the equipment was damaged during the land redistribution exercise and the floods induced by Cyclone Eline.

Because of its informal nature, dambo (wetland) cultivation is not usually included in official estimates of the total irrigation area. Estimates of the total size of dambos in Zimbabwe vary from 20,000 ha to 50,000 ha.

The demand for water is predicted to increase, due to population growth, urbanisation and growth in the industrial, mining and agricultural sectors. There is a need for proper assessment, planning, development and management of water resources to avoid overuse and degradation.

Currently, several problems affect water resources, including siltation of dams (resulting in short life-spans), leakages in urban areas, loss of capacity of groundwater recharge due to soil compaction and algal capping, and inefficient irrigation technologies. These reduce the availability of water resources.

Climate change will invariably affect water withdrawals especially against the predicted decreasing precipitation trend (1mm to almost 15 mm per decade) and the 2°C and 3°C increase in temperature which will also mean higher crop evaporative demand (Gumbo, 2006).

9.2 Key organisations in the water sector

Table 14 provides an overview of the key organisations involved in water resources management in Zimbabwe.

The Ministry of Water Resources, Development and Management is responsible for policy formulation for water management, while ZINWA is the implementing agency. For efficient and effective water management, the country is divided into seven catchments, based on the major river systems and managed by catchment councils. A catchment council is in charge of water affairs in its catchment and consists of elected representatives from the water users in the catchment, including farmers.

Zimbabwe's current Water Policy is guided by the framework document 'Towards Integrated Water Resources Management: Water Resources Strategy for Zimbabwe', developed in the late 1990s. The document also guided the 1998 Water Act. It makes specific reference to the adoption of the integrated water resources management (IWRM) strategy, embodied in the 1998 Water Act. The IWRM strategy provides a good platform for implementing water demand management. It has led to the implementation of market-based interventions in water resources management (e.g. paying for water, effluent charges, the 'polluter pays' principle), technological interventions (loss reduction and recycling), special measures for irrigation, mandatory measures, and raising public awareness. Zimbabwe's national Water Policy provides an effective framework for water resources management, but needs to make specific references to climate change to ensure plans and programmes are coordinated.

Table 14. Zimbabwe's water sector: institutions and roles

Institution	Role in water sector
Ministry of Water Resources, Development and Management	Formulate and implement sustainable policies on the development, use and management of water resources. Also responsible for the overall/national planning, management, regulation and standardisation of irrigation development and adoption of appropriate technology.
Ministry of Agriculture and Rural Development	Overall development and implementation of the Government's policy on agriculture and irrigation.
Department of Research and Extension Services	A functional arm under the Ministry of Agriculture and Rural Development which provides extension services to irrigators, soil surveys and irrigation development.
Agricultural and Rural Development Authority	Quasi-government agency responsible for the operation of government-owned irrigated estates and farms.
Department of Irrigation	As specialist department under the Ministry of Agriculture and Rural Development responsible for irrigation planning, identification of schemes, designing, construction, operation and management of existing and new schemes.
Department of Water Development	A specialist department under the Ministry of Water Development with the main task of formulation of national policies and standards for planning, management and development of the nation's water resources.
Zimbabwe National Water Authority (ZINWA)	Water planning quasi-government agency advising Catchment Councils and Sub-catchment Councils. Key roles in the management of the water permit system and the operation of water pricing systems, planning, coordination, management of water resources and the delivery of water.
Catchment Councils – linked to ZINWA	Prepares outline plans, determines applications and grant permits for water withdrawals and use, regulates and supervises exercise of water rights, and supervises performance of sub-catchment councils. Sub-catchment councils carry out day to-day water management.
District Development Fund	Tillage services to irrigators. Maintains infrastructure such as boreholes and small dams. Plans and constructs small irrigation schemes.
Ministry of Local Government, Public Works and National Housing	Working through the Rural District Councils to mobilise the local community, farmer selection and irrigation plot allocation in smallholder irrigation development.
Environment Development Agency under the Ministry of Environment and Tourism	Environmental impact assessments for new irrigation schemes and dams, pollution abatement, environmentally healthy catchments, water quality.

Source: Gumbo, 2006

9.3 Water policy and its relevance to climate change

Zimbabwe's Water Policy is enshrined in the Water Act of 1998 (see Box 7), and founded on IWRM principles and provides a basis for the water sector's response to climate change. It was partly a response to the devastating drought of 1992, which provided the impetus for policy-makers to respond to similar challenges in the future. To this end, the Water Policy was a response to the effects of climate variability and change.

Box 7. Provisions of the 1998 Water Act

- All water (surface and underground) is owned by the State and all water use except primary requires state approval.
- Unit of management for water – Catchment Councils.
- Time bound water permits (subject to application and intended use) issued by the Catchment Councils as against water rights held in perpetuity.
- Priority date system replaced with proportional water allocation.
- Polluter pays principle recognised and water treated as an economic good.
- Water is allocated for environmental purposes and linked to drought preparedness and degradation of catchments.
- Setting up a national water authority.

9.4 Vulnerabilities and opportunities

Climate change projections for Zimbabwe provide ample evidence that water resources will be significantly affected by climate change, with wide-ranging consequences for social and economic development. Higher temperatures will affect soil moisture content, rates of evapotranspiration, and lead to changes in the intensity and timing of rainfall and the occurrence of extreme weather events. These changes will alter the supply and demand of water resources, as well as the quality.

9.4.1 Rainfall patterns and run-off

Model experiments suggest that annual rainfall will become more variable across Zimbabwe in the future. This variability will occur in all seasons, but will be greater for the early and late rains than for the main rainy season (December to February).

As a result of greater rainfall variability in recent years, drought events have become more frequent. Many of Zimbabwe's serious droughts have coincided with an El Niño events (e.g. 1982–83 and 1991–92), reducing total rainfall to as little as 30% of the annual average (Orlove and Tosteson, 1999). Zimbabwe also experiences extreme rainfall events and flooding, related to La Niña events. The 2007 floods are a case in point, which resulted in extensive flooding in some parts of Zimbabwe as well as other southern African countries.

As rainfall becomes more unreliable and temperatures increase, the availability of fresh water will decrease. The majority of Zimbabwe's water is taken from reservoirs, particularly for urban centres and large-scale irrigation schemes. According to the National Communication on Climate Change (Ministry of Mines, Environment and Tourism, 1998) the yield from these dams could be reduced by 30–40% due to climate change. The water level in one of Zimbabwe's main reservoirs, Umzingwane near Bulawayo, has been declining since 1977. In rural areas, where water supply is less secure, there will be an increased risk of water shortages for agriculture and domestic consumption.

9.4.2 Surface water resources

Evapotranspiration under climate change is predicted to increase by 4–25% in river basins, and runoff is projected to decline by up to 40%, with the Zambezi Basin being the worst affected (Chagutah, 2010). Water available for storage from runoff varies between seasons. The estimated long-term mean is 20 billion m³ per year, excluding the flows of the Limpopo and Zambezi rivers.

A sensitivity analysis of water storage in Zimbabwe's main reservoirs during the 1991–92 drought cycle indicated that, with a 2°C mean temperature increase and a potential evaporation exceeding the long-term average by 30–90%, the water level decreased to 10% of capacity. In 2007, most of Zimbabwe's reservoirs had extremely low water levels due to high evaporation, resulting in some being decommissioned.

The last six years have been the warmest of the last fifteen, and evaporation has increased. Due to the reduced water levels, many rural wells and boreholes have dried up, urban water supplies have been severely limited throughout the country, and hydroelectric power generation has gradually fallen, threatening several industries.

9.4.3 Groundwater availability

The current and projected long-term variation in rainfall will adversely affect groundwater recharge and levels of groundwater tables. This will negatively affect water supply from groundwater sources for agriculture and domestic purposes. This was evident during the 1992 drought adversely affected groundwater resources. Rainfall in 1992 was just 30% of the average amount, and the water table in some areas dropped by 100–200 metres, traditional shallow wells and boreholes dried up, and a number of rivers, reservoirs and their related ecosystems disappeared (Gumbo, 2006). This had great consequences for rural households that relied on groundwater for domestic water supply.

Knowledge of current groundwater recharge and levels in Zimbabwe is poor, and there has been little research on the impact of climate change on groundwater resources. Such information and knowledge is vital in planning on the future use of groundwater.

9.4.4 Impacts on water use

More variable rainfall, surface water resources and groundwater will impact agriculture, industry, energy production and ecosystems (as detailed in relevant sections of this Report). It will also impact on domestic water use. The 1991–92 and 2007 droughts illustrate the effects of climate change on domestic water supply. Due to these droughts, water for domestic purposes was frequently cut and water rationing was put in place in many urban areas, as were power cuts.

For Bulawayo, such measures have become normal. This is mainly because its dams are located in drought-prone areas and rainfall in the catchment areas of these reservoirs has been decreasing over the years. In November 2007, the City of Bulawayo had to decommission three of its five supply dams, namely Lower Ncema, Upper Ncema and Umzingwane, because no significant inflows took place during the rainy season.

As a result, Bulawayo has for years been putting in place water-rationing measures, which usually see residents receiving water once or twice a week. The impact of climate change on water supply is likely to undermine improved access to water and sanitation for the population, with negative consequences on human health and socio-economic development.

9.5 Mitigation in the water sector

The relationship between water resources and climate change mitigation measures is complex and dynamic, as one aspect feeds into the other. Put simply, mitigation measures in other sectors can influence water resources, while measures for water resources management influence greenhouse gas emissions.

Water management activities that influence greenhouse gas emissions include the construction of water reservoirs, which, in turn, emit small amounts of greenhouse gas as water conveys carbon in the natural carbon cycle. Water reservoirs also absorb CO₂ at their surface. The extent to which water reservoirs in Zimbabwe emit and absorb greenhouse gases has not yet been studied. Expanding the area for irrigation, as is planned in Zimbabwe, and the use of more effective irrigation techniques, can enhance carbon storage through yields and residue returns.

Other key mitigation measures in the water sector include hydropower and wastewater treatment. Hydropower, as a renewable energy source, contributes to reductions in greenhouse gases. In addition dams constructed for hydropower can also serve as a means for regulating water flows, especially in flood prone areas. As such, dams, in general, contribute to flood control, thereby mitigating potential damages due to floods.

With reference to wastewater treatment, it is a major source of methane and nitrous oxide emissions. In Zimbabwe, as population growth increases and many people residing in urban areas, there is need for urban authorities and ZINWA to develop wastewater infrastructure to contribute to reduction in methane and nitrous oxide emissions.

Mitigation practices in other sectors, such as land use management and forestry, affect water resources. Reduced tillage, afforestation, re-afforestation, and greater use of perennial crops, which are aimed at improved land use management and soil carbon conservation, improve the supply and quality of water resources, such as groundwater.

9.6 Adaptation in the water sector

To adapt to the increasing impacts of climate change on water resources, water managers and policy-makers need to address supply and demand issues. On the supply side, the following adaptation strategies can be implemented:

- Limit groundwater extraction by issuing of permits and fees for groundwater extraction
- Increase storage capacity by building reservoirs and dams to manage the variability of water resources and regulate floods
- Work on the maintenance, rehabilitation and re-engineering of existing systems, including dams, irrigation systems, canals, pumps, rivers and wetlands; and,
- Develop and implement of rainwater harvesting and storage techniques (see Box 8).

On the demand side, the following strategies should be considered:

- Improve water-use efficiency by recycling water and providing multiple-use water schemes
- Change the cropping calendar, crop mix, and areas planted to reduce the demand for water
- Improve the efficiency of irrigation technology to deliver more crops per drop; introduce drip irrigation, wastewater reuse and water recycling
- Promote indigenous practices for sustainable water use (e.g. dambo cultivation); and,
- Expand the use of economic incentives, including metering and pricing, to encourage water conservation

It is important to remember that the concept of integrated water resources management governs water sector policy and legislation. As such, the Water Policy provides an instrument that can contribute to adaptation measures; issues relating to coordinated management of land and water resources, water metering and pricing, effective systems of water allocation, and resolving conflicts between competing water uses, are already embedded in national policy framework.

The policy framework should also incorporate climate change adaptation within the governance of water resources. This will provide a more effective basis for climate change adaptation in the water sector. For effective adaptation, water management institutions should be strengthened at all levels and capacities built for holistic water management in the context of climate change.

Box 8. Rainwater harvesting

There are current initiatives in Zimbabwe to encourage local communities and households to embark on rainwater harvesting for domestic and productive use. These will allow communities to capture rain or floodwater. The harvested water can be used during dry spells or after the rainy season.

Organisations such as the Zvishavane Water Project have been promoting rainwater harvesting for schools, communities and household in Zvishavane and Chivi districts. The project has enabled households, schools and communities to have water for domestic purposes as well as for nutrition gardens.

9.7 Research and technical assistance

Research and technical assistance should prioritise the following:

- Assessments of the impact of climate change on surface and groundwater resources
- Efficient use and management of surface and groundwater resources under changing climatic conditions
- The use of indigenous knowledge systems in forecasting and managing water resources, as well as in mitigation and adaptation strategies
- Impact evaluations of adaptation initiatives in the water sector, such as multiple-use schemes and rainwater harvesting; and,
- Reviews of the 1998 Water Policy to take into account climate change

It is also important to strengthen ZINWA and catchment and sub-catchment councils through funding and capacity building, so they can deliver their water resources management functions effectively in the context of climate change. This includes developing and updating catchment and sub-catchment water demand needs, projecting future water demands, and developing appropriate water allocation mechanisms that support poverty reduction, livelihood improvement and economic development goals.

9.8 Summary

It is apparent from the foregoing that rainfall patterns have changed, with a distinct decreasing pattern emerging. Therefore, there is need for Zimbabwe to institute a water development programme, particularly stored water for both domestic and productive uses, underlined by efficient approaches to the use of water. The development of appropriate irrigation systems will need to involve farmers in planning, implementation and management processes. Policy-makers also need to know more about groundwater reserves in Zimbabwe. This information will help in planning how groundwater can be obtained and allocated for domestic and productive purposes. A focus on efficient use of water for productive purposes will, in part, entail the introduction of technologies such as drip irrigation, wastewater treatment, reduce wastewater discharge and improved management of wetlands. Further, investment in micro hydroelectric projects is vital, as this will reduce pressure on the energy supply from the Kariba Dam. These micro schemes will also allow communities to be partners in the generation and management of their electricity.

The Water Act and the Zimbabwe National Water Authority Act, both of 1998, should be revised to take into account the changed landscape of water users and likely impacts of climate change on water resources. The revised policy should acknowledge the important role water plays in agricultural production, industrial development and human health. In order to effectively deliver on their mandates, key institutions for water development and management must be supported through capacity building and improved funding.

10. Disaster preparedness and response

This section presents an overview of climate-related hazards, their frequency and impacts on social and economic development. It examines current disaster management efforts by the Government, through the Civil Protection Department and the enabling policy and institutional framework. It also provides recommendations on reducing climate change risk through disaster risk reduction, as well as technical and research requirements.

10.1 Overview of climate-related disasters in Zimbabwe

Zimbabwe has witnessed an increasing number of weather-related hazards, namely droughts, floods and, more recently, tropical cyclones. These have adversely affected people's livelihoods and undermined the country's economic development. Table 15 presents data on natural disasters from the World Health Organization's Emergency Events Database (EMDAT). It shows that drought is the most common disaster, and its frequency per decade is increasing. Floods are also common. Table 16 shows how the intensity of droughts has increased in recent years.

Table 15. Ten largest natural disasters in Zimbabwe 1980–2011, by (a) number of people affected (b) cost of damage

Disaster	Year	Number of people affected
Drought	1982	700 000
Drought	1992	5 000 000
Drought	1998	55 000
Drought	2001	6 000 000
Drought	2007	2 100 000
Drought	2010	1 680 000
Epidemic	1996	500 000
Epidemic	2008	98 349
Flood	2000	2 000 000
Flood	2001	30 000

Disaster	Year	Damage (\$ 000)
Drought	1982	2 500 000
Drought	1991	50 000
Flood	2000	72 900
Flood	2001	3 600
Flood	2003	200 000
Storm	2007	1 200

Source: EMDAT, www.emdat.be. Accessed April 2011

Table 16. Drought Occurrence According to Intensity 1950–2000

Mild	Moderate	Severe	Extreme
1963/64	1959/60	1981/82	1986/87
1964/65	1967/68	1982/83	
	1972/73	1983/84	
		1991/92	

Source: Adapted from Manatsa et al, 2010

Figure 12 shows flood-prone areas in Zimbabwe. Floods often damage crops and harm livestock, resulting in loss of life. Floods are often caused by tropical cyclones from the Indian Ocean. The accompanying high winds often cause structural damage as they track inland from the Mozambique coast.

In 1999 Cyclone Eline, which sustained winds of up to 120 km per hour, claimed more than 70 lives. Livestock were killed, and infrastructure was extensively damaged as the cyclone swept across the eastern part of the country. Up to 70% of crops in the affected region were destroyed, leaving approximately 1 million people in need of food, shelter and drinking water.

10.2 Civil protection policy and institutional framework

Disaster management in Zimbabwe operates under the legal and institutional framework of the 1989 Civil Protection Act No. 5. The Department of Civil Protection in the Ministry of Local Government, Public Works and National Housing coordinates it. The Government initiates disaster preparedness programmes through the appropriate sector ministries, with the local administration implementing them and maintaining their effectiveness. The Civil Protection Department has only seven full-time members: the director, the deputy director and five operational officers.

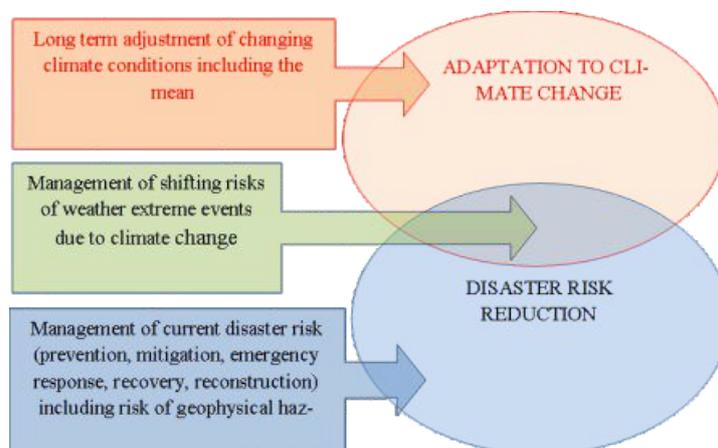
The Department is mostly state-funded, through the Disaster Fund. This money is only released after the President declares a state of disaster. In the event of major disasters, where more resources are required, there is legislation through which the treasury can release additional funding. However the funding is usually less than the amount needed to successfully manage the disaster. This has left the Department to rely on development partners (like UN agencies and NGOs) to fund some of its disaster management initiatives. But with the country's standoff with the international community, such funding has gradually dried up.

The National Civil Protection Coordination Committee is made up of senior officers from selected ministries and departments, parastatals and NGOs. It directs most of the national disaster management agenda. Other members, especially from the private sector, are co-opted when necessary. At the provincial level, the committee is known as Provincial Civil Protection Coordination Committee; at the district level, the District Civil Protection Coordination Committee.

10.3 Disaster management and climate change

It is critical for disaster risk management to become a central component in all of Zimbabwe's climate change adaptation strategies. Climate change increases the frequency and intensity of hydro-meteorological hazards. Efforts for disaster risk management aimed at reducing vulnerabilities to extreme weather events should dovetail with efforts to promote climate change adaptation. Figure 13 illustrates the links between disaster management and climate change adaptation.

Figure 13. The overlapping agendas of climate change adaptation and disaster risk reduction



Source: World Bank, 2010

The links between disaster risk management and climate change adaptation include the management of extreme weather events. This can be broadened to cover the generation and communication of climate risk and vulnerability information, institutional capacity and coordination, community-level activities, and financing disaster risk reduction and climate change adaptation.

A key entry point in establishing an effective legislative and policy framework is replacing the Disaster Management Act of 1989 with the proposed Emergency Preparedness and Disaster Management Act (currently being drafted). The new Act should not focus on relief and rehabilitation efforts, but lay the legal framework to address pre-disaster prevention and preparedness, as well as post-disaster response, recovery and reconstruction. This will open avenues for climate adaptation to be incorporated in the legislation.

The Act could be used to:

- mainstream risk management in climate-sensitive sectors including agriculture, fisheries, water, infrastructure and health
- introduce disaster risk management operations across administrative levels, from ward to national levels
- enhance links and synergies between humanitarian agencies and the most vulnerable rural communities

- renew interest in preparedness and contingency planning to prepare for more frequent and less predictable multiple hazards
- access new or additional financial instruments from the regional and international community.

There are many regional and international players, such as FEWS-Net, that aim to reduce climate change vulnerability. The Civil Protection Department should foster links with established international and sub-regional programmes to enhance its capacity. Sub-regional networks can be used for information and knowledge sharing, especially regarding methods and technologies for preparing for disasters.

10.4 Current initiatives

Successive climate-related disasters and global movements since the 1990s have triggered a paradigm shift in disaster management, leading to a host of new initiatives to reduce the risks of disasters.

For example, the SADC Hydrological Cycle Observing System (SADC-HYCOS) project installed five data collection platforms along major rivers in Zimbabwe to assist in early warning for floods, monitoring and water resource management. The Department of Meteorological Services installed automatic weather stations in major cities, enabling continuous collection of data about weather elements that are needed in atmospheric research. The Civil Protection Department, with assistance from UNDP, developed a 'Disaster risk reduction resource' book, which is being used as a reference book in schools and universities across Zimbabwe.

10.5 Research and technical assistance

The generation and provision of reliable and appropriate information on present and future climate risks is a key component of adaptation. Improving data sources and modelling capacity is an adaptation in itself and a resource on which to base adaptive decisions and actions. However, the understanding of climate change at local levels is severely limited, as the collection of data of a sufficiently high resolution and continuity remains a fundamental problem.

Low-resolution data has insufficient temporal and spatial coverage to detect crucial local climate change trends or validate projections from regional climate models.

In view of this, Zimbabwe must:

- improve data collection for monitoring hazards
- establish hydro-meteorological early warning systems at national, provincial and district levels
- provide resources (technology and funding) to the hydro-meteorological monitoring departments of ZINWA and Meteorological Department
- build the capacity of staff in relevant government agencies, at national and sub-national level, to enable them to monitor and respond to weather-related disasters
- restoring recording stations and data collection platforms for hydrological monitoring, including those managed by ZINWA and the Meteorological Department, and those installed under the SADC-HYCOS project; and,
- promote inter-sectoral coordination and collaboration on research into disaster risk reduction.

Zimbabwe needs technical assistance from regional and international disaster reduction agencies to support education and training, including public awareness programmes. There should be a systematic approach to mainstreaming disaster risk management training and capacity building, one that emphasises climate change adaptation through formal education in schools, colleges, universities and other technical and professional training institutions.

An effective disaster database for the management of all disasters, at all levels, is long overdue. Currently Zimbabwe relies on international organisations such as EMDAT for its disaster statistics. Although this data is better than nothing, its reliability is often questionable. Inadequate data and the lack of readily available national disaster information leads to poor planning, a lack of institutional memory, and a lack of effective monitoring and evaluation of trend analysis and forecasts. A disaster database would enable continuous monitoring of events and facilitate analysis, research, storage and application to new project plans.

Research is needed to develop a hazard diagnosis tool to assist in identifying areas of high vulnerability to different hazards. This mapping tool should consider social and economic aspects of population vulnerability and the vulnerability of the infrastructure, and have the capacity to be updated to reflect the changing climatic and socio-economic patterns.

10.6 Summary

Climate change adaptation and disaster risk reduction are closely linked. Adapting to climate change requires preparing for long-term changes in average climatic conditions and addressing short- to medium-term impacts of climate variability and extreme events.

The reduction of current and future vulnerabilities to climate change should build on existing disaster risk management efforts. The Climate Change Office and the Civil Protection Department should foster a close collaborative framework, not least as they rely on the same baseline information, such as hydro-meteorological data used in early warning systems and for long-term climate predictions.

Disaster management and climate adaptation currently fall within different ministries and are addressed nationally under different policy frameworks. Consequently, they are managed through different departments that have little cross-sector coordination. The location of the Climate Change Office within the Ministry of Environment and Natural Resources Management tends to isolate it institutionally from the development agenda where most adaptation activities take place.

There are persistent gaps between the production of climate risk information and the ability of decision-makers and vulnerable stakeholders to interpret and react to such information. The uptake of climate information is also hampered by lack of trust; it will require concerted efforts for to build bridges between scientists and stakeholders within implementing institutions.

Part D – Sectoral Analysis II

11. Mining

The anticipated growth in Zimbabwe's mining sector has important implications for climate change. Mining contributes to climate change due greenhouse gas emissions associated with the sector (as it is dependent on thermal power). Open cast mining results in the clearing of forests, which are major carbon sinks, for the construction of mine plants and other infrastructure such as roads and civil works. Blasting emits gases into the atmosphere that may contribute to climate change. Coal dumps that are not rehabilitated may cause spontaneous fires, which also emit greenhouse gases.

Both underground and open cast mining are also vulnerable to the impacts of climate change. Climate change can cause energy shortages and, to some extent, shortages of raw materials. And changes in water availability may threaten water-reliant production and processing techniques.

11.1 Overview of the mining sector

The mining sector accounts for around 44% of Zimbabwe's GDP, 5% of formal employment, and at least 30% of foreign exchange earnings. Major mining products include gold, platinum, nickel, diamonds, ferro-alloys and coal, which are invariably exported. Mining output declined by 14% in 2000 as a result of mine closures, power shortages and depressed international prices for minerals. This declining trend in the formal mining sector continued up to 2008. For instance, gold production – accounting for about half the total value of the mining sector – declined from 22.07 tonnes in 2000 to 18.04 tonnes in 2001 (AfDB/OECD 2003:358) and to 13 tonnes in 2011 (Mining Review, 2011; AfDB/OECD 2003:358). In contrast, artisanal mining underwent a boom during the period of economic contraction as many people resorted to gold panning throughout the country and informal alluvial diamond mining in Marange to earn a living.

Despite the decline in the mining sector, the sector's relative economic importance increased, from 3.8% of GDP in 2001 to 6.4% by 2006. Recent years have seen

resurgence in the mining sector, with increased production in gold, coal, platinum and diamonds. Table 17 shows the increased production of key minerals from 2009 to 2011.

Table 17. Mineral Production in Zimbabwe 2009–2011

Mineral	Total production			
	2009	2010	June 2011	Projected total 2011
Gold (kg)	4 966	9 620	5 521	13 000
Nickel (tonnes)	4 858	6 133	3 858	8 400
Coal (tonnes)	1 606 315	2 668 183	1 018 543	3 000 000
Chrome (tonnes)	201 000	516 776	241 371	61 000
Platinum (kg)	6 848	8 639	5 305	12 000
Diamond (carats)	1 305 693	8 435 584	2 329 441	8 200 000

Source: Ministry of Finance, 2011

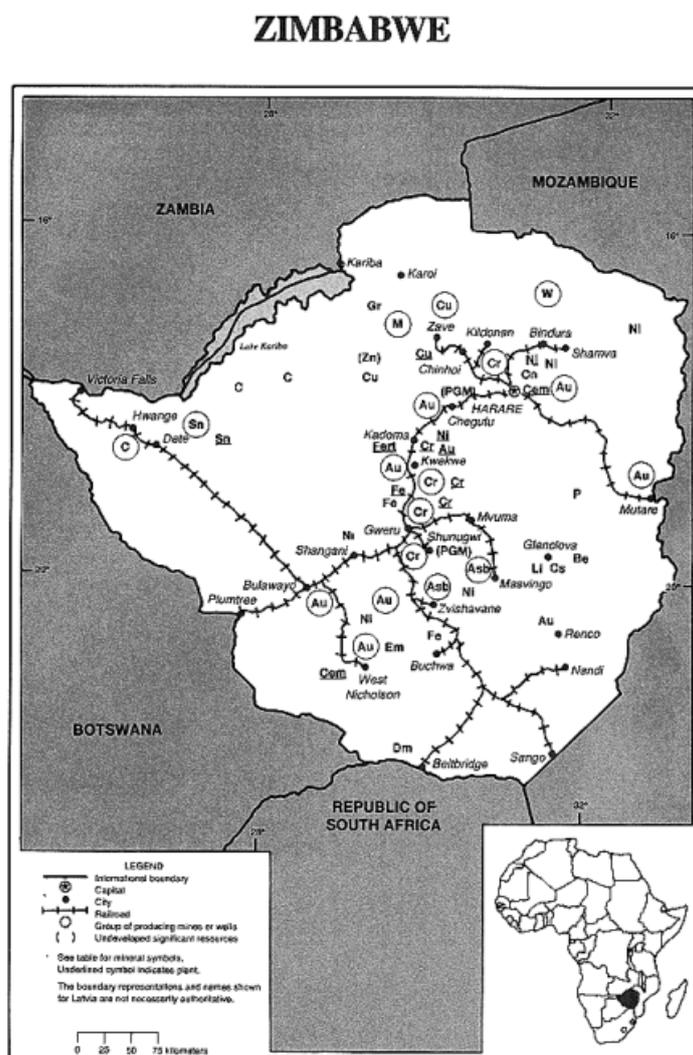
Table 17 shows that there has been significant growth in the mining sector, fuelled by buoyant international prices for minerals and improved electricity supply, making the sector a key contributor to GDP. Growth in the sector is projected to continue in the next 10 years. For example, in 1999 gold production was 27 tonnes per year; projections for 2015 are 50 tonnes per year. Platinum was being mined at 170,000 ounces per year but is projected to reach 1 million ounces in 2015.

Coal is mostly used for electricity production and industrial uses. The Hwange Power Plant uses about 2.5 million tonnes of coal per year at peak production. At its peak (around 1998), Hwange Colliery was producing about 6 million tonnes per year, but this has since reduced to less than 3 million tonnes per year. New coalmines have opened recently, but production figures are not yet available. Most new mines produce coal for the metal industry, especially for chrome smelting. Increased output is inevitable with revitalisation of other productive sectors.

It is anticipated that coal liquefaction may be adopted for a liquid fuel supply. Given the huge coal reserves in Zimbabwe, coal mining is poised for considerable growth. There is also a significant amount of coal bed methane, estimated at 33 terra cubic feet.

The revival of iron and steel processing in Kwekwe (which is under new management) will result in significant production of iron and steel, as well as increase the demand for coal. Alluvial diamond mining in Marange, considered one of richest diamond fields in the world, has also led to tremendous growth in the mining sector. Figure 14 shows the location of formal large-scale mines, which are concentrated on the Great Dyke. Large mines are located along the main rail links.

Figure 14. Mines in Zimbabwe



11.2 Mining policy

Mining policy can reduce the contribution of mining to climate change while at the same time reducing its vulnerability to it. The Mines and Minerals Act (Chapter 21:05) is the principal legal instrument governing mining in Zimbabwe. However, this was passed in 1961, well before climate change began to receive international attention; any reference to climate change in the Act is implicit rather than explicit. Climate change issues resulting from mining are addressed by the Environmental Management Act (Chapter 20:27) and regulations made under it, and the Mines and Minerals Amendment Bill of 2007.

The Mines and Minerals Amendment realises forests are important in the sustainable management of natural resources. In Section 36 (1), the Mines and Minerals Act states:

'Every owner or occupier of private land may apply for and shall be granted by the mining commissioner a reservation against the cutting or the taking by prospectors or miners of fifty per centum of such indigenous wood or timber as is existing on his land at the time of his application for the reservation'.

This can be interpreted as a realisation of the need to ensure that trees and forests are not wantonly cut during exploration and mining operations. Furthermore, the mining commissioner may, through a notice authorised by the Minister, reserve the cutting down of specified indigenous wood or timber by a holder of a prospecting licence or a special grant in terms of Section 37 (1).

These provisions have some relevance to climate change. While the reservations do not stop prospecting or actual mining activities, they ensure that these are done in a sustainable manner. However, these reservations only apply to indigenous wood or timber.

Under Section 257 (B), large mining companies are required to establish environmental rehabilitation funds, used for:

- quittance work or other work that will be required upon the cessation of mining operations in the mining lease or mining locations; and
- any other work required, whether under this Act or any other enactment, to protect or to restore the environment from the consequences of the miner's mining operations.

These funds, which must be established within one year of operations starting, can be used for activities that have direct implications on climate change.

For example, rehabilitation may include growing trees, which will act as carbon sinks. The funds also mean rehabilitation work is timely; in the case of coal mining, planting trees reduces the outbreak of spontaneous fires, a major source of air pollution that causes climate change.

In Section 97 of the Environmental Management Act, mining is a First Schedule activity, one that must not be undertaken before an Environmental Impact Assessment (EIA) is carried out. If the EIA shows that the proposed mining activity will contribute to greenhouse gas emissions, there are strong grounds to apply technological processes to mitigate the emissions.

The 2009 Environmental Management (Atmospheric Pollution Control) Regulations, Statutory Instrument 72, have provisions applicable to mining. Air pollution contributes to climate change and these regulations can be used as mitigation measures against climate change. Section 3 of the Regulations sets objectives to prevent air pollution and set emission standards for certain activities. These include the burning of waste at landfill, the burning of vehicle tyres, the burning of bitumen, the burning of metallic wire coated with any material, the burning of oil in the open air, the operation of an incinerator, and any activity that emits a pollutant into the atmosphere.

Further, the regulations make it an offence for an owner or occupier of land or premises with a disturbed surface area to cause or allow fugitive dust to be emitted into the atmosphere as a result of activities on the disturbed surface area, in excess of the prescribed amount in the Third Schedule. Mining activities emit fugitive dust. These provisions compliment Section 63 of the Environmental Management Act on air quality standards.

Some mining waste can result in spontaneous fires, if they are not rehabilitated quickly. These fires cause air pollution, which contributes to climate change. Section 24 (1) of the Environmental Management (Effluent and Solid Waste Disposal) Regulations, Statutory Instrument 6 of 2007 regulates the management of mining waste. The regulations state that any person authorised to carry out any type of mining activities shall, in accordance with the Mines and Minerals Act, do so in a manner that does not negatively impact on the environment.

Furthermore, the person is required to rehabilitate the land to the satisfaction of the Environmental Management Agency within one year of operations ending. Delays in carrying out timely rehabilitation can again result in spontaneous fires and air pollution.

11.3 Climate change vulnerabilities and opportunities

As noted at the start of this section, both underground and open cast mining can contribute to climate change, and are vulnerable to its impacts. But mines are located based on the availability of resources, not on climate factors or the suitability of land to withstand climate impacts. Coalmines at Hwange and Gokwe constantly threaten to pollute the Zambezi River; gold mines are found in places where water scarcity threatens people's survival, despite the possibility of gold mining having highly detrimental impacts on water.

Small-scale miners pose a unique threat to the environment. They exploit mostly alluvial gold and have no capacity to mitigate environmental damage. In addition, small-scale miners lack the skills necessary for efficient mineral extraction so achieve low yields. Small-scale miners are driven by limited opportunities elsewhere in the economy, such as limited jobs in agriculture due to droughts. The damage caused by small-scale mining methods threatens surface water resources and flooding is exacerbated by deforestation and the siltation of water courses.

But climate change offers important opportunities for the mining sector to reduce emissions and trade carbon credits on the international carbon market. Mines that can install clean technology, such as for capturing and storing carbon, and hold carbon credits issued by the Government, can trade their surplus credits on the international market. However, Zimbabwe is yet to put in place a framework for carbon markets.

11.4 Mitigation in the mining sector

One way to reduce emissions from the mining sector is to make operations more energy efficient. Zimbabwe faces a critical electricity shortage, affecting the operations of mining and industry. Most private investors are seeking ways to alleviate these shortages. The Business Council for Sustainable Development in Zimbabwe has been working with various partners to encourage members to adopt energy efficient production methods.

These include the adoption of a wide array of energy efficiency methods in industrial processes and improved energy management. In the first National Communication to the UNFCCC, Zimbabwe presented opportunities for carbon emission reductions. Energy audits in mines and mineral processing plants showed simple measures have significant potential to reduce energy use, for example such as replacing lamps, insulating process tanks, staff training and repairing compressed air pipes. Table 18 summarises some of these opportunities.

Table 18. Options for reducing carbon emissions in the mining sector

Option	Activities
Improved energy efficiency	<ul style="list-style-type: none"> • Adopt practices that reduce energy consumption per unit of mineral produced, including technology and management options
Process changes	<ul style="list-style-type: none"> • Redesign production processes to reduce the carbon intensity of production (mixing technologies from compressed air to mechanical stirrers, maintaining material temperature when transferring between processes)
Waste recycling or reuse	<ul style="list-style-type: none"> • Import waste from other facilities and blend with product to reduce energy intensity and carbon intensity of products (cement blending with blast furnace slag, coal fines mixed in brick clay, coal ash used for cement blending, recycling glass and steel)
Technology upgrades	<ul style="list-style-type: none"> • Change technology to enable better processing and finer control of product quality to increase value and reduce demand (clinker mills to enable high blending ratios, waste dump reprocessing for chrome and gold extraction)
Use of clean technology, especially in coal mining	<ul style="list-style-type: none"> • Use carbon capture and storage technologies • Use pollution control devices, such as advanced scrubbers, that clean pollutants from flue gases before they exit a plant's smokestack • Use chemical looping combustion technology to concentrate CO₂ levels in exhaust • Produce ultra clean coal, which reduces ash from the coal allowing it to be directly fired in gas turbines at higher efficiency and with lower greenhouse gas emissions • Coal gasification including underground gasification in situ • Capture and use fugitive emissions from coal mines

Low-carbon opportunities tend to favour larger mining operations. Despite their impacts on carbon sinks and inefficient production methods, there are fewer opportunities for small-scale miners. The challenge of poor regulation and monitoring of small-scale miners is therefore a barrier to sustainable development. Delegating the regulation and supervision of small-scale miners to local authorities may improve the situation (Shoko, 2003). Moreover, stimulating the agricultural sector may create jobs and reduce the number of small-scale miners.

11.5 Adaptation in the mining sector

Higher temperatures, more variable rainfall and a greater frequency of extreme events mean that mining companies need to strengthen safety procedures, pump capacity and contingency plans. There could also be important spill-over effects from adaptation in the mining sector. For example, improved water efficiency in mines could release water for agricultural use. In this respect, mining companies should benefit from, and be party to, climate projections, policy and programming from the Climate Change Office.

When mines are closed there is usually no initiative to modify the water supply system for continued use. Pumps and power transformers are abandoned underground and water storage facilities such as dams are left without maintenance. Some mine infrastructure is handed over to local authorities, which have no capacity to operate and maintain it. One strategy to improve the utility of mining infrastructure is to introduce options for long-term use towards the end of a mine's operational life.

Waste material from mines is often considered a hazard. Mine dumps pose a landslide hazard and some of the minerals left in the dump decompose and form acidic or alkaline run-off, which is detrimental to soils and surface water. Some rocks that appear suitable for construction have high sulphides or other compounds, making them unsuitable for building aggregate. Some mine waste can be used for construction, especially road stabilisation and filling dam walls. Granite and limestone quarries offer such materials.

The presence of mines can increase the available skills for adapting to climate change in remote districts. In Gokwe, the prevalence of sodic soils causes soil erosion problems. A mining company has previously offered to provide skills and equipment to help recover some of the gulleys. The mine also offered to provide advisory services to the

communities through the GEF Small Grants Program. It is also common for mining companies to maintain local roads as a community service, especially in areas with limited access.

Larger mining companies, such as Hwange Colliery and the Zimbabwe Iron and Steel Company (now called NewZim Steel owned by Essar), provide municipal services as well as health and education facilities. Due to their reliance on local labour, mines naturally integrate local communities into their social services. Given the prevalence of malaria in the two districts there is a natural link between mining company health services and malaria prevention. This could be important as disease patterns shift in the changing climate.

Mining companies are also natural partners in disaster management. They provide services such as fire fighting, search and rescue, and accident response and recovery as part of their activities. These are also a requirement for communities to survive extreme events. There is a need to consolidate collaboration between mining companies and local authorities so that these services can be wider reaching and more efficient.

11.6 Summary

The importance of mining to Zimbabwe's economic recovery and growth is underscored by the sector's tremendous performance in the past three years, with important contributions to GDP growth and employment. But mining also contributes to climate change; there is a need for mining companies to use clean technologies and energy efficient methods. The Government needs to produce a regulatory framework for the sector based on climate change, to provide a legal basis to steer the sector towards low-carbon production and processing. It must encourage the mining sector to mitigate its greenhouse emissions through the use of clean technologies, particularly in coal mining.

The Government must also support climate change adaptation activities in mining communities. With regards to mitigation, carbon capture and storage can be regulated to form an integral part of planning before a new mine is commissioned. With regards to adaptation, a proportion of funds contributed by mining firms to Community Trust Funds could be used to support community-wide climate change adaptation.

Research, capacity building and funding needs to be provided to technical colleges and universities to build the critical skills to develop the required technologies, monitor and assess greenhouse gas emissions, enforce government regulations, and foster a transition to low-carbon mining.

12. Energy

Zimbabwe's energy resources include fuel wood, coal, coal bed methane, hydropower, solar energy, sugar bagasse, wood waste, animal waste, urban waste and crop waste. This section examines Zimbabwe's current and future energy supply, and the complex links between energy and climate change, and suggests relevant climate change adaptation and mitigation options.

12.1 Overview of Zimbabwe's energy sector

Table 19 shows Zimbabwe's energy use in 2005. Current energy use is dominated by fuel wood, which is used in households, followed by coal and petroleum fuels.

Table 19. Energy use in Zimbabwe, 2005

Energy source	Usage in terajoules (TJ)	% of total
Fuel wood	170 000	41.5
Coal	129 950	31.7
Hydroelectricity + imported electricity	42 941	10.5
Diesel	39 079	9.5
Petrol	17 633	4.3
Jet A1	10 359	2.5
Total	409 962	100.0

Source: Ministry of Environment and Tourism, 2008

12.1.1 Fuel wood

In 2004, fuel wood resources in accessible woodlands covered about 20% of the total land area, representing a stock of 320 million tonnes, with a sustainable yield of 13 million tonnes per year (AfDB, 2011). Total national fuel wood consumption is estimated at around 9.4 million tonnes per year.

The current demand for fuel wood can be met sustainably, but there is an increasing demand for fuel wood in urban areas, as well as rural areas with few fuel wood resources. Recent power outages

have also increased demand for fuel wood, as some areas experience up to 18 hours of electricity outages a day. There is a need for planned reforestation and afforestation programmes to meet this increased national demand, while maintaining the area covered by woodland.

Zimbabwe has a significant number of timber plantations. Production is dominated by three large organisations, namely Border Timbers Limited, Forestry Commission, and Wattle Company Limited, which produce about 87% of the national output. In 2002, plantation forests occupied about 0.02% of the total land area, the majority in the Eastern Highlands. These comprised 81,000 ha of pine, 24,000 ha of eucalyptus and 13,000 ha of wattle.

Timber plantations produce over 70,000 tonnes of biomass waste annually and this has the potential to fuel power plants to create electricity or other forms of energy. This wood waste is generally used in process steam boilers for lumber drying kilns. However, at the largest mills the amount of biomass waste generated on-site could alone yield as much as 4 MW of usable power. As such, biomass waste has the potential to provide sustainable power for local consumption.

12.1.2 Coal

Coal is another key energy source, second in importance after fuel wood. Zimbabwe's coal reserves are estimated at about 10.6 to 26 billion tonnes in situ in 21 deposits, of which 2 billion tonnes are considered mineable by open cast methods (AfDB, 2011). To date, only 3 million tonnes per year are used to generate power at Hwange Power Station and the small power plants in Bulawayo, Harare, and Munyati. Hwange Power Station is the main producer of thermal power, and consumes about 2.5 million tonnes of coal per year. At present, it operates at about 50% capacity.

Industrial coal is used for steam raising and smelting. The major users of coal are the steel, chrome and cement industries. Since 2000 production in the food and textile industry has fallen, reducing its coal consumption. Tobacco curing was another major user of coal but now depends mostly on fuel wood. High efficiency tobacco barns, which achieved low coal intensity per unit of tobacco, are now less popular with farmers due to their dependence on electricity for driving the air supply and circulation system. Frequent power cuts make this more efficient technology less reliable.

Zimbabwe is also endowed with coal bed methane deposits, located at Beitbridge, Chiredzi, Hwange and Lupane. These are estimated at more than 600 billion m³ and could also generate electricity.

12.1.3 Petroleum fuels

Petroleum fuels are another important source of energy, especially for the transport sector. Diesel is the main fuel used for public road transport, agriculture machinery, rail transport and road freight. Gasoline is mostly used for light passenger vehicles. In 2005 diesel consumption was 900 million litres per year and gasoline was 730 million litres per year. Transport services use 46% of petroleum fuel, 26% is used by commerce, 14% by agriculture, 10% for manufacturing and 4% for mining (Reserve Bank of Zimbabwe, 2005).

12.1.4 Renewables

There are significant renewable energy sources in the country, including hydroelectricity, solar radiation and wind. Hydro-electricity forms about 50% of locally produced grid electricity at present. Hydropower potential on the Zambezi River is estimated at 37 terrawatt hours (TWh) per annum, of which about 10 TWh per year have been harnessed (ibid). The Zambezi River offers opportunities for large-scale hydropower at Batoka Gorge (4370 gigawatt hours/GWh), Devil's Gorge (3000 GWh), Mupata Gorge (3000 GWh) and Katambora Gorge (2000 GWh). All these sites would be shared with Zambia, as they lie on the border. The Zambezi catchment is vulnerable to droughts, though, despite encompassing some of the high rainfall regions of southern Africa. In 1992 the water level Kariba Dam reached low of 1 m above the power station intake, threatening hydropower generation. Potential for small-scale hydropower also exists. Because of Zimbabwe's terrain and rainfall pattern, small hydropower potential is mostly concentrated in the Eastern part of the country.

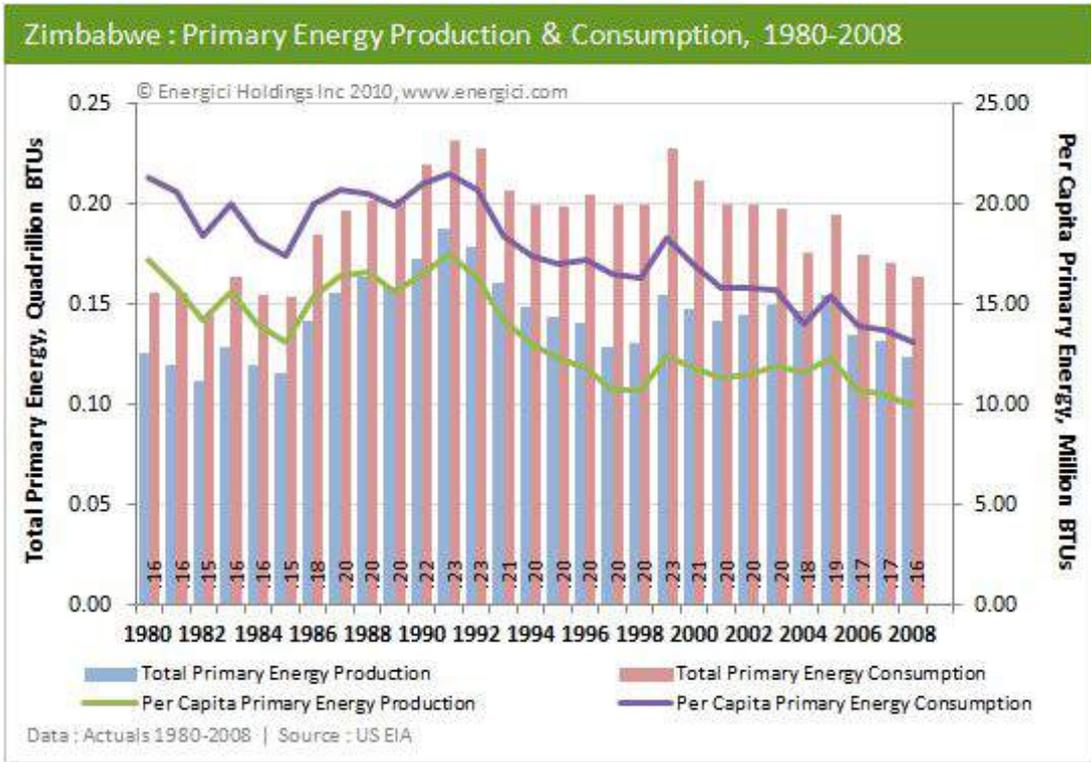
Solar radiation is available at an average of 2,000 kilowatts (kW) per hour per km² per year, spread over roughly 3,000 hours per year. At this rate, photovoltaic cells could generate the current total electrical energy consumption of 10,000 GWh with 10% efficiency and with installations covering 1.3% of Zimbabwe's total surface area. There is also considerable potential for wind energy, particularly for water pumping.

Ethanol is increasing in importance as a source of energy. An ethanol distillation plant was installed at Triangle in the 1980s, and has since supplied anhydrous ethanol for the transport sector, blended with gasoline at a rate of up to 13%. The recent construction of the Chisumbanje Ethanol Plant points to the increasing prominence of ethanol in Zimbabwe's future energy supply.

Biogas offers an additional source of household energy. More than 400 biogas digesters have been installed in Zimbabwe, which range in capacity from 3–16 m³ (AfDB, 2011).

Figure 15 illustrates the declining trend of energy consumption from 1980 to 2008. This can be partly explained by de-industrialisation, a result of the economic structural adjustment programme of the 1990s and the decade-long economic crisis from 2000 to 2009, which reduced industrial energy use.

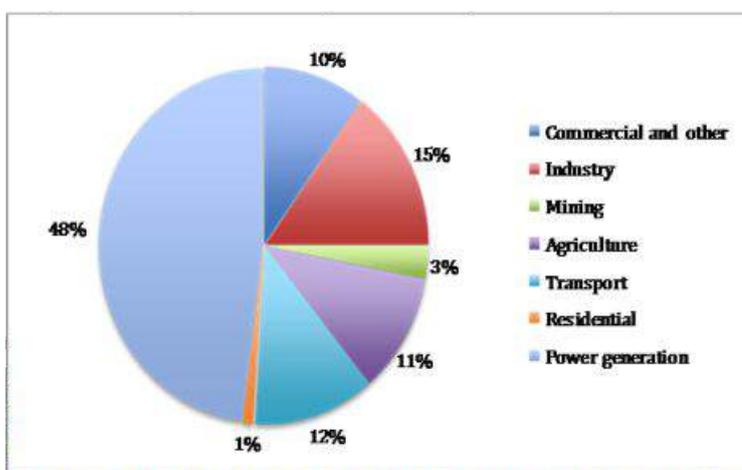
Figure 15. Primary energy production and consumption in Zimbabwe 1980–2008



Source: Energeci Holdings, 2010

The Energy Resource Assessment of 1998 shows that the bulk of the Zimbabwe's energy resources are from renewable energy sources. However, fossil fuels and unsustainable fuel wood harvesting dominate energy use. The 1994 greenhouse gas inventory for Zimbabwe showed the energy sector being responsible for 80% of the greenhouse gases emitted by the country. Importantly, Zimbabwe's first National Communication on Climate Change of 1998 highlighted how the country is a net sink for greenhouse gases due to absorption of carbon by forests. Figure 16 shows Zimbabwe's greenhouse gas emissions from commercial energy.

Figure 16. Greenhouse gas emissions from commercial energy use



Source: Government of Zimbabwe, 1998

12.2 Energy and the Medium Term Plan

The energy section of Zimbabwe's Medium Term Plan (2011–2015) focuses on electricity. Electricity supplies are the major source of concern for the country. Installed capacity is performing below potential due to old equipment and a lack of maintenance, as Table 20 shows. Current electricity demand is outstripping supply due to inadequate capital investment. Electricity use is now mostly for residential customers due to the reduction in industrial production.

The energy chapter in the Medium Term Plan acknowledges the importance of independent power producers and the role they play in improving the sustainability of the sector. Such producers have an impact on climate change by either increasing emissions or providing much-needed experience with renewable energy.

However, they face the same tariff-driven challenges as the Zimbabwe Electricity Supply Authority (ZESA) and need assistance to refurbish their equipment.

Table 20. Electricity production capacity, based on 2010 figures

Power station	Type	Name plate rating (MW)	Available capacity (MW)	Available capacity being used (%)
Hwange	Thermal	920	524	57
Kariba	Hydro	750	710	95
Harare	Thermal	100	20	20
Munyati	Thermal	100	40	40
Bulawayo	Thermal	90	25	28

Source: Government of Zimbabwe, 2011

12.3 Future energy sources

Energy projections in Zimbabwe indicate an increasing diversity of sources, with ethanol biofuel and thermal power gaining prominence in the country's energy mix. Biofuel production is focused on increasing national capacity for power generation and reducing the fuel import bill. The projected increase in bio-fuel is mainly based on the revival of ethanol production at Triangle Sugar Estate and new production at Chisumbanje.

Zimbabwe has a long history of ethanol production at Triangle Sugar Estate, which is valuable experience in ethanol use for power generation and fuel blending. Hippo Valley Sugar Estate, with a current 45 million litres per year capacity is another big ethanol producer, and there is potential for 45 million litres per year in Chiredzi and the 375,000 litres per day from Chisumbanje.

There is also a nascent *Jatropha*-based biofuel sector. In the early 2000s, Zimbabwe began a programme to encourage *Jatropha* seed production by small-scale farmers for biodiesel. By 2009 the National Oil Company of Zimbabwe had contracted 300 small-scale farmers, and provided 30 million seedlings to plant on about 1000 ha of land. Initial targets were to achieve 10% petroleum diesel displacement by 2017. Producers in Mtoko and Mudzi collect seeds for use as household fuel, and also use the *Jatropha* as a live fence to control livestock near fields and homesteads. Some community groups in the districts have acquired oil extraction machines and are producing oil for use in lighting and soap production, but there is yet to be a vibrant technology market to use *Jatropha* oil as fuel.

Projections for future coal use are based on the country's significant reserves, estimated at approximately 10.6–26 billion tonnes. There is also an estimated 900 billion m³ of coal bed methane. This resource needs to be confirmed before extraction can be planned. Discussions have also taken place on use of this gas for electricity production.

Hydropower is projected to continue growing, with improvements in production capacity at Kariba Dam and the development of new potential sites, including those along the Zambezi River and rivers in the Eastern Highlands (such as the Pungwe River) and on several dams (such as Osborne Dam). The Zambezi has an additional 3840 MW of potential electricity that can be developed at three gorges upstream from Cabora Bassa Dam.

Solar energy is viewed as a potential energy resource. Zimbabwe has experience with converting solar energy for lighting through the GEF Solar Lighting Pilot Project, which ran from 1995 to 1998. The project was limited to small systems for rural households, funded through revolving loans. There continues to be a market for such systems, with demand focused on lighting, TVs and radios.

The Rural Electrification Agency installed over 61 solar mini-grid systems in schools and plans to install 500 systems nationwide. Stand-alone solar home systems have also been installed in many rural homesteads. The main reason for using solar mini-grids is to avoid grid extension and reduce the cost of rural electrification. Many urban centres, like Harare, are increasingly installing solar-powered traffic lights. Larger installations for mini-grids are planned for the next eight years.

Solar water heaters can be used for preheating water used for industrial processes. There are a few manufacturers of solar water heaters in Zimbabwe, most focusing on units for households. There are also imported units that offer higher quality finishes but at higher prices. Solar energy can also be used to dry agricultural products and for air conditioning in buildings, as seen in Harare's East Gate shopping.

Wind energy has historically been used for pumping water, mainly for livestock. The low wind speeds in Zimbabwe meant multi-blade, low-speed machines were used, but these require heavy lifting equipment and technical skills for ongoing maintenance. Only well-established farmers or companies could own and operate them.

In the mid-1990s, the country ran a project to determine wind profiles in various parts of the country. This did not generate sufficient data to produce a wind map but enabled the design and production of a wind electric machine able to operate at low wind speeds. A company is now manufacturing these and exporting them to South Africa and as far afield as the US.

Electricity is the main source of energy for industrial and social development in Zimbabwe. The capacity to generate electricity is projected to grow for both hydropower and thermal energy (see Table 21). The growth in power generation is based on the projected increase in the demand and consumption of electricity.

Table 21. Zimbabwe's capacity for electricity generation

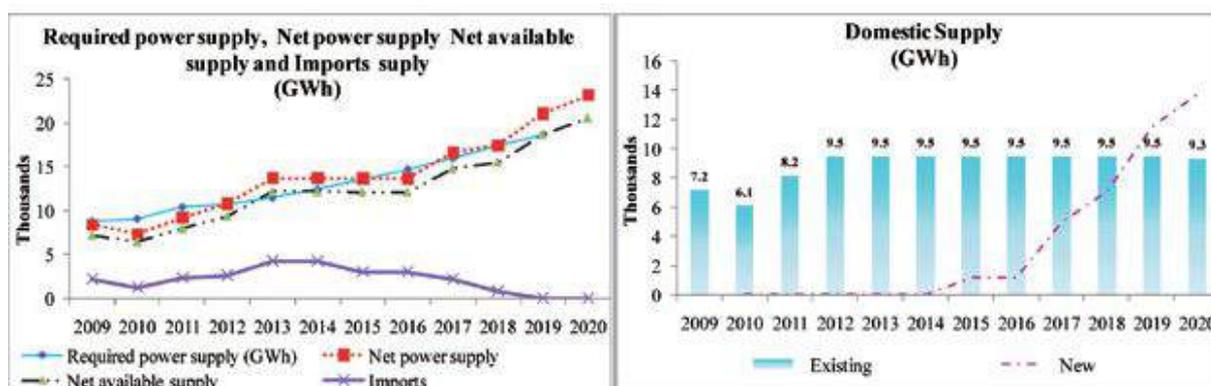
Power station	Electricity production capacity (MW) per year			
	2012	2013	2014	2015
Kariba	750	1000	1050	1050
Hwange	920	1200	1520	1520
Harare	40	60	100	100
Bulawayo	60	80	90	100
Munyati	60	80	100	100
Total	1830	2420	2860	2860

Source: Government of Zimbabwe, 2011

Using the base-case scenario, the demand for electricity is projected to grow at an average rate of approximately 8% per year up to 2020. Figure 20 shows the projected supply and demand for electricity from 2009 to 2020.

It is apparent that there is the potential to embed climate change mitigation measures, such as clean technologies, within Zimbabwe's energy sector. These measures should focus on thermal energy, which is expected to provide the bulk of electricity in the next 10 years. The anticipated growth in hydropower, biofuels, and solar energy to support a projected growth in energy demand (Figure 17) provide significant opportunities for climate change mitigation in the energy sector.

Figure 17. Projection of Electricity Demand from the Base-Case Scenario



Source: ZESA Holdings and Annex Table 1.1 for population data.

Source: cited in AfDB, 2011

12.4 Institutions in the energy sector

The energy sector falls under the Ministry of Energy and Power Development, which is responsible for policy formulation, performance monitoring and regulation of the energy sector. In addition, the Ministry has the responsibility to promote new and renewable sources of energy, and energy conservation. The Ministry supervises specialised public agencies and parastatals, mainly the Zimbabwe Electricity Supply Authority and the National Oil Company of Zimbabwe (NOCZIM). The Zimbabwe Electricity Supply Authority was restructured into a holding company through the Electricity Act of 2002, which led to the establishment of four companies:

- The Zimbabwe Power Company, responsible for all power stations.
- The Zimbabwe Electricity Transmission Company, responsible for the supply of power to the transmission grid.
- The Zimbabwe Electricity Distribution Company, responsible for power distribution; and,
- Powertel, responsible for providing communication services to the power companies as well as providing data services to other users.

The provision of power to rural areas, especially schools, health centres, irrigation schemes, government offices and community projects are the responsibility of the Rural Electrification Agency, created through the Rural Electrification Act of 2001.

ZESA Enterprises, a private sector entity, manufactures equipment used in the power sector for sale to public and private organisations. It is also responsibility for the maintenance and repair of equipment for power plants.

Restructuring and deregulation of the energy sector has enabled various private sector

entities to enter the sector, especially for the procurement and delivery of petroleum fuels. A few producers have entered the market, mostly for small production facilities.

There are a few independent private producers (IPPs) involved in power generation in Zimbabwe. Most of the power generated is sold to the national grid. These include the Nyamingura IPP (a 1.1 MW hydroelectric plant), the Charter IPP (500 MW co-generation plant), and five community-owned small hydro plants in the Eastern Highlands, whose capacities go up to 20 kW. These were installed by Practical Action Southern Africa, mostly with European Union funding.

Energy is a service to all other economic sectors and representation at the local level has always been through parastatals and other line ministries. This increases the communication path from implementation to policy-making. In most cases, local-level institutions are not aware of energy policy. Line ministries lack the technical skills to manage energy, meaning policy decisions are not taken at the national level and implementation is inefficient. An example is the use of diesel power for water pumping at irrigation dams where available hydropower could be used. The limited identification of opportunities could be a direct result of poor interaction with the Ministry of Energy and Power Development at the local level.

The Ministry of Energy and Power Development is working to establish regional representation to replace the centralised structure that has existed since 1980. The current policy draft addresses this issue by making a commitment to establish Provincial Energy Offices.

12.5 National energy policy

In 2010, the Government accepted the National Energy Policy, which was produced through a consultative process supported by technical studies. Box 9 outlines its key elements, through which the Ministry aims to develop and promote renewable energy.

Border Timbers Limited produces 400 kW from sawmill waste at the Charter Sawmill in Chimanimani; Inyanga Hydro in the Eastern Highlands Tea Estate produces 1 MW; Enda Zimbabwe and a Canadian partner installed a 750 kW small hydro plant at Rusitu, *but this was decommissioned due to operational*

challenges; the two sugar mills in the country are set to export 5 MW each to the national grid, subject to appropriate tariff agreements; Green Fuel, a new sugar cane to ethanol plant, has been set up and will produce 15 MW, with about 6 MW for the national grid.

Box 9. Key elements of the National Energy Policy

The goal of the National Energy Policy is to meet the energy needs of the people of Zimbabwe for social and economic development in a sustainable manner.

Policy objectives

- Ensure availability, affordability and accessibility of electricity for all consumers.
- Stimulate sustainable economic growth and poverty eradication.
- Provide a platform for adequate and reliable access to electricity to all, at competitive prices.
- Allow access to IPPs and private–public partnerships and other joint ventures.
- Promote the use of modern energy fuels in rural areas, especially coal and electricity, as well as the promotion of renewable energy technologies.
- Improve energy security through diversity in supply.
- Reduce the negative environmental impacts of energy resource exploitation and use.
- Promote the use of clean energy technologies to mitigate climate change.

Policy measures

- Maintain a dynamic system of development planning process.
- Facilitate efficient use of existing infrastructure.
- Adopt energy efficiency on the supply side.
- Observe environmental regulations in all power sectors.

- Develop local capacity for manufacturing of electricity equipment

Source: Government of Zimbabwe 2008; AfDB, 2011

The energy sector has a history of energy shortage across its energy resources. These include: poor security of supply; widespread deforestation partly driven by the unsustainable collection of firewood; and a shortage of foreign exchange, which limits the ability to import energy technologies. As a result, the Energy Policy reflects the Government's interest in developing local energy technologies and securing energy supply. For example, the Government has:

- diversified energy sources through increased production of biofuels and promoting the use of solar energy
- improved access to commercial energy for poor and rural communities through the Rural Electrification Programme introduced a cost-reflective pricing model for energy through setting tariffs on a cost-plus basis
- developed infrastructure through the expansion of the hydropower station at Kariba
- encouraged investment in the energy sector through increased private sector participation
- promoted regional and international cooperation on energy, such as contributing to the Southern African Power Pool cooperation
- encouraged optimal use of energy resources
- promote information communication technologies in the energy sector; and,
- develop a consolidated national database, which is supported by legislation.

12.6 Medium Term Plan 2011–2015

The Medium Term Plan highlights the critical role of energy supply in economic recovery. The electricity sub-sector is recognised as the most critical component, sometimes at the expense of other energy sources. Current policy, as stated by the Medium Term Plan, is to restore electricity production capacity to meet demand through:

- the restoration of production at Hwange by 2012
- the lease of small thermal plants to private investors
- the installation of prepaid meters to reduce bill collection periods; and,
- the introduction of demand-side management measures to save 300 MW per year.

Thermal power plants using old fuel-combustion technologies cannot achieve higher efficiency levels. Leasing old thermals is going to increase the amount of high-carbon electricity in the national grid. Therefore, there is need to upgrade thermal power stations such as Hwange Power Stations to improve efficiency and the reduction of CO₂ emissions into the atmosphere.

The proposed regulatory measures in the Medium Term Plan focus on increasing participation by other investors, enforcing environmental legislation, and strengthening regulation of the energy sector. The regulations do not mention climate change, except generally under environmental impact assessments. Proposed measures mention low-carbon technologies as an objective, but do not provide an explicit link between cleaner energy and grid electricity.

The measures refer to smaller solar technologies that continue to require reduced duties and taxes. Large renewable energy projects fall under national projects, which are exempt of duties and taxes. Some of the planned projects do not have clear short-term targets, as projects have long lead times. For example, the Batoka Gorge project needs at least six years to develop and most likely ten years to be completed. The Medium Term Plan indicates this project will be implemented without indicating targets for the period.

The Medium Term Plan refers to petroleum supply projects and the use of biofuels. Institutional issues surrounding NOCZIM as both an importer and distributor are to be reviewed. The Medium Term Plan also indicates the use of ethanol biodiesel, which implies private sector involvement in the supply chain. The production of biodiesel is dependent on availability of oil seed but this is not an explicit objective.

The Medium Term Plan prioritises the refurbishment of Feruka Refinery. If implemented, this will have an impact on climate change by localising fuel production emissions and increasing the availability of heavy fuel oils that are more polluting than renewable fuels, such as biofuels. However, the oil pipeline as a regional hub would reduce – if not eliminate – road and rail oil transfer, which emits more greenhouse gases. It is apparent that the planned interventions make limited connections between local supply interventions and global priorities for energy use. Reference to climate change seems coincidental, without any specific targets for climate change performance.

12.7 Climate change vulnerabilities and opportunities

The energy sector is vulnerable to the effects of climate change in several ways.

These include:

- Changes in seasonal and daily temperatures and precipitation affect the timing of peak electricity demands and the size of these peaks. For example, Zimbabwe's predicted temperature increase is likely to increase demand for electricity for cooling industrial machines and households.
- Changes in temperature and precipitation also affect water availability for cooling power generators. · Higher temperatures will increase electricity demand for cooling and refrigeration equipment. This may increase the number of blackouts.
- Changes in cloud cover, temperature and pressure patterns directly affect wind and solar resources, affecting resource availability and productivity.
- Extended periods of drought reduce the water available for hydropower generation. For example, the 1992 drought led the electricity sector to curtail demand by about 20% after water levels at Kariba Dam dropped to critical levels.
- The increased intensity and frequency of severe weather events affects energy infrastructure, including power plants, transmission lines, refineries, pipelines and power lines. Heavy storms and floods pose a significant threat to energy infrastructure; falling trees or lightning strikes often pull down power lines. In the early part of the rainy season each year, the Zimbabwe Electricity Supply Authority faces an upsurge in distribution network faults, mostly due to water damaging cables or trees leaning on or falling into overhead power lines. These disruptions may result in higher energy prices in the long term.
- The increased intensity and frequency of severe weather events also impacts on the design and safety requirements of future energy infrastructure. One of the impacts of dry, hot weather is the failure of the safety systems attached to power lines. Under normal circumstances, a conductor touching the ground causes a fuse to blow or a switch to open. Under very dry conditions, low voltage lines tend to fail this safety function, as the ground does not conduct enough electricity to blow the fuse. Preventive measures will require utilities to add new protective measures or to bury existing power lines deeper into the ground where the soil is moist.

Coal is vulnerable to climate change. Hwange coalmine has stockpiles of high-sulphur coal dumps that industry cannot use. These dumps are prone to spontaneous combustion due to high temperatures and methane. If the climate becomes increasingly dry and hot, there will be more coal dump fires. These fires release more fossil carbon into the atmosphere and also release high levels of sulphur oxides. Severe weather events can affect the distribution of petroleum and diesel, which is critical for transport. Severe storms and rains that cause flooding may make rail and road transportation inaccessible and damage bridges used for fuel distribution. Any significant disruption to the transport infrastructure has serious implications for energy service reliability

12.8 Mitigation in the energy sector

Climate change mitigation in Zimbabwe's energy should focus on reducing energy demands, increasing the efficiency of energy production technology, and shifting to renewable and cleaner energy sources, which, in combination, can lower greenhouse gas emissions.

The potential for climate change mitigation in the energy sector has been analysed. Table 22 lists these options and shows the potential reduction as a percentage of Zimbabwe's total emissions.

Table 22. Options for reducing CO₂ emissions

CO ₂ reduction option	Reduction (%)
Energy-efficient boilers	23
Energy savings in the industrial sector	4
Energy-efficient motors and power factor correction	2
Increased hydropower	5
Energy-efficient furnaces	2
Central photovoltaic power	2
Coal for ammonia	1
Total CO₂ reductions	38

12.8.1 Energy efficiency

There are opportunities to increase energy efficiency on both the supply and demand side (see Box 10). Improving equipment for power generation, transmission and distribution can increase supply-side energy efficiency. Demand-side opportunities include improving the energy performance of cooking stoves, lamps, appliances, boilers, buildings and vehicles, and of processes particularly in the energy-intensive industries of cement, chemicals, fertilisers, iron, steel and paper.

Since Zimbabwe has committed to undertake a significant programme to rehabilitate both hydro and thermal power stations, there is an opportunity to improve their efficiency in generating and distributing electricity. Cleaner technologies can also be installed in thermal power stations. Reducing transmission losses is cost-effective and can lead to significant reductions in carbon emissions.

Box 10. Energy efficiency projects in Zimbabwe

Energy-efficient cooking stoves

The Department of Energy, along with some NGOs, has been promoting the fuel-efficient Chingwa wood stove since 1982. This has been successful, with 114,000 stoves installed. The Chingwa stove consumes less energy and emits less CO₂.

Energy-efficient lightbulbs

Since 2010, the Zimbabwe Electricity Supply Authority has been promoting energy-efficient bulbs in households. The Authority is planning to hand out compact fluorescent lamps in exchange for less efficient incandescent lamps, and is also implementing investigative projects to improve the market for these efficient technologies. A trial project is being implemented in Belvedere, Harare, and will be monitored independently. The findings of this monitoring will be used to assess the possibility of trading carbon-emission reductions on international markets.

12.8.2 Fuel substitution

There are opportunities to switch to less carbon-intensive fuels on the demand and supply sides. The demand-side fuel switching strategies include the use of ethanol in vehicles and electricity generation. For example, biofuel production at Triangle and Chisumbanje, for fuel blending and for generating electricity, is a climate change mitigation measure.

Examples of supply-side fuel switching include the development of bagasse/biomass/ cogeneration/bioenergy systems, and using micro hydropower, wind and off-grid solar photovoltaics, as well as other renewable energy (see Box 11).

Box 11. Fuel-switching projects in Zimbabwe

Chisumbanje and Triangle sugar mills produce ethanol for fuel blending and power generation. They have expressed an interest in generating power for the national grid but tariffs remain a challenge. An ideal sugar cogeneration plant would have a separate entity supplying steam for sugar processing and using the high-pressure steam for power generation. Such a system, with 80 steam boilers, could generate about 100 MW from existing sugar mills in the Chiredzi area.

Wind energy is used to pump water in rural areas, and solar photovoltaic systems have been installed in rural schools and health centres. These were introduced in areas where there was no electricity.

There are eight functional micro-hydropower stations for electricity generation in Zimbabwe, and ten potential schemes. The Zimbabwe Power Company is set to invest in small hydropower plant above 10MW in capacity, and the Rural Electrification Agency is set to implement plants including those below 10 MW in capacity. Recently they commissioned a 24 kW micro hydro plant at Chipendeke in Mutare District, to replace diesel for grain milling, and kerosene and candles for lighting.

12.9 Adaptation in the energy sector

Climate change adaptation efforts currently focus on rural livelihoods. Industry has not taken up the concept of adapting to climate change, possibly due to the emphasis on climate change mitigation. Electricity plans are, however, sensitive to the possibility of diminishing hydropower resources. The Power System Development Plan has acknowledged this sensitivity, especially in the mid-1990s, as the upgrading of the Kariba Dam, construction of the dam at Batoka Gorge, and the expansion of Hwange Coal Power Station took varying levels of priority. Water use efficiency should be a priority, and there is a need for greater coordination of the Zambezi hydropower systems, at least from Victoria Falls (Zambia) to Caborra Bassa.

12.10 Summary

Zimbabwe's energy sector has the potential to contribute significantly to reducing CO₂ emissions, given the dominance of fuel wood and thermal energy as well as the continued use of inefficient technology. The National Energy Policy and the Medium Term Plan 2011–2015 provide an effective policy and institutional framework for Zimbabwe's energy sector to provide low-carbon energy. Both documents emphasise developing renewable energy sources and promoting energy efficiency in domestic and industrial processes.

However, funding and technical capacity to support the transition into low-carbon energy generation and supply, and to implement energy-efficient options, is still lacking. There has been little investment in low-carbon energy sources and renewable sources from the private sector or public and donor agencies. Furthermore, the Ministry of Energy and Power Development has limited technical and research capacity to develop effective policy responses that focus on energy, climate change and socio-economic development.

Despite these challenges, there is an opportunity to embed climate compatible energy policy and programmes, given the significant development and rehabilitation of the energy sector that is part of the Government's ongoing strategy for economic recovery and growth.

There are several priorities regarding climate change and energy:

- Policy-makers need support to better understand and assess the effects of climate change on energy, as well as the effects of energy supply on climate change. This will enable them to develop and implement appropriate policies and programmes for climate change, energy and development.
- The development and implementation of energy-efficient measures for households and industries should focus on measures that hold the greatest potential to reduce CO₂ emissions.
- There should be more research into biofuels and renewable energy sources in rural areas, such as solar, wind, hydropower and biogas; and,
- Zimbabwe should introduce more efficient coal-fired industrial furnaces and more efficient, cleaner coal technology for energy production.

13. Urban infrastructure

More than 50% of Zimbabwe's 13 million people live in urban areas (AfDB, 2011). This fact alone means that the country's towns and cities will be at the forefront of efforts to adapt to climate change, as well as providing opportunities to mitigate its effects.

13.1 Overview of Zimbabwe's urban areas

Zimbabwe's urban population stands above 7 million, excluding at least another 100,000 people in mining towns and Growth Points. At 5–6%, the urbanisation rate in Zimbabwe is higher than population growth rate of 4.3% (Government of Zimbabwe, 2011). There are 32 urban settlements (see Table 23) with built-up areas. As Zimbabwe's urban centres increase in number and size, environmental transformation and climate implications also rise.

Table 23. Zimbabwe's Urban Centres

Town/city	Population	Town/city	Population
Beitbridge*	40 000	Kariba	34 000
Bindura	40 000	Karoi	37 000
Bulawayo	1 500 000	Kwekwe	120 000
Chegutu	120 000	Lupane	3 000
Chinhoyi	150 000	Marondera	80 000
Chipinge	30 000	Masvingo	110 000
Chiredzi	35 000	Mutare	300 000
Chirundu*	5 000	Mvurwi	9 000
Chitungwiza	1 000 000	Norton	80 000
Epworth*	80 000	Plumtree	30 000
Gokwe	10 000	Redcliff*	40 000
Gwanda*	80 000	Rusape	59 000
Gweru	300 000	Ruwa*	30 000
Harare	2 500 000	Shurugwi	25 000
Hwange	15 000	Victoria Falls*	45 000
Kadoma	120 000	Zvishavane	40 000
Total		7 107 000	

Sources: UNICEF; 2011; authors' estimates (*)

There is inadequate information on the effects of climate change on urban infrastructure in Zimbabwe. The fourth Zimbabwe United Nations Development Assistance Framework (2012–2015) aims to address this issue.

Urban development in Zimbabwe has proceeded in a way that makes urban areas prone to flooding and excessive moisture in areas with poor drainage (due to the nature of soils and inadequate physical infrastructure), as well as the effects of strong winds, cyclones and heat waves. The vulnerability of urban areas, and sites within them, depends on a number of factors, including topography, quality of available physical infrastructure, community and state institutions, and the level and distribution of economic development.

Transport networks expand with urbanisation, for both private and public vehicles. Public transport in urban Zimbabwe is currently based on kombis, 10–30 seat passenger vehicles mainly imported as second-hand units, mostly from Japan. These are generally fuel-inefficient, leading to high emissions. Zimbabwe's high rates of urbanisation and increasing urban poverty put a strain on municipal resources. This makes it difficult to expand and maintain urban infrastructure. These strains are seen in road infrastructure, water and sanitation, housing and the energy sector.

Studies on water and sanitation, commissioned by the World Bank and coordinated by the United Nations Children's Fund (UNICEF), cite low water coverage, unreliable services, mechanical and electrical malfunctioning of treatment plants, and distribution systems that have exceeded their operational life (World Bank, 2010; UNICEF and Vitens-Evides International, 2009). Though urban areas remain generally well planned and well governed (World Bank, 2002), the effects of economic strain are visible (AfDB, 2011).

In terms of climate change, there are four important dimensions.

- Zimbabwe's infrastructure is susceptible to the increasing frequency of extreme weather conditions like flooding.

- The ageing and congested industrial, residential and commercial infrastructure is energy inefficient, breaks down frequently, and generates waste which reduces urban environmental quality. For Harare, this has often been expressed in relation to the city having lost its 'sunshine status'. The decline in environmental quality has reduced the quality of life, evidenced by streams of sewage in some residential areas of Chitungwiza, Harare and Kadoma.
- Information on the extent and implications of urban adaptation is limited; knowledge on the required transformation of physical infrastructure, policies, laws and bylaws, organisational structures and overall urban governance is lacking.
- General climate change awareness is not supported by critical action to improve relevant policy and practice.

13.2 Urban infrastructure, development policy and climate change

Planning, developing and managing urban areas, including the specific infrastructure needs and services, are governed by a mosaic of sector-specific laws and policies. These are administered by an equally diverse set of national and sub-national organisations.

The principal pieces of legislation are the Regional, Town and Country Planning Act and the Urban Councils Act. The Regional, Town and Country Planning Act guides master and local planning, while the Urban Councils Act defines the setting up and functioning of local authorities. Subsidiary legislations (statutory instruments, council by-laws, policies and directives) generally come from these two pieces of legislation.

Other legislations include laws governing public health, the environment and public finance. Zimbabwe used to apply a system of rating urban areas based on population, industrial base and municipal financial performance (rates base), which constituted an Urban Development Policy. However, this system has collapsed and efforts at developing a comprehensive Urban Development Policy have not yet borne fruit. Master and local planning under the Regional, Town and Country Planning Act currently lag behind schedule, and some smaller councils lack the capacity to plan long term.

Deregulation of urban transport networks under the 1990s economic structural adjustment programme saw 10–16 seat commuter buses replace conventional Zimbabwe United Passenger Company vehicles. This led to a chaotic urban transport system. It put a strain on road infrastructure, public facilities (e.g. at bus stands) and exacerbated congestion, with implications for pollution and overall urban functionality. An integrated urban transport policy is needed as a starting point for designing and executing climate compatible transport infrastructure.

Organisations involved in urban planning include central government ministries, state-owned enterprises, local authorities, civil society organisations, professional bodies and private sector companies. Key organisations include the institutes for architects, planners and engineers. The government ministries responsible for local government, transport and communication, energy, water, environment and health are critical in terms of determining relevant policies and standards, and overseeing the activities of state and non-state agencies.

Environmental impact assessments conducted under the Environmental Management Act are the main instrument for ensuring adherence to urban planning principles. Urban legislation also seeks to protect the environment, for example by prohibiting construction work and cultivation on wetlands and riverbanks, allowing space for vegetation in built-up areas, and issuing fines to ensure compliance. There are, however, questions about the effectiveness of the bureaucratic structures and practice in the public sector. And private sector adherence to existing legislation and policy is questionable.

Climate change needs to be more comprehensively included in urban governance. This will guide the proposed development of an Urban Development Policy, or at least help to improve existing policies, legislation and institutional structures.

13.3 Climate change vulnerabilities and opportunities

Zimbabwe's urban areas and infrastructure are vulnerable to several climate-related hazards. The main ones are storms, localised flooding and water logging, drought-induced water scarcity, and urban warming.

Drainage infrastructure in some areas has collapsed due to age, and in others due to over-use. This suggests that past designs for floodwater are not suited to current rainwater levels. Increased groundwater extraction has also affected soil stability in some areas and dried out some wetlands, which affects road foundations, warps roads and creates potholes.

The serious lack of urban housing, estimated to be more 1.3 million units, has resulted in an increase in informal housing units, especially on hastily acquired farms where urban authorities were not involved in the planning processes. Harare and other urban areas have a number of such housing schemes (Marongwe et al, 2011). For some new schemes, tenure insecurity stalls proper servicing and housing development, as councils consider the areas outside their jurisdiction. The net result is poor access to human settlement services (water, sanitation, energy), which place a heavy dependence on environmental resources. The 2008 cholera outbreak, in which at least 4,300 Zimbabweans died, showed the effects of infrastructure collapse and its implications for urban residents. The outbreak also showed local authority weaknesses. City councils, particularly Harare, lacked the capacity to ensure access to safe and adequate water. Water and energy scarcity have worsened since 2008, with the water situation only partially resolved through UNICEF support. In other urban areas, that have sprawling layouts, such as Bulawayo, investment in water, sewerage, roads and other urban services is expensive, which further slows vital renovation and improvements.

13.4 Current initiatives

Since establishing the Coalition Government in 2009, Zimbabwe has conducted several studies to deepen understanding of institutional recovery. Urban local authorities have also been rehabilitating urban infrastructure, using national and donor funding.

In a joint venture with EasyPark of South Africa, Harare is launching an inner city parking improvement programme. This initiative, replicated by other cities to varying degrees, involves urban infrastructure investments and improvements that allow for climate change adaptation and mitigation. However, Harare is yet to introduce a park-and-ride system to reduce inner city congestion and its associated emissions.

To address chronic power shortages, there are plans to resuscitate urban thermal power stations in Harare and Bulawayo. These will, however, emit CO₂. Small-scale, household-level installations of solar lighting and water heating technology are also increasing.

The World Bank-coordinated Multi-Donor Trust Fund, the European Union, Swedish International Development Cooperation, the Commonwealth Local Government Forum, UNDP, UNICEF and the Government of Zimbabwe have all undertaken studies covering urban development and local government. However, no specific or coordinated action has followed, except for investment by agencies like UNICEF in urban boreholes, water treatment plant rehabilitation and water purification chemicals. And none of these studies or investments has been framed as being climate change adaptation, rather focused on 'recovering institutions'. Their major contribution has been towards policy review and strengthening institutional systems.

At central government level, the Zimbabwe United Nations Development Assistance Framework has identified priorities for support. Beyond this, there has been discussion between UN-Habitat and the Ministry of Local Government on an Urban Development Policy. The Ministry of Local Government facilitated stakeholder input into a draft National Housing Policy, which includes climate issues. The Ministry has a draft infrastructure policy and has consulted on regulations governing the importation of second-hand vehicles.

13.5 Research and technical assistance

It is important to fund research to analyse the links between urban infrastructure and climate change. Key areas of focus include institutional competences or preparedness, policy adequacy and performance management. Such analytical work will guide the development of relevant guidelines and policies.

Other priority research and policy areas include:

- A study to inform development and application of climate compatible guidelines on urban planning and land use designs, waste management, urban transport planning and management, energy efficiency and building designs

- Research on appropriate building materials, design guidelines and actual model designs for climate resilient infrastructure (roads, housing, schools and health facilities)
- An assessment of city-level climate change impacts, preparedness and capacity building, focusing on both local authorities and communities. Information dissemination and city-level dialogue on climate change is lacking at present, with planning and budgeting processes not taking relevant issues into account
- A study of the top six and bottom six urban areas (by population) will help inform the development of an appropriate framework; and,
- A study leading to the development of a sustainable urban infrastructure financing and implementation framework including the necessary incentive-penalty regime.

13.6 Summary

Zimbabwe's urban planning regime does not sufficiently address the climate challenges for planning, engineering, environmental health and the financial architecture for urban infrastructure in the coming decades. There is also concern about the quality and inclusiveness of local governance, as well as the extent of community participation and preparedness. Encouragingly, space exists to undertake research and analysis that can guide city-level climate change adaptation and mitigation.

14. Transport

Zimbabwe's transport sector consists of road, rail and air networks, and a small ferry service for passengers and freight on Lake Kariba. The sector mainly relies on fossil fuels. As the economy grows increases, transport activity will also increase due to trade. And with increasing incomes associated with economic growth, there is likely to be an increase in vehicle ownership. However, increased transport activity will result in congestion, air pollution and increased demand for petroleum. These will increase greenhouse gas emissions.

This section examines the links between transport and climate change in Zimbabwe. It presents an overview of the transport sector, the contributions of the transport sector to climate change, and the likely effects of climate change on the sector. It then analyses options for climate change mitigation and adaptation within the sector, and outlines priorities for research and technical assistance in Zimbabwe's transport sector.

14.1 Road network

The road network consists of 88,100 km of classified roads, of which 17,400 km are paved (see Figure 18). Approximately 5% of the road network is classified as 'primary roads', including some of the most heavily used arterials that link Zimbabwe with its neighbours and play a major role in the movement of the country's imports and exports (AfDB, 2011). Secondary roads constitute 14% of the network, and link the country's main economic centres and enable the internal movement of people and goods. About 71% is tertiary feeder and access roads that link rural areas to the secondary road network.

Zimbabwe's road density is about 0.23 km per km². This is high compared with many developing countries, comparable to high income, non-OECD countries and lower middle-income countries. Both primary and secondary roads, collectively referred to as the trunk road system, carry over 70% of vehicular traffic. This means that a significant number of the population have access to roads.

There has been a steady increase in vehicle ownership. The number of vehicles in 2009 was 828,395, including around 200,000 motor cycles (Central Vehicle Registry, 2010). The main reason is the relatively easy access to low-cost, second-hand vehicles.

Also, credit schemes supported by the Government and private companies have enabled people to buy vehicles from the national car manufacturing plant, Willowvale Mazda Motor Industries. Driving this trend has been an emergent middle class that prefers private transport. Vehicles per kilometer of road is high and is comparable to middle income countries (AfDB, 2011).

There has been similar growth in heavy freight trucks and passenger transport. The development of road freight has come mainly from private, family-led companies that took the opportunity to provide road freight because of the poor condition of the rail system, which used to carry a significant portion of the goods.

Figure 18. Zimbabwe's road network



Source: AfDB, 2011:5

14.2 Rail network

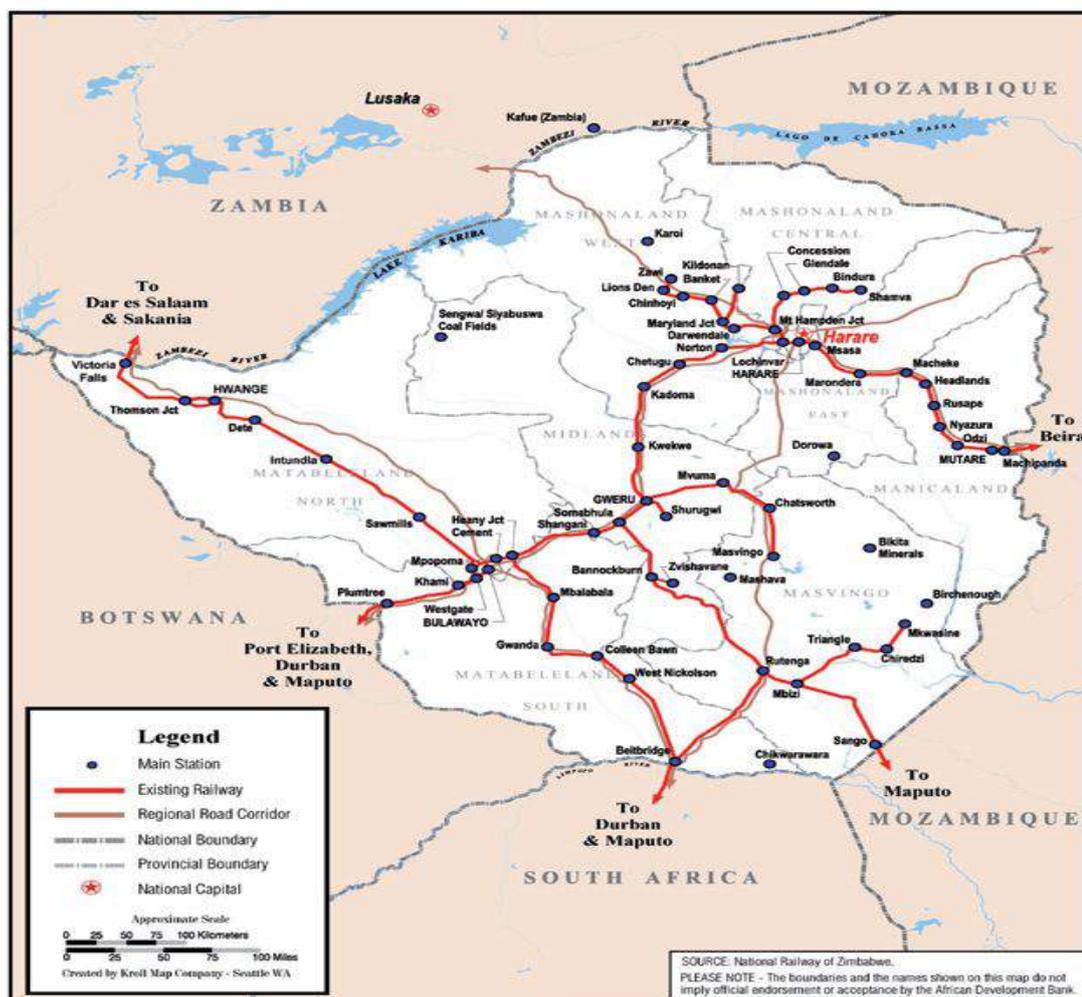
Rail is important for climate change mitigation, as it offers lower fuel costs and carbon intensity per tonne of freight compared to road transport. Zimbabwe's rail network covers a total track length of 4,313 km of rail. This connects all major mining, industrial and agricultural centres, as well as international rail routes to the Democratic Republic of the Congo, Zambia, Botswana, Mozambique (and its ports of Beira and Maputo), and South Africa (see Figure 19). Only 313 km of the rail is electrified, using a 25 kV overhead system. The total rail fleet is estimated to be 30 electric locomotives, 87 steam locomotives, and over 300 diesel locomotives (Mbohwa, 2001). In the past decades, steam locomotives were scrapped but a few are now being restored because of a diesel fuel shortage (ibid). A study in 2003 indicated that 44% of the fleet had reached the end of their life span.

The National Railways of Zimbabwe provides mainline passenger services between Bulawayo to Harare, Victoria Falls and Chiredzi, and between Harare to Mutare. Suburban commuter services in Harare and Bulawayo, both introduced in 2001, boosted passenger traffic to a peak of 17.4 million in 2007. However, the number of passengers declined to about 2 million in 2009, due to the unreliability of the services and stiff competition from buses and commuter buses, which are generally faster and more frequent, despite having higher fares and being overcrowded.

For the past 10 years, the rail network has deteriorated badly. Low investment in the rail network is encouraging the use of alternative transport. In 1990 rail freight was about 14.3 million tonnes, about 80% of capacity. By 2009 this had reduced to 2.7 million tonnes, or 15% of capacity.

Zimbabwe also has a private rail company, the Bulawayo Beitbridge Railway, which provides rail link between Bulawayo and Beitbridge at the border with South Africa. Prior to this opening, the rail service between Zimbabwe and South Africa went through Botswana, adding 200 km to the journey. The new railway line has shortened the journey to the South African from Bulawayo from six days to nine hours. This provides a much-improved rail service to South African ports from Bulawayo and other destinations along the line.

Figure 19. Zimbabwe's rail network



Source: AfDB, 2011

There are plans to extend the rail network by another 1340 km. The route considered most urgent is from Lions Den to Chirundu, with the possibility to extend to Kafue in Zambia (due to grain transfers on that route). Other projects include the Chitungwiza to Harare commuter rail (26 km), Nyazura to Mvuma (210 km), Mutare to Mkwesine (215 km), Kadoma to Sengwa (180 km), Kwe Kwe to Itundla (285 km) and Mashava and Bikita Minerals (165 km).

14.3 Air transport

Zimbabwe has a small aviation sector compared to its neighbours. The national airline, Air Zimbabwe, provides the bulk of the passenger and cargo service. Zimbabwe has three major international airports, at Harare, Bulawayo and Victoria Falls. There are also airports at Kariba, Hwange and Buffalo Range, which can receive medium-sized craft for tourist purposes. The Airforce of Zimbabwe operates a predominantly military fleet but provides search and rescue services in emergencies.

14.4 Pedestrian traffic

Pedestrian traffic is a major component of transport in Zimbabwe. Infrastructure for pedestrian traffic is very poor, however. Only a few roads have cycle paths and basic pedestrian management systems, such as traffic lights, zebra crossings and road guards, need major refurbishment. The Government removed duty and taxes on bicycles, keeping their cost low, but in the absence of the necessary infrastructure most commuters prefer motor vehicles.

14.5 Institutional arrangements

The institutional and policy framework governing the transport sector varies from one sub-sector to another, but broadly falls under the Ministry of Transport, Communication and Infrastructure Development.

The Department of Roads is responsible for the management of the primary, secondary and tertiary road network. It shares responsibility for operation and maintenance of secondary roads with the District Development Fund, and with the District Councils for feeder roads. The unpaved tertiary road network is managed jointly by the District Development Fund and by Rural District Councils under the Ministry of Local Government, Public Works and Urban Development. Urban councils and the Ministry of Local Government, Public Works and Urban Development are responsible for the management of urban roads. They receive some grant funding from central government to support infrastructure development but this is rarely sufficient.

The Zimbabwe National Road Administration is responsible for fixing road user charges and collecting charges, fuel levies and other revenue for the Road Fund. The Ministry of Finance is responsible for providing funds to the Ministry of Transport through budget allocations.

Despite the existence of an elaborate institutional framework, there is currently no overarching policy document for the road network. Nonetheless, three important draft documents guide policy in the road:

- The Road Sub-sector Policy Green Paper of March 1999
- The Draft National Transport Policy of September 2005; and,
- The Road Act of 2001.

The Green Paper is modelled around the 1996 SADC Protocol on Transport, Communications and Meteorology, and provides a framework for road management and financing. The Road Act, established by the Zimbabwe National Road Administration and the Road Fund, covers road authorities and their functions, and the planning, development, construction and maintenance of the road network. This includes the regulation of standards, classification of roads, safety and environmental considerations, control of entry upon roads, and the acquisition of land and materials for road works.

14.6 Climate change and the transport sector

The link between the transport sector and climate change is mainly through energy use and greenhouse gas emissions. The transport sector is responsible for about 12% of Zimbabwe's greenhouse gas emissions (Ministry of Mines, Environment and Tourism, 1998). These figures are expected to increase as the economy recovers and people's disposable income increase. It is widely acknowledged that economic growth increases the demand for transport, while the availability of transport stimulates even more development by facilitating trade and services (IPCC, 2007: 329). Further, with increasing incomes, most people will opt to buy private vehicles, which are both a status symbol and more convenient and faster than public transport. However, these increase the consumption of oil-based fuels, mainly petrol and diesel.

Current estimates suggest that Zimbabwe needs over 1 billion litres of diesel and over 730 million litres of petrol per year for transport. This equates to 744,000 tonnes CO₂ from diesel consumption and 543,120 tonnes from gasoline combustion per year. In addition, vehicles release nitrous oxide, methane and other organic pollutants, determined by

average speed and vehicle technology. High engine temperatures, caused by low speeds, emit more nitrous oxide, and incomplete combustion from too low or too high speeds emits methane. Fuel leakages also emit greenhouse gases in the form of non-volatile organic pollutants. The current and projected growth in the transport sector will increase greenhouse gas emissions in Zimbabwe.

14.7 Medium term plan and the transport sector

The Medium Term Plan 2011–2015 lists projects to improve the road transport network. The focus is on improved service provision through:

- rehabilitation and maintenance of all roads
- upgrade of the trunk network
- rehabilitation of bridges
- promotion of road safety
- network expansion into rural areas
- promotion of fleet renewal and refurbishment
- development of export/import corridors; and,
- construction of tollgates and improved revenue management.

Surprisingly, there is no mention of improving vehicle efficiency. The Medium Term Plan also lists projects to improve the rail system. These focus on rehabilitating and refurbishing the network, as well as increasing the availability of locomotives. Public–private partnerships are mentioned as a way of financing rehabilitation and infrastructure expansion. There is no mention of a commuter service to complement road transport.

Air transport is mentioned only in terms of improvements to ground and navigation facilities; aircraft are not mentioned. This indicates a conservative approach for the medium term, which focuses on returning the available facilities to acceptable service.

In general, the transport fleet is not likely to see vehicle improvement or a reduction in average age. The sector will continue to follow the natural growth that has seen investors importing second-hand vehicles and longer vehicle retention periods. Emissions of carbon per kilometre of travel will therefore continue to grow relative to international trends.

14.8 Vulnerability to climate change

The fixed nature of transport infrastructure makes it vulnerable to floods, storms and extremely high temperatures. Bridge foundations are eroded by increased run-off, which affects the stability of bridges. Floods often wash roads and small bridges away; Cyclone Eline damaged bridges and road infrastructure, some of which remain unrepaired nine years after the event.

Tarred roads are also susceptible to extreme temperatures, as high temperatures can lead to tar melting or softening. It is common during the hottest months in Zimbabwe to see paved road surfaces that have been damaged from softened tar; corrugations and ridges in roads require frequent maintenance to prevent accidents or subsequent storm damage as water soaks the road bed as the surface becomes permeable.

Concrete surface tend to withstand temperature effects better than bituminous ones. However, the production of cement is a major source of greenhouse gases. Cement is made by reducing limestone to lime which yields CO₂ as a bi-product. There is an argument that cement reabsorbs CO₂ with time, but the technical estimates of this are not yet in the UNFCCC methodology.

14.9 Mitigation in the transport sector

The transport sector can contribute to climate change mitigation through the following:

- Use alternative fuels, such as biofuels, for transport. Given increased ethanol production in Zimbabwe, there is an opportunity to promote the use of petrol blended with ethanol to reduce greenhouse gas emissions, or to use ethanol in its 'pure' form to reduce dependence on oil-based fuels
- Improve current vehicle technologies, by importing fuel-efficient models or installing fuel-efficient transmission technologies in local car assembly plants. Zimbabwe has a lot of old vehicles, which consume more fuel and emit more greenhouse gases than newer models
- Reduce the loads on freight vehicles, thereby reducing the energy required to operate it
- Develop an efficient public transport system to counter the increase in private vehicles, such as rail services for inter-city and suburban travel

- Promote cycling and revive and expand cycle routes in major urban areas. Cycling has experienced a boost in the past decade, in response to fuel shortages and high commuter fares
- Improve driving practices, for example ensuring proper tyre pressure, reducing maximum speeds, and shutting cars off when idle. These eco-driving practices can be integrated into the Highway Code and form a core aspect of driving lessons in Zimbabwe. The Traffic Safety Board of Zimbabwe should also promote them
- Improve land use and transport planning so that it is easier to travel between employment and residential districts; and,
- Introduce transport pricing, such as fuel pricing and taxation, vehicle license/registration fees, tolls and road charges and parking charges; these can all influence travel and fuel demand.

14.10 Adaptation in the transport sector

Adaptation in the transport sector focuses on constructing transport infrastructure that can withstand the adverse effects of climate change. This should focus on the following:

- Physical changes, for example ensuring that surface materials used for tarred roads can withstand high temperatures. In addition, the construction of drains along roads, and bridges at appropriate heights, can reduce the risk of flooding and flood damage.
- Procedural changes, including checking drains in vulnerable areas when heavy rain is forecast. This can be enhanced by mandatory drainage inspection before the rainy season commences.
- Organisational changes, such as changes in policy, standards, contracts, decision-making and investment. Sharing weather forecasts and information between the Department of Meteorology and the Department of Roads can inform preparation when floods are predicted. The transport sector plays an important role in disaster preparedness and response. Road, rail and air transport are used for emergency response as well as relief. For example, during the 1992/93 drought Zimbabwe imported over 2.4 million tonnes of food. This relied on the coordinated use of road and rail transport to move these large volumes in a short time. Rail transport is used for bulk movement of goods for relief purposes.

- Air transport, mainly helicopters, is available for emergencies and rescue missions, especially during floods. For instance, during the floods caused by Cyclone Eline in 2000, helicopters were used to assess the damage caused and, more importantly, in rescue missions. Six helicopters rescued about 8,000 people within a week

14.11 Research and technical assistance

The following are priorities for research and technical assistance within the transport sector:

- A detailed study that provides an updated analysis of the transport sector, its contribution to greenhouse gas emissions, the likely effects of climate change on the sector, and opportunities for climate change mitigation and adaptation.
- Promoting the use of alternative fuels such as biofuels for transport.
- Promoting the installation of fuel-efficient transmission technologies.
- Institutional collaboration for integrated planning and information sharing.

14.12 Summary

The transport sector is a major user of energy and a major source of greenhouse gases. Zimbabwe, as an importer of vehicles, has limited influence on technology, but has the opportunity to influence the vehicle mix and average age of its fleet. However, vehicles that are manufactured locally should be equipped with the necessary technologies for fuel efficiency and the consumption of blended fuel. Given that transport is a service sector, it is paramount that planning is integrated with planning for the productive sectors. Historically the transport sector in Zimbabwe has planned jointly with the mining sector as well as industry to optimise service provision during peak demand periods.

The major challenges of poor access to capital, limited access to technology, poor administrative structures including regulation, and lack of suitable financing options, could be overcome by integrated planning. In the past, the rail network has benefited from finance from mining companies, especially for rail wagons. Industry was also involved in logistical planning, especially during the peak demand events of 1992. The view that private sector involvement will bring more capital needs to be sensitive to the cost of such capital in the absence of other economic measures.

Where passenger and freight volumes are low, financiers tend to demand shorter payback periods and higher interest rates. The transport network imposes a heavy maintenance burden on the national budget, especially after extreme weather events. Optimised planning and expansion of the transport system is therefore essential to minimise costs. In the past, a split responsibility between local authorities and central government has seen service levels interrupted through inconsistent maintenance of major roads. It is essential that responsibility for road maintenance is allocated according to national benefits. This will require studies on the economic value of roads, which at present has not been done in sufficient detail.

Part E – Legal Framework

15. Legislative framework governing climate change in Zimbabwe

15.1 Introduction

Analysis of the links between climate change and the various sectors of the economy, and the opportunities for adaptation and mitigations for each sector, is important. But such an analysis is incomplete if it does not pay adequate attention to the legislative framework that provides a legal basis for mainstreaming suggested policy options in national development framework and programmes.

This section considers the key legislation governing various sectors in Zimbabwe, such as agriculture, biodiversity, energy, forestry, mining and transport, and assesses their relevance to climate change. The analysis in this section assesses of relevant provisions in law and highlights the strengths, and weaknesses. Further, this section examines how the various legal provisions can be integrated to form overarching and coordinated climate legislation. While the majority of laws do not specifically mention the term 'climate change', there are many instances in which issues relating to climate change can be inferred. Provisions for climate change-related legislation are scattered in various pre-existing legal provisions.

15.2 Environmental Management Act

The Environmental Management Act provides the overarching framework for environmental management in Zimbabwe, with implications for other sectors. The main objectives are:

- to provide for the sustainable management of natural resources and protection of the environment
- the prevention of pollution and environmental degradation; and,
- the preparation of a National Environmental Plan and other plans for the management and protection of the environment.

Addressing climate change through mitigation and adaptation is one of the ways the Environmental Management Act promotes sustainable development.

To this end, the Act can be extended to cover legislative issues related to climate change, if the term 'environment' is defined in its broadest sense.

Specifically, the Act recognises the links between pollution and environmental degradation. Air pollution contributes to the emissions of greenhouse gases, thus it is an important factor in climate change debates. Section 4 (1) (a) makes provisions for a right to a clean environment that is not harmful to health. Furthermore, Section 4 (2) (g) prescribes that any person who causes pollution, in this case air pollution, shall meet the cost of addressing such pollution or environmental degradation as well as the cost of preventing, controlling or minimising further environmental damage. These penalties are a deterrent to those who cause pollution and environmental degradation that contributes to climate change.

Section 55 makes provisions for the establishment of the Standards Enforcement Committee, including air quality. The functions of the Standards Enforcement Quality, in terms of Section 63 of the Act, include recommending the following to the Environmental Management Board: ambient air quality standards; emission standards for various sources; criteria and guidelines for air pollution control, for both mobile and stationary sources. By addressing air pollution, the Act includes climate change-related issues.

The objective of the Environmental Management (Atmospheric Pollution Control) Regulations, Statutory Instrument 72 of 2009 is to prevent air pollution. These forbid the following activities: burning waste at a landfill, burning vehicle tyres, burning bitumen, burning metallic wire coated with any material, burning oil in the open air, the operation of an incinerator, and any operation that causes the emission of pollutants into the air. These Regulations compliment Section 63 of the Environmental Management Act.

Section 4 (2) (h) of the Environmental Management Act calls for the implementation of global and international responsibilities relating to the environment. These relate to conventions and declarations to which Zimbabwe is a signatory. Some conventions and protocols are linked to climate change.

Sections 97–108 of the Environmental Management Act require project proponents of scheduled projects to undertake EIAs before they start.

The projects for which EIA reports and certificates are mandatory are provided for in the First Schedule of the Environmental Management Act. In the energy sector, projects requiring an EIA include: petroleum production; storage and distribution, in particular oil; gas exploration and development projects; pipelines; oil and gas separation; processing; handling and storage facilities; oil refineries. An EIA is also required for projects such as thermal power stations, hydropower stations and high voltage power transmission lines. The above projects have great implications for climate change, as most of them are based on exploitation of fossil fuels whose footprint on climate change is huge.

Lack of environmental education and awareness are some of the major contributory factors to climate change. For this mindset to change there is need for environmental education and awareness-raising. Section 4 (2) (d) of the Environmental Management Act calls for the promotion of environmental education, environmental awareness and the sharing of knowledge and experience with a view to increasing the capacities of communities to address environmental issues. Environmental issues can be interpreted broadly to include climate change.

Analysis shows that there are legal provisions embedded within the Environmental Management Act that constitute the essential elements for governing climate change, particularly on issues pertaining to greenhouse gas emissions, climate change education and awareness, and the effective adoption of global climate change commitments into national legal frameworks. But although the Environmental Management Act is an important piece of legislation, it is broad and does not provide sector-specific legal guidance. Consequently, a sector-specific analysis of legislative provisions is important to provide clear legal guidance on issues related to climate change.

15.3 Agriculture and biodiversity legislation and climate change

There are several laws and policies in the agriculture sector with implications for climate change. These include the Land Acquisition Act, National Biotechnology Authority Act, Plant Breeders Act, Research Act, and the Environmental Management (Access to Genetic Resources and Indigenous Genetic Resource-Based Knowledge) Regulations.

15.3.1 Land Acquisition Act, Chapter 20:10

The Land Acquisition Act empowers the Government to compulsorily acquire land. It also sets the procedures for compulsory acquisition of land, especially acquisition of agricultural land for resettlement purposes. The implication of the Act for climate change issues cannot be overemphasised. It supports the constitutional provisions under which land can be acquired for forestry, environmental and agricultural purposes. Given this position, it is possible that land can be acquired for purposes of resettling rural communities displaced by floods or droughts, or for other purposes. However, it remains to be seen whether the Government has mainly been resettling people to address historical imbalances in land ownership, rather in response to climate-related disasters.

15.3.2 Agricultural and Rural Development Authority Act, Chapter 18:01

The Agricultural and Rural Development Authority Act established the Agricultural and Rural Development Authority. Some of the functions of the Agricultural and Rural Development Authority, outlined in Section 18 of the Act, have implications for climate change. These include the duty to plan, coordinate, implement and promote agricultural development in Zimbabwe. Further, the Agricultural and Rural Development Authority has a duty to plan and carry out schemes for the development, settlement and use of state land. In terms of the First Schedule, which supports Section 21 (1) of the Act, the Agricultural and Rural Development Authority has the power to construct, establish, acquire, maintain and operate dams, reservoirs and irrigation schemes. This will be done with the approval of the Minister of Agriculture. In addition, the Agricultural and Rural Development Authority has powers to operate or establish irrigation schemes and farming (including ranching, forestry, and the settlement of farmers on land), research into agriculture, and to supply technical expertise and other advice and information to farmers.

The above functions place the Agricultural and Rural Development Authority at the core of ensuring that the agricultural sector adapts to the effects of climate change. Some of the functions, for example promoting land irrigation, resettling farmers and operating dams, are important adaptation measures.

However, the major problem with the Act is that while it provides wide powers to the Agricultural and Rural Development Authority, the Authority is not well resourced to effectively carry out its mandate. Given the increasing adverse impacts of climate change on the agricultural sector, it is not clear whether the Authority will be able to respond effectively to these challenges. Also, the Act does not contain explicit language on climate change, but contains a general framework within which measures to promote climate change adaptation can be adopted in the agricultural sector.

15.3.3 Agricultural Research Act, Chapter 18:05

The Agricultural Research Act established the Agricultural Research Council. Some functions of the Agricultural Research Council have implications for climate change, including the promotion of agricultural research. While the Act does not explicitly mention research on the impacts of climate change on the agricultural sector, it gives the Agricultural Research Council the duty to carry out and promote agricultural research. Agricultural research regarding the impacts and opportunities arising from climate change is key to Zimbabwe and should be fully pursued by the Agricultural Research Council.

15.3.4 Research Act, Chapter 10:22

The Research Act established the Research Council of Zimbabwe, which has power, under the terms of Section 16 of the Act, to promote, direct, supervise and coordinate Zimbabwe's research interests. Research interests may be pursued in various sectors. However, Section 16 (1) (c) states that the Research Council has a duty to ensure that people, animals, plants and the environment are generally protected from the effects of potentially harmful research undertakings. Accordingly, the Act provides for the establishment of Safety Boards on potentially harmful research, for purposes of monitoring and supervising potentially harmful research or undertakings.

While the Research Act does not specifically mention climate change research, it has implications on research that may be undertaken on climate change adaptation or mitigation in Zimbabwe. Such research will be covered by the Act and should be undertaken under the monitoring and supervision of the relevant Safety Board.

15.3.5 National Biotechnology Authority Act, Chapter 14:31

The National Biotechnology Authority Act was passed in 2006. It established the National Biotechnology Authority, whose function is to support and manage biotechnology research, development and application. The Act defines biotechnology in Section 2 as any technique that uses living organisms or parts of organisms to make, modify or improve plants or animals. It also provides for the importation, exportation, use and release on the market of any biotechnology product that is likely to have an adverse effect on human health, the environment, the economy or national security.

Functions of the National Biotechnology Authority include the development of a policy for safety in biotechnology, the review of proposals concerning high-risk organisms and controlled experimental trials, and making decisions on whether to approve or prohibit them. In Section 22 (2) (a), the Act provides for the development of guidelines and standards on the contents of risk assessments and EIAs, as well as the requirements for the importation or exportation of biotechnology products that are likely to have an adverse effect on human health, the environment or the economy.

The Act has implications for climate change debates in the agricultural and environmental sectors. For the environmental sector, it incorporates environmental principles such as EIAs and risk assessments for biotechnology products, which may cover the potential impacts relating to climate change.

Furthermore, many scientists in the agricultural sector have been trying to develop new crop and seed varieties, especially genetically modified organisms (GMOs) or seeds that are resistant to droughts, plant diseases and pests. GMOs have been touted as the panacea to the droughts caused by climate change. But due to the uncertainties around the potential impact of GMOs on the environment, health and safety, the Biotechnology Act states that the Biotechnology Board may prohibit any activity involving GMOs. This provision does not prohibit GMOs, but leaves it upon the Board to make a decision whether to prohibit or allow GMOs or their products.

15.3.6 Access to Genetic Resources and Indigenous Genetic Resource-Based Knowledge Regulations of 2009

The Access to Genetic Resources and Indigenous Genetic Resource-Based Knowledge Regulations were passed by the Minister of Environment and Natural Resources in 2009, under the terms of the Environmental Management Act (Chapter 20:27). The purpose of the Regulations is to protect the rights of communities and local authorities to their genetic material and indigenous genetic resource-based knowledge. In addition, the Regulations were meant to promote indigenous genetic resource-based knowledge by conserving and strengthening communal systems of informal knowledge, collective innovation and transmission, as these do not conform to notions of private ownership, intellectual property rights or individual privilege over knowledge or innovations. The Regulations state that genetic resources and indigenous genetic resource-based knowledge may be accessed based upon explicit prior informed consent, if the community shares the benefits equitably. These Regulations have many implications for climate change, especially regarding communal farming. The genetic resources and knowledge referred to include plants and crops that have been grown by communities since time immemorial, and which have, in many cases, been freely saved and exchanged among people from season to season. The knowledge referred to is the knowledge held by communities on how to plant particular crops, and cropping times.

Some crops or seed varieties that are threatened by climate change, and climate change is negatively affecting cropping systems. To protect genetic resources, Section 5 (2) (h) provides for the establishment of a Genetic Resources and Indigenous Genetic Resource-based Knowledge Protection Committee, whose functions include monitoring the causes of the loss or scarcity of genetic resources. This is an opportunity to better understand how climate change is causing the loss of genetic resources in communal lands around Zimbabwe.

Another important aspect of the debate on climate change is that communities should continue adapting to climatic changes as they have been doing for years, albeit in ways that are appropriate to the scale of the threat climate change poses. Accordingly, the Regulations gives communities the right to continue saving and exchanging genetic resources from year to year, rather than relying on GMOs or seeds protected by intellectual property rights.

The communities can innovate by themselves to cope with changing weather and soil conditions. However, while the Regulations are new they do not specifically mention climate change as a major threat to genetic resources and the loss of knowledge. They only state the need for the Committee to monitor the causes of loss of genetic resources. Further, the implementation of the Regulations may be problematic, as they may conflict with other laws that give the State power over communal lands and forests. Further, the Regulations have not yet been implemented for long enough to merit a thorough assessment of their effectiveness.

The Environmental Management Act provides for the conservation of biological diversity in Section 116. It empowers the Minister of Environment and Natural Resources Management to take necessary measures for the conservation of biological diversity in Zimbabwe. Measures critical for agriculture and climate change adaptation include: measures to protect the indigenous property rights of local communities in respect of biological diversity; measures that control or restrict the use, handling, movement, packaging, and import and export of GMOs; measures that prohibit the importation or introduction into the wild of exotic animal and plant species; and measures regarding the establishment and management of germplasm banks, botanical gardens, zoos and animal sanctuaries. These measures may protect plant and animal species threatened by climate change.

15.3.7 Other agriculture-related laws

Many other laws in the agriculture sector have implications on climate change. Four key pieces of legislation include the Plant Breeders Rights Act (Chapter 18:16), the Plant Pests and Diseases Act (Chapter 19:08), the Seed Act (Chapter 19:13), and the Fertilizer, Farm Feeds and Remedies Act (Chapter 18:12).

The Plant Breeders Rights Act provides for the registration of the rights of plant breeders with respect to certain plant varieties. A breeder is defined in Section 2 of the Act as the person who directed, developed or discovered the new plant variety. Plant breeders' rights are granted for new varieties of plants that have not been offered for sale before, and are distinct from any other variety. The variety should be uniform in its relevant characteristics and stable. The Act seeks to protect the rights of the person who is registered as the holder of such rights.

The Act seeks to reward people who develop new varieties of crops or plants by granting them intellectual property rights over the plant for a specific period of time, to encourage them to develop new varieties. This creates an opportunity for plant breeders to develop new crop varieties that may resist pests and droughts that are caused by climate change – an important way in which the agricultural sector can adapt to climate change.

However, in many cases plant breeders are private companies and not communal farmers. Instead, the rights of communal farmers will be protected through new regulations, such as Environmental Management (Access to Genetic Resources and Indigenous Genetic Resource-Based Knowledge) Regulations of 2009.

The Plant Pests and Diseases Act provides scope for the eradication and prevention of the spread of plant pests and diseases in Zimbabwe. Section 4 gives power to the Minister of Agriculture to make regulations, issue an order or notice for the eradication of pests, or for the prevention or control of plant attacks by pests or diseases. The Minister of Agriculture can also order the disinfection, treatment and destruction of pests or host plants.

The Act also imposes a duty on the owner of the land on which pests or plant diseases are found to take reasonable measures to eradicate, reduce or prevent the spread of the pests. The Act may become vital in the climate change debate, in the event of crop or plant diseases and pests resulting from changing weather patterns. The Minister of Agriculture is expected to make an order or regulations to deal with new emergencies (pests and diseases), while the landowner is required to take appropriate measures.

The Seed Act (Chapter 19:13) provides for the registration of seed and regulates the importation, exportation and sale of seed in Zimbabwe. People selling seeds must be registered, and it is an offence to make a false or misleading statement or advert about the seeds being offered for sale. The Seed Act provides scope for the elimination of both unregistered seeds and the importation of seeds unsuitable for farmers in Zimbabwe, for example those sold under the pretext that they are drought or pest resistant. In many cases, farmers living in low rainfall areas have been duped by seed sellers who claim that the seeds are resistant to pests and drought.

The Fertilizer, Farm Feeds and Remedies Act (Chapter 18:12) provides for the registration and restrictions on the sale of fertilisers and farm feeds. The application of fertilisers to increase crop yields in light of low rainfall is a key element of the agriculture sector. The Act tries to protect farmers from buying fake fertilisers, farm feeds or remedies. It also makes it an offence for any person to make misrepresentations and false adverts on farm feeds, fertilisers and remedies.

15.4 Forestry legislation and climate change

The Forest Act (Chapter 19:05) and the Communal Lands Forest Produce Act (Chapter 19:05) are the two principal legal instruments governing forest management in Zimbabwe. The objectives of the Forest Act include the protection of private forests and trees, the conservation of timber resources, compulsory afforestation, and regulation and control of the burning of vegetation. The Communal Land Forest Produce Act includes among its objectives regulation of the exploitation of forests and regulation and encouragement for the establishment of plantations within communal land. The legal provisions in two Acts have important implications for climate change.

Under Section 14 (2) of the Communal Lands Forest Produce Act, the Forestry Commission has the power to establish and control plantations and forest nurseries. With local authority approval, inhabitants, associations or a group of inhabitants can establish and control forest nurseries. These plantations and trees planted from nurseries act as carbon sinks, reducing the amount of greenhouse gases in the atmosphere that causes climate change. The Minister of Environment and Natural Resources Management may also declare a forest a protected area.

The Forest Act reinforces the role and importance of forests in climate change management. A landowner or land occupier is required to give notice of intention to dispose of indigenous timber, and the Minister may give orders to restrict the cutting or removal of indigenous timber under Sections 55 and 56. While these orders are restricted to indigenous timber, they prevent wanton deforestation – a contributor to climate change. The control of fires and burning of vegetation also has links to climate change, as these can result in forest fires that destroy forests and cause air pollution.

The Forest Act was put in place during the colonial era (1888–1965) and remains fundamentally unchanged from its original provisions. Its formulation was mainly influenced by the Commonwealth Forest Association Conferences debates, which endorsed strict conservation of forests based on law enforcement (Brown, 2003). This resulted in the commonwealth countries demarcating large tracks of land as protected forests.

The Forestry Act achieves many things:

- It established the Forest Commission for the administration, control and management of state forests in Zimbabwe
- It provides for the setting aside of state forests and the protection of private forests, trees and forest produce
- It established the Mining and Timber Permit Board to control the timber cutting for mining purposes
- It provides for the conservation of timber resources and compulsory afforestation of private land
- It regulates and controls trade of forest produce; and,
- It regulates and controls the burning of vegetation.

The Forestry Commission's duties include the consideration of all matters arising from or relating to forest policy in Zimbabwe, and submitting reports and recommendations to the Minister of Environment. In addition, the Commission is tasked with: the control, management and exploitation of state forests, plantations and forest nurseries; the establishment, maintenance and improvement of forest plantations and nurseries; surveying forest resources in Zimbabwe; conducting research into forests and forest products; investigating matters related to the use and occupation of forests, and advising the President on whether the occupation is legal or not; authorising the sale and purchase of timber products; managing protected forests.

The Forestry Act forbids the cutting of timber from state lands, as well as indigenous trees from privately owned land, without a permit from the Mining Timber Board. The Act therefore has huge provisions for conserving timber (Nickerson, 1994). Private landowners may also be instructed by the Minister to put in place certain conservation measures.

The Forest Act still reflects the thinking and debate of the colonial era, despite the current developments on conservation and forest management. This may be attributed to exclusionary conservation policies, which increasingly result in local hostilities and conflicts as indigenous peoples living around protected areas continue to illegally extract and make use of resources (Pimbert and Pretty, 1995; Hasler, 1996; Gibson, 1999; Duffy, 2000; Prabhu, 2003; Dzingirai and Breen, 2005). In many cases, indigenous groups have destroyed infrastructure put in place to protect natural resources (Murombedzi, 1994). In trying to protect natural resources, some governments have developed measures to track and shoot poachers in forests. Even with such measures in place, many protected areas continue to be degraded, leaving conscientious ecologists and practitioners certain that some other way of doing conservation was needed (Dzingirai and Breen, 2005).

Thus, there has been increased pressure for developing countries to implement decentralised and community-based natural resource management approaches (Borinni-Feyerabend, 1996; Leach, 2002; Wilshusen et al, 2002; Dzingirai and Breen, 2005). Such projects have taken various forms, and a diversity of names have emerged, including joint forest management, co-management, collaborative management, and shared forest management. This shift has been widely promoted by proponents of participation, as the new approaches incorporate the views of local communities whose livelihoods depend on the resources. It is now being argued that the participation of local communities in management and benefit sharing is the most effective incentive and method for sustainable forest management. This shift towards participation by local communities was incorporated into the World Conservation Strategy in 1980. For Zimbabwe, this aimed to integrate rural development goals with conservation objectives and ensure the participation of local people (IUCN, 1980).

In its current state, the Forestry Act does not reflect the environmental rights and guiding principles enshrined in Zimbabwe's environmental policy and strategies. Furthermore, it does not consider the current debates on environmental issues or those relating to climate change. Although the Act does not recognise the participation of local communities in the management of state forests, some pilot resource-sharing projects have been implemented in Mafungautsi State Forests to generate lessons to influence policy.

Further research was conducted jointly by the Center for International Forestry Research and the Forest Commission, under the Adaptive Collaborative Management Project (Mutimukuru-Maravanyika et al, 2008; Mutimukuru-Maravanyika and Almekinders, 2010; Mutimukuru-Maravanyika 2010). But despite the lessons learned during this project, the Forestry Act remains the same.

The Forestry Commission is currently engaged in the National Forest Programme, funded by the FAO, to develop a new forest policy. The National Forest Programme is currently undertaking a review process to ensure that there are synergies between new forestry policies and practice on the ground. The Programme will also help Zimbabwe's forestry sector to integrate sustainable forest management into poverty reduction strategies, and build consensus on how to address forestry issues at the national level. This process provides a unique and timely opportunity for climate change issues to be addressed in forestry policy.

15.5 Water legislation and climate change

The main pieces of legislation in Zimbabwe's water sector that have implications for climate change include the Water Act (Chapter 20:24), the Zimbabwe National Water Authority Act, the Environmental Management Act (Chapter 20:27), and regulations made under the terms of the Water Act and the Environmental Management Act.

The Water Act regulates the development and use of Zimbabwe's water resources. It establishes the institutional framework for water resources management, including ZINWA, Catchment Councils and Sub-catchment Councils. The Act also recognises various uses of water, such as primary (domestic) use, agricultural, industrial, electrical and recreational use.

The Water Act has various provisions with implications on climate change. Under Section 6 (2) (g), the Minister of Water Resources has a duty to ensure that research is carried out, and information obtained and kept, on hydrological and hydro-geological matters, such as the quality and quantity of the country's water resources. In the same vein, land may be acquired by the Minister of Water Resources to construct hydrological stations for measuring and monitoring rainfall.

Additionally, the officers of ZINWA have the power to obtain and record information and statistics relating to the hydrological conditions of Zimbabwe's surface water and groundwater. These measurements are important for understanding the impacts of climate change on water availability and planning.

A key feature of the Water Act is the permit system for water use, which is critical during droughts. For example, while a permit is not required for primary use of water under the terms of Section 33 (1) (a), a Catchment Council may limit the quantity of water abstracted for primary purposes to ensure equitable distribution and use of water.

The Act also states that whenever the volume of water in any river system is insufficient to satisfy demand, the Catchment Council may revise, reallocate or reapportion permits and put in place conditions that ensure equitable distribution and use of the available water. This provision is critical during periods of drought. The power vested in the Catchment Councils is important as a policy decision and as an adaptation strategy, as it ensures that all people cope and manage to access water during periods of shortage.

Further, there are several other climate change-related adaptation measures implicit in the Water Act, which may be invoked to enable people to cope with droughts, floods and other emergencies caused by climate change. For example, Section 57 of the Act gives the Minister of Water Resources the power to issue a notice to reserve any specified quantity of water for future use, as well as the power to declare any area as a water restriction area, if water use is approaching the potential limit of the catchment.

Section 61 (1) of the Act states that if the flow of water in any public stream or water storage works has ceased, or the levels have fallen or are likely to fall, the Minister may declare the area to be a water shortage area, on the recommendation of ZINWA and in consultation with the relevant Catchment Council. If an area has been declared a water shortage area, the Catchment Council may: suspend or amend any water use permits; make orders on abstraction, appropriation, control or use of the water; and determine the priority for water use in the area.

The Catchment Council may also restrict the sinking of boreholes or wells or fix the maximum volume of water which may be abstracted from any public stream, water storage work, borehole or well in a water shortage area, under the terms of Sections 63 and 64. These provisions provide a legal framework for coping with water shortages during drought periods.

Sections 99–102 of the Water Act make provisions for the safety of dams. They prescribe some of the safety requirements for the construction of both small and large dams, in terms of design, plans and specifications. The Act prescribes that the adequacy and safety of every dam has to be certified by an approved civil engineer and dams must be periodically inspected. The law recognises the need to ensure that dams are strong enough to withstand floods. Dam safety measures and procedures are critical in the event of floods, and may reduce the destruction of property, homes and livestock of communities living downstream. This is a climate change adaptation measure.

Section 109 (1) of the Water Act specifically relates to floods. Sub-section (1) states that if the owner of a dam learns of a flood that may affect the dam, s/he shall take all reasonable and practical steps to deal with the flood. In addition, the owner of the dam is required to notify the Secretary in the Ministry of Water Resources and ZINWA of the flood. The law makes it an offence to not take reasonable or practical steps or to notify the Ministry. Although The Water Act it does not explicitly link the floods to climate change, these provisions may be sufficient for dam owners to respond to climate change related floods.

The Zimbabwe National Water Authority Act established ZINWA, which is mandated to carry out several functions that have implications for climate change adaptation in Zimbabwe. One of the Authority's critical functions is to advise the Ministry of Water Resources on the formulation of policies and standards on: water resources planning, management and development; hydrology; dam safety; and the protection and conservation of water resources. These functions encompass climate change adaptation issues, such as the monitoring of rainfall, the safety of dams against floods, and the need to conserve water when there are shortages.

In addition, ZINWA is mandated to: undertake research studies; develop a database on hydrological issues and publish the findings; and produce maps, plans and other information necessary for development and exploitation of water resources. These activities will help to understand how climate change affects water resources management. More importantly, ZINWA has the responsibility of advising the Ministry of Water Resources on the exploitation, conservation and management of water resources of Zimbabwe, with the objective of taking appropriate measures to minimize the impact of drought, floods or other hazards. This function places the Authority at the centre of ensuring that people are not greatly affected by droughts and floods. Given this legal position, it is incumbent upon the Authority to ensure that the Ministry of Water Resources is appropriately advised to adopt measures to adapt and cope with climate change.

ZINWA can promote climate change adaptation, and has the power to construct, establish, acquire, maintain or operate dams, reservoirs, canals, water distribution works and hydropower stations in any area. These powers are provided in the Schedule to Section 6 of the Act and place the Authority at the core of ensuring water availability even during times of shortage.

The Water Act establishes Catchment Councils and Sub-catchment Councils, which have responsibility for managing river systems. The key functions of these Councils include: preparation and updating outline plans for river systems; deciding and enforcing water allocations and reallocation; working with ZINWA to maintain a database and information system for the catchment; determining applications for the use of water and imposing the conditions that are necessary; monitoring the activities of Sub-catchment councils (by Catchment Councils); and maintaining all registers of permits issued for access by members of the public. Under Section 12 (1), Catchment Councils have the following powers: to grant or refuse applications for a provisional permit or temporary permit for use of water; to carry out inspections; to revise or cancel permits; to grant permits for the construction of water storage works; to ensure compliance with the Water Act. The functions of Catchment and Sub-catchment Councils provide an institutional framework for adaptation to climate change in the water sector.

Despite the fact that the legislation governing water has important climate change implications, it makes no explicit reference to climate change.

Further, the implementation and enforcement of various pieces of legislation is often hindered by political, economic and social factors. These include shortages of funds, fuel, transport and equipment, and government interference in the operations of public bodies and local authorities. Communities also lack knowledge of these laws and how to claim their rights, which also stifle implementation and enforcement of these laws.

15.6 Disaster management legislation and climate change

The Disaster Management Act No.5 was enacted in 1989. This was before the establishment of the first global environmental UN agenda (Agenda 21 of the 1992 UN Conference of Environment and Development), indicating that disaster management issues in Zimbabwe have been handled by an out-dated legal framework, one enacted before the UNFCCC process increased global attention on climate change.

The Act provides for the Disaster Fund but is silent on resources for prevention and mitigation measures. Nor does it fund disaster management authorities at sub-national or local levels. Officers in the provinces and districts execute the role of the Civil Protection Department on a part-time basis and without a budget. They depend on funding and instructions from the national headquarters in Harare.

The legal framework provides mostly for relief and response efforts, but does not address the most pertinent issues related to mitigating climate risks. This inclination towards relief and response is visible in Table 24, which shows the line ministries responsible for coordinating the main activities regarding disaster management. This is a product of the legal framework.

Table 24. Functional sub-committees on disaster management

Sub-committee leader	Function
Ministry of Public Services, Labour and Social Welfare	Food supplies and food security
Ministry of Health and Child Welfare	Health, nutrition and welfare
Zimbabwe Republic Police and Defence Forces	Search, rescue and security
Ministry of Finance	International cooperation and assistance

Reducing vulnerability centres on understanding and addressing the underlying problem while building resilience against the same. Current responses to disasters do not address the root causes of disasters; instead they focus on relief. This perpetuates existing risk and leads to a cycle of recurrent disasters. While it is important for responses to be timely and to provide appropriate humanitarian assistance, it is equally crucial that national efforts deal with the longer term challenges associated with disaster risk reduction.

In its current state, the Civil Protection Department is inadequately equipped with the right strategies and instruments to reduce vulnerability, the key aspect of reducing climate change risks. Without adequate emphasis for long-term preventive measures and mitigation, coupled with a systematic approach through careful planning, climate events may soon overwhelm Zimbabwe's capacity to cope.

Fortunately the Civil Protection Department acknowledges that it faces significant governance challenges, precipitated by the weak institutional policy framework to respond to disasters and manage national risk-reduction measures. One problem is poor staffing levels, in terms of both numbers and skills; for example, few officers are qualified disaster managers.

The institutional landscape to address disaster risk reduction across various ministries and agencies is unclear. Partnerships with other disaster management agencies, academia, NGOs and the private sector are also weak. This is evident in the lack of an audited account of all the disaster management activities taking place across the country. There are, however, efforts to reform the Civil Protection Department so it conforms to current international standards in disaster risk reduction.

15.7 Mining legislation and climate change

The Mines and Minerals Act (Chapter 21:05) is the principal legal instrument governing mining in Zimbabwe. But this was passed in 1961, well before climate change was an issue, so any reference to climate change is implicit rather than explicit. Climate change-related issues emanating from mining are mainly addressed in the Environmental Management Act and its related regulations, and the Mines and Minerals Amendment Bill of 2007.

As noted, forests are major carbon sinks. The Mines and Minerals Act acknowledges that forests are an important component of sustainable management of natural resources. Section 36 (1) states that:

Every owner or occupier of private land may apply for, and shall be granted by the mining commissioner, a reservation against the cutting or the taking by prospectors or miners of fifty per centum of such indigenous wood or timber as is existing on his land at the time of his application for the reservation.

This realises the need to ensure that trees and forests are not wantonly cut during exploration and mining operations. Furthermore, the mining commissioner may, through a notice authorised by the Minister of Mines, reserve the cutting down of specified indigenous wood or timber by a holder of a prospecting licence or a special grant in terms of Section 37 (1).

These legislations have some relevance to climate change. While they do not stop prospecting or actual mining activities, they ensure that they are done in a sustainable manner. However, they are only applicable to indigenous wood or timber.

Section 97 of the Environmental Management Act lists mining as one of the activities in the First Schedule, which must not be undertaken before an EIA is carried out. This can be seen as an indirect reference to activities that are related to forestry and climate change. If the EIA shows that the proposed mining activity will contribute to significant climate change impacts, which in turn affect sustainable development, this may be a reason not to permit it.

The Environmental Management (Atmospheric Pollution Control) Regulations, Statutory Instrument 72 of 2009 has provisions applicable to mining. Air pollution contributes to greenhouse gas emissions and these Regulations can be used as mitigation measures against climate change. Section 3 of the Regulations sets emission standards for certain activities (see Section 15.2 of this Report).

Some wastes from mining activities, such as spoil heaps from opencast coal mining, can result in spontaneous fires if they are not rehabilitated.

These result in air pollution, which contributes to climate change. Section 15 (1) of the Environmental Management (Environmental Impact and Ecosystems Protection) Regulations, Statutory Instrument 7 of 2007 requires land users, landowners and designated authorities to put in place fire prevention measures on their land. Section 15 (2) makes it an offence for anyone to deliberately start a fire that they cannot extinguish which can damage the environment. By preventing fires, which destroy carbon sinks and prevent air pollution, these Regulations contribute to climate change mitigation.

Mining equipment can also contribute to climate change if it contains ozone-depleting substances, which are a minor contributor to climate change. The Environmental and Natural Resources Management (Prohibition and Control of Ozone Depleting Substances and Ozone Depleting and Ozone Depleting Substances Dependent Equipment) Regulations, Statutory Instrument 2 of 2011 regulate the import, export, installation, decommissioning and destruction of these substances and equipment and ensure they are handled in a manner that does not harm the environment.

15.8 Energy legislation and climate change

Energy legislation plays a critical role in combating climate change. It provides scope for the development of standards and benchmarks for emission levels, and sets the institutional framework for energy use, distribution and production. Zimbabwe has various pieces of legislation that regulate the energy sector and have implications for climate adaptation. These include the Energy Regulatory Authority Act of 2010, the Electricity Act (Chapter 13:19), the Rural Electrification Fund Act (Chapter 13:20) and the Petroleum Act (Chapter 13:22).

15.8.1 Energy Regulatory Authority Act 2010

The Energy Regulatory Authority Bill of 2010 seeks to establish a single regulatory authority to cover both the electricity and petroleum sectors, which are still being regulated by different and separate bodies under the terms of the Electricity Act (Chapter 13:19) and the Petroleum Act (Chapter 13:22). The Bill seeks to consolidate the functions that were being carried out by the Electricity Regulatory Commission and the Petroleum Regulatory Commission and ensure that the Energy Regulatory Authority performs these.

The Authority will play a critical role in regulating the whole energy sector, both renewable and non-renewable energy sources. Several provisions in the Energy Regulatory Authority Bill have implications for climate change.

In Section 2, the Bill identifies 'energy sources' as any source of renewable or non-renewable energy. More importantly, it defines renewable energy as 'energy generated from natural resources such as sunlight, wind, rain, tides, geothermal heat, plants and biomass which are naturally replenished'.

This answers the ever-increasing calls to recognise the importance of developing, producing, applying and distributing renewable energy, rather than continued reliance on fossil fuels and non-renewable energy sources, most of which are responsible for current high levels of greenhouse gas emissions.

Section 7 (1) gives power to the Zimbabwe Energy Regulatory Authority Board, with the agreement of the Minister of Energy and Power Development and after consultation with stakeholders, to declare that any energy source not regulated under any other enactment shall be subject to licensing under the Energy Regulatory Authority Bill. This provision provides scope to declare and license alternative and renewable energy sources in the future, which may be climate friendly. It also means that energy sources not specifically regulated under a specific law, such as biofuels, can be licensed under this Bill. Currently, biofuel production projects are being undertaken in the absence of a specific law to regulate them. However, the provisions of this Act are not specific about the procedures that should be adopted by those producing biofuels. There is a need to adopt regulations that specifically apply to biofuel production.

Section 4 (1) of the Energy Regulatory Authority Bill outlines the functions of the Energy Regulatory Authority. These are to: license and regulate energy industries; identify, promote and encourage the development of renewable energy sources; ensure access to affordable and environmentally sustainable sources of energy to consumers. These are testimony to the need to ensure that the Authority promotes the development of energy sources that do not contribute to climate change, by using technologies that eliminate greenhouse gas emissions.

The other key function of the Authority, under Section 4 (1) (q), is to assess, promote studies about, and advise the Minister of Energy and Power Development and licensees on the environmental impact of energy projects before licensing them. This allows the Authority to carry out EIAs, or advise those who are licenced to conduct them, before energy projects begin. This provides the opportunity to assess the potential impact of, for example, thermal power stations on climate change. EIAs are important in the fight against climate change and environmental degradation, as they identify the environmental risks that may result from a project. EIAs are regulated under the Environmental Management Act (Chapter 20:27).

Although the Energy Regulatory Authority Bill has important legal provisions that have implications for climate change, it lacks legal provisions to regulate and control the development, production and distribution of specific energy sources, although it does provide a framework within which renewable energy sources can be licensed. In addition, the Bill is too general and falls far short of what such legislation should contain. These shortcomings are exacerbated by the fact that the Bill does not make specific reference to climate change issues in the energy sector, despite being developed when climate change was a topical issue. And while the Bill is broadly progressive, lack of funds and human resources may hinder its effective implementation.

15.8.2 Electricity Act, Chapter 13:19

The Electricity Act provides for the establishment of the Zimbabwe Electricity Regulatory Commission. However, the Commission will be replaced by the Energy Regulatory Authority, to be established under the terms of the Energy Regulatory Authority Bill, which will take over all the functions of the Commission. The Electricity Act also provides for the licencing and regulation of the generation, transmission, distribution and supply of electricity.

Some functions of the Commission with implications on climate change are stated in Section 4. These include licencing and regulating people who generate, transmit, distribute and supply electricity. Any person who intends to generate more than 100 kW of electricity is required to apply for a licence. The only specific reference to environmental issues is in the Second Schedule of the Act,

which provides for the compulsory acquisition of land to facilitate the transmission and distribution of electricity. Before the servitude is granted, the Commission has to consider a report by the Ministry of Environment on the anticipated environmental impact of the works. The Act does not contain any major provisions on how climate-related challenges in power generation can be handled. It is silent on the implications of electricity generation, production and distribution on climate change. Given that the production of thermal energy is a major source of greenhouse gas emissions, there is a need for legislative guidance on how this will affect Zimbabwe's commitments within the UNFCCC framework, to which the country has signed.

15.8.3 Rural Electrification Fund Act, Chapter 13:20

The Rural Electrification Fund Act provides for the establishment of the Rural Electrification Fund, which is administered by the Rural Electrification Fund Board. The purpose of the Fund is to facilitate rapid and equitable electrification in rural areas of Zimbabwe, promote rural development, identify rural electrification projects, act as a centre of information, carry out research, and keep abreast of worldwide technological developments in rural electrification.

The other purpose of the Fund is to give attention to off-grid, stand-alone technologies to supply electricity to rural areas. Rural electrification is important as it reduces reliance on firewood, which depletes forests that act as carbon sinks. The Rural Electrification Fund Board is responsible for giving financial assistance to rural electrification projects. In Section 2 of the Act, an electrification project is defined as a project in a rural area that entails the construction of works for the distribution of electricity and the financing of its end-use infrastructure, including the construction of isolated mini-hydro electricity, solar power and wind generators for centres away from the national grid.

It is evident that the legislation was formulated with the objective of promoting renewable energy sources in rural areas not connected to the national electricity grid. These projects are sustainable technologies, as they do not cause significant greenhouse gas emissions. In addition, the legislation provides for the gathering of information, research and technological advancement. This means that the Act ensures that rural communities learn from other countries, where new renewable technologies are being tested and applied.

In practice, the provisions of the Act have been implemented and applied through the Rural Electrification Agency, which has been implementing alternative and renewable energy projects, for example solar energy to schools, clinics and the homesteads of chiefs.

In addition, a 6% levy is being paid by all electricity consumers in Zimbabwe to support rural electrification projects. However, Zimbabwe's suppressed economic conditions have adversely affected the implementation of the programme objectives. Limited funding causes problems for the implementation of laws on rural electrification projects. The rural electrification levy imposed on electricity consumers has not translated into massive rural electrification. Further, the sanctions imposed on Zimbabwe have reduced the ability of local investors to attract the foreign investment and technology required in the sector.

15.8.4 Petroleum Act, Chapter 13:22

The Petroleum Act regulates and licenses the petroleum industry. Section 2 defines petroleum products as petrol, diesel fuel, paraffin and liquid petroleum gas, among others. Section 4 of the Act states some functions of the Petroleum Regulatory Authority critical to climate change. These include promotion of the production, procurement and sale of petroleum products, and the advancement of technology relating to the petroleum industry.

No person is allowed to produce, sell or procure petroleum products without a licence. In Section 5 (2) and 5 (3), the Act states that protect consumers, the Authority shall fix safety, health and environmental standards that the licensee must adhere to. Further, the Authority has the power to develop consumer protection standards, while the Minister of Energy has the power to introduce regulations.

The petroleum industry has great implications for climate change, especially the production of petrol and diesel from fossil fuels. The Act has no specific provisions on this, but there are general provisions about the development of technology relating to the petroleum industry, without stating whether this technology will be new technologies that reduce greenhouse gas emissions. The only provision in the Act that remotely seeks to protect the environment deals with the powers of the Authority to put in place safety, environmental and health standards to protect consumers.

It is hoped that the Authority can use this to put in place measures and standards that make the petroleum industry reduce its climate change footprint by adopting cleaner methods and technologies.

As stated earlier, all projects that relate to the production, storage and distribution of petroleum should be subjected to an EIA, under the terms of the Environmental Management Act (Chapter 20:27). This offers some hope that climate change issues may be considered before projects to produce petroleum products begin. A key limitation of the Petroleum Act is that it does not make reference to EIAs, which leaves investors in the petroleum sector with no environmental guidance for their activities. Further, the Petroleum Act does not explicitly mention fuels (petrol and diesel) generated from renewable sources, such as bio-diesel. It contains general guidelines on petroleum products, with a bias towards fossil fuels.

While the Energy Regulatory Authority Act provides scope for regulating the various facets of the energy sector, there is a need to develop specific regulations to support the Act and set explicit procedures and parameters under which technologies will be promoted, in light of the challenges posed by climate change.

15.9 Transport legislation and climate change

According to Section 68 of the Environmental Management Act, it is an offence for an owner or operator of a vehicle to operate it in a way that results in air pollution in violation of emission standards. The penalty for causing air pollution includes a fine and a jail sentence, depending on whether it is a first or second conviction.

The Environmental Management (Atmospheric Pollution Control) Regulations, Statutory Instrument 72 of 2009 sets emission standards for motor vehicles. The Regulations give inspectors powers to test and inspect motor vehicles to determine if they comply with emission levels. If not, inspectors can order that the vehicle is not used on any road, or can set conditions under which the motor vehicle can be used.

The Government of Zimbabwe is proposing to ban the import of second-hand vehicles more than five years' old, through Section 65 of the Road Traffic (Construction, Equipment and Use) Regulations, Statutory Instrument 154 of 2010. This could be interpreted as a measure to combat climate change, as older vehicles have lower fuel conversion efficiency, leading to high emissions due to incomplete combustion of the fuel.

16. Recommendations

There is unequivocal evidence that Zimbabwe is experiencing the effects of a changing climate. These threaten to undermine economic recovery, threatening efforts to reduce poverty and achieve the Millennium Development Goals.

However, there is considerable scope for the Government to effectively respond to the challenges that climate change poses. The following actions are recommended as first steps towards building climate resilience in Zimbabwe.

Develop a National Climate Change Strategy that aims to increase the integration of adaptation and mitigation initiatives in economic and development activities

Making social and economic development resilient to a changing climate demands a coordinated policy and institutional framework. Decision-makers need to implement the suggestions and recommendations for research, policy and technical assistance highlighted in the Baseline Report. This will require a bold vision and a long-term agenda for the development of a National Climate Change and Development Strategy for Zimbabwe. To be effective, this strategy must be informed by sound scientific analysis of existing impacts and future threats – as well as opportunities for poverty alleviation and development.

Develop a National Adaptation Programme of Action and address priorities for adaptation research and technical assistance within sectors

For the agriculture sector, these include allowing meteorologists to work more closely with agricultural systems to improve early warning systems, and to further support the development of drought-tolerant varieties of staple grains.

In the water sector, these include strengthening catchment-based water resources management, irrigation development, improved irrigation technology, increasing efficiency through recycling water, multiple-use water schemes and water pricing schedules.

Key priorities regarding extreme events are to ensure the new Environmental Protection and Disaster Management Act incorporates adaptation priorities, and developing greater links between the Climate Change Office and the Civil Protection Department.

Technical assistance can help to finalise the new Urban Development Policy and the preparation of city-level disaster preparedness studies by local authorities. Overall, Environmental Impact Assessments, the key tool for adherence to environmental standards, should be amended and used to create a knowledge base in the Climate Change Office of adaptation and disaster risk requirements, as well as possible mitigation opportunities.

Seize opportunities for mitigation research and technical assistance

In the forestry sector, technical assistance can facilitate Zimbabwe's application to the UN-REDD secretariat, to update the national inventory, and launch baseline surveys for REDD+ sites.

In the mining sector, technical assistance is required to implement energy efficiency improvements, waste recycling and technology upgrades. Similarly, in the energy sector, technical assistance could help to realise 20–30% energy efficiency savings through industrial energy management, and packaging coal-based emission reductions into offset projects.

Research is required to further understand the links between land reform and land degradation, while technical assistance is required to reduce the impact of small-scale tobacco production on deforestation, and the conversion of timber concessions into farms. Overall, there is need for technical assistance to help convert feasible offset opportunities into carbon credits.

Access international climate financing

The current international climate regime offers many opportunities for Zimbabwe to benefit from adaptation and mitigation funding. These include applying to join the UN-REDD process in the forestry sector, identifying projects that are applicable for climate finance mechanisms such as the CDM (recognising however the uncertain future of such), and putting in place early the likely accessibility criteria for the Green Climate Fund such as strong governance, monitoring and reporting of climate change activities. Accessing these sources of international funding will help many of the opportunities that Zimbabwe has come to fruition.

Realising these opportunities will assist the country in ensuring climate change does not undermine poverty reduction and Zimbabwe's future prosperity. Advancing this agenda will require clear political support, committed leadership, and extensive consultation with, and participation of, a broad range of stakeholders.

Complete the Second Communication on Climate Change by the Climate Change Office

Submission of National Communications to the UNFCCC is an important factor in the international climate change architecture. The Climate Change Office should be the coordinating body for such, but requires statutory powers to enforce the submission of returns from each sector in order to track greenhouse gas emissions.

Clarify roles and improve coordination

This needs to be done between government agencies on the one hand, and NGOs, researchers and international agencies on the other. There is already sufficient political support and momentum across the board to allow policy progress to be made on climate change and development; this needs to be linked to the Medium Term Plan.

Increase support to the Climate Change Office, expand its mandate and decentralise some functions

The Climate Change Office needs recurrent funding to fulfil its mandate, expand, and decentralise to provincial levels. In its present form it has a narrow focus on mitigation, but Zimbabwe's top priority should be adaptation. As climate adaptation needs to be driven by impacts, the Climate Change Office's mandate should be expanded to explicitly include oversight and strategic management of adaptation plans and programming. This should include a 'climate change desk' in each relevant ministry.

The recently appointed National Task Team on Climate Change provides a high-level organ for the Climate Change Office to liaise and consult with, as well as to be accountable to. The National Task Team provides the necessary political clout to support coordinated activities on climate change legislation, policy and budget reforms.

The Climate Change Office should continue to be supported by an expanded National Steering Committee on Climate Change, to which it should also be held accountable.

Decentralising some functions to the provincial and district level, perhaps through extending the mandate of the District Environmental Committees, will help to overcome a considerable lack of vertical coordination on climate change between local and national levels. This move would also increase the geographical representation within the National Steering Committee on Climate Change. An enhanced, decentralised Climate Change Office could provide the necessary leadership and guidance to ensure sectoral priorities are pushed through budgets, medium term expenditure frameworks and into programming.

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