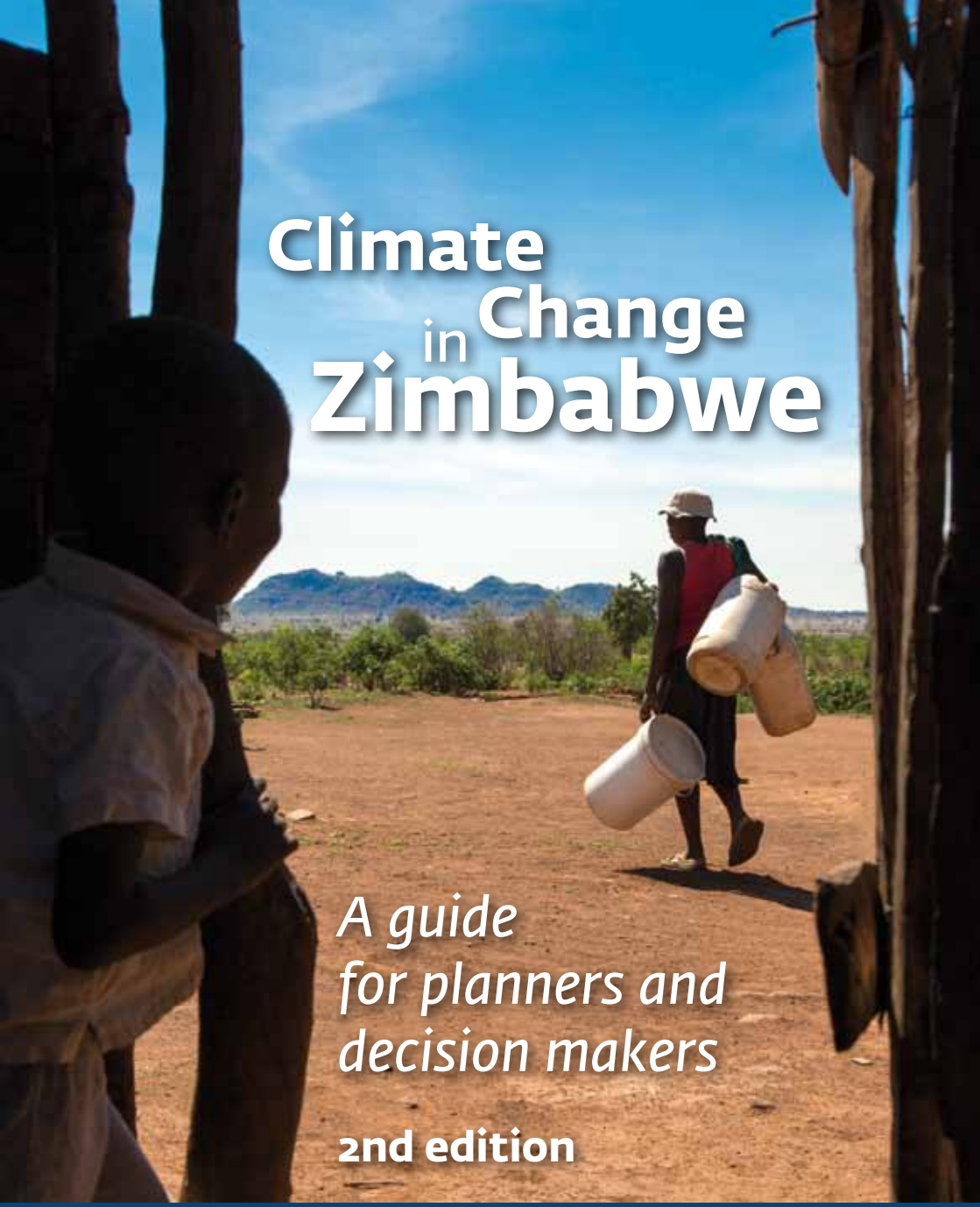

Climate Change in Zimbabwe

A guide for planners and decision makers

2nd edition

Konrad Adenauer Stiftung

Anna Brazier

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For full biographies of our contributors please refer to the back or the book.

Acronyms and abbreviations

NEPAD	New Partnership for Africa's Development
ClimDev-Africa	Climate for Development in Africa
AGRITEX	Department of Agricultural Technical & Extension Services
AIDS	Acquired immune deficiency syndrome
CA	Conservation agriculture
CBA	Community-based adaptation
CDKN	Climate and Development Knowledge Network
CDM	Clean development mechanism
COP	Conference of parties
EMA	Environmental Management Agency
ENSO	El Niño–Southern Oscillation
FAO	Food and Agriculture Organisation of the United Nations
GCF	Green Climate Fund
GDP	Gross domestic product
GEF	Global Environment Fund
GoZ	Government of Zimbabwe
HIV	Human immunodeficiency virus
INDC	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
LED	Low Emissions Development
MSD	Meteorological Services Department of Zimbabwe
$MtCO_2e$	Metric tons of CO_2 equivalents
NAMA	Nationally appropriate mitigation actions
NAPA	National Adaptation Programme of Action
NCCRS	National Climate Change Response Strategy
NCP	National Climate Policy
NDC	Nationally Determined Contributions
NGO	Non-governmental organisation
REDD+	Reducing emissions from deforestation and forest degradation

UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WFP	World Food Programme
ZimAsset	Zimbabwe Agenda for Sustainable Socio-economic Transformation
ZimStat	Zimbabwe National Statistics Agency
ZINWA	Zimbabwe National Water Authority

Contents

Foreword

Africa is experiencing unprecedented climate change phenomena that are likely to lead to a crisis of human survival and national development unless urgent steps are taken to curtail human behaviour impelling climate change. While Africa has not contributed significantly to climate change, the continent remains highly vulnerable to frequent extreme weather events such as floods and droughts. This vulnerability has been greatly exacerbated by poverty and the limited adaptive capacities of communities. Zimbabwe has not been spared the harm of climate change, which has been aggravated by its geographical position in the semi-arid belt of southern Africa and its reliance on rain-fed agriculture and other climate-sensitive livelihoods options.

Climate change has resulted in declining water resources and water quality, reduced agricultural productivity, damaged infrastructure, loss of lives and ecosystems and degradation, among other impacts. The livelihoods of the people of Zimbabwe depend on vulnerable natural resources, and their depletion as a result of climate change will lead to further poverty and set back the country's efforts to achieve sustainable development.

Zimbabwe views climate change as a direct threat to its socio-economic development, with the potential to reverse the hard-earned developmental gains achieved over past decades.

This book provides an overview of climate change issues, drivers, impacts and actions from climate negotiations, from a technical, financial and practical perspective. It also discusses – and provides useful links to – opportunities for low-carbon development which are available to climate-proof our development.

The book is the product of a collaborative effort, with contributions and reviews from government departments, academia, civil society and the private sector. It is hoped that the book will be of use to policy implementers, planners and decision makers from all sectors of Zimbabwe.

Washington Zhakata

Director of Climate Change Management, Ministry of Environment, Water and Climate, Zimbabwe

Introduction

The first edition of this book came out in 2015 and stocks ran out so quickly that the publishers had to order a second print run. Before going to a third print run it was decided that the book was due for revision. Although the first edition was considered useful and user-friendly, it was published before the landmark Paris Climate Conference (COP 21) in December 2015, the Sustainable Developmental Goals and the Sendai Framework for Disaster Risk Reduction. Much has changed since then, including local climate governance. Leading climate change experts in Zimbabwe have reviewed and contributed to this fully revised and updated version. The information presented here is therefore as reliable and dependable as any information on climate change can be, considering the difficulty of predicting its effects.

The book presents information about climate change management that is up-to-date, accurate, relevant and useful. It aims to inspire its readers to action, particularly communicators, educators and people who decide and implement policy – the media, community leaders and mobilisers, parliamentarians, councillors, business leaders and NGO project staff.

Style: Climate change is a complex, multifaceted and multi-sectoral subject and we have tried to keep the information brief and to the point in order not to overwhelm the reader with excessive detail and points of view. The reason for this is to inspire action.

For more information: For the reader who is interested in exploring topics in greater depth we provide links to useful websites, articles and other information sources. Appendix 2 contains a list of resources, including contact details for useful

local organisations, government departments, academic and research institutions, NGOs and websites.

References: Citations are presented as notes at the end of each chapter, with a bibliography at the back of the book.

Language: Climate change is a topic that abounds with new terms. We have avoided jargon and overly academic terminology where possible. A glossary of important terms appears at the back of the book.

This book in brief

Chapter 1 discusses at the causes of climate change – the long-term change (over a minimum of 30 years) in the average weather conditions. There is consensus among governments and scientists that the accelerated climate change phenomena being observed globally are due to the excessive build-up of greenhouse gases in the atmosphere. Although these gases occur naturally, huge amounts are increasingly being released through human activities, especially the burning of fossil fuels (coal, oil and natural gas).

Greenhouse gases trap heat in the atmosphere, causing global warming. This disrupts weather patterns and ocean currents, leading to long-term changes in the climate. Historically, developed countries have been responsible for most of the emissions. As developing nations' economies grow they are increasingly responsible for emissions.

Chapter 2 gives an overview of Zimbabwe's environment, resources, human capacity and economy as well as its people's vulnerability to hazards and shocks and the ability of the nation to adapt to climate change and variability.

Chapter 3 examines the changes that are already occurring as a result of global warming and discusses the impact that climate change could have on Zimbabwe in the future. Various climate models project that average temperatures across Zimbabwe will rise by more than 4°C before the end of the 21st century. Rainfall is projected to become more variable. These changes have the potential to affect Zimbabwe's food security, health, infrastructure, energy supply and the economy generally.

Chapter 4 gives an overview of the international agreements that have been put in place to mobilise the global community to address climate change. A major player is the United Nations Framework Convention on Climate Change (UNFCCC) whose main objective is to stabilise the greenhouse gas concentrations in order to prevent dangerous interference with the climate system. Each year a conference of the parties (COP) session is held in a different country to assess progress. To date the most notable of these meetings was COP21, held in Paris in 2015, where governments pledged to keep global temperature rises well below 2°C above pre-industrial levels.

Zimbabwe has a National Climate Policy and a National Climate Change Response Strategy. It has submitted its Nationally Determined Contributions (NDCs), to the UNFCCC.These give Zimbabwe a clear target to work towards in terms of both adaptation to and mitigation of climate change.

Chapter 5 discusses adaptation to climate change by reducing the vulnerability of communities, increasing their ability to adapt and by reducing the risks of climate hazards (disaster risk reduction). Zimbabwe is aiming at adaptation measures that will lead to sustainable development, including improved management of water, land and vegetation, and climate-proofing businesses and human communities.

Chapter 6 discusses options for reducing greenhouse gas emissions and finding ways to remove excess carbon dioxide from the atmosphere (carbon sequestration). Mitigation of climate change will entail the use of technologies alongside fundamental changes to economies and societies. Zimbabwe has produced an ambitious emissions reduction plan with a target to reduce energy sector greenhouse gas emissions per capita by 33% below business-as-usual levels by 2030. Zimbabwe will achieve

this mainly through changes to power generation systems and improved efficiency in industry, and by instituting climate-smart agriculture methods.

Chapter 7 looks at **Climate finance** and other critical enablers for enhanced climate action. It discusses international and domestic climate finance options, examines the barriers that may be faced in accessing climate finance and presents some ways to overcome them.

Chapter 8 summarises the recommendations in this book on how planners and decision makers can start to put climate change mitigation and adaptation strategies in place and how they can access finance in order to do so.

1 The basics of climate change

This chapter was reviewed by Elisha Moyo, Dr Ndebele-Murisa, Dr Dube and Dr Mugabe with contributions from Shingirai Nangombe.

This chapter looks at what is causing climate change. The greenhouse effect is explained, the action of greenhouse gases is described and the sources of greenhouse gases are analysed. The countries most responsible for causing climate change are named and their contributions are listed. We discuss which countries and populations will be most affected by climate change and examine some of the scientific and other evidence that shows that climate change is already happening.

Chapter summary

Climate change will make it harder for farmers to plan what to plant

Weather, climate variability and climate change

Climate change is defined as the long-term change (over decades or centuries) in the Earth's climate caused by the release of greenhouse gases – notably carbon dioxide and methane – that trap heat in the atmosphere. These gases can be released through natural causes or human activities. Climate change brings about measurable changes in temperature, rainfall or wind patterns, among others, that occur over several decades or longer.

The Earth's climate has been changing for millions of years, but it is changing faster today than it has for thousands of years (especially since 1980). Most models describing the climate system have shown that the very rapid changes recorded in the

past century have been mainly caused by human activities. These changes are the focus of this book.

Climate change sceptics and denialists

Some people, including politicians and a few scientists, do not believe that climate change is happening. They argue that most scientists have got their facts wrong and that global warming is not real. Others believe that global warming and climate change are occurring, but they do not think that human activities are responsible. They believe that climate change is a natural phenomenon linked to the rotation of the earth and volcanic activity. Yet others argue that the impacts of climate change predicted by the Intergovernmental Panel on Climate Change and others are exaggerated. It is important to note that 97% of scientists around the world agree that the rapid and increasing global warming that is being observed is largely due to greenhouse gas emissions caused by human activities. A vast amount of evidence has been collected to support this view.

In order to understand climate change, we must first understand the difference between weather, climate and climate variability.

Weather is the state of the atmosphere, such as temperature, humidity, wind and air pressure, at a given time and place. Weather can change from hour to hour and from day to day. One day may be sunny, the next windy and the next rainy. In some places the weather can change so rapidly that we experience several types of weather in a day.

Climate describes the average weather conditions that occur in a particular place or region over at least 30 years. We can say that

the climate of Zimbabwe is basically warm, sunny and dry with hotter temperatures between mid-August and November and cooler temperatures between May and mid-August. Zimbabwe has seasonal rainfall that typically occurs between mid-October and mid-March. Statistically, if you pick any day in June in a 30-year record from a weather station in Zimbabwe, there is a high chance that the weather will be cold and dry, whereas in December its likely to be hot and wet. That defines the climate of the station.

Climate variability

It is normal for a climate to vary across time and space. Zimbabwe's rainfall varies according to the time of year and between years. Some years are wet; others have droughts, with more recent years becoming dryer. Temperature averages and extremes of hot and cold also vary naturally, and some seasons and years are hotter and colder than others.

Climate variability refers to non-permanent and shorter-term changes (those that occur daily, seasonally, annually, inter-annually or over several years), including the fluctuations associated with El Niño (dry) or La Niña (wet) events.[1] In one climate cycle (30 years) it is possible to have a cooling trend lasting up to 10 years followed by warming trend of maybe three years, then a drying trend for five years. A country with an unusually wet rainfall season (such as those in Zimbabwe in 1999/2000 and 2016/2017) may be experiencing climate variability. It would be incorrect to conclude that the climate has changed to one of heavy rainfall based on one season's rainfall.

The World Meteorological Organisation (WMO) and the Intergovernmental Panel on Climate Change (IPCC)

The climate is being observed and monitored by the WMO through national meteorological services which have records of more than 100 years of weather observations. These are complemented by research institutions and remote sensing satellites, radars, buoys and terrestrial equipment.

The WMO and the United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) in 1988 to assess the scientific, technical, and socio-economic information relevant to the understanding of climate change, its potential impacts and options for adaptation and mitigation. The IPCC is a group of thousands of scientists from across the world which, under the coordination of the United Nations, produces reports assessing global knowledge and evidence about climate change.

To date, the IPCC reports have become the scientific basis for global climate negotiations, vulnerability assessments and the introduction of the Intended Nationally Determined Contributions (INDCs) which are discussed in a later chapter. The IPCC is thus central to any climate interventions and finance across the globe.

The fifth assessment report of the IPCC was published in 2014 and much of the information in this book is taken from it. Unfortunately, the past five IPCC assessments have often failed to address adequately the needs of Africans. This is because governments and scientists in developing countries are poorly represented in IPCC meetings, although these countries bear the brunt of climate change.

The greenhouse effect and global warming

The greenhouse effect is a natural phenomenon which is strengthened by human activities. A greenhouse is a glass building that allows light and heat in, but prevents heat from escaping. Its original function was to enable plants to be grown in cold countries during winter. The gases in the Earth's atmosphere act like the glass in a greenhouse: they allow the sun's short-wave radiation to pass through, but restrict long-wave radiation (heat) from escaping back into space. The gases trap the heat, causing temperatures in the atmosphere to rise. The atmosphere therefore keeps the planet about 15°C warmer than it would otherwise have been. Without the natural greenhouse effect, the Earth would be too cold for life.

However, human activities have caused excessive greenhouse gases to build up in the atmosphere, causing the planet to heat up too much and too fast, an effect known as global warming. The gases that trap this heat are called greenhouse gases.

Figure 1 shows how greenhouse gases become trapped in the atmosphere and cause global warming. The heating of the atmosphere disturbs the climate system, the global energy balance and hydrological cycles. This leads to many other changes, including increases in extreme events such as heat waves, erratic rainfall, violent storms, intense tropical cyclones, droughts, and the melting of ice packs and snow caps on mountains and at the north and south poles. Global warming also affects ocean and wind currents, leading to changes in rainfall patterns and increases in extreme weather events, including storms, floods, fires and droughts. Sea levels rise as the ice melts.

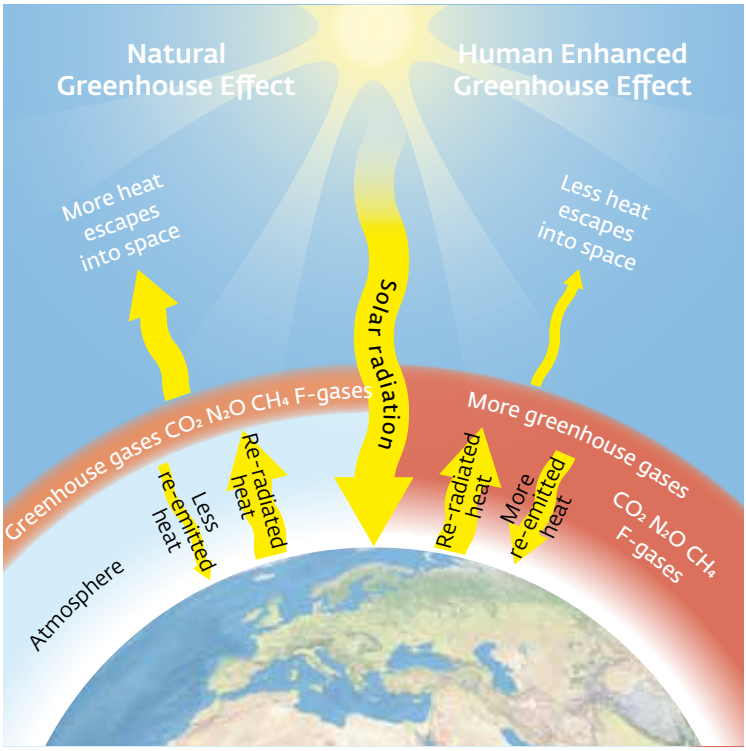


Figure 1: The natural and human enhanced greenhouse effect

Adapted from Will Elder, National Parks Service, Washington D.C.: http://peabody.yale.edu/sites/default/files/documents/teachers/Global%20Warming_1.pdf

Greenhouse gases

The burning of coal or oil (known collectively as **fossil fuels**) for industry and transport and to produce electricity releases greenhouse gases into the atmosphere. Large-scale commercial agriculture and forest clearing also contribute to greenhouse gas emissions. Figure 2 shows the main greenhouse gases and their contribution to climate change. From this we see that carbon dioxide (CO_2) emissions from burning of fossil fuels as well as deforestation and other land-use activities are major contributors of greenhouse gases. Methane (CH_4) mainly comes

from livestock and municipal waste management. Nitrous oxide (N_2O) comes from agricultural activities mainly related to fertiliser use. Fluorinated gases (including chlorofluorocarbons and hydrofluorocarbons) come from industrial processes, refrigeration (including air conditioning) and some consumer products.

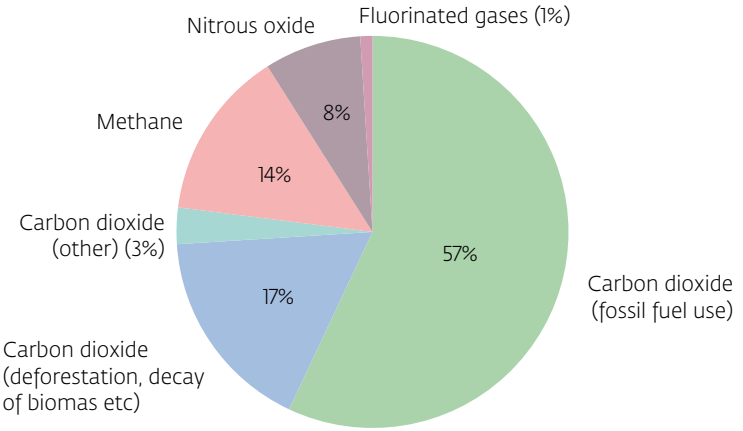


Figure 2: The main greenhouse gases responsible for climate change

Source: Environmental Protection Agency, based on data from Working Group III to the fifth assessment report of the Intergovernmental Panel on Climate Change

Measuring emissions

Scientists express greenhouse gas emissions in metric tons of CO_2 equivalents. This is a measure of the impact of the different greenhouse gases in terms of the amount of CO_2 that would create the same amount of warming.

Figure 3 shows the main activities that cause the release of the greenhouse gases and the percentage contribution of these activities to climate change globally. Although carbon dioxide is the most commonly occurring greenhouse gas, methane and fluorinated gases in particular are more powerful agents of the greenhouse effect.

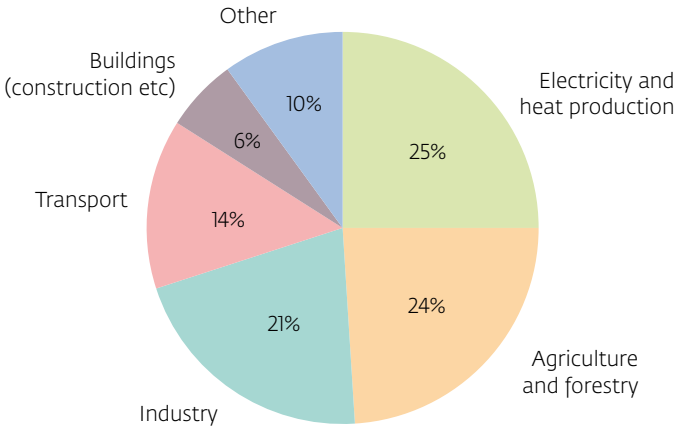


Figure 3: The main human activities that release greenhouse gases
Adapted from IPCC 2014a

As countries have developed and economies and populations have expanded, more and more greenhouse gases have been released into the atmosphere. Figure 4 shows how the concentration of CO_2 (in red) has risen as global average temperatures (in yellow) have increased.

The graph does not prove that greenhouse gas emissions cause climate change, but there is a strong correlation between the two sets of data. Most scientists use this data as a foundation for their evidence that climate change is caused by human activities.

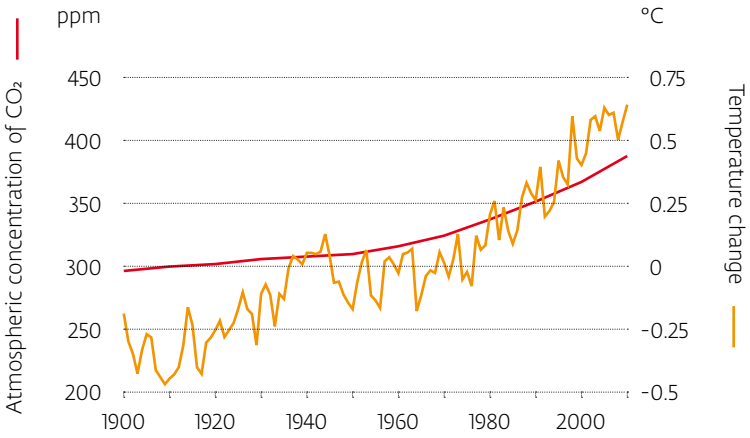


Figure 4: World atmospheric concentration of CO_2 (in parts per million) and average temperature change in degrees Celsius

Source: International Energy Agency 2013

To understand climate change, it is useful to know about the natural cycle of carbon and how human activities have altered it. Figure 5 in the box on page 13 shows the main processes involved in the carbon cycle.

Greenhouse gas emissions from land use and forestry

The carbon released from burning fossil fuel is considered to be a more dangerous contributor to climate change than that from natural sources because it is being reintroduced into the carbon cycle after being locked out for thousands of years. The natural sinks of carbon, including the soil, trees and plants and the oceans, are unable to cope with this extra carbon and it is accumulating in the atmosphere and causing the greenhouse effect.

Carbon released when forests are cleared for uses such as

agriculture or when wood is burned for fuel also releases unwanted carbon into the atmosphere. As seen from Figure 3 they contribute 11% of emissions. However, the original source of this carbon was the natural carbon cycle; thus it is easier for the natural carbon sinks to absorb this carbon than that from fossil fuels. That said, it is obviously better not to cause the release of carbon into the atmosphere from land clearance and deforestation. As seen in chapters 5 and 6, reducing deforestation and general clearance of vegetation are important ways to reduce greenhouse gas emissions and the impacts of climate change.

Who is causing it?

The countries responsible for releasing the largest amounts of greenhouse gases into the atmosphere (historically) are also the richest and the most industrially developed. Their development and economic growth have been achieved using fossil fuels as an energy source for industry and commerce. Therefore, they have achieved their level of development through activities that have polluted the atmosphere (which is a common good) and led to climate change, among other negative impacts.

Figure 6 shows the top 10 countries emitting the most greenhouse gas in 2011 as measured in metric tons of CO_2 equivalents ($MtCO_2$ e). These figures are somewhat contentious and need to be carefully analysed alongside figures for per capita emissions (carbon dioxide emissions in relation to population) for the same countries. China produces around 22% of global greenhouse gas emissions, while the United States is responsible for 12%. If we look at emissions per capita, however, the rate for China is less than half that for the USA (6.52 $MtCO_2e$ compared to 17.62 $MtCO_2e$ for the same year). In terms of per capita emissions

The carbon cycle

All living things, as well as the soil, air and oceans, contain carbon. The carbon found in rocks is not very active in the carbon cycle. As far as climate change is concerned, the main sources of carbon are the atmosphere (2%, mainly as CO_2 and CH_4), plants and soil (5%), fossil fuels underground (8%) and the oceans (85%). In the carbon cycle plants take CO_2 from the atmosphere during photosynthesis and it becomes part of their tissues. At night plants produce a smaller amount of CO_2 as they respire. When plants die and decay the carbon in their tissues becomes part of the soil. Bacteria return some of this carbon to the atmosphere. Plants in the ocean (phytoplankton) absorb huge amounts of CO_2 from the atmosphere.

For millions of years carbon was passed between plants, the soil, the oceans and the atmosphere in the normal processes of the carbon cycle, with no input from the fossil fuel carbon source. In fact, because fossil fuels formed as decayed plant and animal matter became buried, fossil fuel carbon was effectively taken out of the cycle.

In the last 250 years the increasing extraction and use of fossil fuels (the main source of CO_2) and clearing of forests (a smaller source of CO_2) have disrupted the natural carbon cycle. Natural processes have managed to absorb much of the extra carbon that we have introduced. The ocean has absorbed about 28% of the extra carbon, while soils and plants have absorbed about 32%. But 40% has remained in the atmosphere and has caused the warming. As human activities put more and more carbon into the cycle, the ability of the oceans, plants and soils to absorb the extra carbon is decreasing.

Although the oceans have absorbed about one-quarter of the extra carbon in the atmosphere from fossil fuels, the extra carbon in the water has made the oceans more acidic. This acidity is killing sea life.

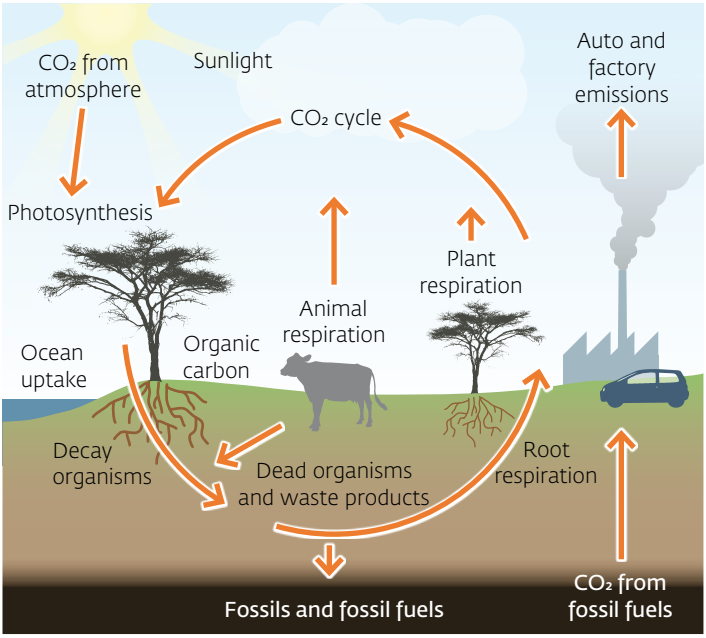


Figure 5: The main processes in the global carbon cycle

For more information on the carbon cycle, visit http://carboncycle.aos.wisc.edu/

the top three countries in 2013 were Saudi Arabia (19.65 $MtCO_2e$), Australia (18.02 $MtCO_2e$) and Canada (16.24 $MtCO_2e$)[2]. Although China is currently the largest emitter shown in the graph, this is a recent trend. In terms of historical emissions, the U.S. and Europe have contributed the most greenhouse gas emissions.

The biggest new emitters are countries with rapidly growing economies: China, India, Russia, Indonesia and Brazil. In Africa two of the most developed economies, South Africa and Nigeria, have the highest emissions. If we leave out the figures for South Africa and Nigeria, the continent contributed only 4.6% of total average global greenhouse gas emissions in 2011. Zimbabwe's total emissions are 64 $MtCO_2e$, which is 0.14% of the world total.

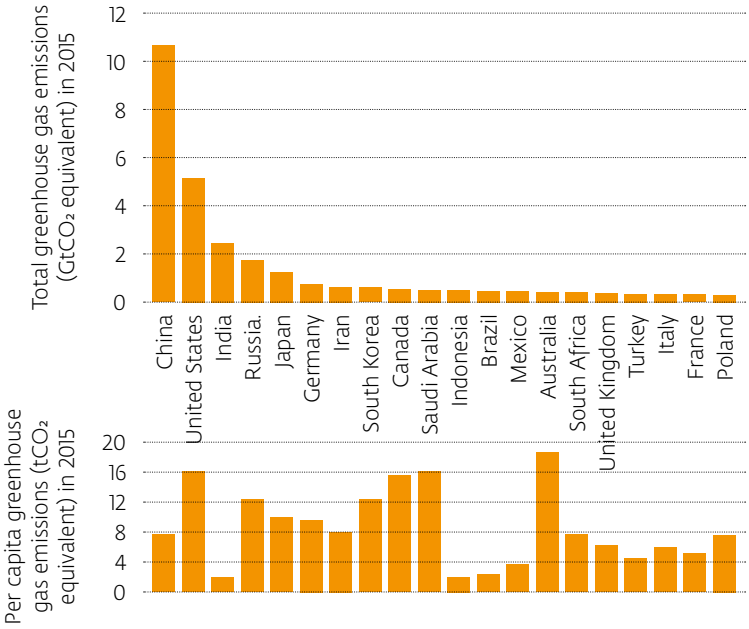


Figure 6: Greenhouse gas emissions in 2015 for the top 20 biggest emitters

Sources: http://edgar.jrc.ec.europa.eu/overview.php?v=CO_2ts_pc1990-2013 and https://en.wikipedia.org/wiki/List_of_countries_by_carbon_dioxide_emissions

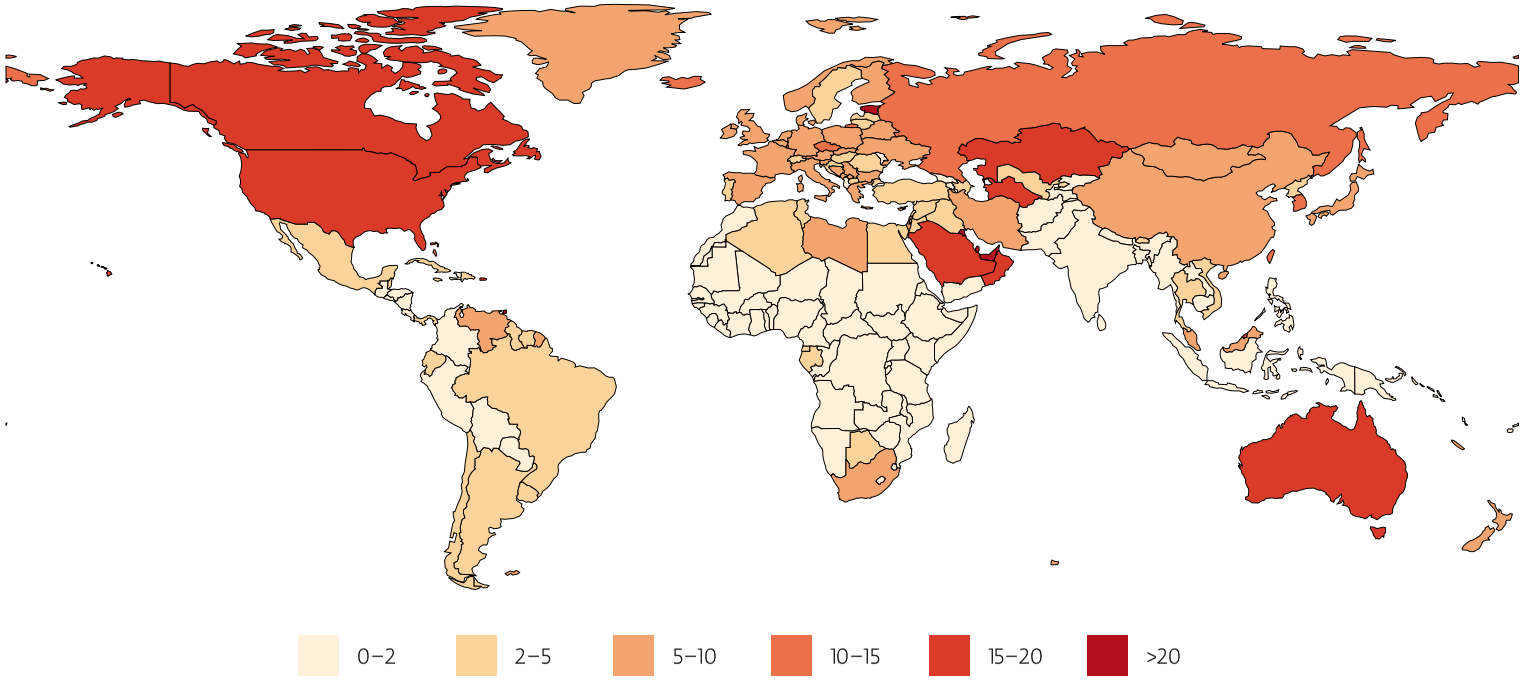


Figure 7: Greenhouse gas emissions (in tonnes of CO_2 equivalent) per capita

Source: United Nations Statistics Division 2010

Figure 7 shows the CO_2 emissions per capita around the world in 2010. The countries shown in the palest colour produce the lowest emissions per capita.

It seems therefore that emitting increasing amounts of greenhouse gases has been a prerequisite for growth and development. However, there are other ways for countries to develop, as seen in chapter 6.

Climate injustice

Every living thing on Earth will be affected by climate change, but the regions that will experience the most severe impacts are in the developing world. This is due to several factors: many are in the tropics and sub-tropics where temperatures are already high; low adaptive capacity; lack of finance to institute protective infrastructure and adaptive mechanisms; and the multiple stressors that they already bear, including hunger, poverty and disease. Developing countries that lack climate-resilient infrastructure and whose populations rely on livelihoods like agriculture, fishing and forestry that draw on natural resources and are sensitive to climate are extremely vulnerable to the impacts of climate change (see chapters 2 and 3 for more details).

If developing countries followed the same developmental pathway taken by industrialised countries, more greenhouse gases would be released into the atmosphere, leading to more global warming. In global climate change negotiations industrialised countries insist that developing nations reduce their greenhouse gas emissions.

However, they do not offer adequate assistance to help developing

Many Zimbabwean children already travel far to collect water. This will worsen in future

nations develop in a way that contributes less to climate change, a principle that is enshrined in the United Nations Convention on Climate Change (UNFCCC).

All countries understand that development (which is every nation's right) is tied to some increase in emissions. Developing countries therefore feel they have to exercise their right to development without restrictions. They face a difficult choice: either to stop developing or to continue to develop and contribute to climate change, incurring fines for the extra emissions under the global climate change treaties. They are therefore expected to pay for a problem that they did not cause. These political squabbles are paralysing climate change action. For more on this issue see chapter 4.

Evidence for global climate change[3]

Meteorological services across the globe have routinely measured climate change phenomena for centuries. The amount of CO_2 that has been entering the atmosphere from human activities has been recorded every year since 1958. The increased levels in CO_2 strongly mirror the increased temperatures experienced by the planet (as shown in Figure 4).

Scientists first described the greenhouse effect in the mid-19th century when they observed the heat-trapping abilities of CO_2 and other greenhouse gases. Since then scientists around the world have collected vast amounts of evidence that have led them to agree, without doubt, that the recent rapid change in the global climate and consequent rises in atmospheric and ocean temperatures have been caused by human activities.

Evidence from temperature measurements

Scientists get an impression of the Earth's past climate by studying tree rings, ice cores, coral growth rings and sediments at the bottom of lakes. The studies show that in the past century the planet underwent an extreme and unusual increase in temperatures that is unlike anything experienced in the last 1,000 years. Detailed global temperature data collected when records began in 1850 show a sharp rise that strongly correlates with increasing levels of greenhouse gases in the atmosphere due to human activities. Most of the increase in temperatures has occurred since the 1970s. Most of the highest atmospheric and ocean temperatures have been measured in the past 10 years. According to the National Aeronautics and Space Administration (NASA), 2016 was globally the warmest year on record and the third warmest in a row,[4] and 2017 is the second hottest year so far.[5]

Figure 8, taken from the IPCC's fifth assessment report,[6] depicts globally averaged surface temperatures from 1880 to 2012 and shows a warming of 0.85°C. The total increase between the average of the 1850–1900 and the 2003–2012 periods is 0.78°C.

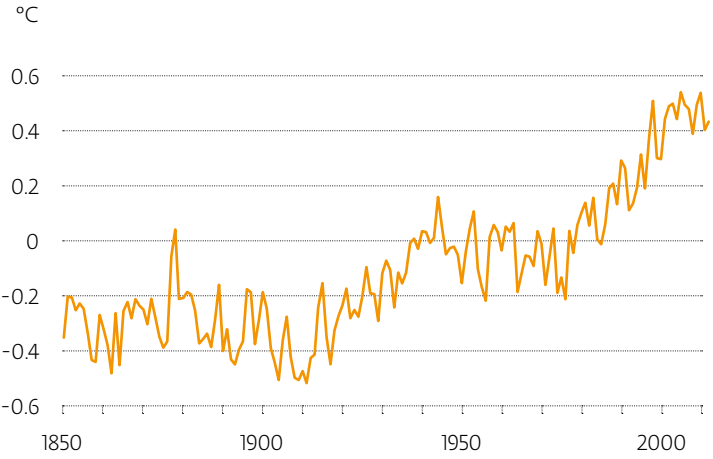


Figure 8: Observed globally averaged combined land and ocean surface temperature anomaly 1850–2012

Source: IPCC 2013 AR5 WG1

Evidence from the oceans

Scientists have measured many other effects that are correlated with the increase in greenhouse gas emissions. The oceans absorb large amounts of the CO_2 that has been emitted through a natural process. While this has reduced some of the worst effects of climate change, it has also caused the oceans to become more acidic, killing sea life and ruining the global fishing industry on which millions of people depend on for food and income. Scientists argue that as ocean temperatures rise, their ability to absorb CO_2 will be reduced.

Evidence from snow and ice

Global warming has caused melting of glaciers and snow and ice on mountains and at the poles. The melting has caused sea levels to rise by 17 cm in the past decade, threatening hundreds of coastal cities worldwide with flooding. Moreover, because snow and ice are an important water store, the melting has led to a decrease in the quantity and quality of water available in many countries.

Melting of snow and ice in the Himalayas threatens the water supply of billions

India, China, Pakistan, Nepal, Bhutan and Bangladesh (which contain over half the world's population) depend on the snow and ice in the Himalaya mountains for their water supply.

Normally, during the warm summer months, the snow and ice in the mountains slowly melt and supply Asia's major rivers, including the Ganges. In winter, cold temperatures cause more snow and ice to form, creating a huge water store for the next year.

If the snow and ice melt too quickly and do not re-form due to warmer winters, the result could be avalanches, floods and landslides followed by major rivers running dry and leaving billions of people with drastic water shortages.

Furthermore, the continued melting of glaciers affects the ocean's thermohaline circulation (also known as the Great Ocean Conveyor Belt, which is driven by differences in temperatures and salinity) as well as the ocean water density and the ocean-atmosphere interactions. These disturbances could be catastrophic

for the climate system, causing warm ocean currents to move from the equator to the polar regions and reducing coldness there.

Evidence from plants and animals[7]

Plants and animals as well as fish in rivers and seas have shown the impact of climate change by shifts in their locations and reductions in their populations. Since 1970 scientists have measured a decline of 52% in representative populations of mammals, birds, reptiles, amphibians and fish, which is attributed to human activities, including climate change. As temperatures have risen, plants and animals have moved to cooler areas to survive.

Evidence of extreme events[8]

There has been an increase in the frequency and intensity of extreme weather events such as heat waves, droughts, tropical cyclones and storms. Heat waves have increasingly fanned wildfires on almost every continent, particularly in North America and Australasia, destroying vast areas of vegetation, human settlements and sometimes human lives. In recent years storms and floods have caused devastation to crops and settlements, particularly in Asia, Europe, Africa and Latin America.

Endnotes

1 World Meteorological Organisation: www.wmo.int/pages/prog/wcp/ccl/faqs.php

2 Data from Union of Concerned Scientists website taken from the Energy Information Agency data compiled by the Energy Information Agency (www.ucsusa.org)

3 Most of the information in this section has been taken from IPCC 2014a – "Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report IPCC", Geneva: www.ipcc.ch/report/ar5/syr/, accessed August 2015. A summary is available at http://climate.nasa.gov/evidence/

4 NASA. "Warmest Year on Record Globally": www.nasa.gov/press-release/nasa-noaa-data-show-2016-warmest-year-on-record-globally

5 Climate Central. "2017 Second Hottest Year": www.climatecentral.org/news/midway-point-2017-2nd-hottest-year-21625

6 IPCC 2013. "The Working Group I Contribution to the IPCC's Fifth Assessment Report": www.ipcc.ch/pdf/assessment-report/ar5/wg1/WGIAR5_SPM_brochure_en.pdf

7 For more information about the impact of climate change on plants and animals, see "Living Planet Report 2016". World Wildlife Fund: http://awsassets.panda.org/downloads/lpr_living_planet_report_2016.pdf

8 For more information on climate extremes and climate change, see Sneed, A. 2017. "Yes, Some Extreme Weather Can Be Blamed on Climate Change". *Scientific American*: www.scientificamerican.com/article/yes-some-extreme-weather-can-be-blamed-on-climate-change/;
Huber, D. and Gulledge J., 2011. "Extreme Weather and Climate Change". Centre for Climate and Energy Solutions: www.c2es.org/publications/extreme-weather-and-climate-change; and
Union of Concerned Scientists. "Is Global Warming Linked to Severe Weather?": www.ucsusa.org/global_warming/science_and_impacts/impacts/global-warming-rain-snow-tornadoes.html#.WcDj7tFx3IU

2 The Zimbabwean context

This chapter was reviewed by Dr Dube with contributions from Shingirai Nangombe, Prof. Mugabe, Elisha Moyo and Dr Ndebele-Murisa

In this chapter we look at the current state of people, land and economy in Zimbabwe, in terms of vulnerability to climate change as well as the adaptive capacity of Zimbabwean communities.

Chapter summary

Zimbabwe is endowed with abundant human and natural resources and infrastructure – roads, urban and rural settlements, healthcare and educational facilities – giving it the potential for high adaptive capacity. However, the availability of most natural resources is climate-sensitive. The economy is heavily reliant on rain-fed agriculture, mining and hydro-powered electricity. Thus, its strength and stability are linked to the climate and the state of water resources. Due to historical injustices and more recent socio-economic and developmental setbacks, many of these resources have become degraded, leading to increased vulnerability to hazards and shocks, including those linked to climate change and variability.

> Vulnerability denotes the level of exposure to hazards, sensitivity to the effects of hazards and the capacity to adapt to the new conditions that climate change is likely to present, including developing resilience to potential hazards.

Climate[1]

Zimbabwe is located in the sub-tropics, which makes rainfall the most important climate parameter. The climate is strongly influenced by the movement of the Inter-Tropical Convergence Zone, which brings rainfall through the collision of warm moist air masses from the north and cool air masses from the south. Zimbabwe has a hot rainy season with significant rainfall for about four months between October and March followed by a dry period of about six months. The cold dry season lasts for about three months from May to July.

Most rural Zimbabwean depend on water sources that are far from their homes. This will worsen in future

Rainfall

Zimbabwe has one of the most variable rainfall patterns in terms of distribution across time and space, and dry spells and droughts are part of a normal cycle. During an average rainy season, it is normal for the country to experience four to five dry spells of different lengths. Flash flooding and hailstorms are often experienced during the rainy season.

Figure 9 shows the variability in average seasonal rainfall since records began in 1901. As is shown by the strongly zigzagging line, Zimbabwe has experienced wide fluctuations in average seasonal rainfall over the last century. The red line on the graph indicates that average rainfall is gradually declining. The decline is attributed to natural and human-induced climate change.

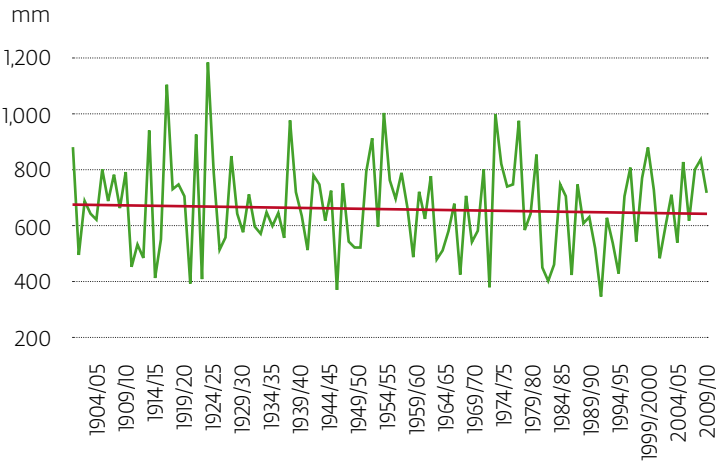


Figure 9: Zimbabwe average seasonal rainfall (mm) 1901/02 to 2009/10

Source: Meteorological Services Department of Zimbabwe

Zimbabwe also experiences wide variations in the rainfall distribution across the country. The higher-altitude districts along the central watershed and the eastern highlands typically experience greater amounts of rain (above 1,000 mm per season) than low-lying areas and in the west (350–450 mm per season). The western parts usually receive the first rains of the season when cloud bands appear from the west before the main rain-bearing systems build up, producing the convectional rainfall which is the bulk of the type of rainfall received across the country during a normal rainy season.

The southern and south-eastern parts occasionally experience drizzle, or *guti*, and light rain brought by cool, moist south-easterly air masses from the Indian Ocean during both summer and winter. Relief rainfall is often experienced along the main watershed and in the eastern highlands. Figure 10 shows the average rainfall distribution across the country.

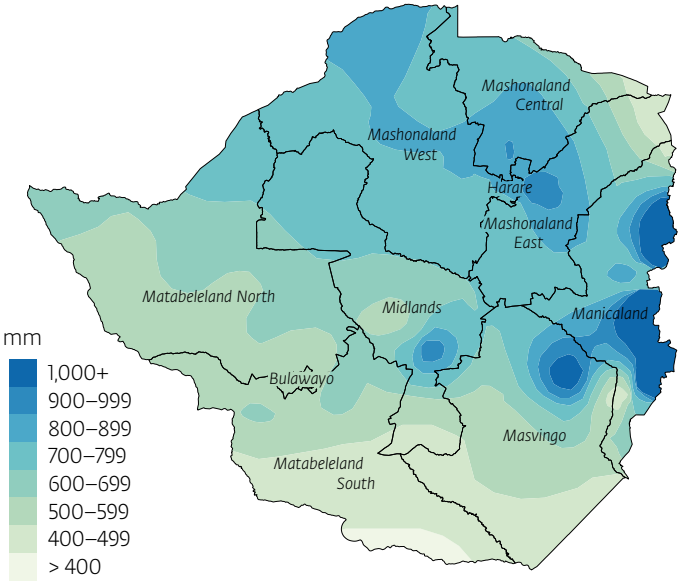


Figure 10: Zimbabwe average annual rainfall map 1980/81 to 2009/2010

Source: Meteorological Services Department of Zimbabwe[2]

Temperature

Temperature also varies across Zimbabwe and this is mainly due to differences in altitude. On average the elevated central watershed and eastern highlands experience lower temperatures than low-lying areas in the west and south. Figure 11 shows the average maximum temperatures across the country, with the lowest maximum temperatures being experienced in the eastern highlands and the hottest in the low-lying areas in the west and extreme south. All areas have a daily temperature range which is lowest just before sunrise, usually increasing by more than 10°C to reach the maximum around mid-afternoon.

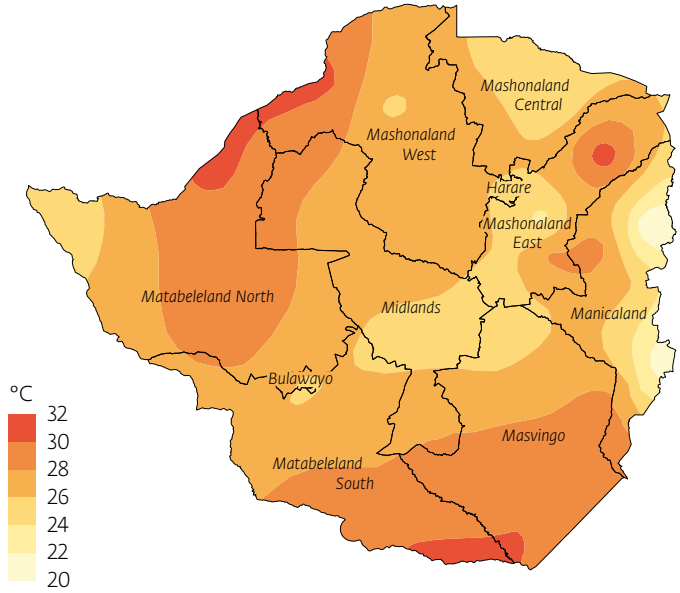


Figure 11: Zimbabwe average maximum temperatures map 1980/81 to 2009/2010

Source: Meteorological Services Department of Zimbabwe

Climate-related hazards

Weather hazards experienced in Zimbabwe commonly include tropical cyclones and thunderstorms, sometimes leading to hailstorms, heat waves, floods and flash flooding. The most flood-prone areas are shown in Figure 12b. The country is often affected by mid-season dry spells and droughts lasting from one to three years and occurring every five to seven years.[3] Figure 12a shows the most drought-prone areas. Temperature extremes can cause ground frost during the cold season and heat waves during the hot season. In the past few years there has been an increase in violent storms, with sudden strong winds occurring over small geographical areas (micro- and macro-bursts). These can cause serious destruction to property, crops and forests as well as loss of life.[4]

Rainfall over Harare

Droughts and floods are part of a natural cycle, partly influenced by a climate pattern called the El Niño–Southern Oscillation (ENSO), which originates in the equatorial Pacific Ocean. Researchers have long noted that ENSO is a dominant mechanism responsible for weather and climate extremes over Southern Africa,[5] hence its use for drought predictions. During some years of the cycle, sea temperatures in the equatorial east Pacific Ocean rise above normal and this causes rainfall fluctuations across the southern hemisphere. An El Niño can last up to nine months. The correlation between El Niño events and droughts in Zimbabwe is very high.[6] The past 10 drought years in southern Africa were all El Niño years.[7] The opposite of an El Niño is called La Niña (also referred to as the cold phase of El Niño) and often results in heavy rainfall and flooding in parts of Zimbabwe. La Niña effects result from the waters of the Pacific Ocean cooling below average temperatures.

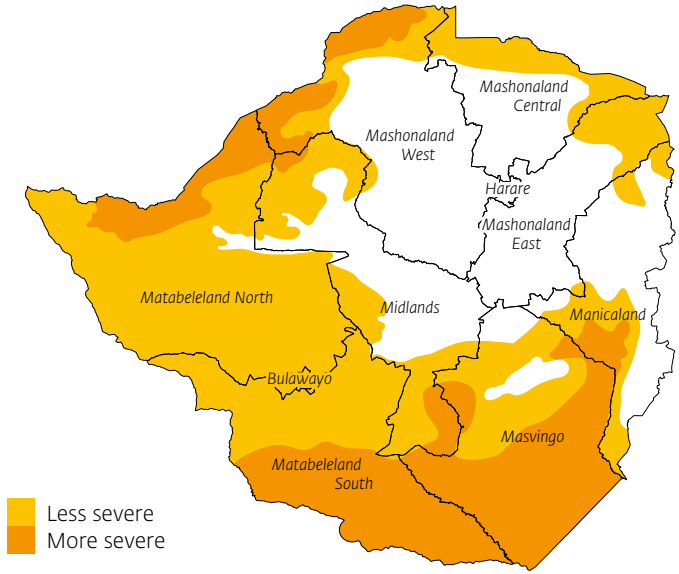


Figure 12a: Zimbabwe's drought-prone areas

Source: Zimbabwe National Water Authority

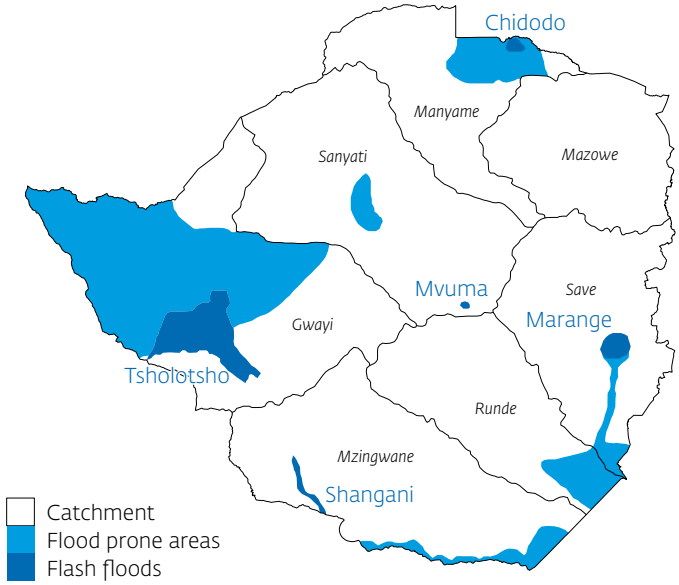


Figure 12b: Flood-prone areas

Source: OCHA

Climate change is expected to bring an increase in average temperatures across the country of up to 4°C by the end of the century.[8] Most climate models project a decrease in average rainfall in most parts of the country under the most probable and worst-case emission scenarios. Other models project small increases in some parts of the northern and eastern parts of the country.[9] Rainfall variability and extremes are expected to increase and climate-related hazards such as droughts and floods are likely to become more frequent and severe. These impacts are described in detail in chapter 3.

Natural resources

Zimbabwe has abundant natural resources, including minerals, agricultural land, water, forests and wildlife.[10] The population in urban and rural areas depends heavily on ecosystem services that provide a clean, regular water supply, fertile soils and trees for fuel, building and fencing. Many Zimbabweans draw on important food sources – fruit, vegetables, mushrooms and insects – and timber and non-timber products harvested from natural areas in times when agricultural produce is out of season.

Ecosystem services

An ecosystem is a community of living organisms, such as plants and animals, and the non-living parts of their environment such as soil, rocks, air and water. Ecosystem services are the benefits that humans get from ecosystems. They include food, clean water and air, waste disposal (through decay), fertiliser, fuel, control of pests and diseases, and climate regulation.

Degradation of natural resources

These vital natural resources and services have become degraded through various human activities. Some notable examples are soil erosion, siltation of rivers and dams, veld fires, burning for land clearing, infrastructural developments and cultivation in wetlands, deforestation and poor grazing management. The establishment of human settlements in fragile ecosystems, lack of control of water run-off on slopes and uncontrolled open-cast mining have added to the degradation of ecosystems and the services they provide.

Deforestation has become a major problem as forests are cleared in preparation for agriculture, for fencing and as firewood for cooking, tobacco curing and brick making. Zimbabwe is losing its forest cover at a rate of 9% per decade and lost 36% of its forests between 1990 and 2015.[11]

Destruction of natural habitats, pressure from human settlements and poaching have decimated wildlife populations, particularly those of endangered species. Climate change will accelerate the degradation and its impacts will be felt more strongly.

Natural/agroecological regions

Zimbabwe is divided into the five natural regions shown in Figure 13 based on soil types, vegetation and climate. The regions were mapped as a result of a rigorous agroecological survey of soils, vegetation and climate carried out in the 1960s to help planners identify the optimum types of agricultural land use for each part of the country. Many scientists propose that the natural region map be redrawn because of climate change, with regions IV and V

covering more area and regions I, III and IV less.[12] This is discussed in detail in chapter 3.

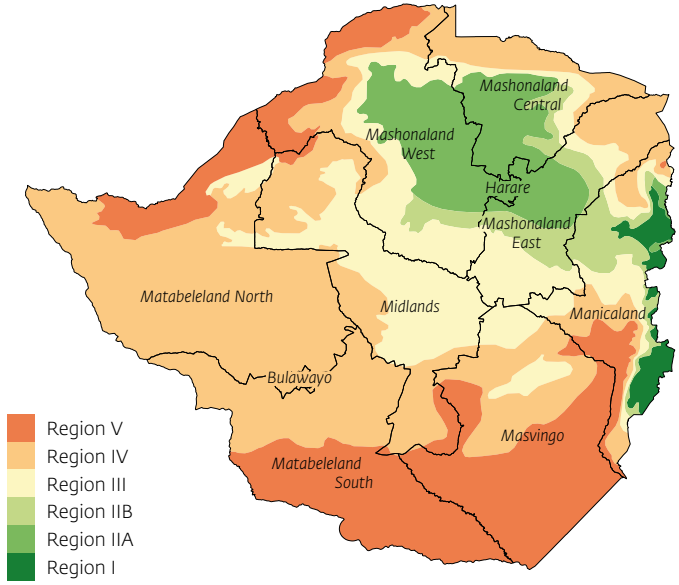


Figure 13: Zimbabwe's natural regions

Source: Meteorological Services Department

Natural Region descriptions

Region I: High rainfall (over 1,000mm per year), low temperatures and steep slopes. Suitable for high-value arable farming, dairy, horticulture and forestry.

Region II: Medium rainfall (750 to 1,000 mm per year). Temperatures are not extreme and soils are generally good. Suitable for intensive farming, including horticulture and dairy.

Region III: Low rainfall (500–750 mm per year), with mid-season

A typical rural scene in northern Zimbabwe

dry spells and high temperatures. A semi-intensive farming region suitable for field crops such as maize, soya, tobacco and cotton as well as livestock.

Region IV: Low rainfall (450–650 mm per year), with severe dry spells during the rainy season and frequent seasonal droughts. Suitable for livestock and drought-tolerant field crops such as sorghum, millet, cowpeas and groundnuts.

Region V: Highly erratic and very low rainfall (less than 650 mm per year). Suitable for livestock, wildlife management, beekeeping and non-timber forest products.

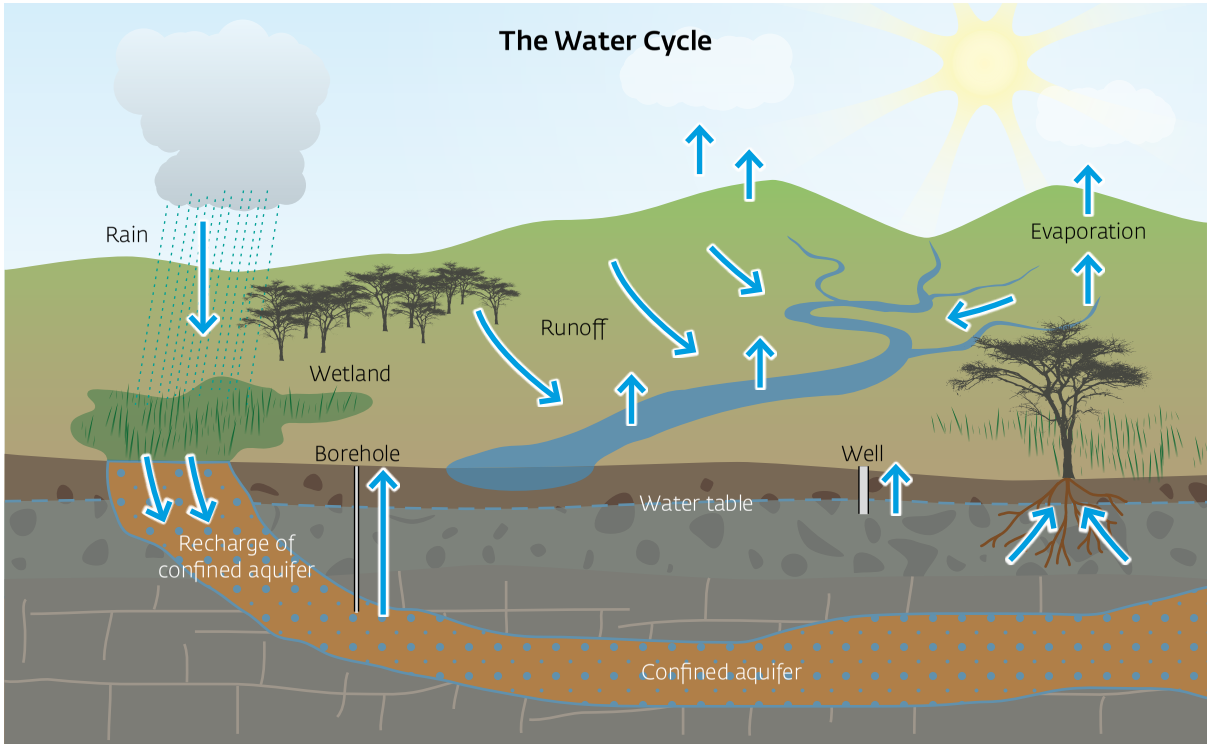
Communities in natural regions IV and V, which make up about 64% of the land area, tend to be most vulnerable to climatic extremes, which is aggravated by poverty and lack of livelihood options. These regions are already feeling the impacts of climate change and variability and will be the hardest hit in the future.

Water[13]

Water availability dictates the distribution of livelihoods and economic activities that occur across Zimbabwe. According to analyses[14], the southernmost districts of Zimbabwe experience physical water scarcity, meaning that there is insufficient water to satisfy human needs. The rest of the country experiences economic water scarcity, denoting a lack of infrastructure and limited finance that hinder access to water that is available in nature. Water is also central to many climate adaptation options, from irrigation and aquaculture to diversified livelihoods such as mining.

The diagram overleaf explains the water cycle, showing the atmospheric, surface and underground water stores and the links between them. Due to its seasonal rainfall pattern, Zimbabwe has only a few months of the year during which to recharge surface and underground water stores.

Water exists in the air, soil, rocks and in plants. It evaporates from surface stores, including plants, rivers and dams, and becomes stored in clouds. It returns to the earth as rainfall, some of which runs off surfaces and ends up in wetlands, streams, rivers and dams. Some water seeps into the soil and recharges the underground stores, including the soil and aquifers.



The total available water for Zimbabwe today is around 20 million megalitres (1 megalitre = 1 million litres).[15] This is in the form of surface water (streams, rivers and dams) and underground stores, including wetlands and aquifers (water-storing rock). Zimbabwe has over 8,000 dams, the largest of which is Kariba with a capacity of 1.8 million megalitres. Kariba supplies 80% of Zimbabwe's electricity. Generation of electricity from hydropower will be affected by climate change since lower rainfall means less water in Kariba and hence less generating capacity.[16]

Underground water

It is estimated that 8 million megalitres of underground water is available through wells and boreholes.[17] This supports 70% of Zimbabwe's population, mainly in rural areas. Most water demand is agriculture-related, for irrigation and livestock, as shown in Figure 14. Shallow wells, which serve most families in rural areas, draw on water stored in the soil. They tend to dry out with use and when the water table (the level of water in the soil) lowers as the dry season progresses. However, wells quickly recover their capacity if rainwater is able to flow through the soil to recharge the water table and if the soil in the area is protected to reduce compaction and erosion. Boreholes, on the other hand, tap into aquifers and are a more reliable water source. Depending on the rock type, some underground aquifers are recharged by rainfall; non-rechargeable aquifers become permanently dry once the water has been extracted.

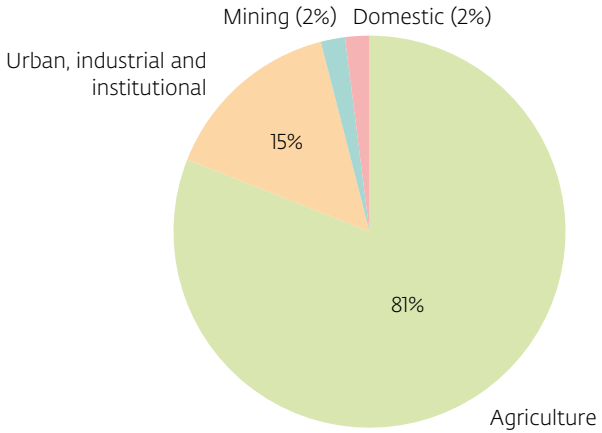


Figure 14: Water use by sector in Zimbabwe

Adapted from GoZ 2014 data

Threats to water resources

Reduced ground cover and expansion of human settlements increase surface water run-off, leading to soil erosion and siltation of water bodies. They also decrease the rate of infiltration, which slows the recharging of underground stores.

Population growth, demand for water from growing economic activity and increased consumption are widening the gap between water supply and demand. Pollution of surface and underground water and inappropriate irrigation methods, which can lead to a damaging build-up of salt in soil,[18] reduce the amount of water that can be used and degrade soil quality.

The quality of water for both urban and rural communities has deteriorated due to several factors: population pressure; climate fluctuations; cultivation and construction on watercourses and wetlands; and pollution from agriculture, industry and mining.

A typical wetland system in Zimbabwe with a small stream surrounded on either side by areas of saturated soil

This has led to increased health hazards, including diarrhoeal diseases and a cholera outbreak in 2008/2009, which was the worst in African history.[19]

Climate change is predicted to have a negative effect on the quantity and quality of Zimbabwe's available water. For example, the quality of Harare water improves when the main reservoir receives high rainfall, which dilutes the waste that flows into the lake. Climate-related changes in rainfall and water also have implications for the health and functioning of water ecosystems: rivers and streams, for example, need a minimum flow threshold for their living organisms to survive.

People [20]

Zimbabwe has a diverse population, with 67% living in rural areas. The national census of 2013 put the total population at 13,061,239, of which 41% were under the age of 15.[21] The total fertility rate is 3.8 children per woman, which is one of the lowest in sub-Saharan Africa. The population is predicted to double in about 70 years based on these figures. Life expectancy is 58 years and the average household size is 4.2 people.

Compared to other countries in the region, Zimbabwe has substantial infrastructure in terms of healthcare, schools and transport networks,[22] although they have been run down by the political and economic problems experienced in the past two decades. The country boasts one of the most educated populations in Africa, with an overall literacy rate of 96% (94% for women).[23] There is also a vast wealth of local traditional knowledge that has enabled Zimbabwean communities to adapt to a fluctuating climate for centuries.

The range of livelihoods is diverse. The Zimbabwe Vulnerability Assessment Committee (ZimVAC, 2011) conducted a national survey identifying 25 main livelihoods linked to geographical areas. The survey highlights the dependence of Zimbabweans on natural resources as a source of livelihoods. This survey also provides "a foundation for better understanding of the dynamics of change and vulnerability within households".[24]

Health

The main health issues in the country are high child mortality and poor maternal health. The 2015 demographic health survey found that 27% of children under five years were suffering from chronic under-nutrition, or stunting, a drop from 39% in 2010.[25] Stunting

Many grandparent-headed households in Zimbabwe already struggle to feed their dependants

in Zimbabwe is related to poor dietary diversity, maternal and child feeding practices and diarrhoeal and other diseases.

The most prevalent diseases are the human immunodeficiency virus (HIV) and acquired immune deficiency syndrome (AIDS), malaria, tuberculosis and diarrhoeal infections. HIV/AIDS prevalence has fallen to 14.7% from a peak of 27.7% in 1997.[26] Over half of the population lives in areas infested by malaria-transmitting mosquitoes.[27] Transmission of malaria is related to temperatures and rainfall and is highest during the rainy season. Most malaria cases and deaths come from Manicaland, Mashonaland East and Mashonaland Central.[28]

Resilience and vulnerability

The variable climate and turbulent history of Zimbabwe have bred a population that is familiar with adversity, having developed

both positive and negative strategies for coping with long-term hardship and acute shocks due to a range of factors, including:[29]

- The colonial relocation of the majority into marginal reserves that became overpopulated and degraded
- The effects of economic sanctions imposed on Rhodesia during the 1960s
- The impacts of economic structural adjustment programmes in the 1990s
- The HIV and AIDS pandemic in the 1990s
- Recent economic and political instability (2000–present)

This has given rise to a resilient and adaptable people. However, past and present challenges have created vulnerability. The Zimbabwe Poverty Atlas 2015[30] uses a range of statistics related to welfare and inequality to give a detailed overview showing that poverty is widespread in most rural communities. Levels were highest overall in Matabeleland North (85.7%) with "hotspot" districts identified as Nkayi (95.6%), Lupane (92.9%), Gokwe South (90.9%) and Mudzi (90.0%). Prevalence for Harare and Bulawayo was considerably lower at 36.4% and 37.2% respectively. The causes of rural poverty relate in part to adverse climate and environmental conditions that disrupt agriculture, the main livelihood activity.

Urban drift and cross-border migration have extended the range of families' sources of income, but as seen during the HIV and AIDS epidemic, they have also removed the most economically and physically productive family members from the home, leaving female-, grandparent- and child-headed families to cope with rural hardships. Women, children, the elderly and the disabled are particularly vulnerable to hazards and shocks, especially in rural areas.[31] Cultural norms burden women with the responsibility to provide food, fuel and water, a responsibility that will be made increasingly difficult by climate change.

It is expected that climate change will exacerbate hardship and poverty among the people of Zimbabwe.[32]

Economy[33]

Zimbabwe has a diverse economy thanks to its amenable climate, abundant resources and highly educated population. This diversity strengthens Zimbabwe's adaptive capacity. However, the economy and agriculture in particular are heavily dependent on rainfall patterns, which make them sensitive to the impacts of climate change. Figure 15 shows how gross domestic product (GDP) has been strongly associated with rainfall fluctuations in the past. During years where rains have been good, GDP has increased proportionally. During drought years GDP has fallen.

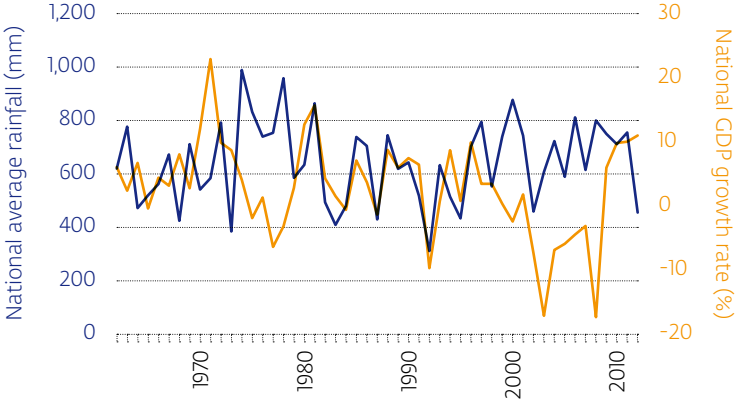


Figure 15: Variation in national GDP growth in relation to national average rainfall 1962–2012

GDP data: www.indexmundi.com/facts/zimbabwe/gdp-growth

Rainfall data: Meteorological Services Department

Figure 16 shows the contributions to GDP of the major economic sectors. About 60% of the population is employed in agriculture, which contributes about 15% to GDP. Most agriculture is carried out by smallholder farmers, who mostly live in communal farming areas. Mining makes the largest contribution to the economy and is the largest earner of foreign currency, contributing to 50% of exports, although it employs only 5% of the country's workers. Tourism, which is dependent on the quality of wilderness areas, including national parks and reserves, is an important contributor of foreign currency earnings and employment.

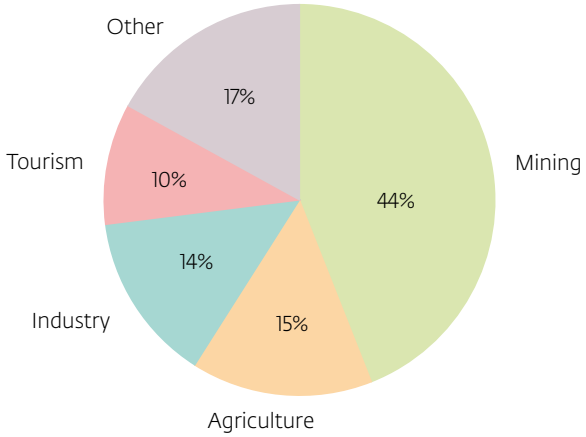


Figure 16: Contribution to national GDP by sector in Zimbabwe

Adapted from GoZ 2014 data

Energy

Most energy for industry, commerce and urban domestic activities comes from electricity, which is supplied by hydroelectric and thermal generation. Transport is mainly by road, fuelled by petrol and diesel. In the rural areas firewood is the main fuel for cooking

and heating, lighting is provided by kerosene, and food processing and irrigation are powered by petrol or diesel.

Zimbabwe has suffered periods of chronic electricity shortages in recent years. This, coupled with poor electricity coverage in rural areas, has led increasing numbers of Zimbabweans to install small solar systems or petrol- or diesel-powered generators. As the shortages have intensified, more people have turned to firewood for cooking, heating and agricultural activities such as tobacco curing. A recent study found that 37% of urban households are using firewood as a source of energy.[34] The current circumstances present opportunities to push the energy sector towards increased efficiency and more resilient low-carbon, renewable options such as solar.

Impacts of climate change

Climate change is likely to set back economic production in Zimbabwe. It will increase degradation of the natural environment on which so many people depend for their livelihoods. It will reduce water availability for agriculture and the generation of hydroelectricity on which industry depends. The natural regeneration of forests that supply firewood will be reduced as rainfall patterns change and extreme temperatures intensify the spread of wildfires.[35] As crops fail, people are likely to turn to other sources of income that are dependent on natural resources, including activities such as brick moulding, artisanal mining and sale of firewood, which adds to the degradation of resources.

In this chapter we have looked at the Zimbabwean context in terms of its vulnerability and adaptive capacity to shocks and hazards particularly those related to climate change. In the next chapter we will examine the impacts of climate change.

Endnotes

1 This section is based on information from Zambuko, C. 2011. "Climate Issues and Facts". Zimbabwe Meteorological Services Department: www.itu.int/ITU-D/emergencytelecoms/events/Zimbabwe_2011/Climate%20Issues%20and%20Facts-%20Zimbabwe%20-%20Dept%20of%20Met.pdf, accessed August 2015

2 Meteorological Services Department: http://weather.utande.co.zw/climate/climatechange.htm

3 Davis, R. and Hirji, R. 2014. "Climate Change and Water Resources, Planning, Development and Management". Issues paper. World Bank and Government of Zimbabwe: http://documents.worldbank.org/curated/en/2014/10/23839207/climate-change-water-resources-planning-development-management-zimbabwe, accessed August 2015

4 Moyo, E.N. and Nangombe, S. 2015. "Southern Africa's Violent Storms: Role of Climate Change". IUTAM Symposium on the Dynamics of Extreme Events Influenced by Climate Change 2013. *Procedia* IUTAM 17: 69-78www.sciencedirect.com/science/article/pii/S2210983815002497/pdf?md5=d19a37ea855bb478603a34f968b3a464&pid=1-s2.0-S2210983815002497-main.pdf, accessed August 2017

5 Rocha, A, and Simmonds, I. 1997. "Interannual Variability of South-eastern African Summer Rainfall. Part II: Modeling the Impact of Sea-surface Temperatures on Rainfall and Circulation". *International Journal of Climatology* 17: 267–290;
Manatsa, D., Chingombe, W. and Matarira, C. H. 2008. "The Impact of the Positive Indian Ocean Dipole on Zimbabwe Droughts". *International Journal of Climatology* 28: 2011–2029. doi:10.1002/joc.1695

6 Nangombe, S., Madyiwa S. and Wang J. 2016. "Precursor Conditions Related to Zimbabwe's Summer Droughts". *Theoretical and Applied Climatology* DOI 10.1007/s00704-016-1986-4

7 Ibid.

8 Rurinda J., van Wijk, M.T., Mapfumo, P., Descheemaeker, K., Supit, I, and Giller K.E. forthcoming. "Simulating Maize Yield Responses to Climate Change and Adaptive Farm Management Options for Supporting Smallholder Farmers Decisions in Zimbabwe" in *Global Change Biology*, 21(12)

9 IPCC 2014a. "Climate Change 2014: Synthesis Report". Contribution of Working Groups I, II and III to the Fifth Assessment Report". IPCC, Geneva: www.ipcc.ch/report/ar5/syr/, accessed August 2015 and
Moyo, E.M. 2017. Draft DPhil thesis

10 Mutasa M. and Ndebele-Murisa M.R. 2015. "Biodiversity and Human Development in Zimbabwe" in Murisa T. and Chikweche T. eds. *Beyond the Crises: Zimbabwe's Transformation and Prospects for Development*. Trust Africa, Dakar, and Weaver Press, Harare

11 Food and Agriculture Organisation 2015. "Global Forest Resources Assessment Country Reports, Zimbabwe, Africa": www.fao.org/documents/card/en/c/da5d758a-af38-45f7-b4ac-483ebd41782e/, accessed August 2015

12 Mugabe, F. T., Thomas, T. S., Hachigonta, S. and Sibanda, L. 2013 eds. "Zimbabwe" in *Southern African Agriculture and Climate Change: A Comprehensive Analysis*. Research monograph, International Food Policy Research Institute, Washington, DC: http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/127792, accessed August 2015;
Brown, D., Chanakira, R., Chatiza, K., Dhliwayo, M., Dodman, D., Masiiwa, M., Muchadenyika, D., Mugabe, P. and Zvigadza, S. 2012. "Climate Change Impacts, Vulnerability and Adaptation in Zimbabwe". IIED Climate Change Working Paper 3, October 2012: http://pubs.iied.org/pdfs/10034IIED.pdf, accessed August 2015

13 Most of the information in this section is from Davis, R. and Hirji, R. 2014. "Climate Change and Water Resources, Planning, Development and Management". Issues paper. World Bank, Government of Zimbabwe: http://documents.worldbank.org/curated/en/2014/10/23839207/climate-change-water-resources-planning-development-management-zimbabwe, accessed August 2015

14 For more information, see UN Water: www.un.org/waterforlifedecade/scarcity.shtml and FAO http://www.fao.org/documents/card/en/c/a2128b09-361c-5468-9d93-2189cc430234/

15 Davis and Hirji 2014

16 Ibid.

17 Government of Zimbabwe 2014. "National Climate Change Response Strategy": www.ies.ac.zw/downloads/draftstrategy.pdf, accessed August 2015

18 For more information, see FAO. "Salty Soils": www.fao.org/docrep/r4082e/r4082e08.htm

19 Niang, I., Ruppel, O.C., Abdrabo, M.A., Essel, A., Lennard, C., Padgham, J. and Urquhart, P. 2014. "Africa" in *Climate Change 2014: Impacts, Adaptation, and Vulnerability*. Part B: "Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change" (Barros, V.R., Field, C.B., Dokken, D.J., Mastrandrea, M.D., Mach, K.J., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R. and White, L.L. eds). Cambridge University Press, Cambridge and New York:1199-1265

20 Most information in this section is taken from the National Climate Change Response Strategy, GoZ 2014

21 ZimStat 2013a "Census Report 2012": www.zimstat.co.zw/Census/CensusResults2012/National_Report.pdf, accessed August 2015

22 UNDP Human Development Report: http://hdr.undp.org/en/countries/profiles/ZWE; Index Mundii : www.indexmundi.com/g/rank.html, accessed August 2017

23 ZimStat 2013b. "Poverty, Income, Consumption and Expenditure Survey Report 2011/2012": www.zimstat.co.zw/dmdocuments/Finance/Poverty2011.pdf, accessed August 2015

24 Zimbabwe Vulnerability Assessment Committee 2011 "Zimbabwe Rural Livelihoods Baseline Profiles 2011"

25 GoZ 2015 "Zimbabwe Demographic and Health Survey 2015, Final Report": https://dhsprogram.com/pubs/pdf/FR322/FR322.pdf, accessed August 2017

26 UNAIDS 2015: www.unaids.org/sites/default/files/country/documents/ZWE_narrative_report_2015.pdf, accessed August 2017

27 USAID: http://photos.state.gov/libraries/zimbabwe/231771/PDFs/PMI%20USAID.pdf, accessed August 2017

28 USAID: www.pmi.gov/docs/default-source/default-document-library/country-profiles/zimbabwe_profile.pdf?sfvrsn=28, accessed August 2017

29 For details, refer to Raftopoulos, B. and Mlambo, A. 2009 eds. *Becoming Zimbabwe: A History from the Pre-Colonial Period to 2008*. Weaver Press, Harare.

30 ZimStat. "Poverty Atlas 2015": www.zimstat.co.zw/sites/default/files/img/publications/Accounts/Poverty_Atlas_0.pdf, accessed August 2017

31 Manjengwa, J., Matema, C., Mataruka, J., Tirivanhu, D., Mufaro, T. and Feresu, S. 2014. "Children and Climate Change in Zimbabwe". UNICEF and Institute of Environmental Studies, University of Zimbabwe: www.unicef.org/zimbabwe/Children_and_Climate_Change_in_Zimbabwe_Report_2014.pdf, accessed August 2015;
Chagutah, T. 2010. "Climate Change Vulnerability and Adaptation Preparedness in Southern Africa". Zimbabwe Country Report, Heinrich Böll Stiftung Southern Africa: http://za.boell.org/sites/default/files/downloads/HBF_web_Zim_21_2.pdf, accessed August 2015

32 Ibid.

33 Most information in this section is taken from "National Climate Change Response Strategy": www.ies.ac.zw/downloads/draftstrategy.pdf, accessed August 2015

34 Manjengwa *et al* 2014

35 This section is based on information from Zambuko 2011

A typical Zimbabwean landscape

3 The impacts of climate change

This chapter was reviewed by Dr Dube with contributions from Shingirai Nangombe, Prof. Mugabe, Elisha Moyo and Dr Ndebele-Murisa

This chapter looks at the current and future impacts of climate change, first at the global level, then on Africa and finally on Zimbabwe's natural resources, economy and its people.

Chapter summary

The Earth for the rest of the century[1]

The effects of climate change are already being recorded across the globe. Although it is difficult for scientists to determine accurately how the Earth's systems will respond to more greenhouse emissions and changes in climate, they offer some plausible options on how we may be affected. Advances in science and improvements in computer power have helped scientists develop models that represent the Earth's climate system. They enable the modelling of past, current and future emissions and their possible effect on the climate.

The impacts of climate change will depend on:

- The rate at which concentrations of greenhouse gases build up in the atmosphere and our efforts to reduce their emissions
- How strongly these increases in emissions affect the atmospheric water and energy budgets in terms of temperature and rainfall and sea level changes, among other key phenomena
- Natural climate fluctuations due to phenomena such as volcanic activity, changes in the Sun's intensity and changes in ocean circulation patterns[2]

The measures that we put in place to adapt to climate change will significantly influence how we are affected. Climate scientists now know that even if greenhouse gas emissions are stopped completely, many of the harmful effects of climate change will persist for decades due to the complex nature of the Earth's natural systems.[3] An analysis of the proposed national climate actions put forward by many governments as part of the Paris climate change agreement supports this.

Climate models and emissions scenarios

Scientists have developed several powerful computer models to help project how the climate will change across the world. The models draw on knowledge of atmospheric physics, equations of motion and meteorological data that have been routinely collected by meteorological departments in most countries over a long time. The computer projections are adjusted to match real, observed changes to increase their power and accuracy.

The models have been developed using imagined scenarios[4] of how greenhouse gas emissions are expected to change and how societies and economies could react to climate change, for instance through new policies, population dynamics and technological advancements. Each emission storyline represents a possible future with different demographic, social, economic, technological, and environmental developments.

Figure 17 highlights the areas across the globe where impacts are likely to be most severe. It can be seen from this map that the tropics are likely to experience the worst impacts of climate change.

Temperature changes and extremes

The latest report of the IPCC, issued in 2014,[5] projects that by the end of the century the average global temperature is very likely to rise by at least 2°C above pre-industrial levels. The Paris climate agreement that was signed by 195 countries in 2016 (see chapter 7) aims to keep global temperature increases to well below 2°C. However, recent projections, based on current government pledges and action, show that the Earth is on track to reach an average rise of 3.6°C by the end of the century.[6] Some areas on the planet are projected to have a higher magnitude of warming while others will cool.

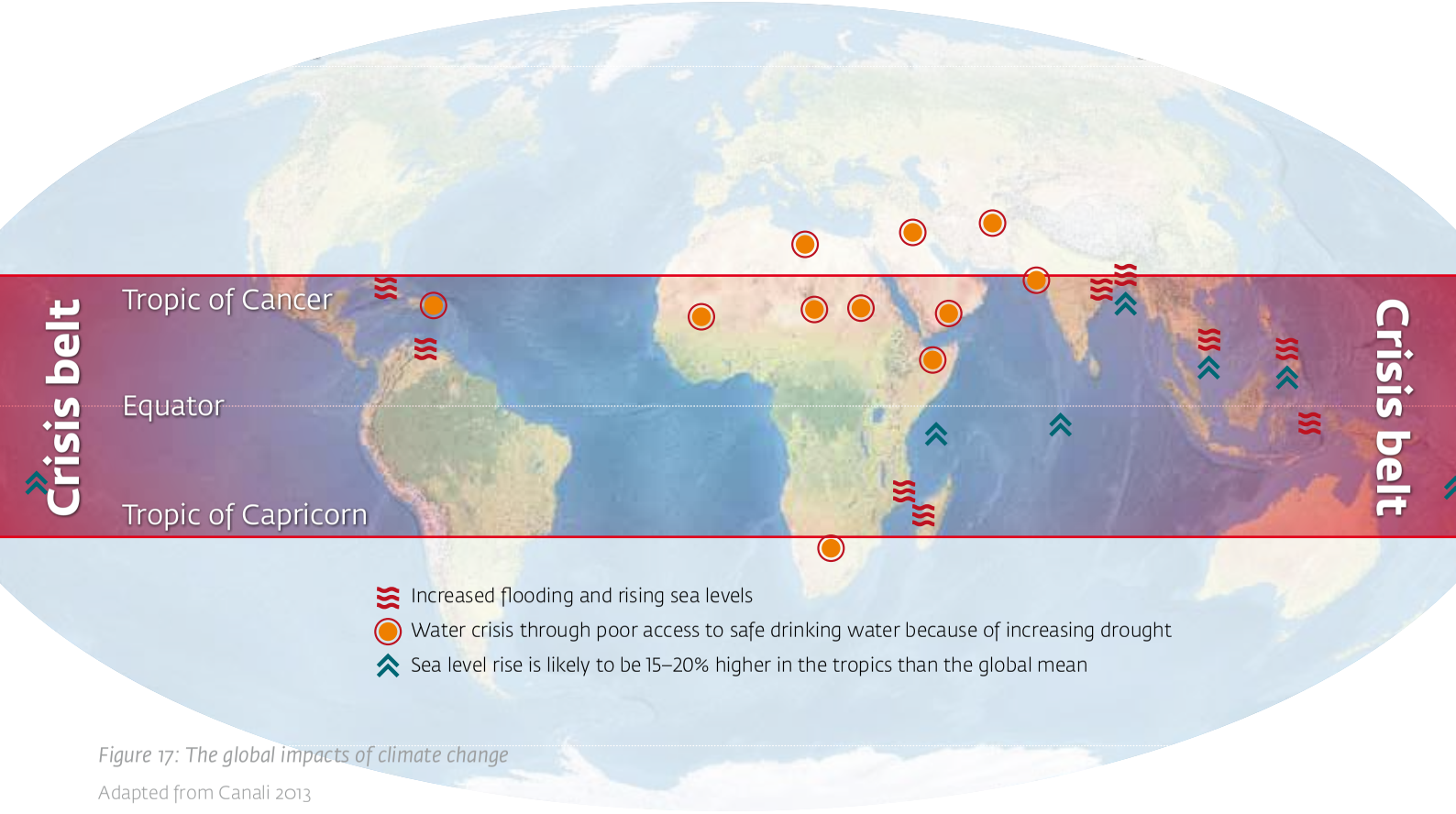


Figure 17: The global impacts of climate change

Adapted from Canali 2013

What does a rise of 2°C or 3°C mean?

A temperature change of a few degrees does not sound like much. Our bodies can hardly detect the difference between 0.5°C and 1°C, so it can seem hard for us to understand why two or even three degrees would make such a difference. However, the Earth is very sensitive to changes in climate. For an overview of what degree-by-degree changes in temperature will mean for humans and the planet, see *Six Degrees: Our Future on a Hotter Planet* by Mark Lynas, at www.youtube.com/watch?v=R_pb1G2wI0A or www.youtube.com/watch?v=7T9IjSEqT74 for a summary.

As explained in chapter 1, the rise in temperatures will have major impacts on global weather patterns as well as sea levels and many other natural systems. The impacts are likely to be most severe in the tropics, especially in Africa, Asia and South America. Studies on China, Europe and the United States foresee a strong likelihood of permanent shifts in seasonal temperature patterns to unprecedented levels by 2050.[7]

For example, the Mediterranean has been identified as a region that will be particularly prone to heat extremes, including heat waves.[8] Heat waves occurring in the rural USA, the Mediterranean and Australia have been linked to widespread outbreaks of wildfires which decimate large areas of natural vegetation, causing compounded environmental damage. It is likely that these events will become more common.[9]

Rainfall changes and water availability

The IPCC reports foresee that dryer regions such as southern

Africa are likely to become dryer and that wet regions along the equator are likely to become wetter in the course of this century. Rainfall is likely to increase in some high- and mid-latitude areas: the Arctic and Antarctic, northern Europe, northern Asia, northern USA and Canada, the southern parts of South America and southern Australasia, East Africa and other areas close to the equator. Rainfall is likely to decrease in the mid-latitude dry regions: southern Europe, parts of Asia, Australasia, North and South America and the sub-tropics, including southern Africa.

With a 2°C temperature rise above pre-industrial levels we can expect a 30% reduction in water availability in many sub-tropical regions, including the Mediterranean, southern Africa, central and southern South America and south Australia.[10] Water scarcity in the Mediterranean, North Africa and the Middle East is likely to exacerbate political instability and conflicts in these regions.[11]

Melting ice and sea levels

As the Earth warms, snow and ice on mountains will continue to melt rapidly. Since these are important stores of water, many communities which rely on them in different parts of the world, particularly in Asia and north and south America, will suffer water shortages. The ice caps at the poles will also continue to melt rapidly, accelerating the rise of sea levels. In fact, recent studies show that past and current sea level rises are much faster than projected by climate models.[12]

Rising sea levels will threaten the lives and livelihoods of millions of people in coastal areas across the world, submerging buildings and crops. According to the IPCC, sea levels could rise by between 26 cm and 55 cm by the end of the century if greenhouse gas emissions are reduced, but could increase by between 45 cm and

82 cm if emissions continue at the current rate of increase.[13] An additional problem is that rising sea levels introduce salt in the coastal soils, which raises the saltiness of the soils and renders them unfit for supporting important ecosystems like mangroves.

By 2100 sea levels could be up by 98 cm and could continue to rise for centuries even if greenhouse gas emissions are stopped. Although this does not sound like a lot, a small rise in sea levels can have a huge effect on aquatic life on which many human communities depend. By the end of the century between 147 million and 216 million people who currently live on land that will be under water or regularly flooded will be displaced.[14] Several major cities across the globe will be affected,[15] millions of hectares of agricultural land will be lost and some island states in the Pacific and the Maldives will be submerged.[16]

The growing influx of fresh water into oceans will change the water density and threaten the circulation system of the oceans (thermohaline circulation), which is critical for heat distribution across the Earth. Some studies suggest a worst-case scenario where the thermohaline circulation could shut down, resulting in the rapid cooling around the poles and heat accumulation on the equator.

Changes in the oceans

Rising temperatures and the acidification of the oceans due to the extra carbon dissolved in the water will cause extinctions, severely reducing the catches of global fisheries on which millions of people depend for food and jobs. The effects will be particularly evident in tropical coastal regions and islands where coral reefs, which support commercial fish production as well as tourism, will be almost completely destroyed.[17]

Impacts on plants and animals

It is projected that by 2050 one quarter of Earth's species are at risk of extinction if global warming continues.[18] In the past decade scientists have observed some animals and plant species – those that inhabit cooler climates – occurring in colder areas closer to the north and south poles or in higher altitudes in the Alps, in Queensland, Australia, and in Costa Rica. Fish populations in the North Sea have been observed moving their habitats northwards.[19] Plants are particularly vulnerable as they are slow to migrate to new areas in order to escape warming and drying. Many animals will lose their habitats and die as vegetation patterns change and water becomes scarce. Polar bears, sea turtles, whales, pandas, orang-utans, elephants and tigers are particularly under threat from climate change.[20] Mosquito-borne diseases such as malaria and the zika and chikungunya viruses may spread more rapidly and more widely. Invasive alien species may also be a common future as the climate changes.

Impacts on human communities

In 2006 Sir Nicholas Stern, a leading economic adviser to the UK government, produced a landmark report on the economics of climate change.[21] Although he was criticised by some as being alarmist, many take the report as a serious appraisal of the economic and development impacts of global climate change. The report was one of the first to catalogue the huge economic costs of climate change and to highlight that the benefits of swift action substantially outweigh the costs of switching to a low-carbon path. The report estimates that the global economy would eventually benefit by $2.5 trillion per year from switching to a low-carbon economy.

As things stand, climate change is likely to cause immense harm.

Many of Zimbabwe's iconic wildlife species will be threatened by climate change

Water resources will become severely stressed and competition for water will likely increase among geographical regions and socio-economic sectors such as domestic, agriculture and industry. Global food security is likely to be severely threatened. Production of all of the major food staples – maize, rice, soy and wheat – will be disrupted by changing rainfall patterns, rising temperatures, water shortages and spreading pest and disease infestations, particularly in tropical regions.[22] In some high-latitude regions yields of these crops may increase.[23]

The most recent IPCC report (AR5) projects that climate change will exacerbate health problems, particularly among low-income communities in developing countries.[24] Because built-up environments are hotter, urban communities will be at added risk from extreme events such as heat waves, water scarcity and flooding. Other resource pressures and extreme weather events are likely to bring about increased migration and escalate the threat of violent conflicts.

Impacts on Africa[25]

Africa is predicted to be the continent that will be worst affected by climate change because much of it lies between the tropics and because of its fragile economies and vulnerable populations. However, climate change will have a modest effect overall in comparison to Africa's other problems, notably the increasingly severe stresses on water resources brought about by urbanisation, the growth in populations and agriculture and land-use change, according to the most recent IPCC report.[26] This reinforces the idea that Africa needs to address development, adaptation and resource management issues urgently in preparation not just for climate change but also for a generally hazardous future.

The IPCC projects that average temperatures across most of Africa will increase more quickly than the global average: by the end of the century much of Africa could become 3°C to 6°C hotter and rainfall is likely to decline over North Africa and the south-western parts of South Africa. The effects of climate change will not be uniform. East Africa will be worst affected by flooding, West Africa will suffer a major decline in food production and southern Africa will be subjected to water shortages, tropical cyclones and drought.[27] Figure 18 summarises the major shake-ups foreseen in Africa as a result of climate change.

Summarising the data from several recent reports,[28] the major risks for Africa are seen as:

- A reduction in annual rainfall and groundwater recharge, except in East Africa where rainfall will increase
- A shift in rainy seasons and more frequent dry periods
- More frequent climate hazards – droughts, heat waves, wildfires, storms, tropical cyclones, intense rain and floods – causing damage to natural systems, crops, transport networks and human settlements

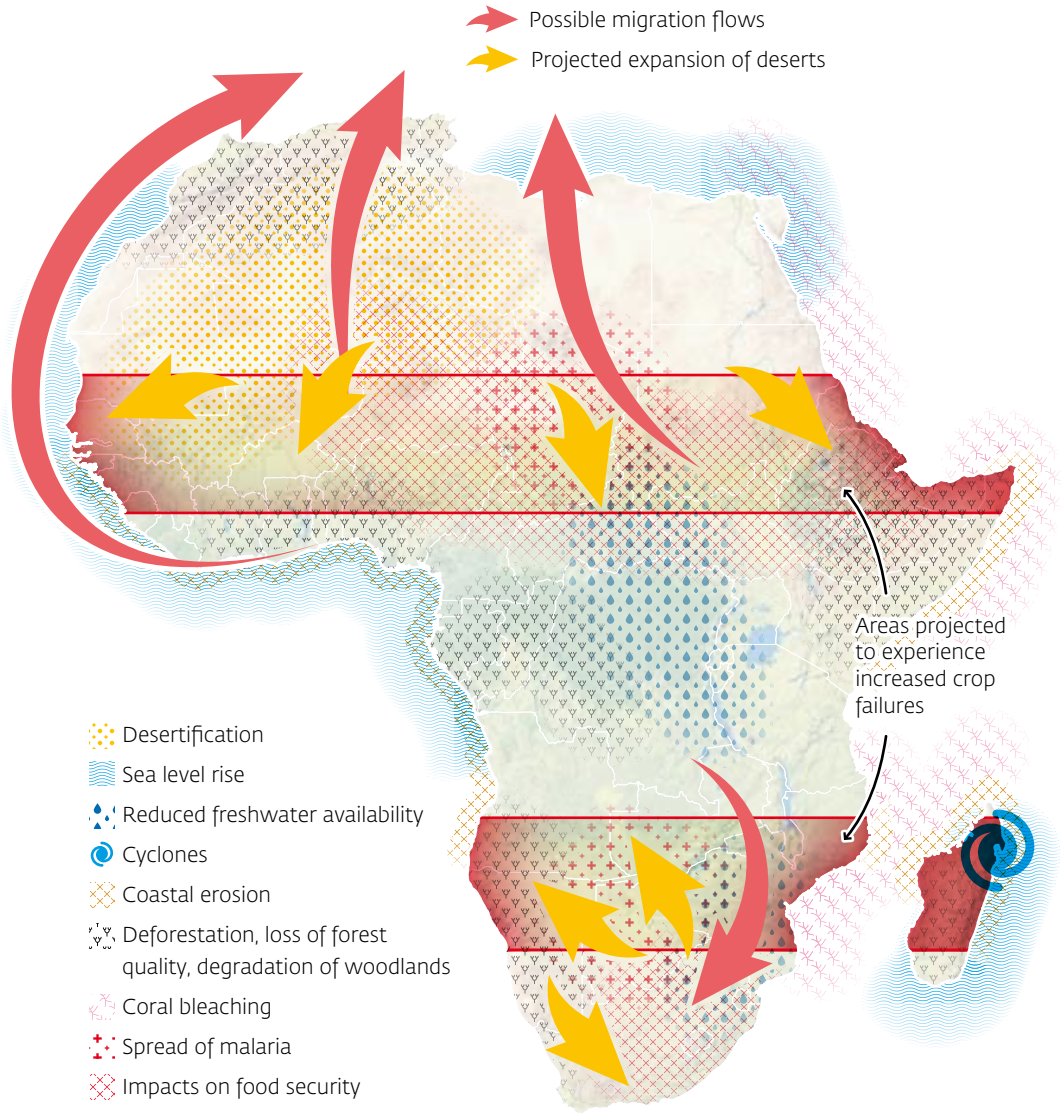


Figure 18: The expected impacts of climate change on Africa

Adapted from Canali 2013

Rural woman and children are particularly vulnerable to the impacts of climate change

- Threats to soil fertility from erosion and rising temperatures. A 4°C warming could result in crop failures occurring as often as every two years[29]
- Rising sea levels threatening coastal communities, especially in Mozambique and Nigeria where the greatest number of people will be affected in sub-Saharan Africa[30]
- Accelerated expansion of deserts, especially in Namibia and Botswana and southern Zimbabwe
- Increase in ocean acidity, resulting in degradation of coral reefs and damage to fisheries
- Reduced quantity and quality of water available for domestic and economic activities. Groundwater recharge rates have been projected to decline by 30–70 % in the western parts of southern Africa and to increase by around 30% in some parts of East and south-eastern Africa[31]
- Agriculture affected by heat and water stress and shortened growing seasons. Declines in crop yields of 27–32% for maize, sorghum, millet and groundnuts for a warming by 2050 of

about 2°C above pre-industrial levels[32]

- Shifts in ecosystems and shrinking grasslands for grazing animals
- Accelerated species extinction and destruction of wildlife habitats, depleting important ecosystem services such as the provision of fertile soil and clean water, and damaging tourism
- Spreading pest infestations and diseases of crops and livestock such as Rift Valley fever
- Harm to human health: injuries from extreme weather events; heat stress that can limit outdoor activities and lead to death; hygiene- and sanitation-related diseases such as scabies, diarrhoea, conjunctivitis, cholera and trachoma; malnutrition; and an increase the distribution of malaria[33]
- An upsurge in migration and displacement of human populations due to drought, floods, rising sea levels and other extreme events (see Figure 18), as well as social conflicts as people compete for dwindling resources[34]

Impacts on Zimbabwe

As noted in chapter 2, the vulnerability of natural and human systems – their sensitivity and exposure to hazards and their adaptive capacity – will determine the eventual impacts of climate change. From our appraisal of the Zimbabwean context in chapter 1 we can summarise factors contributing to Zimbabwe's vulnerability and adaptive capacity (Table 1).

Climate impacts

The observed and projected increase in rainfall variability makes it increasingly difficult for people who depend on rainfall and water

resources – including those involved with agriculture, tourism and industry – to plan their activities. Communities that have been made vulnerable by economic hardship and disease will find it even harder to cope let alone recover from climate-induced shocks and losses. Figure 19 presents a generalised view of how climate change could impact on crop yields in Zimbabwe, but as noted in the previous section, the climate models do not give a clear picture of what the future holds for our country.

Table 1: Factors contributing to Zimbabwe's vulnerability and adaptive capacity in the face of climate change.

Factors contributing to vulnerability	Adaptive capacity success factors
• The climate of Zimbabwe is already variable in terms of rainfall, mid-season dry spells and extremes • Dependence of a large proportion of the population on rain-fed agriculture for food security and livelihoods • Energy production partly dependent on hydroelectricity, which is vulnerable to rainfall fluctuations • Much of industry is climate-sensitive – industrial processes depend on labour and raw materials from rain-fed agriculture • Industry and agriculture are not highly mechanised and depend largely on human labour that can succumb to heat, illness and many other factors relating to climate change • Degradation of natural resources (soil, water, vegetation and wildlife) due to poor land management • High concentration of the population living in rural areas where climate impacts will be strongest • Widespread poverty, malnutrition and health problems in some districts • Physical and economic water scarcity in parts of the country • Lack of means to put adaptation plans and disaster risk reduction measures into practice (including financial resources, technologies, governance and institutional frameworks)	• Abundant natural resources • Basic infrastructure – roads, settlements and health and educational facilities • Diverse economy • High literacy levels • Relatively low fertility rate so the population is growing gradually • Extensive indigenous knowledge in some communities relating to survival in harsh environmental conditions (although this is being lost through urban drift) • Availability of indigenous crops that are drought-resilient and tolerant to high temperatures (although these are not favoured by the population) • High levels of social capital and strong social networks

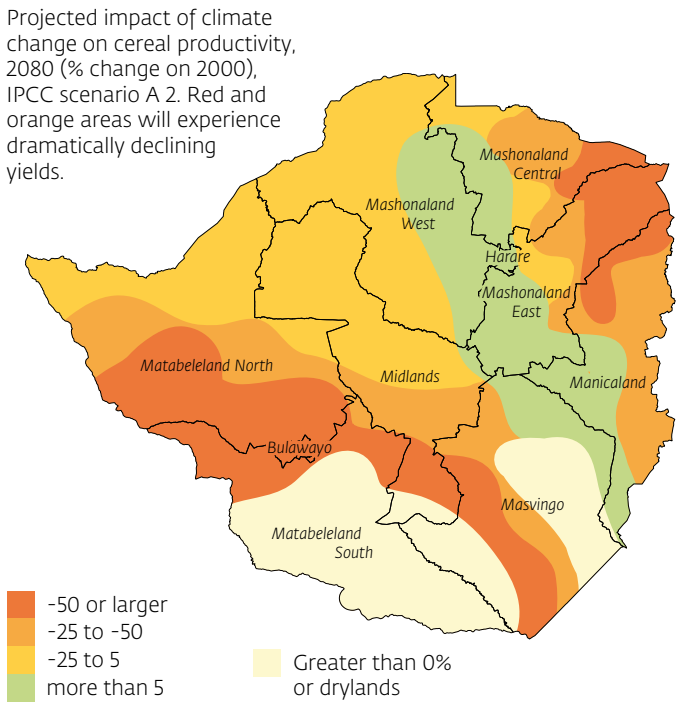


Figure 19: A generalised view of some likely impacts of climate change on crop yields in Zimbabwe

Source: adapted from Fischer (2005)

According to several studies[35], it is likely that by 2050 and until the end of the century there will be:

- A decrease in total annual rainfall of between 5% and 18%, with the highest decline seen in the south and west[36]
- A possible increase in rainfall in the north and east[37]
- Delayed onset and early ending of the rainy season
- More frequent and longer mid-season dry periods
- Reduced groundwater recharge
- Erratic rainfall distribution across the country
- More droughts and floods that may recur in successive years
- A temperature increase of 3°C–6°C, by the end of the century[38]

Temperature changes

Since 1900 average annual surface temperature across Zimbabwe has increased by 0.4°C. Studies and farmers' perceptions acknowledge that there are now more hot days and fewer cold days than in the past. The temperature increase has been most pronounced during the dry season. The five warmest years on record have occurred since 1987.[39] Figure 20 shows likely temperature changes across southern Africa using two different climate model scenarios: one which can be thought of as best case (urgent action is taken to reduce greenhouse gas emissions and global warming) and a worst-case scenario (humanity continues on a business-as-usual pathway).

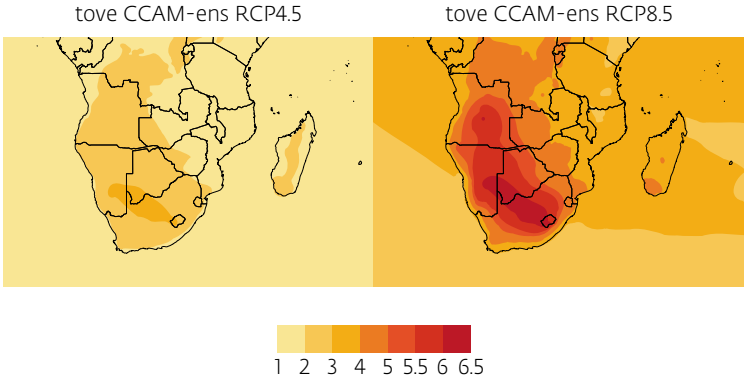


Figure 20: Likely changes in temperature across Southern Africa

Source: Francois Engelbrecht, CSIR RCP8.5 Scenario, means of six global models down-scaled to ~15 km using CCAM

Impacts on rainfall

The total amount of rain received during a typical rainy season has fallen by about 5% since 1900. There is evidence of greater intra- and inter-seasonal rainfall variability as well as unpredictability

Crop pests are likely to become more of a problem for farmers as temperatures rise

in temporal and spatial distribution. While the observed cumulative seasonal rainfall total remains largely unchanged, more dry days have been recorded during the rainy season combined with few heavy rain episodes. Droughts and floods have consequently increased in frequency since 1990, often occurring back to back with a flood year immediately following a drought year. Violent storms have become more numerous, affecting areas where storms were not previously known and destroying property and lives in many communities every year.[40]

The effect of climate change on rainfall in Zimbabwe differs from one climate model to the next, which is why the projected range of rainfall decline of between 5% and 18% is so large.[41] But while the aggregate change in rainfall seems small, there are likely to be greater fluctuations in rainfall in different areas at different times, which cancel each other because of spatial and temporal averaging.

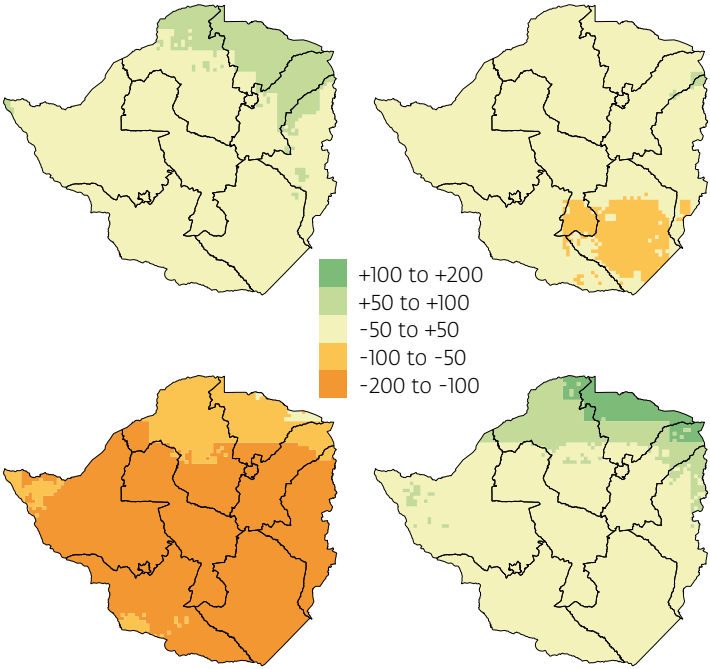
These changes are likely to lead to

- Reduced water supply for domestic and agriculture use from both surface and groundwater sources
- The expansion of natural region V, the shrinking of natural region I and shifts in the areas covered by natural regions III and IV (see Figure 22 for a comparison between the existing and proposed new natural regions) [42]
- Degradation of natural resources, especially soil, water, natural vegetation, crops and livestock, and extinction of wildlife species
- Reduced food security because of the impacts on agriculture, possibly leading to increased undernutrition, particularly in children
- Greater incidence of diseases such as diarrhoea, malaria and cholera due to reduced water quality, higher temperatures and increased flooding

Figure 21 shows projected rainfall changes under four downscaled climate models. The ECHAM5 model shows a significant decrease in annual precipitation – between -50 mm and 200 mm – over most of the country; CSIRO-MK3 shows decreased annual precipitation only in the south; CNRM-CM3 and MIROC3.2 show annual precipitation increasing in the extreme north and little change in the rest of the country.

Impacts on natural resources

As mentioned in chapter 1, Zimbabweans depend heavily on ecosystem services that provide, among other things, clean water, fertile soils, timber and fuelwood and nutritious wild foods. These services are already under pressure from overexploitation and poor resource management, and will therefore come under greater stress during climate change.



Notes: All maps assume the A1B scenario using different models. Clockwise, from top left: the CNRM-CM3 general circulation model (GCM); CSIRO-MK3 GCM; MIROC3.2 medium-resolution GCM; and the ECHAM5 GCM.

Figure 21: Projected changes in mean annual precipitation (mm/annum) for Zimbabwe between 2000 and 2050 using the A1B scenario

Source: IFPRI [43] calculations based on downscaled climate data; available at http://ccafs-climate.org/

Impacts on plants and animals

Losses and even extinctions of many plant, animal and other species are indicated as parts of the country dry up and become hotter. As wildlife struggle to survive on dwindling resources,

they are likely to encroach increasingly on human settlements, threatening people, livestock and crops. Soils are likely to become degraded as vegetation loss and erosion are exacerbated by changing rainfall patterns, droughts, floods and wildfires. This will in turn push species of vegetation to the brink and beyond. As climate change reduces food security and disrupts agricultural livelihoods, people will also likely encroach into protected and gazetted forests, parks and wetlands, intensifying human-wildlife conflicts and accelerating the degradation of forests, land and water resources.

Water resources

Most at threat will be water resources. The World Bank in partnership with the government of Zimbabwe has produced a report[44] predicting that climate change is likely to cause annual rainfall to decrease in all catchments except Mazowe and Manyame. The largest decline, it states, will be in the Runde and Mzingwane catchments where average rainfall could decline by between 12% and 16% by 2050.[45] The report predicts that climate change will also reduce the recharge rates of wetlands and aquifers.

There will be less water for irrigation, energy generation for mining, manufacturing and commerce, tourism and human health. Even in a best-case scenario, states the World Bank report, there is likely to be a 38% decline in national per capita water availability by 2050.[46] Urban and rural communities in the south and west could be seriously affected by water stress. The report notes that climate change will cause increasing dependence on groundwater sources, which will need better management.

Case study 1: Coping with climate change in Muzarabani

In hot, dry Muzarabani, a district on Zimbabwe's northern border with Mozambique, droughts and floods are common, and community members say that the climate in the area is becoming drier with shorter growing seasons punctuated by mid-season dry spells. Rivers, streams, ponds and wetlands are drying up and pest populations are increasing. Locals have noted changes through their study of the behaviour of migratory birds (*mashuramurove*) and the flowering pattern of certain trees that they use to predict droughts and floods.

Short-term coping practices and long-term adaptive strategies based on indigenous knowledge are being adopted. These include social safety nets such as "the chief's granary" (*zunde ramambo*) whereby the community contributes to a grain store to help needy families during times of hardship. In addition, community members carry out *nhimbe*, or collective work.

Drought-coping measures:

- Wild fruit harvesting
- Dry planting (before the rains have started)
- Streambank cultivation
- Conservation agriculture
- Planting drought-tolerant small grains
- Traditional food storage and processing techniques

Flood-coping measures:

- Traditional flood-proof building designs, temporary migration and dual-season cropping
- Indigenous adaptation strategies can be used effectively in conjunction with conventional strategies through the participation of local community members. For more on adaptation, see chapter 5.

Source: Chanza 2015

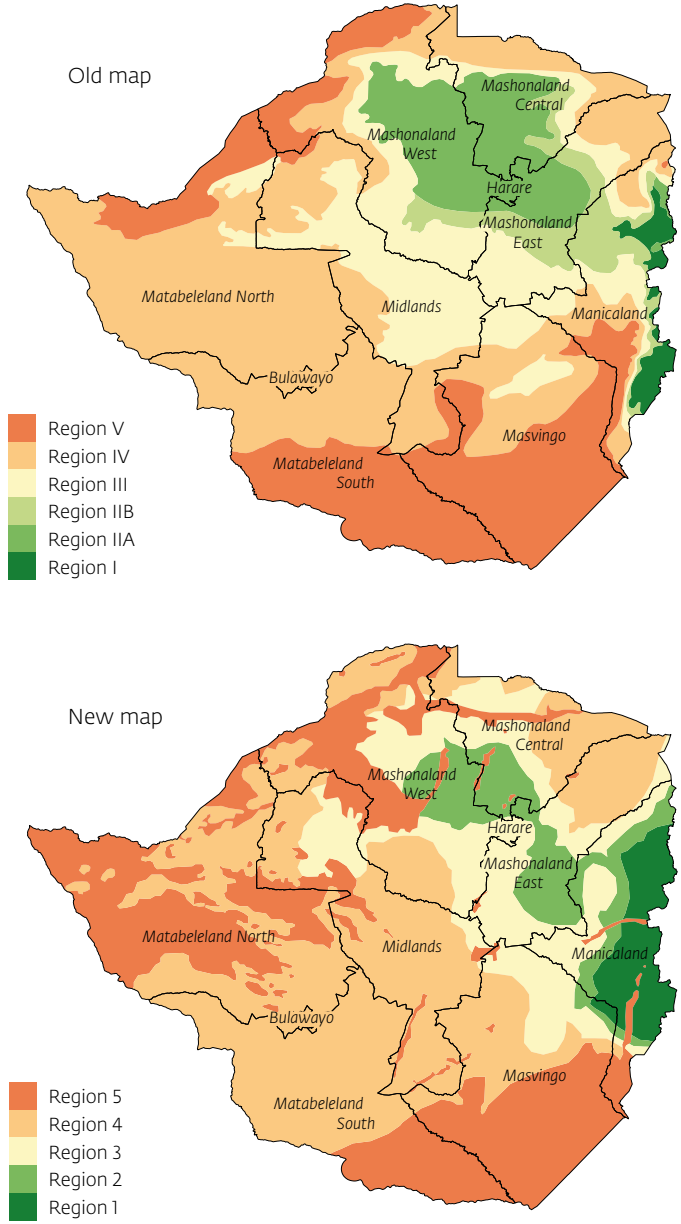


Figure 22: Comparing the old map of the natural regions of Zimbabwe with a new map based on changes related to soils and climate

Source: Mugandani *et al* 2012

Collecting water from dry river beds is likely to become more common as rivers dry up

Redrawing the natural regions

A one degree rise in temperature has already made itself felt in Zimbabwe. Various studies and observations have led to the conclusion that the natural regions, which were mapped to guide farming activities and land use, need revision, in view of the observed changes in rainfall and temperature among other factors. Figure 22 shows the results from a recent study that recommends that the natural regions be modified to take into account changes that have been brought about by climate change and land-use practices. A comparison of the maps shows how the boundaries and the areas of the natural regions have changed. The percentage changes are shown in Table 2.

Table 2: Percentage changes in area under old and new maps of the natural regions of Zimbabwe

Natural region	Old map (% area)	New map (% area)
1	1.8	4
2	15	7
3	18.37	16.1
4	37.8	39.9
5	26.7	32.5

Impacts on people and the economy[47]

The disruption to the economy is most likely to be seen in agriculture, industry and tourism. Human health and livelihoods are also under threat.

Agriculture

Zimbabwe's farming systems are already insecure as they depend mainly on seasonal rainfall. The dry areas of Zimbabwe experience droughts in three of every five years and droughts will likely increase due to climate change.[48] Poor land-use practices in the form of inadequate soil and water management, reduced biodiversity and unsuitable crops have led to degradation of the resource base on which agriculture depends. Climate change will hasten the degradation and exacerbate food insecurity, which is already prevalent.

It is predicted that rising temperatures will lead to a greater incidence of heat stress and spreading infestations of pests and outbreaks of diseases. This will reduce productivity of crops and livestock and drive up expenditure on pesticides, herbicides

and veterinary drugs. Sorghum is sensitive to extreme heat, as is maize, particularly to temperatures above 30°C. High temperatures also lessen the nutrient content and storage capacity of the soil, leading to reduced soil fertility and obliging farmers to spend more on fertilisers.

While the mean changes in climate over Zimbabwe appear to be minor, they will result in significant inter- and intra-seasonal variations as well as spatial shifts in rainfall. There are likely to be shifts in the start and end of the rainy season, and the onset of the rains may be delayed by between four and six weeks.[49] This will mean changes in planting and harvesting dates, the length of the growing season and the types of crops and livestock that farmers are forced to adopt.

There will be increased demand for irrigation and greater strain on groundwater resources to support crops and livestock because rainfall will be inadequate, especially in areas where water is already scarce and of poor quality.

Livestock and wildlife will suffer from changes in the quality of grazing land due to changes in rainfall, higher temperatures and the increased likelihood of wildfires. Changes in rainfall and lack of crop residues will reduce fodder availability. Dairy farming may decline in the face of water shortages and diseases among herds.

Wheat, maize and horticultural growing areas will shift and yields could decline. Maize will be particularly hard hit. The IPCC predicts yield loses of between 18% and 30% for maize in southern Africa by 2050[50] and notes that sorghum yields could also decline. Areas suitable for growing maize are projected to shrink by 2080. One study predicts that the south and west will become less suitable for sorghum and maize cultivation, while the north, central and eastern areas will favour maize, sorghum and cotton.[51]

Crops such as groundnuts, roundnuts and cassava may benefit from increased CO_2 levels,[52] while areas suitable for growing sorghum and cotton are likely to increase by 2080.[53]

Pests and diseases

Climate change poses threats to crops and livestock in the form of pests, diseases and invasive weeds encouraged by increasing average temperatures, warmer winter minimum temperatures, changes in precipitation patterns and water shortages.

One study suggests that the habitat of the African coffee white stem borer, *Monochamus leuconotus* – an important pest of coffee in Zimbabwe – will expand by up to 50% due to reductions in rainfall.[54] The incidence of smut disease, which attacks sugarcane, maize, sorghum and other grains, is likely to spread in the hotter weather. Longer dry spells are likely to exacerbate the symptoms of ratoon stunting diseases which decimate sugarcane in the south-eastern Lowveld.[55]

The fall armyworm (*Spodoptera frugiperda*), a caterpillar native to north and south America with a tendency to maraud in vast numbers, was first detected in Nigeria in 2016. Its presence has been confirmed in Zimbabwe, Zambia, Namibia, Botswana, Congo, Ghana, Kenya, Malawi, South Africa, Swaziland, Togo and Uganda, presenting a serious threat to food security. Up to 130 000 ha of maize were infested during the 2016/17 season in Zimbabwe. The pest can cause crop losses of more than 70%.

Under climate change it can be expected that in Zimbabwe:[56]

- the prevalence of crop pests will change
- invasions by new pests will increase
- major pest outbreaks will increase
- the risk of pesticide residues in food will increase

Urban communities will also be negatively impacted

These events will be driven by outcomes associated with climate change and extreme weather, namely:

- The type of crops and area cultivated, along with fauna, will change, affecting pest prevalence
- Crop failures will increase, leading to new and untested trade pathways, which will increase the risk of new pest entry
- Pesticide use and pesticide resistance will increase, leading to reduced efficacy and food safety risks

Tourism

Zimbabwe's wildlife areas and national parks are already under threat from population pressure, land-use changes, veld fires, poor resource management and poaching. Most of its national parks are in areas that are most susceptible to climate change. Wildlife

is the predominant drawcard, but the animal species that attract tourists require the right habitat, enough food and sufficient water. Habitat loss, lack of grazing, pest infestations, diseases and water shortages are likely to reduce the populations of many animal species and threaten the survival of others, particularly elephants. Loss of plant and animal species are likely to deter visitors, reducing income from an important economic sector.

Industry

Most industrial activities depend on regular supplies of water and electricity, which are disrupted by climate change. Zimbabwe's industry is dependent on human labour and productivity is likely to be affected as climate change takes its toll on human health. Higher temperatures also increase the need for refrigeration and air conditioning. Moreover, most industry relies on agricultural raw materials which are climate-sensitive.

Vulnerable people

Climate change will test the resilience of the Zimbabwean people. Those in rural areas, especially children, women and the disabled among the rural poor, will bear the brunt of the changes. Traditionally, Zimbabwean women, assisted by children, are responsible for the provision of food, water and cooking fuel. They also do most of the work in agriculture. The impacts of climate change will mean more work and greater hardship for women and children[57] as they will have to walk further to collect water and firewood and encounter increasing adversity in food production. Clean water and fuel for cooking will become more scarce, affecting household hygiene and nutrition and undermining the health of pregnant and breastfeeding women and their children. Men will be more likely to leave their family farms in search of work in cities or in other countries, thus adding to the burden

on women left behind. Women and children may be exposed to emotional and physical abuse.

Children, the elderly and the disabled are less mobile than others and more at risk from floods and wildfires. Children and the elderly are also more vulnerable to the effects of heat stress, disease and food shortages.

Human health

Higher temperatures, flooding and reduced rainfall are likely to increase human health problems. Respiratory illnesses due to pollution and smoke, for instance from veld fires, increase with rising temperatures.

Lack of clean water and flooding raise the risk of diseases associated with poor hygiene and sanitation, notably diarrhoea, typhoid, cholera and bilharzia, all of which are already a problem in Zimbabwe.[58] The incidence of less common diseases such as guinea worm and dysentery are likely to increase. Warmer temperatures could increase the spread of meningitis.[59] Food poisoning is likely to occur more frequently as the rise in temperatures shortens the shelf life of perishable foods.

Half the population of Zimbabwe is already at risk from malaria. Figure 23 shows the results of a study by Ebi *et al* (2005) using predictive modelling to project the expansion of areas of malaria transmission under the influence of climate change. By 2050 most of the country could be affected by the disease. The map at left shows the distribution of malarial areas in 2000. The orange and dark red parts show areas with high temperatures that favour the occurrence of malaria-transmitting mosquitoes. The blue, purple and pink parts depict areas of low or non-existent malaria transmission. The map at right shows the predicted spread of

malaria transmission by 2050 driven by rises in temperature across the country.

People living with HIV or who are undernourished will be particularly susceptible to the increased spread of malaria and other diseases as climate change takes effect.

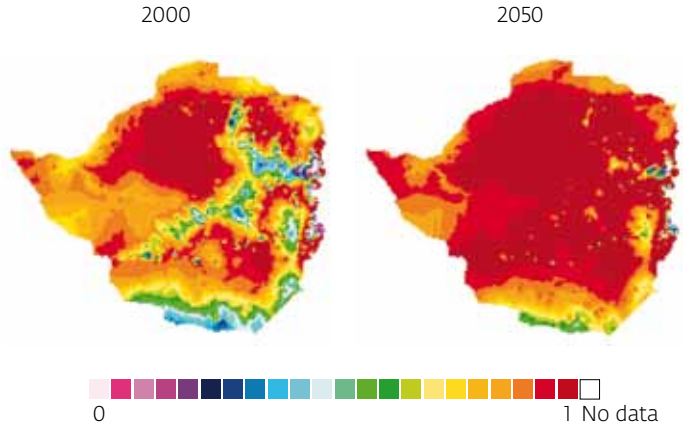


Figure 23: Changes in malaria transmission areas of Zimbabwe with projected temperature increases (using an average emissions scenario) due to climate change

Adapted from Ebi *et al* 2005

Urban communities

Towns and cities, being built-up and with less vegetation, are more likely than rural settlements to experience heat waves, with greater demand for air conditioning, which contributes to greenhouse gas emissions. Air quality is likely to deteriorate, leading to more respiratory illnesses.[60] Cities will be more prone to flooding, particularly those with residential suburbs built on wetlands, like Harare.

The flood mitigation action of wetlands

When left to function in their natural state, wetlands provide natural flood control, allowing excess water to seep into the ground and recharge underground water stores. The increasing expansion of residential and shopping centres on to wetlands destroys this flood-control capacity and reduces the recharge of underground reservoirs. It also diminishes the gradual flow of water into surface reservoirs, thus reducing water security. For these reasons it is important for local government institutions to work with the Environmental Management Agency to protect and conserve Zimbabwe's wetlands.

Urban communities are inordinately dependent on the reliable delivery of utilities such as water and electricity from centralised providers. When climate change puts the provision of such utilities under strain, urban dwellers could be left more helpless than their rural counterparts who are at least able to dig wells and fetch firewood for cooking.

Living standards for urban and rural households alike are expected to decline under the impact of climate change. Hardships experienced by urban families may reduce remittances to their rural kin. Similarly, crop failures due to drought in rural areas may undermine food security among urban households.

Migration and conflicts

There is likely to be an upsurge in cross-border migration and urban drift as populations in southern Africa become increasingly displaced by drought, water shortages, extreme climate events and conflicts over resources.[61] This could mean migration of

"climate refugees" into and out of Zimbabwe at different times. Urbanisation is likely to accelerate, with more people living in urban than rural areas by 2030. The growth of informal settlements with inadequate housing and poor sanitation will likely lead to new health hazards and drive up the crime rate, besides other social problems. Conflicts could occur in both urban and rural contexts as a result of competition for dwindling resources and other climate-related factors.[62]

The adverse consequences of climate change outlined in this chapter can be addressed in two ways. First, we should take measures to help Zimbabweans adapt, which will mean learning to live with warmer temperatures, unreliable rainfall, increasing extremes and declining availability of water. Some of these measures are discussed in chapter 5. Second, we can work together as a global community to reduce greenhouse gas emissions and the amount of greenhouse gases in the atmosphere. Some mitigation measures for Zimbabwe are discussed in chapter 6. Before we look at those issues, chapter 4 examines the policy and governance measures that are being put in place to address climate change.

Endnotes

1 Most of the information in this section is taken from IPCC 2014a. "Climate Change 2014: Synthesis Report". Contribution of Working Groups I, II and III to the Fifth Assessment Report, IPCC, Geneva: www.ipcc.ch/report/ar5/syr/, accessed August 2015

2 Environmental Protection Agency: www.epa.gov/climatechange/science/future.html

3 IPCC 2014a

4 To get an impression of how these different scenarios lead to different temperature increases by 2100, view figure SPM5 in the fourth assessment report of the IPCC: www.ipcc.ch/publications_and_data/ar4/wg1/en/figure-spm-5.html

5 For a useful summary, see https://ipcc-wg2.gov/AR5/report/final-drafts/

6 Climate Action Tracker. Bit.ly/2snPkaK

7 Diffenbaugh, N.S. and Scherer, M. 2011. "Observational and Model Evidence of Global Emergence of Permanent, Unprecedented Heat in the 20th and 21st Centuries". *Climatic Change* 107:615–624. DOI 10.1007/s10584-011-0112-y

8 Orlowsky, B. and Seneviratne, S. 2012. "Global Changes in Extreme Events: Regional and Seasonal Dimension". *Climatic Change* 110:669–696. doi 10.1007/s10584-011-0122-9

9 Brandlin, A.S. 2017. "How Climate Change Is Increasing Forest Fires around the World": www.dw.com/en/how-climate-change-is-increasing-forest-fires-around-the-world/a-19465490

10 Schleussner, C.F., Lissner, T.K., Fischer, E. M., Wohland, J., Perrette, M., Golly, A., Rogelj, J., Childers, K., Schewe, J., Frieler, K., Mengel, M., Hare, W., and Schaeffer, M. 2016. "Differential Climate Impacts for Policy-relevant Limits to Global Warming: The Case of 1.5 °C and 2 °C". *Earth System Dynamics* 7: 327–351, accessed July 2017

11 Ibid.

12 Chen, X., Zhang, X., Church, J., Watson, C.S., King, M.A., Monselesan, D., Legresy, B., Harig, C. 2017. "The Increasing Rate of Global Mean Sea-level Rise during 1993–2014". *Nature Climate Change* 7:492–495. doi:10.1038/nclimate3325: www.nature.com/nclimate/journal/v7/n7/full/nclimate3325.html, accessed August 2017

13 Climate and Development Knowledge Network (CDKN) 2014. "The IPCC's Fifth Assessment Report: What's in it for Africa". Climate and Development Knowledge Network: http://cdkn.org/resource/highlights-africa-ar5/, accessed August 2015

14 Strauss, B. and Kulp, S. 2014. "20 Countries Most at Risk from Sea-level Rise": https://weather.com/science/environment/news/20-countries-most-risk-sea-level-rise-20140924

15 Ibid. For striking visual images of how this could affect major cities in the USA, see www.takepart.com/article/2015/07/15/what-sea-level-rise-looks-america-coast

16 IFAD n.d. "Climate Change Impacts: Pacific Islands": www.ifad.org/documents/10180/9054c140-a03c-4c6e-ae9e-ab9d7972dd19

17 Ibid.

18 www.nature.com/nature/journal/v427/n6970/abs/nature02121.html

19 For more information on threatened species, visit wwf.panda.org/about_our_earth/aboutcc/problems/impacts/species/

20 Ibid.

21 Stern, N. 2006. "The Stern Review on the Economics of Climate Change": http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/sternreview_index.htm

22 IPCC 2014a. "Climate Change 2014: Synthesis Report". Contribution of Working Groups I, II and III to the Fifth Assessment Report IPCC, Geneva: www.ipcc.ch/report/ar5/syr/, accessed August 2015:15

23 Schleussner et al 2016

24 IPCC 2014a:15; CDKN 2014:20

25 For a comprehensive summary of the main impacts on Africa, see "Working Group II to the Fifth Assessment Report of Chapter 22: Africa. IPCC, 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Final Draft": www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap22_FINAL.pdf, accessed August 2015 and CDKN 2014

26 IPCC 2014b:1217

27 Serdeczny *et al* 2016

28 IPCC 2014b; Davis and Hirji 2014; Lesolle, D. 2012. "SADC Policy Paper on Climate Change: Assessing the Policy Options for SADC Member States": www.sadc.int/files/9113/6724/7724/SADC_Policy_Paper_Climate_Change_EN_1.pdf, accessed August 2015;
Shanahan M., Shubert, W., Scherer, C., Corcoran, T., Banda F. 2013. *Climate Change in Africa: A Guidebook for Journalists.* UNESCO: www.unesco.org/new/en/communication-and-information/resources/publications-and-communication-materials/publications/full-list/climate-change-in-africa-a-guidebook-for-journalists/, accessed August 2015;
Serdeczny, O., Adams, S., Baarsch, F., Coumou, D., Robinson, A., Hare, W., Schaeffer, M., Perrette, M. and Reinhardt, J. 2016. "Climate Change Impacts in Sub-Saharan Africa: from Physical Changes to Their Social Repercussions". *Regional Environmental Change*. doi 10.1007/s10113-015-0910-2

29 New, M., Liverman, D., Schroeder, H. and Anderson, K. 2011. "Four Degrees and Beyond: the Potential for a Global Temperature Increase of Four Degrees and Its Implications". *Philosophical Transactions of the Royal Society of London A* 369:6–19. doi:10.1098/rsta.2010.0303

30 Serdeczny et al 2016

31 Ibid.

32 Ibid.

33 Ibid.

34 Ibid.

35 Davis and Hirji 2014; Lesolle 2012; Mugabe et al 2013; IPCC 2014b

36 IPCC 2014b

37 IPCC 2014b

38 Englebrecht, F. 2007. "Projections of Future Climate Change over Africa – Climate Change Impacts on Human Comfort and Energy Demand", CSIR Natural Resources and the Environment Climate Studies, Modelling and Environmental Health: www.mile.org.za/QuickLinks/News/Documents/CCAM_futures_MUT_201309_001.pdf

39 MSD

40 Moyo, E.N. and Nangombe, S. 2015. "Southern Africa's Violent Storms: Role of Climate Change". IUTAM Symposium on the Dynamics of Extreme Events Influenced by Climate Change (2013). *Procedia* IUTAM 17:69–78: www.sciencedirect.com/science/article/pii/S2210983815002497/pdf?md5=d19a37ea855bb478603a34f968b3a464&pid=1-s2.0-S2210983815002497-main.pdf, accessed August 2017

41 Mugabe, F.T., Thomas, T.S., Hachigonta, S. and Sibanda, L.M. 2011. "Southern African Agriculture and Climate Change: A Comprehensive Analysis – Chapter 10 for Zimbabwe". IFRI Publication. doi: http://dx.doi.org/10.2499/9780896292086

42 Ibid.

43 Ibid.

44 Davis and Hirji 2014

45 Davis and Hirji 2014:27

46 Davis and Hirji 2014:33

47 Most of the information in this section is summarised from Davis and Hirji 2014; IPCC 2014b; and Brown, D., Chanakira, R., Chatiza, K., Dhliwayo, M., Dodman, D., Masiiwa, M., Muchadenyika, D., Mugabe, P. and Zvigadza, S. 2012. "Climate Change Impacts, Vulnerability and Adaptation in Zimbabwe". IIED Climate Change Working Paper 3, October 2012: http://pubs.iied.org/pdfs/10034IIED.pdf, accessed August 2015

48 Nyamudeza, P. 1996. "The Effect of Growing Sorghum (*Sorghum bicolour*) in Furrow and on the Flat at Three Populations and Three Row Widths in a Semi-Arid Region in Zimbabwe – Grain Yield Components". *Zimbabwe Journal of Agricultural Research* 31:1–10

49 Lesolle 2012

50 CDKN 2014:20

51 Muriwa et al in Brown et al 2012

52 IPPC 2014b:1219

53 Brown et al 2012

54 Kutywayo, D., Chemura, A., Kusena, W., Chidoko, P. and Mahoya, C. 2013. "The Impact of Climate Change on the Potential Distribution of Agricultural Pests: The Case of the Coffee White Stem Borer (*Monochamus leuconotus P.*) in Zimbabwe". *PLoS ONE* 8(8): e73432. https://doi.org/10.1371/journal.pone.0073432

55 Clowes, M.J. and Breakwell, W.L. 1998. *Zimbabwe Sugarcane Production Manual*. Zimbabwe Sugar Association, Chiredzi

56 Dinesh, D., Bett, B., Boone, R., Grace, D., Kinyangi, J., Lindahl, J., Mohan, C.V., Ramirez-Villegas, J., Robinson, R., Rosenstock, T., Smith, J. and Thornton, P. 2015. "Impact of Climate Change on African Agriculture: Focus on Pests And Diseases". Copenhagen: CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS): www.ccafs.cgiar.org

57 Manjengwa, J., Matema, C., Mataruka, J., Tirivanhu, D., Mufaro, T. and Feresu, S. 2014. "Children and Climate Change in Zimbabwe". UNICEF and Institute of Environmental Studies, University of Zimbabwe: www.unicef.org/zimbabwe/Children_and_Climate_Change_in_Zimbabwe_Report_2014.pdf, accessed August 2015

58 Government of Zimbabwe 2014. "National Climate Change Response Strategy": www.ies.ac.zw/downloads/draftstrategy.pdf, accessed August 2015

59 Ibid.

60 Ibid.

61 Serdeczny et al 2016

62 Ibid.

Children playing in a drying river

4 Climate change governance

This chapter was revised and updated by Washington Zhakata

This chapter looks at international and local issues relating to climate change governance. Since the dangers of climate change emerged, there have been decades of international discussions and negotiations about how to manage the problem. Zimbabwe has been active in most of them and developed important local policy and strategy documents.

Chapter summary

International agreements[1]

It was not until the 1990s that politicians began to take climate change seriously. The adoption of the United Nations Framework Convention on Climate Change (UNFCCC) at the Rio Earth Summit in 1992 marked the beginning of the international community's first concerted effort to confront the climate change problem. The following section gives an overview of some of the key international negotiations, policies and agreements relating to climate change.

The UNFCCC

The UNFCCC is an international treaty whose main objective is to stabilise the greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous interference with the climate system. It came into force in 1994, and 196 nations as well as the European Union (EU) are parties to it as of 2017 and enjoy different statuses. Of these 164 have ratified the framework convention.

Annex 1 of the UNFCCC groups industrialised countries and countries with economies in transition, including the Russian Federation, the Baltic States and several central and eastern European states.

Annex 11 parties are the industrialised countries in Annex 1 without the economies in transition. They are required to give financial resources to developing countries to enable them to reduce their greenhouse emissions and adapt to the impacts of climate change.

Non-Annex 1 parties are mainly developing nations that are recognised as being particularly vulnerable to the impacts of climate change.[2] Zimbabwe is a non-annex party.

The UNFCCC acknowledges that:

- Developed countries should take the lead in combating climate change
- The degree to which developing nations can meet their obligations to reduce greenhouse gas emissions depends on how well they support their obligations with finance and emission-reducing technology
- Economic and social development and poverty eradication are the priorities of the developing countries

The Conference of the Parties

Each year a conference of the UNFCCC parties (COP) session is held in a different country to assess progress. The first conference (COP1) was held in Berlin in 1995. Developing countries tend to be under-represented in these meetings and have formed coalitions to negotiate common positions. Zimbabwe belongs to the Africa Group.

The Kyoto Protocol

In 1997, during COP3, the participants adopted the Kyoto Protocol, which established legally binding obligations for developed countries to reduce their greenhouse gas emissions and provided mechanisms to enforce compliance: Article 3 required developed nations to reduce their overall emissions by at least 5% below 1990 levels in the commitment period 2008 to 2012. Each party was required to have made demonstrable progress in achieving its commitments by 2005. The United States refused to sign because the protocol did not require major growing economies such as China and India to reduce their emissions.

The Kyoto Protocol came into force on 16 February 2005 and was seen as an important political breakthrough – a decision by the

parties to start a dialogue on strategic long-term cooperative action on climate change. To help developed countries achieve their targets the protocol introduced carbon trading and clean development mechanisms (CDMs). The latter allow developing countries to earn emission reduction units by implementing projects that reduce emissions, such as forest conservation. The units can be traded and sold to industrialised countries to meet a part of their emission reduction targets under the Kyoto Protocol.[3]

The Bali Action Plan

The failure of the USA to agree to the Kyoto Protocol was addressed in the Bali Action Plan that was put forward at COP13 in 2007. The plan proposed that UNFCCC parties would agree to the following at COP15 in 2009:

- Quantified "commitments" from developed nations to reduce emissions
- Nationally appropriate mitigation actions (NAMAs) by developing nations, including reduced emissions from deforestation and forest degradation (REDD)
- Mechanisms to adapt to impacts such as changing rainfall patterns, extreme weather events, rising sea levels and shifting patterns of disease
- Technology transfer and development to support adaptation and mitigation
- Finance and investment to pay for all of the above

The Bali Action Plan was not agreed at COP15 and no country was obliged to act. However, a major achievement of the session was the agreement that the average global temperature increase must not exceed 2°C above pre-industrial levels as this would lead to dangerous and possibly irreversible climate change.

In Bali, the parties agreed that:

- The least developed countries (LDCs) would receive funding to produce national adaptation programmes of action (NAPAs)
- Carbon trading and clean development mechanisms would be introduced to allow developed countries to achieve their emissions targets, as explained below.

Carbon emissions trading

Developed countries can meet their mitigation obligations through carbon trading, that is, by purchasing, from a less developed country which has low emissions, the right to emit. The carbon market is based on buying and selling of carbon credits, which are measured in tonnes of CO_2 equivalents (tCO_2e).

The benefits from these markets are presently meagre, but it is hoped that they could increase substantially as the market grows.

For a readable summary of how carbon trading works, visit http://science.howstuffworks.com/environmental/green-science/carbon-trading.htm

The Doha Amendment

The Doha Amendment to the Kyoto Protocol was adopted at a meeting of the parties to the Kyoto Protocol in Qatar on 8 December 2012. The amendment establishes the second commitment period of the Kyoto Protocol, which will end on 31 December 2020. It will enter into force on the ninetieth day after 144 parties sign up.

The Paris Agreement

COP21, held in Paris in 2015, was a milestone session at which UNFCCC parties, the USA included, agreed on a comprehensive, legally binding global agreement. The Paris Agreement is a unifying treaty in global efforts to combat climate change. It commits the parties to ensuring that the rise in global temperature this century is kept well below 2°C above pre-industrial levels and to drive efforts to limit the temperature increase to 1.5°C. Another outcome of the agreement was to include developing countries in climate change mitigation, especially reductions of greenhouse gas emissions.[4]

The Paris Agreement entered into force on 4 November 2016, but implementation of its provisions will commence in 2020. The commitments to the agreement seem to have overshadowed the Kyoto Protocol and it is likely that it will become more significant in combating climate change.

Zimbabwe has ratified the Paris Agreement and prioritises adaptation actions with mitigation co-benefits to address greenhouse gas emissions. Zimbabwe subscribes to the principle of common but differentiated responsibilities in line with national capabilities as enshrined in the UNFCCC.

Intended nationally determined contributions (INDCs)

The Paris Agreement requires all the parties to propose INDCs. These are legally binding statements of the amounts of greenhouse gases that a country proposes to emit from various sectors of their economy, representing emission reduction ambitions to be achieved by 2030. By 1 October 2015, 147 nations (75% of the parties to the Paris Agreement) had submitted their INDCs to the UNFCCC. They represented contributors to

Permanent Secretary for Water and Climate Prince Mupazviriho (in tan jacket) addresses members of the Zimbabwe delegation at the 2017 UN climate conference in Bonn, Germany

Photo: Jeffrey Gogo

approximately 86% of global greenhouse gas emissions in 2010. The INDCs are one of the main deliverables of COP21. The INDCs became nationally determined contributions (NDCs) as countries joined the Paris Agreement.

In 2018 the parties will take stock of the collective efforts in advancing towards the goal set in the Paris Agreement and to inform the preparation of NDCs. There will also be a global stocktake every five years, starting in 2023, to assess the collective progress towards achieving the purpose of the agreement and to inform further individual actions by the parties.

Negotiations since Paris

The year 2015 also saw the establishment of two other key international climate-related governance frameworks – the Sustainable Development Goals/Agenda 2030 and the Sendai Framework for Disaster Risk Reduction.

COP22 took place in Marrakech in 2016 and was notable for the action that took place outside of the negotiations, with politicians and representatives of countries and organisations using the opportunity to announce new initiatives, strategies and financial pledges. Seventy heads of state and governments also attended the high-level segment of COP22 and came up with a proclamation that signals a shift towards a new era of implementation and action on climate and sustainable development. The proclamation calls for further climate action and support, well in advance of 2020, taking into account the specific needs and circumstances of developing countries, LDCs and countries vulnerable to the adverse effects of climate change. The conference concluded with an accord on a 2018 deadline to complete a rulebook for putting the Paris Agreement into operation to ensure confidence, cooperation and success in subsequent years. The accord lifted the air of uncertainty which had dogged countries that had yet to ratify the agreement.

Zimbabwe's climate policies

The government of Zimbabwe and its people are committed to addressing climate change challenges in pursuit of achieving the Sustainable Development Goals as well as obligations under the Paris Agreement with particular reference to the NDCs.

Zimbabwe's national climate change governance processes derive their authority from the Constitution of Zimbabwe, the National Climate Change Response Strategy (NCCRS), the National Climate Policy (NCP) and the laws, Acts and statutory instruments that give effect to the commitments under the conventions, treaties and protocols to which Zimbabwe is a signatory. In addition to being party to international and regional conventions and protocols – the UNFCCC, Kyoto Protocol, Montreal Protocol and The UN Convention to Combat Desertification, among others – Zimbabwe has facilitated the creation of an enabling environment, policies and partnerships with development partners. The NCCRS, the NCP and the Climate Change Management Department in the Ministry of Environment Water and Climate, which coordinates climate change matters, including finance, are part of this.

National Climate Policy (NCP)

The NCP seeks to create a pathway towards a climate-resilient and low-carbon economy in which the people have sufficient adaptive capacity and continue to develop in harmony with the environment. A child-friendly book has been developed in participation with children, using simple language to explain the climate policy.

The NCP is supported by the NCCRS, the National Environmental Policy, Renewable Energy Policy, and Forest Policy, among other instruments that are aimed at achieving sustainable development.

The vision of the NCP is a climate-resilient and low-carbon Zimbabwe. The aim is to climate-proof all socio-economic development sectors to reduce Zimbabwe's vulnerability to climate and climate-related disasters, while implementing a

low-emission development pathway. The purpose of the policy is to guide climate change management, enhance national adaptive capacity, scale up mitigation actions, facilitate domestication of global policies and ensure compliance with global mechanisms.

The NCP will help Zimbabwe to meet its NDCs targets, create resilient communities and guide the country towards an economy that is largely decoupled from climatic variations. The policy provides for strengthening the Climate Change Management Department[5] to coordinate the mainstreaming of climate change across different sectors of the economy. It also provides for the appointment of focal points, development of statutory instruments and implementation procedures to enhance climate action. This is discussed in detail in chapter 7 on finance.

The main aspects of the NCP

Climate change adaptation: The NCP promotes construction of more dams and strengthened irrigation infrastructure, water harvesting and harnessing of ground water resources. It calls for augmenting Zimbabwe's health surveillance system and enhancing our understanding of the links between climate and health. Climate-proofing of infrastructure and human settlements will also be promoted.

Climate change mitigation and low-carbon development: According to Zimbabwe's Second National Communication to the UNFCCC, the country's main emissions sources are: fuel combustion or energy (68.5%), agriculture (22.35%), waste handling (3.93%) and industrial processes (5.21%). This aspect of climate policy sets out to accelerate mitigation measures by adopting and developing low-carbon pathways in the industrial, energy, waste, agriculture, land use, land-use change and forestry sectors.

Climate education, training and awareness: The NCP links with Article 6 of the UNFCCC, which provides for implementation of programmes on education, awareness and training, including the development and exchange of educational and public awareness materials on climate change and its effects.

Weather and climate research and modelling: Weather and climate information is vital to ensure agricultural productivity, availability of water resources, electricity power generation, infrastructure development and aviation services, among other important activities. The policy seeks to strengthen climate science and promote relevant home-grown solutions to the problems of climate change. Knowledge and skills enhancement at all levels of the education systems and in relevant government and non-governmental institutions are priorities.

Technology transfer and information sharing: The policy seeks to remove barriers to technology transfer and encourage collaboration with the private sector, universities, research institutions and development partners in producing and sharing appropriate technologies and technical support for climate-related infrastructure development, preparedness and resilience.

Climate change governance: The policy aims to strengthen climate change management.

National Climate Change Response Strategy (NCCRS)

The Ministry of Environment, Water and Climate, with the guidance of the Office of the President and Cabinet, developed the NCCRS to guide national response measures in addressing the impacts of climate change.[6] Its goal is "mainstreaming climate change adaptation and mitigation strategies in economic and social development at national and sectoral levels through multi-

stakeholder engagement". The strategy has seven pillars:

1. Adaptation and disaster risk management
2. Mitigation and low-carbon development strategies
3. Capacity building to bring about the following: adaptation and mitigation; climate change communication; education and raising awareness; research and development; and appropriate institutions to address climate change issues
4. Governance framework – institutions, networks and negotiations
5. Finance and investment – partnerships and international financing
6. Technology development and transfer, including infrastructure
7. Communication and advocacy, information management and dissemination

The NCCRS document contains sector-specific strategies for:
Natural systems: air, water, land use, land-use change and forestry, and biodiversity and ecosystems
Economic sectors: agriculture and food security, industry and commerce, mining and tourism
Physical and social infrastructure: energy, transport, disaster risk management and social infrastructure, waste management, health, gender, people living with HIV and AIDS, and vulnerable groups, children and youth

In putting the National Climate Policy into operation, the NCCRS will guide the implementation of the provisions of the policy with special attention to mainstreaming climate change adaptation and mitigation strategies in economic and social development at national and sectoral levels through multi-stakeholder engagement.

Zimbabwe's NDCs

Zimbabwe, like the other parties, submitted its INDCs in September 2015.[7] They presented a greenhouse gases emissions reduction target of 33% per capita below the projected business-as-usual scenario by 2030. The target is envisaged to be achieved through renewable energy development, energy efficiency and climate-smart agriculture practices. The INDCs became NDCs, and therefore binding, when the Paris Agreement came into force.

Development of a low-emission development strategy (LEDS) to ensure the NDC target is achieved by 2030 is under way. The framework links the NDC and LEDS to existing and planned mitigation activities, including NAMAs and CDMs. Selected actions for implementation of the NDCs are aligned with the country's development plans, including the Zimbabwe Agenda for Sustainable Socio-Economic Transformation (ZimAsset), the Comprehensive Africa Agriculture Development Programme and the Zimbabwe Agriculture Investment Plan, among others.

The mitigation component of Zimbabwe's NDC focuses on the energy sector because of the extensive energy contributions to the reduction of greenhouse gases in comparison to other sectors. Action in this sector is supported by several initiatives, including the National Climate Policy, Renewable Energy Policy, Biofuels Policy, Transport Policy, Forestry Policy and other instruments seeking to keep greenhouse gas emissions to a minimum and ensuring green development.

Zimbabwe's NDCs also have an adaptation component that seeks to upscale national planning and implementation of adaptation actions that enhance resilience of all sensitive socioeconomic sectors to improve the national adaptive capacity. The agricultural sector also provides opportunities for climate change mitigation

through initiatives such as climate-smart agriculture and sustainable agroforestry-based practices. The sector therefore has multiple benefits, and Zimbabwe foresees greenhouse gas emission reductions while improving agricultural productivity and enhancing national food security.

Additional policies

The legal and governance frameworks regulating environmental protection in Zimbabwe are contained in a wide range of laws and policies falling under the mandates of the ministries responsible for environment, agriculture, mines and energy, health and home affairs, among others.

The Environmental Management Act of 2002 provides the overall framework for sustainable natural resource management and environmental protection. The section most relevant to climate change is chapter 20 section 27. Zimbabwe launched its environment policy in 2009.

The NCCRS identifies the following official instruments that relate to climate change: the National Policy and Programme on Drought Mitigation; the Draft Disaster Risk Management Policy and Strategy, the Science, Technology and Innovation Policy (2012), the Water Policy, the Agriculture Marketing and Pricing Policy and the Small, Micro and Medium Enterprises Policy.[8] The NCCRS also notes that ZimAsset recognises the impact of climate change on agriculture and highlights the need for a climate change policy as a key result area.[9]

Water is administered through the National Water Act and National Water Authority Act, both of 1998, which provide administrative and legal frameworks for management of catchments, water abstraction and regulation of water pollution.

The body responsible for water administration is the Zimbabwe National Water Authority, which is responsible for issuing water permits.

Positive aspects of the water Acts with respect to climate change are:

- The removal of private ownership of water, which grants communities freer and more equitable access to water, a measure that will be important as climate change makes rainfall patterns more variable[10]
- The demand management of water through water pricing, increased water use efficiency measures and reduced wastage

Other policies that are relevant to climate change but which need to be reviewed and updated in the light of the climate change strategy are:
The National Energy Policy
The Statutory Instrument on Air Pollution
The National Climate Policy
The National Biofuels Policy
The Renewable Energy Policy
The Forestry Policy
The Agriculture Policy
The Drought Mitigation Policy and
The Civil Protection Act

Next steps for Zimbabwe

In line with the provisions of the Paris Agreement and the subsequent negotiations the country will maintain a monitoring, reporting and verification (MRV) system for climate

change mitigation and adaptation actions. It aims to ensure transparency of the NDCs implementation. The government will put the requisite legal framework in place to ensure continuous monitoring for biennial reporting on NDCs progress, integrated within existing reporting processes and structures. Development of capacities in MRV systems will link with existing processes, including the preparation of national communications, biennial update reports, Sustainable Development Goals, Agenda 2063 and ZimAsset, among others. The MRV system will reflect the accounting rules to be agreed internationally under UNFCCC and establish a national registry system for readily accessible information.

This chapter looked at the international governance instruments and negotiations around climate change and relevant local policies. The next chapter examines adaptation to climate change.

Endnotes

1 IPCC 2014: Fifth Assessment Report AR5: www.ipcc.ch/report/ar5/

2 United Nations Framework Convention on Climate Change: Parties and Observers: http://unfccc.int/parties_and_observers/items/2704.php

3 https://cdm.unfccc.int/about/index.html

4 UNFCCC: The Paris Agreement: http://unfccc.int/paris_agreement/items/9485.php

5 For more information about the Climate Change Management Department, visit www.climatechange.org.zw/about-climate-change-management-department

6 GoZ 2014 : www.ies.ac.zw/downloads/draftstrategy.pdf

7 Zimbabwe's intended nationally determined contributions submitted to the UNFCCC: www.climatechange.org.zw/sites/default/files/Zimbabwe%20Intended%20Nationally%20Determined%20Contribution%202015.pdf

8 GoZ 2014: "National Climate Change Response Strategy": www.ies.ac.zw/downloads/draftstrategy.pdf, p. 64. accessed August 2015

9 Ibid.

10 Chagutah, T. 2010. "Climate Change Vulnerability and Adaptation Preparedness in Southern Africa. Zimbabwe Country Report". Heinrich Böll Stiftung Southern Africa: http://za.boell.org/sites/default/files/downloads/HBF_web_Zim_21_2.pdf, p. 13, accessed August 2015

5 How can Zimbabwe adapt?

This chapter was reviewed by Dr Ndebele-Murisa, Dr Dube and Elijah Moyo, with additional material contributed by Prof. Mugabe and Tendayi Marowa

This chapter discusses ways in which Zimbabweans can build the resilience and adaptive capacity of human and ecological systems to address climate change today and in the future. It examines the roles of communities, the private sector, development partners and governments and identifies adaptation measures for specific sectors.

Chapter summary

Principles of adaptation

As mentioned in chapter 3, even if greenhouse gas emissions are stopped today (which is extremely unlikely to happen), many of the negative impacts of climate change will continue to have an effect for decades.[1] The IPCC predicts that if greenhouse gas emissions continue to rise there will be cataclysmic results for human societies and natural systems. Therefore, it is crucial that as individuals, communities and as a nation we strengthen our ability to withstand potential adversity and to adapt the ways we live and the resources we use. While there are uncertainties in the climate projections, Zimbabwe will be safer from any potential impacts if it puts adaptation options in place.

Adaptation is described by the United Nations Framework Convention on Climate Change (UNFCCC) in its 2007 report as "the process through which societies increase their ability to cope with an uncertain future, which involves taking appropriate action and making the adjustments and changes to reduce the negative impacts of climate change".[2]

There are two main ways to adapt to future climate change impacts: reducing the vulnerability of communities, including people and the ecological components on which they depend, by building resilience and increasing their adaptive capacity (ability to adapt); and by reducing the risks of climate hazard impacts (disaster risk reduction).

How to climate-proof your community

These principles of adaptation can be applied to any system such as a home, business, school, village, suburb or farm.

1. Learn about the components of your system (social, ecological and economic)
2. Identify potential threats, hazards and shocks
3. Identify areas of vulnerability
4. Identify factors that could increase adaptive capacity
5. Develop a disaster risk reduction plan
6. Put measures in place to reduce vulnerability
7. Put measures in place to increase adaptive capacity

Reducing vulnerability

Vulnerability refers to the degree to which an individual, household or community is sensitive to or exposed to risk of harm. In order to reduce vulnerability, it is important for individuals, families, communities, businesses and the like to identify the ways in which they are vulnerable. One useful tool for doing this is the Participatory Capacity Vulnerability Analysis (PCVA)[3] method developed by Oxfam for helping communities to identify factors which can strengthen their adaptive capacity and reduce their vulnerability so that they can develop plans for community adaptation and disaster management.

Developing adaptive capacity

The manner in which individuals, households, communities or the nation can adapt depends on their vulnerability and their **adaptive capacity** (the ability to respond successfully to climate variability and change). Adaptation can involve changes to behaviour, such as encouraging farmers to plant drought-

resistant crops, and changes to infrastructure, such as digging boreholes or flood-proofing roads and bridges.[4]

Adaptive capacity is necessary for the design and implementation of effective **adaptation strategies** which reduce the likelihood and magnitude of climate change threats and hazards.[5] Adaptive capacity also allows sectors and institutions to take advantage of opportunities or benefits from climate change, such as a longer growing seasons or increased potential for tourism.

Building resilience

Resilience is the ability to withstand and recover from hazards or shocks and is an important part of adaptation. Resilience is enhanced when a person or system can learn from past disasters in order to reduce future risks.[6] If we aim to build resilient communities of people and the ecological resources on which they depend we will have a better chance of successful adaptation to climate change.

In order to apply resilience principles, we need to think about our communities in terms of systems. Resilience recognises that every part of a system – whether a village, forest or farm – is connected. This means that whatever happens to one part of a system can affect many of the other parts. For example, drought reduces water, causing crops to die, soil to be damaged and people to go hungry, as well as health problems and reduced incomes.

Building resilient communities

Because the lives and livelihoods of Zimbabweans are so closely linked to the state of our natural resources and climate, it is helpful to think of our communities as systems made up of human and ecological elements – climate, soil, water, plants and animals. Adaptation to climate change must involve building resilience in both the human and ecological aspects of the community.

Some shocks and hazards that can negatively affect a system are:

- Climate hazards such as drought, heat waves, hail, frost or floods
- Pest or disease outbreaks (affecting humans, crops or livestock)
- Price hikes of food or goods
- Wildfires
- Human conflict and social unrest

As shown in table 1, chapter 3, Zimbabwe has several factors in its favour when it comes to adaptation, including abundant natural resources, a well-educated, resilient population and a diversified economy. The country has comparatively good infrastructure – roads, schools, hospitals, settlements, grain storage facilities and social services – which can all be strengthened to support climate resilience. The social networks in Zimbabwean communities, particularly in rural areas, are still fairly strong. Moreover, a wealth of local and traditional knowledge, which has already enabled Zimbabweans to survive in a highly variably climate for centuries, can be tapped. All these factors will help Zimbabweans to work together to tackle climate change impacts.

Encouraging diversity

One of the most important principles of resilience is encouraging diversity in all forms – for example, obtaining water from many different sources, growing many different crops and having many sources of income. The more diverse elements that are present in a system, the stronger it is; if one element of the system is damaged – through drought, fire, disease or other setbacks – another element is able to take its place. For example, if we grow only maize, a drought may destroy our entire crop, but if we also grow millet, sorghum and legumes, it is likely that some of our crops will survive the drought, giving us at least some food and income. Other non-agriculture livelihood options should also be explored and promoted to cope with climate change.

Adaptation strategies: win-win, low regrets and no regrets

No-regret actions are cost-effective and help address the risks of climate change. They have no serious trade-offs with other adaptation or mitigation objectives.

Low-regret actions are relatively cheap and provide relatively large benefits under projected climate scenarios.

Win-win actions contribute to adaptation and have other social, economic and environmental benefits, including those relating to mitigation.

Adaptation and sustainable development

Many adaptation measures are not specifically related to climate change, but are essentially sustainable ways to improve the management of resources and communities. Thus, most

Growing drought-resistant crops such as sorghum is a climate-smart adaptation

adaptation measures are the foundations of sustainable development and will go towards achieving many of the new Sustainable Development Goals,[7] Africa's Agenda 2063, the SADC industrialisation strategy and many objectives of ZimAsset, the government's blueprint for sustainable economic development.

Because these measures will benefit communities, whether or not climate change happens, they are called "win-win", "no regret" or "low regret" solutions. For example, increasing the diversity of crops to include drought-resistant varieties will not only reduce the risk of an entire harvest being destroyed by drought, pests or intense rainfall, but will also help to improve the soil, reduce pest infestations and diseases and improve family nutrition.

Adaptation and mitigation

Ideally, adaptation measures should also lower greenhouse gas emissions or help to draw greenhouse gases from the atmosphere, thus reducing, or mitigating, the effects of future climate change. For example, planting trees and safeguarding forests will protect the soil and improve the ability of rainfall to recharge underground water stores, and the trees will help to take CO_2 out of the atmosphere, thus reducing global warming.

Different levels of adaptation

Adaptation can occur on many levels. Individuals, households, communities, civil society, the private sector and local and national government departments can all contribute. Studies on adaptation to climate change make the point that each community has different levels of vulnerability and resilience and each situation is different. Therefore, a blanket, top-down approach is not going to be successful.

Indigenous knowledge systems

Building on indigenous knowledge systems such as those described in case studies 1 and 2 recognises that local people have a wealth of knowledge of how to cope with adversity, and building on this can help make adaptation strategies more locally appropriate. Several adaptation projects were initiated in Zimbabwe during the past decade. While there have been successes, critics argue that the duration of the projects was too short for them to be sustainable and that only a few communities were targeted.[8] Some of these projects suffered from the lack of a good sustainability plan, were top-down or the technologies

promoted were not cost-effective. However, important lessons have been learnt from these initiatives. These have led to the development of key climate policies and strategies as well as governance and institutional systems.

One crucial lesson has been that successful adaptation strategies need to come from the community, or bottom-up, while being supported by national coordination, policies, strategies, technology transfer and legislation.

Community-based adaptation (CBA)

Using this method, communities work with government agencies or NGOs to analyse their resources and vulnerabilities and assess their risks of climate change hazards. They then develop ways to build their adaptive capacity, increase their ability to predict potential hazards and develop resilience to enable recovery from them. Several projects in Zimbabwe have used this approach, including those shown in table 3:

Table 3: Some successful CBA projects in Zimbabwe

Name of project and area	Implementing agencies	Main features
Zimbabwe Resilience Building Fund Programmes	UNDP through Action Aid, Welthungerhilfe and Care implementing projects in some of the driest districts	• Identification of hazards (including drought, flooding, crop and livestock pests and disease, human health hazards and price fluctuations of agricultural commodities) • Projects involve developing adaptive capacity and disaster risk management plans

Name of project and area	Implementing agencies	Main features
Coping with drought and climate change in Chiredzi	GoZ, UN Development Programme (UNDP) and the Global Environment Fund (GEF)[9]	• Assessment of climate risks • Assessment of vulnerability of livelihoods and most vulnerable locations • Identification of adaptation strategies • Implementation of pilot project
Managing climate vulnerability in Makuwerere Ward, Mberengwa District	Lutheran Development Services	• Raising awareness of climate change and building community capacity • Promoting sustainable use of woodland for fuel-saving stoves
Increasing food and livelihood security in Bulilimamangwe and Gwanda	Practical Action	• Soil and water conservation techniques • Climate-resilient crop varieties and goat breeds • Livelihood-centred disaster risk reduction
Community-based adaptation to climate change in Africa[10] in Munyawiri Ward, Domboshava area of Goromonzi District	ZERO Regional Environmental Organisation	• Community members identified the impacts of climate change and noted their current strategies to deal with it while making recommendations for future adaptations
Strengthening weather and climate change information dissemination[11] in Chirumanzu, Zvishavane and Gutu	Oxfam in partnership with the Meteorological Service Department (MSD), AGRITEX and Chinhoyi University of Technology	• AGRITEX officers and farmers improved their knowledge of weather, agro-meteorology and climate change adaptation • Weather stations were set up in the target districts • Farmers gained improved access to local weather, climate and agro-meteorological information services
Building adaptive capacity to cope with increasing vulnerability due to drought in Gweru and Lupane District	Midlands State University, the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), Zimbabwe Agricultural Research Institute and AGRITEX	• Developed education, research and extension competencies to create strategies that help rural communities increase their adaptive capacity to cope with risks and opportunities associated with climate change and variability

Case study 2: Mainstreaming climate change adaptation in Zimbabwe's agricultural extension system

The effects of climate change are already being felt by Zimbabwean farmers, resulting in increased vulnerability and reducing their ability to produce adequate harvests.

Practical Action Southern Africa implemented a project in Masvingo, Midlands and Matabeleland South provinces aiming to improve the capabilities of smallholder farmers to cope with and adapt to climate change and variability.

Key project partners were the Department of Agriculture, Technical and Extension Services (AGRITEX) and the Meteorological Services Department. The project enabled smallholder farmers to make better plans and decisions based on accurate climate and weather information. This was achieved by training professional staff from AGRITEX to increase their knowledge and awareness of climate change issues.

Farmers can now make informed decisions about which crops to plant and when to plant them. They are also diversifying their livelihoods to include horticulture, small animal husbandry and growing supplementary feed for livestock during the dry season. The farmers are also using conservation agriculture techniques that give better yields than conventional methods during dry years.

Source: Practical Action: http://practicalaction.org/climate-change-and-extension

Case study 3: Traditional climate forecasting in Munyawiri Ward, Domboshawa

Farmers in Munyawiri Ward use observations of temperature, rainfall, thunderstorms, windstorms and sunshine to prepare for the agricultural season. The method most relied upon is gauging the timing, intensity and duration of cold temperatures during the winter (May to July). A very cold winter is said to lead to a good rainy season.

Elderly male farmers note natural occurrences such as the appearance of certain birds, mating of certain animals and flowering of certain plants to forecast weather trends. The abundance of certain wild fruits indicates the quantity of rain expected. The elevation of birds' nests during the dry season is also important: if nests are built close to the ground, then rains will be poor; when they are high up, good rains can be expected.

Traditional coping mechanisms in the face of climate hazards include growing drought-resistant crops, harvesting rainwater off roofs and diversifying livelihood activities away from agriculture. Traditional leaders advocate time-honoured resource management practices, including protection of riverine vegetation and forests and prevention of wildfires. In this community, however, many no longer respect the traditional leaders and ignore their advice. In order to build resilience, Zimbabwean communities will have to develop new approaches to protecting communal resources and mobilising community support for climate change adaptation strategies.

Source: Zvigadza *et al.* 2010

Case study 4. Seasonal climate forecasting for sustainable crop production

Participatory workshops were held with farmers in Lupane and Lower Gweru to understand their perceptions of changing climate conditions, document indigenous seasonal climate forecast (SCF) systems and evaluate field experimental results based on decisions from these forecasts. Farmers were asked to make predictions for the 2008/2009 and 2009/2010 seasons using their own indicators and perceptions of changing climate conditions before coming up with a consensus on a SCF for the district. Their forecast was compared with the SCF issued by the MSD.

There was impressive consistency between farmers' rainfall predictions using indigenous knowledge of environmental indicators and the actual rainfall totals. The farmers predicted a wetter 2008/9 and a drier 2009/10 season. The MSD SCF was normal to above average for 2008/9 season and normal to below normal for 2009/10. Actual rainfall totals were 1,100 mm and 944 mm in the 2008/9 season for Lupane and Lower Gweru respectively. Rainfall totals for Lupane and Lower Gweru were 617 mm and 505 mm respectively during the 2009/10 season.

Farmers were then asked what management options they would take given the seasonal climate forecast. They took part in field experiments that were designed to test how their decisions about crop variety selection, tillage methods and fertiliser types and amounts, based on the SCF affected crop yields.

Adding recommended amounts of fertilisers resulted in yield

increases of 40% over yields with half the recommended amounts. Growing long-season varieties resulted in higher yields (22%) than for short-season varieties in the wetter 2008/9 season, while short-season varieties had yield advantages of 36% over the longer-season varieties in the 2009/10 season, which was relatively dry. Frequent weeding resulted in an 8% increase in maize yields compared to weeding once in a season. The study demonstrates that knowledge of the coming season assists farmers in coming up with adaptive strategies for climate variability and change. Some of the indices used for predicting the coming season are listed below.

Table 4: Indigenous knowledge indices used for predicting the coming season

Wet year	Drought year
Rhus lancea (African sumac), called *mutepe* in Shona and *ucane* in Ndebele, and *Lannea discolour* (*mugan'acha*, *mumbumbu*) trees produce lots of fruits	*Rhus lancea* produces few fruits while *Lannea discolour* produces fruits but aborts
Azanza garkeana (*mutowhe*, *uxakuxaku*) do not fruit well	*Azanza garkeana* fruit well
Heat waves experienced	Heat waves not experienced
Early haziness soon after winter	Extended winter period
Frogs turning brownish	White frogs appear in trees
Water birds making a lot of noise	Lots of thunderstorms without rains
Butterflies seen hovering in the air from north to south starting in October	Early rains starting from early October

Source: Chagonda et al 2013

Governance and institutional frameworks

Local and national government can facilitate the implementation of adaptation strategies through:

- Enacting policies and strategies that support adaptation and deter vulnerable activities
- Facilitating the development of local adaptation plans, including disaster risk-reduction measures, information dissemination and capacity building
- Enforcing laws that protect vulnerable and marginalised groups and natural resources
- Raising awareness of climate change issues and adaptation issues
- Facilitating the sharing of information about successes and learning among communities
- Developing and implementing a national framework for climate services
- Disseminating climate information from national and local meteorological stations to farmers through extension agents

Super computer improves weather forecasting

The government of Zimbabwe acquired a high-performance super computer in 2012. Housed at the University of Zimbabwe, it is being used in several research fields. The MSD was one of the first institutes to use the computer, to downscale complex global weather forecasting models in order to generate daily weather forecasts. This has helped improve the accuracy of weather forecasting in Zimbabwe, contributing significantly to the development of early warning systems at community level.

The NCP and NCCRS have already been mentioned. For more

details of how the government is supporting the adaptation process, visit the Climate Change Management Department website at www.climatechange.org.zw/ where you can download several useful resources.

Case study 5: Climate-proofing Nyanyadzi irrigation scheme

The increasing frequency of drought and heavy rainfall events, coupled with shifting rainfall patterns, is a major challenge facing rural communities in the south-western areas of Chimanimani District. Nyanyadzi irrigation scheme should be an important adaptation component in the district, but it declined in productivity when soil erosion caused heavy siltation after its construction in 1935, and it became dysfunctional in 2000.

An integrated micro-watershed management project to climate-proof the irrigation scheme, which benefits 721 farmers on 412.38 ha as part of an adaptation and resilience strategy for Chimanimani District, was initiated by a partnership of NGOs and government departments under the UNDP/GEF-supported project, "Scaling up Adaptation in Zimbabwe, with a Focus on Rural Livelihoods (2014–2018)".

The partnership brought together UN agencies, civil society, government departments, the local authority and local community. The government contributed technical expertise and machinery for conservation works and desiltation of canals and water reservoirs. This lowered the project implementation costs by about 70%.

The integrated micro-watershed approach covered investments in silt traps, storm drains to redirect runoff, dead-level contours, rainwater harvesting at a school in the area and tree and grass planting over 180 ha of the sub-catchments to improve ecosystem health. These investments left the irrigation scheme better protected and prevented siltation when Cyclone Dineo ravaged the area in 2016–17, to the delight of the farmers.

Desiltation of a weir, an overnight storage dam and canals was undertaken with machinery and technical support from the Department of Irrigation. For the first time in 17 years gravity-fed water from the Nyanyadzi River started reaching all the four blocks of the irrigation scheme, enabling farmers to plant winter wheat, tomatoes, onions, sugar beans, maize and groundnuts. Farmers' incomes are expected to more than double by the fourth year. Private sector markets have been established for Michigan pea beans and a micro-finance institution has come on board to support the farmers.

Diversion drain within Nyanyadzi catchment

Photo: Oxfam

The project reduced run-off, soil erosion and sedimentation, and stormwater damage to irrigation and other infrastructure while increasing groundwater recharge and the ecological integrity of the catchment system. It improved irrigated cropping potential with a year-round cropping calendar, increasing farmer income potential from the current $2,844 to $6,479 per annum by year four after investment, and improved coordination between the government, UN agencies and civil society. To ensure sustainability the project supported strengthened governance of the scheme. In all the project has enhanced the livelihoods and adaptive capacity of the targeted population.

Dr L. Unganai, Oxfam 2017

Adaptation options for different sectors

Table 5 summarises some of the specific adaptation measures that have been proposed for Zimbabwe. Some of these are described in detail in the following section.

Water management

As discussed in chapter 3, water is the resource that will be most severely affected by climate change. Therefore, building resilient water management systems will be a crucial climate change strategy for Zimbabwe. First, we need to understand the factors influencing the water cycle, which are described in chapter 2, notably the vital role of aquifers and wetlands, as well as vegetation cover in the form of forests and grass. Underground

Passing knowledge to younger generations is an important adaptive measure

water does not evaporate and it is usually cleaner than water stored on the surface as it better protected from pollutants.

The following methods are recommended for improving the resilience of underground water stores:

Improving infiltration

This can be achieved by protecting the soil to encourage water to infiltrate. Soil protection measures include:

- Protecting areas of river catchment (the land uphill from the river), including wetlands, springs, and vegetation along streams and rivers
- Preventing deforestation
- Managing grazing areas to reduce compaction

- Avoiding use of fire to clear land and reducing risk from wildfires
- Water harvesting, including dead-level contours and catch dams that allow water to sink into the soil, particularly on slopes
- Reduced ploughing using conservation agriculture[12] methods, including minimum tillage and mulching
- Agroforestry – planting beneficial trees and shrubs around fields and between crops

Reducing evaporation

- Planting soil-improving crops such as legumes between main crops to cover the soil
- Mulching crops with crop residues
- Planting trees around gardens and fields to act as windbreaks
- Encouraging evergreen agricultural technologies and agroforestry
- Protecting vegetation along streams, rivers and wetlands and around the edges of dams
- Introducing drip irrigation and bottle-watering methods

Using mulch

Mulch is any material that is used to cover the soil. The most effective type of mulch is organic matter that increases soil fertility while covering the soil to prevent erosion and reduce evaporation. As mulch decays it increases the organic matter content of the soil, which reduces erosion and improves the water- and nutrient-holding capacity of the soil.

Expanding irrigation

Dryland crop production is not reliable and most farmers get a good yield in only three out of five years, especially in semi-arid areas.[13] Zimbabwe has many small, medium and large dams, but most are underutilised for irrigation. Other options for irrigation are the use of wells and boreholes and sand abstraction from dry river beds.

Limited irrigation makes the agriculture sector highly sensitive to climate hazards, while improved irrigation builds farmers' resilience to climate change and variability and drought. Irrigation ensures that the crop is never short of water; hence its use as an adaptation strategy. It has the following advantages:

- Improved and more consistent crop yields, greater food security and enhanced living standards
- Generating income through growing of cash crops and growing crops during the dry season
- Providing opportunities for fish farming, which improves nutrition

While expansion of irrigation is crucial to building resilience in Zimbabwe, much depends on sustainable management of resources – for instance by using efficient technologies such as drip irrigation – and balancing the water cycle by increasing infiltration and reducing evaporation.

Table 5: Adaptation strategies for some of the main sectors that will be affected by climate change

Sector	Adaptation measure
Water	• Improved monitoring and analysis of available national surface and groundwater reserves • Improved water supply to communities from groundwater sources • Protecting catchments, especially wetlands • Preventing deforestation and promoting afforestation • Managing grazing areas • Reducing fires • Water harvesting • Conservation and climate-smart agriculture • Agroforestry • Planting cover crops • Mulching • Planting windbreaks • Drip irrigation • Using underground water stores rather than dams
Land	• Gulley reclamation and slope protection • Reduced burning and land clearance • Improved grazing management • Protection of forests and planting of windbreaks • Conservation agriculture • Crop rotation, intercropping, compost and mulch
Vegetation	• Crop diversification • Planting mixtures of crops and cultivars adapted to different conditions as intercrops • Using crop varieties that are more tolerant to climate stresses • Using climate forecasting to reduce production risk • Encouraging the sustainable use of forests • Controlling fires • Promoting alternatives to firewood • Promoting agroforestry • Encouraging seed banks • Improving post-harvest storage • Encouraging integrated pest and disease management
Business	• Investigating alternative inputs, outputs, products and processes • Diversifying energy supply to reduce reliance on grid electricity • Optimising water supply • Adopting an inclusive business model, working with all value chain actors to promote adaptation solutions • Adopting the circular economy concept whereby resources are conserved with little waste • Promoting worker health and welfare

Sector	Adaptation measure
Human communities	• Raising awareness, informing and educating • Strengthening community-based decision making and collective action • Identifying and addressing areas of vulnerability • Developing adaptation plans and disaster risk management strategies • Building on successful indigenous practices and scientific approaches • Climate-proof infrastructure, including roads, bridges and buildings • Diversifying livelihoods • Conducting research on climate-resilient crops and livestock

Land management

Adaptive land management techniques hinge on proper planning of land-use developments to avoid damaging natural resources through pollution, destruction of vegetation and soil erosion.

Mining is a rapidly expanding economic sector that has caused widespread land degradation in Zimbabwe. Informal open-cast mining and panning in rivers have been especially implicated, but large-scale mining operations must share the blame.[14] The main problems created by mining are land degradation, soil erosion, hazards from open pits and shafts, deforestation and pollution. In order to build the adaptive capacity of land-based activities in future, small- and large-scale mining operators must abide by the law and be prosecuted for not doing so. However, it remains one of the adaptation measures in many parts of the country; it therefore needs to be formalised, decriminalised and practised in a sustainable way.

Climate-smart agriculture (CSA)

The main land-use activity in Zimbabwe is agriculture. Some agricultural activities such as deforestation, burning of vegetation, pollution of soil and water by agricultural chemicals

and uncontrolled livestock grazing can harm natural systems. Rising temperatures and other harmful consequences of climate change for vegetation and water are likely to reduce soil fertility. Zimbabwean soils tend to lack fertility because of their diminished capacity to store nutrients and water, and in many areas the soil structure makes them vulnerable to erosion. Many farmers pay high prices for chemical fertilisers. Soil fertility and water-holding capacity are affected by the structure of the soil and its organic content. These in turn are damaged by many common agricultural practices, including deforestation, burning and ploughing.

The Food and Agricultural Organisation (FAO) of the United Nations defines CSA as "agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces/removes GHGs (mitigation) where possible, and enhances achievement of national food security and development goals".[15]

CSA techniques include mulching, intercropping, conservation agriculture, crop rotation, integrated crop-livestock management, agroforestry, improved grazing and better water management.[16] They also cover innovative practices such as better weather forecasting, early warning systems and risk insurance designed to increase the resilience of smallholder farmers and poor communities to shocks, which are often weather- and climate-related. The main benefits of implementing improved cropland management practices are higher and more stable yields, increased system resilience and therefore enhanced livelihoods and food security, and reduced production risk.[17]

Conservation agriculture (CA)

In the last two decades there has been a global campaign to promote CA, which advocates minimising tillage, increasing soil

organic matter content and water harvesting by using planting basins. Such agricultural methods are also an important way of removing CO_2 from the atmosphere and storing it in the soil. Thus, improved soil management can also mitigate climate change. Case study 6 looks at experiences with CA in Zimbabwe.

Case study 6: Experiences with CA in Zimbabwe

CA recognises that care of the soil is fundamental to successful and drought-resilient agriculture. It incorporates three principles: minimal soil disturbance, permanent soil cover and crop rotation. These methods reduce soil erosion, improve soil fertility, conserve water and improve yields.

Since ploughing damages soil structure, CA encourages the planting of crops directly into basins. Crop residues are left as mulch on the soil surface to protect it from wind and water erosion and reduce evaporation. Cereals are rotated with legumes in alternating seasons. CA is also being promoted with micro-dosing of fertilisers, a method whereby farmers use extremely low rates of fertiliser with effective results.

Critics say CA is labour-intensive, deprives livestock of crop residues and increases the need for weed management. For these reasons, it increases the workload of women who already bear the main burden of farm labour.

Proponents argue that after the second or third season, farmers can use the same planting holes as in the previous season. Moreover, as mulch builds up, fewer weeds emerge. Mechanical planters have been introduced and gradually the idea has spread.

A farmer making CA planting basins

CA is the best practice developed so far for addressing current and future problems relating to soil fertility and agriculture, and has been shown to produce higher yields than conventional agricultural methods, particularly during drought years. The FAO estimates that over 300,000 farmers are practising CA in Zimbabwe today.

Source: ICRISAT

Other methods for improved land management are:

- Gulley reclamation and protection of slopes using plants and earth structures
- Reduced burning and land clearance
- Construction of dead-level contours
- Improved grazing management
- Protection of forests and planting of windbreaks
- Improving soil fertility with crop rotation, intercropping (planting different crops together), compost and mulch

Vegetation management

We depend directly on vegetation for food, fuel and other products. Livestock and wildlife, which make an important contribution to livelihoods and the economy, depend on vegetation for fodder and shade. Vegetation provides communities with other important ecosystem services, including protection of the soil, improved soil fertility, better infiltration of water into the soil, purification of the air and improvement of the climate. Areas with vegetation have a cooler, moister and less windy climate.

The plants that we depend upon will be harmed by climate change. Crops in particular will be affected by drought, reduction in soil fertility, pest infestations and disease outbreaks, while forests will be threatened by clearing for farming and fuel and by wildfires. The following measures can reduce the impacts of climate change in relation to vegetation:

- Encouraging crop diversification by planting a wider range of drought-tolerant crops
- Encouraging the sustainable use of forests for honey and other non-timber forest products such as edible insects and indigenous fruits so that people realise a value from living trees
- Fire control through firebreaks and avoiding fires to clear land for crops
- Protecting and managing grazing areas
- Promoting alternative fuels to firewood and encouraging energy-efficient cooking methods
- Promoting agroforestry, including live fencing and woodlots
- Encouraging communities to save their seeds and develop seed banks for local varieties
- Improving post-harvest storage of crops, such as grain stores, to prevent destruction by insects and increase food security during times when food is scarce

Agroforestry integrates trees and field crops

- Encouraging integrated pest and disease management to reduce pest infestations and diseases using cultural, biological and physical methods rather than depending on chemicals that may exacerbate pest problems in the long term.

Integrated pest and disease management (IPDM) is an effective, environmentally sensitive approach to controlling pests and diseases through cultural, biological and mechanical methods in order to reduce dependence on pesticides. See www.epa.gov/agriculture/tipm.html

Case study 7: Barriers to agroforestry adoption in Zimbabwe

Agroforestry involves growing beneficial trees or shrubs as part of cropping systems. Trees can produce a wide range of products, including food, fodder, firewood and timber. They can improve the soil, protect it from erosion and increase its water content.

Trees can be integrated with crop systems as woodlots, windbreaks and live fences. Certain trees can be planted in strips between crops or along contour ridges.

Encouraging communities to benefit from natural forests – by harvesting fruit, honey and insects, for instance – is also an important part of agroforestry.

The Ministry of Agriculture and development organisations introduced agroforestry technologies – notably alley cropping, woodlots, windbreaks and planting fruit trees on crop land – in Zimbabwe in 1980. However, the levels of adoption have been negligible. A study in Goromonzi District found that farmers who adopted agroforestry practices had greater crop yields and better income levels than non-adopters. Those who adopted tended to be younger, better educated and wealthier in terms of land, assets and livestock. The researchers recommended that educating farmers in agroforestry techniques and targeting younger farmers could help improve adoption.

Source: Mutambara et al 2012

Business adaptation and infrastructure resilience

The impacts of climate change will significantly affect food security, water availability and human health. These are all factors on which commercial enterprises in Zimbabwe depend. In addition, extreme events can affect infrastructure, labour, inputs and markets.

Lack of food and poor human health can lead to low employee morale and reduced productivity. Shortages and deteriorating quality of water can reduce product quality and quantity, having consequences for profitability and growth. Water shortages will affect hydropower generation, causing electricity shortages that threaten economic development and social well-being.

Cyclones have destroyed roads and bridges in the past, thus affecting ready movement of goods and people. High ambient temperatures can cause buckling of rail lines, leading to train derailments. Businesses are vulnerable to climate change and must therefore adapt to it and mitigate its harm.

Practical steps for business

Business leaders must find ways to alleviate the impact of extreme events on their operations in the short and long term. The following steps can be taken:

- Raise awareness on climate change and possible impacts on sector-specific operations
- Identify climate risks such as water scarcity and floods and assess severity of impact
- Identify adaptation solutions such as efficient water and power utilisation
- Prioritise and develop budgets

- Implement adaptation measures
- Spread the risks through insurance
- Commission monitoring and evaluation to find out if measures are working and adjusting when necessary

Knowledge sharing and learning and active and sustained engagement of stakeholders are important in all the above steps.

Specific adaptation measures that business can take

Many of the measures that businesses can take cover both adaptation and mitigation.

- Diversify energy supply to reduce heavy reliance on grid electricity. This entails improving energy efficiency and switching to alternatives – solar for pumping and heating water, hydropower generation on inland dams, using industrial waste as an energy source and developing renewable energy technologies like biogas
- Optimising water supply by applying improved water management measures such as rainwater harvesting, recycling and re-using water and considering inputs, processes and products that require less water
- Adopting an **inclusive business** concept model. This entails working with all value chain actors – inputs suppliers, service providers and consumers, among others – to promote innovative adaptation solutions like efficient utilisation of water and energy
- Adopting the **circular economy** concept in which all elements in the consumption chain work together to retain resources in the economy for as long as possible and with little waste
- Promoting worker welfare: managing the health and welfare of workers by providing nutritious meals at work,

monitoring temperatures, instituting flexible working hours during times of extreme heat and installing air cooling systems that run on renewable energy sources and do not use CFC or HFC gases.

Disaster risk reduction to protect infrastructure

Zimbabwe has recently experienced violent, short-lived, tornado-like storms which have destroyed houses, property, livestock, wildlife, crops and even lives. It has not recovered fully from tropical Cyclone Eline since it swept through the country in 2000, putting into question the country's climate-related disaster preparedness and adaptive capacity. Researchers and practitioners have called on decision makers, policy makers and households to consider having at least one resilient house to use as shelter in times of severe storms. Some have advocated the adoption of building codes and housing standards even in rural areas where there has been the most destruction due to non-resilient infrastructure.

The power shortages of 2015–2016 following the low dam levels in Kariba demonstrated the vulnerability of Zimbabwe's industry due to over-reliance of hydropower, which is sensitive to seasonal rainfall performance. This calls for diversification of power sources and decoupling of climate behaviour from power generation. As temperatures fluctuate from one extreme to another, the need for heating in winter and cooling in summer is becoming clearer.

Elisha Moyo 2017

Beekeeping provides income and helps conserve forests

Human communities

Strengthening the resilience of human communities to cope with climate change depends on increasing their capacity to function as self-supporting units. Zimbabwean communities used to be tight-knit social networks with a strong spirit of cooperation. Traditional leadership and indigenous knowledge were valued and respected, and traditional and cultural rules governing human behaviour and protecting environmental resources were strictly upheld. As shown in case study 3, over the years these traditional social systems have become eroded and a more individualistic mentality has prevailed that has led to over-exploitation and degradation of communal resources.

Ways will have to be found either to replace these old systems or design more resilient ones. The new systems can encourage the participation and empowerment of groups, particularly of women, that were left out of decision-making processes in the past. They should also focus on strengthening household resilience. The following measures can help:

- Raising awareness and informing and educating people about the causes and impacts of climate change are a crucial first step; schoolchildren, teachers and community opinion leaders such as pastors, chiefs and headmen and business executives can play an important role
- Strengthening community-based decision making and collective action while avoiding a dependency syndrome and a victim mentality
- Identifying areas of vulnerability that can be exacerbated by climate change and that need to be addressed – poverty, malnutrition, disease, poor sanitation and hygiene and improved social safety nets
- Developing adaptation plans and disaster risk management strategies in participation with stakeholders, especially vulnerable groups that are often left out of decision making, notably women, children and the disabled
- Building on successful indigenous practices as well as new scientific approaches
- Improving roads, bridges and buildings that may be susceptible to climate change hazards
- Promoting green buildings that use passive cooling systems
- Diversifying livelihoods into climate-resilient areas, including animal husbandry, horticulture, aquaculture and off-farm activities
- Identifying and promoting household adaptation systems

Case study 8: Climate-smart villages in Buhera, Chiredzi and Chimanimani

In Buhera, Chiredzi and Chimanimani districts, high rates of poverty, declining agricultural productivity, chronic hunger and child malnutrition are being exacerbated by the effects of climate change. Droughts, floods, heavy rainfall, heat waves and mid-season dry spells are increasing while the summer rains are said to start later and end sooner. Thousands of rural households are being put at risk by the interaction of climate change with a fragile ecology, population pressure, over-dependence on climate-sensitive economic sectors particularly agriculture, a degraded natural resource base, institutional failure and limited access to livelihood assets.

Oxfam, in partnership with Plan International, the Southern Alliance for Indigenous Resources and the University of Zimbabwe, is implementing a project that is targeting 10,000 households to scale up adaptation measures and reduce the vulnerability of rural communities, particularly women, to climate variability and change.

The project has been working with farmers, local leaders and government departments to develop climate-smart villages with increased understanding of climate variability and associated risks. Improving farmers' adaptive capacity and helping them diversify and strengthen their livelihoods are achieved through investments in water, climate-adapted farming practices, natural ecosystem restoration, protection and management, improving access to inclusive financial services and linking smallholder farmers to markets.

The partnership is also working to improve the local rainfall observation network through weather and climate forecast products, an ICT-based climate information dissemination system and a tool to help extension workers support farmers to make informed decisions based on the local weather and climate forecasts.

In particular, the target communities have learnt the importance of soil water storage since this provides more than 90% of the rural water supply and the soil is the only natural water reservoir for crops and plants. Directing available surface water into the soil and underground for use when surface supplies are limited is therefore important to boost the amount of water held in these reservoirs.

As part of its adaptation strategy, Zimbabwe would do well to rely more on subsurface reservoirs and integrated management approaches to respond to the challenges of increased demand for water and the growing unpredictability of rainfall and temperature. Managing deforestation, overgrazing, soil erosion, pollution and extraction, as well as protecting wetlands, are important strategies for boosting soil and groundwater recharge. District climate change adaptation plans should include soil and groundwater management as an important focus area.

Dr L. Unganai, Oxfam Zimbabwe

Farmers will have to switch to more resilient livestock in future

In this chapter we looked at ways in which Zimbabwean communities, government departments, and businesses can build resilience, develop ways to adapt to climate change and improve progress to achieving sustainable development. In the next chapter we examine ways in which Zimbabweans can contribute to climate change mitigation. Appendix 1 lists details of organisations involved in adaptation projects.

Endnotes

1 For more about this topic, see "UNFCCC 2015 Synthesis Report on the Aggregate Effect of the Intended Nationally Determined Contributions": https://unfccc.int/resource/docs/2015/cop21/eng/07.pdf

2 UNFCCC 2007. "Climate Change: Impacts, Vulnerabilities and Adaptation": https://unfccc.int/resource/docs/publications/impacts.pdf

3 Turnbull, M. and Turvill E. 2012. *Participatory Capacity and Vulnerability Analysis: A Practitioner's Guide. An Oxfam Disaster Risk Reduction and Climate Change Adaptation Resource*. Oxfam International: www.africa-adapt.net/media/resources/895/ml-participatory-capacity-vulnerability-analysis-practitioners-guide-010612-en.pdf

4 Brown, D., Chanakira, R., Chatiza, K., Dhliwayo, M., Dodman, D., Masiiwa, M., Muchadenyika, D., Mugabe, P. and Zvigadza, S. 2012. "Climate Change Impacts, Vulnerability and Adaptation in Zimbabwe". IIED Climate Change Working Paper 3: http://pubs.iied.org/pdfs/10034IIED.pdf, accessed August 2015.

5 Brooks, N., Adger W.N. and Kelly, P.M. 2005. "The Determinants of Vulnerability and Adaptive Capacity at the National Level and the Implications for Adaptation. *Global Environmental Change* 15:151–163

6 Davis, R. and Hirji, R. 2014. "Climate Change and Water Resources, Planning, Development and Management". Issues paper. World Bank and Government of Zimbabwe: http://documents.worldbank.org/curated/en/2014/10/23839207/climate-change-water-resources-planning-development-management-zimbabwe, accessed August 2015

7 The UN's Sustainable Development Goals replaced the Millennium Development Goals at the end of 2015

8 Brown *et al.* 2012

9 www.undp-alm.org/sites/default/files/downloads/focus_on_climate_change_zimbabwe_-_april_2013.pdf

10 www.acts-net.org/programmes-projects/projects?id=35

11 http://oxfaminzimbabwe.org/index.php/strengthening-weather-and-climate-change-information-dissemination-systems-in-zimbabwe/

12 See www.fao.org/ag/ca/Training_Materials/CA_toolbox_Zimbabwe.pdf for more information

13 Nyamudeza, P. 1996. "The Effect of Growing Sorghum (*Sorghum bicolour*) in Furrow and on the Flat at Three Populations and Three Row Widths in a Semi-Arid Region in Zimbabwe – Grain Yield Components". *Zimbabwe Journal of Agricultural Research* 31:1–10

14 Zimbabwe Environmental Lawyers Association: www.zela.org

15 IPCC 2007 Climate Change 2007. "Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change". Chapter 8 – Agriculture. *Climate Change* 2007: Cambridge and New York, Cambridge University Press: www.ipcc.ch/publications_and_data/ar4/wg3/en/contents.html

16 World Bank 2012. "Climate-Smart Agriculture and the World Bank: The Facts": http://climatechange.worldbank.org accessed 29 January 2013

17 Conant, R. T. 2009. "Rebuilding Resilience: Sustainable Land Management for Climate Mitigation and Adaptation, Technical Report on Land and Climate Change for the Natural Resources Management and Environment Department". Rome, Food and Agriculture Organisation
Vallis, I., Parton, W.J., Keating, B.A. and Wood, A.W. 1996. "Simulation of the Effects of Trash and N Fertilizer Management on Soil Organic Matter Levels and Yields of Sugarcane." *Soil Tillage Research* 38, 1–2:115–132

6 Mitigation options for Zimbabwe

This chapter was reviewed by Dr Ndebele-Murisa, Dr Dube and Elijah Moyo, with additional material contributed by Tendayi Marowa.

In this chapter, we discuss mitigation – the ways in which we can reduce greenhouse gas emissions and their load in the atmosphere. We present some technological ways to lessen emissions and reduce the global greenhouse gases in the atmosphere (carbon sequestration), and large-scale interventions that change the Earth's natural systems to counteract climate change (geo-engineering). We also discuss the social and economic structural transformations that need to take place for the climate change problem to be addressed effectively. We then look at Zimbabwe's international mitigation commitments and options.

As we have already noted, the most effective strategies for Africa to deal with climate change will be solutions that combine sustainable development, adaptation and mitigation.

Chapter summary

What does mitigation entail?

Mitigation of climate change involves efforts to reduce or prevent greenhouse gas emissions and the greenhouse gas load in the atmosphere. This needs to be achieved through technological solutions accompanied by structural changes in the social and economic systems of our societies. These changes are the foundation of sustainable development, which requires ecological, social and economic solutions in order to meet the **needs** of the present without compromising the well-being of future generations.

Steps to introducing mitigation measures

These principles of mitigation can be applied to a system such as a home, business, school, village, suburb or farm.

1. Conduct an energy audit of your system
2. Analyse the processes used in your system – for instance for heating, lighting, cooking, manufacturing, transport and waste
3. Identify ways that energy can be produced and used more efficiently
4. Identify ways to reduce energy consumption and introduce renewable energy technologies, including waste-to-energy projects
5. Identify materials that can be replaced with non-greenhouse gas alternatives, such as refrigerants and low-energy alternatives such as using compost instead of inorganic fertiliser.
6. Identify elements in your system that could be developed as carbon sinks such as tree planting and composting of organic waste
7. Institute the mitigation measures

Global emissions sources

Figure 4 in chapter 1 showed that in 2010 the major sources of global greenhouse gases were energy production (24%), industry (21%), agriculture (14%) and transport (14%). The fifth assessment report (AR5) of the IPCC[1] shows that global greenhouse gas emissions rose from 27 billion tons, or 27 gigatons (Gt), in 1970 to 49 Gt in 2010. Globally, carbon dioxide from fossil fuel combustion and industrial processes contributes the bulk of emissions – 55% in 1970 and 65% in 2010, followed by methane (19% in 1970 and 16% in 2010) and nitrous oxide (7.9% in 1970 and 6.2% in 2010).

Over a period of 40 years annual global greenhouse gas emissions rose by 22 $GtCO_2e$, which gives an average increase of 0.55 Gt CO_2e per year.

Global emissions drivers

According to AR5, greenhouse gas emissions are mainly driven by energy use, population size, economic activity, lifestyle, land use patterns, technology and climate policy. Working from a global population of 7 billion and the 2010 global emissions figure of 49 $GtCO_2e$, we get a global average of 7 tCO_2e per capita, or 7,000 $kgCO_2e$ per person per year.

When reporting national greenhouse gas emissions under the UNFCCC national communications guidelines, the following categories are generally used: energy sector; industrial processes; solvents and other product use; agriculture; waste; and land use, land use change and forestry. The energy sector covers electricity production, transport and other energy emissions, and in 2010 it contributed around 49% of global emissions.

View of Harare with the power station in the foreground

How much is a gigaton?

One gigaton is:

- More than the mass of all the humans on the planet
- More than the annual global production of iron and steel
- 2,740 Empire State Buildings or 77 Empire State Buildings made out of solid lead
- 142,857,142 African elephants. That's enough elephants stacked on top of each other to reach from Earth to the Moon and halfway back

Projected emission scenarios

Scientists have developed different emissions scenarios, called "representative concentration pathways" (RCPs), based on reasonable assumptions about global developmental trajectories and what could happen up to the year 2100.

From figure 24 we can see that different emissions scenarios lead to different outcomes. There are four RCPs that range from low to very high future emissions (RCP2.6, 4.5, 6.0 and 8.5). At one extreme is RCP8.5, known as the "business-as-usual pathway". This assumes that CO_2e concentrations are allowed to continue increasing above 1,000 parts per million. This scenario leads to a projected global temperature rise of around 4°C above pre-industrial levels. At the other extreme, RCP2.6 represents a scenario in which societies try to keep global warming below 2°C above pre-industrial temperatures, the goal of the Paris Agreement. This will require considerable global action to cut emissions.

The 2°C increase from present-day global average temperatures is considered the threshold at which climate change becomes "dangerous". The 4.5 and 6.0 RCPs fall between the low and high extreme RCPs of 2.6 and 8.5.[2]

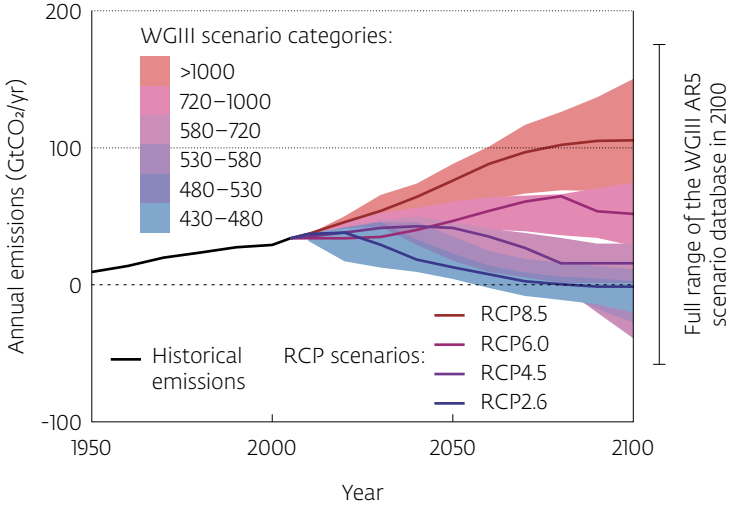


Figure 24: Annual anthropogenic emissions up to 2100

Source: IPCC AR5

Zimbabwe's emissions

Zimbabwe's contribution to the climate change problem is very small. Its emissions per capita are a quarter of the global average and electricity consumption per capita is about 20% of the global average.

Zimbabwe's latest submission to the UNFCCC was the Third National Communication (TNC) whose reporting year was 2006. The country's estimated emissions were 22,019 $GgCO_2e$, but due to its large areas of forest cover, carbon dioxide removals from the atmosphere through the land use, land use change and forestry sector were estimated at 83,000 $GgCO_2e$, making Zimbabwe a net carbon sink.

Several factors affect Zimbabwe's greenhouse gas emission levels. Population and economic growth are major drivers. Accelerated urbanisation also plays a role: as people move to towns and cities, their lives and livelihoods hinge on activities that require increasing levels of energy compared to those in rural areas. Table 6 compares Zimbabwe's greenhouse gas emissions with global emissions, while figure 25 shows the main sectors responsible for greenhouse gas emissions.

Table 6: Comparison of Zimbabwe's emissions with the global emissions

Item	Global position	Zimbabwean position
Emissions	49 $GtCO_2e$ (2010)	0.022 $GtCO_2e$ (2006)
Relative emissions	100%	Approximately 0.05% of global emissions
Approximate per-capita emissions	7 tCO_2e	1.7 tCO_2e
Biggest source of greenhouse gases	Energy sector (49% in 2010)	Energy sector (48% in 2006)
% contribution of forestry to greenhouse gases	11% in 2010 (net emitter)	Net sink
Approximate electricity per capita (kWh/capita)	3,400	600

IPCC 5th Assessment Report (AR5) and the Third National Communications (TNC)

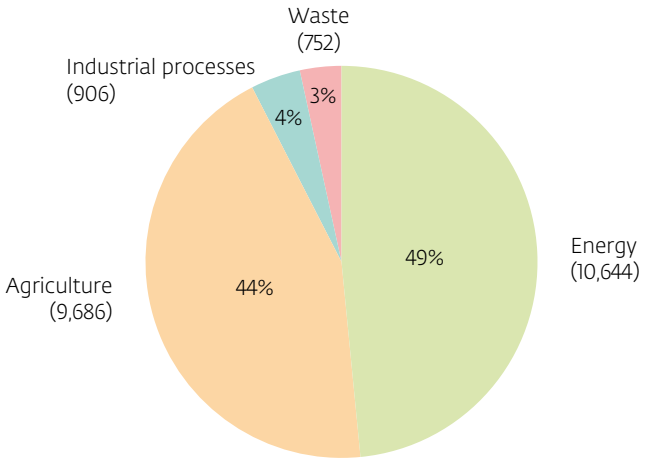


Figure 25: Zimbabwe's greenhouse gas emissions in 2006 ($GgCO_2e$)

Source: Government of Zimbabwe 2016. Third National Communication to UNFCCC

Energy production emissions

Greenhouse gases released during the burning of fossil fuels – coal, oil and natural gas – to generate power are the largest contributors to Zimbabwe's emissions. Figure 25 shows that in Zimbabwe the energy sector was the largest contributor to greenhouse gas emissions in 2006. Despite this, the country is failing to supply sufficient power to meet domestic and industrial demand. There are too few power stations and they are handicapped by outdated equipment and lack of maintenance, leading to inefficiency and unnecessary greenhouse gas emissions.

Rural energy emissions

Few people in rural areas have access to electricity and rely on fuelwood – and in some areas charcoal – for cooking, lighting and heating as well as for small-scale processing, brick making and agricultural activities, notably tobacco curing. Coal is used for large-scale tobacco curing and firewood for smaller-scale curing.

The harvesting and use of trees as an energy source is unsustainable, and little effort is being put into replacing trees in the form of woodlots or protective regeneration of natural forests. Moreover, the increasing incidence of runaway wildfires plays a major role in destruction and degradation of forests.

Urban energy emissions

Most urban families use electricity for cooking, heating and lighting, but due to the erratic supply, many households have turned fuelwood as a supplementary source. Those who can afford it use liquefied petroleum gas, solar systems or generators using petrol or diesel.

Zimbabwe's road, rail and air transport systems run on petroleum derivatives. Imported petrol is blended with ethanol produced by a biofuel plant attached to the main sugar refinery in Chisumbanje. The plant generates electricity to run its operations and to supply the local community. The blending of ethanol with petrol contributes to reducing Zimbabwe's greenhouse gas emissions from imported liquid fuels.

Figure 26 shows that around 55% of Zimbabwe's electricity is generated using clean sources and 2% is from renewable energy sources (excluding large hydro).

Most rural Zimbabweans use firewood for cooking

Zimbabwe is a developing nation which is not only improving per capita access to energy but also access to modern and sustainable sources of power. By 2018 an additional 300 megawatts (MW) of hydropower will be added to the national electricity grid. Although Zimbabwe has no internationally binding commitment to reduce emissions up to 2020, it has been adopting renewable and cleaner energy sources and improving energy efficiency. However, financial challenges have held back significant transition to low-carbon development pathways. We discuss this in detail later in this chapter.

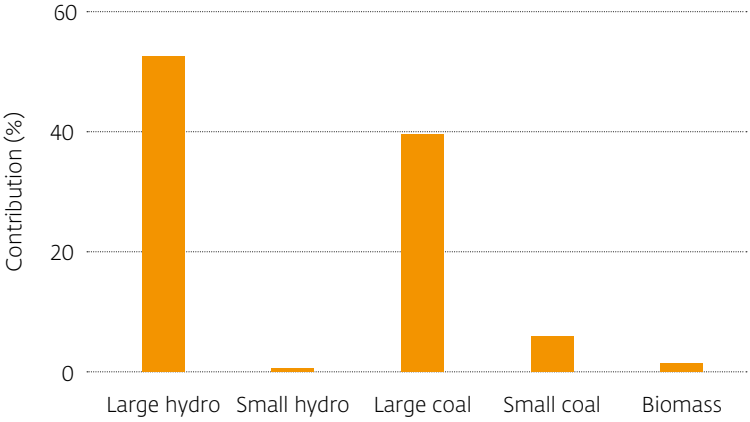


Figure 26: Contribution of energy sources in electricity production in Zimbabwe in 2015

Source: Government of Zimbabwe 2016. Third National Communication to UNFCCC

Technological mitigation solutions

Technological climate change mitigation solutions include methods for reducing the amount of greenhouse gases entering the atmosphere, facilitating the removal of greenhouse gases from the atmosphere (carbon sequestration) and manipulating the Earth's natural systems in order to reduce the impacts on climate change (geo-engineering). These measures are summarised in table 7.

Reducing emissions

The commitments submitted by the parties to the Paris Agreement to date will reduce by no more than a third of the

Alternatives to firewood as a fuel source must be sought

levels required to achieve the 2°C target by 2030, risking warming of up to 3.4°C. One of the objectives of a UNFCC facilitative dialogue to be held in 2018 is to raise ambition among the parties. To meet the 2°C goal, massive investments need to be made in the coming decades in low-carbon and climate-resilient infrastructure. According to the International Energy Agency, globally a cumulative US$48 trillion to US$53 trillion investment will be needed by 2035 to strengthen energy supply and energy efficiency.[3]

Reducing the amounts of greenhouse gases being released into the atmosphere will require a major restructuring of both industrialised and developing societies, and this process is already beginning. Societies will need to focus on shifting towards alternative energy sources, including renewables such as solar, wind, wave and biomass. Other important changes will need to

include the following: better energy efficiency; finding alternative materials such as refrigerants; improving systems of industrial, agricultural and food production and consumption; and greening cities.

Table 7: Summary of technological options for mitigation

Reducing emissions	Carbon sequestration	Geo-engineering
Alternative energy sources: Renewables, such as solar, wind, wave, hydro and biogas, nuclear energy and natural gas (fracking) **Alternative materials:** replacing HFCs in refrigerators and air conditioning with non-GHGs and finding alternatives to cement **Transformation of industrial processes:** alternative products, alternative inputs, recycling or re-using waste and increasing efficiency **Transformation of agriculture and food systems:** reducing deforestation and land clearing, conservation farming and regenerative agriculture, improved livestock production and transition to greater consumption of plant-based foods **Green cities:** improved public transport, electric vehicles, alternative energy, green buildings and waste management	**Biological processes:** forest protection, agroforestry, wetlands, regenerative agriculture, ocean fertilising and seaweed farming **Artificial methods:** modified power stations, burial of crop residue, or biochar, ocean storage, geological sequestration (storage in rock), manufacture of mineral carbonates, industrial sinks such as eco-cement and chemical scrubbers (artificial trees)	**Carbon dioxide removal:** burial of biochar, reforestation and ocean fertilisation **Solar radiation management:** space-based sunshades, cloud-brightening, reflective aerosols, growing pale-coloured crops, and reflective roofing materials

Sources: Project Drawdown: www.drawdown.org/solutions-summary-by-rank; Conserve Energy Future: www.conserve-energy-future.com/carbon-sequestration.php; Oxford Geoengineering Programme: www.geoengineering.ox.ac.uk/what-is-geoengineering/what-is-geoengineering/

Alternative energy sources

Finding alternative energy sources is one of the major ways that the world can fight climate change. Ideally this could involve a shift of the global economy towards renewable energy, which has low carbon emissions such as solar photovoltaic (solar PV), wind, hydro and wave energy, and biogas. Energy solutions for transport will be crucial, as cars and particularly aeroplanes are a major contributor to greenhouse gas emissions.

Unprecedented gains have been made in the uptake of renewable energy in the past decade, with China leading a revolution in supply of cheap solar energy. According to a report by British Petroleum, renewables now account for nearly 8% of global electricity generation. This may not sound like much, but it is put into perspective when we find that renewables contributed to almost 40% of the growth in global power generation in 2016.[4]

A report by the Renewable Energy Policy Network[5] states that newly installed renewable power capacity set new records in 2016, with 161 gigawatts (GW) added. This raised the global total by almost 9% relative to 2015, with solar PV accounting for around 47% of the total additions followed by wind power at 34% and hydropower at 15.5%. The report notes that for the fifth consecutive year investment in new renewable power capacity was almost double the investment in fossil fuel-generating capacity. The world now adds more renewable power capacity annually than it adds in net new capacity from all fossil fuels combined. Other highlights from the report are that the cost of electricity produced by solar PV and wind is falling rapidly and that 2016 was the third year in a row for emissions from fossil fuels to fall.

Biofuels are made from fresh plant or other organic materials, including human and animal waste. They include bio-ethanol, biodiesel and biogas. Although the burning of biofuels releases greenhouse gases, growing the plants from which biofuels are made removes CO_2 from the atmosphere. Critics of biofuels argue that they do not make a meaningful reduction to greenhouse gas emissions and that diverting land, water and other resources to produce them threatens food security, particularly in developing countries.

Some analysts argue that although rapid, the growth in renewables is not fast enough to replace fossil fuels as sources for power generation in time to achieve the 2°C target for the Paris Agreement. In addition, developing ways to store energy from renewables when, for example, the sun is not shining or there is no wind, is proving to be a major obstacle. The technology for energy-efficient batteries is improving and it is hoped that solar, wind and wave energy sources will soon become widely available and viable.

Subsidies for fossil fuels or electricity from coal power plants tend to make renewable energy projects unattractive. Some developed countries are building new coal power plants that are more energy-efficient, release fewer emissions and remove CO_2 from the atmosphere through carbon capture storage. Most developing countries, Zimbabwe included, have not embraced the new and expensive technology.

Nuclear energy and fracking

In most developed countries natural gas and nuclear power are replacing coal in power generation. Although they produce fewer emissions than coal, they are not popular and carry major risks. Natural gas extraction often involves hydraulic fracturing, or "fracking", which can cause environmental damage through use of huge amounts of water during extraction and endanger health through potential pollution of underground water reserves by fracking chemicals. Nuclear power became increasingly unpopular after a nuclear power plant in Fukushima, Japan, was severely damaged in March 2011 by a tsunami. The accident caused radiation leaks that forced more than 100,000 people to leave their homes and contaminated the Pacific Ocean. This highlighted the danger which nuclear power plants face from extreme events, which are likely to worsen due to climate change.

For more information visit http://www.bbc.com/news/uk-14432401

Alternative materials

Surprisingly, one of the main ways to reduce greenhouse gas emissions is to substitute the materials that we use for refrigerants. Refrigerants, the chemicals used in the cooling systems of air conditioners and refrigerators, have a history of causing serious environmental problems. Chloroflurocarbons (CFCs) and hydrochloroflurocarbons (HCFCs) were widely used as refrigerants until it was discovered that they were destroying the ozone layer – the layer in the atmosphere that protects life on Earth from the harmful effects of the Sun's ultraviolet radiation. CFCs and HCFCs were phased out under the Montreal Protocol in 1987. Unfortunately, the gases used to replace them,

hydroflurocarbons (HFCs), turn out to be one of the most potent greenhouse gases, with a capacity 1,000 to 9,000 times greater than carbon dioxide to warm the atmosphere.[6] Under the Kigali Accord signed in 2016 HFCs will be phased out by 2028. Some analysts claim that phasing out HFCs could avoid emissions of 87 $GtCO_2e$ by 2050 and regard it as the most effective way to reduce the greatest amount of emissions.[7]

The global cement industry contributes more than 5% of CO_2 emissions annually. Finding different ways to manufacture cement and using different materials in cement production could avoid 6.7 $GtCO_2e$ by 2050.[8]

Agriculture and food systems

Food production and other farming activities contribute hugely to greenhouse gas emissions. Firstly, land clearance for agriculture and other uses contributes 11% of global greenhouse gas emissions. Crop and livestock production uses inputs such as fertilisers and other chemicals, animal feeds and mechanised equipment, all of which contribute to greenhouse gas emissions. Even ploughing releases carbon dioxide into the atmosphere. When crops grow they absorb CO_2 from the atmosphere, but when they are harvested they release a considerable amount of CO_2. Livestock production contributes to the release of methane and other greenhouse gases.

Much land under cultivation is devoted to producing livestock feed as the global demand for meat increases. Intensive poultry and pork production and cattle feedlots are major contributors to greenhouse gas emissions. In *Drawdown: The Most Comprehensive Plan Ever Proposed to Reverse Global Warming*, author Paul Hawken notes that "If cattle were their own nation, they would be the world's third-largest emitter of greenhouse gases". He estimates

that raising livestock accounts for nearly 15% of annual global greenhouse gas emissions.[9] Hawken adds that an even more important contributor to global greenhouse emissions from the food system than livestock production is food waste: one-third of food that is produced is never consumed and reducing food waste by 50% could avoid 26.2 $GtCO_2e$ by 2050.

Greening cities

Urban areas are major contributors of greenhouse gas emissions. Transforming transport systems for people and goods between and within cities will be crucial to addressing the climate change problem. This will require such solutions as mass switching to electric vehicles and improving mass transport systems by road, rail, air and sea. Heating, cooling and lighting of buildings is also a major contributor that will need to be addressed through new technologies and energy sources. Construction methods and materials will need to be revolutionised. Waste production and management are other areas of major concern that need to be addressed. The technology for many of these problems is available, but it needs legal and policy measures as well as economic incentives to be put into place in order to encourage uptake on a mass scale.

Carbon sequestration

Methods for removing carbon from the atmosphere can be natural or artificial. Natural methods include conservation of forests and wetlands and agricultural practices.

Forests and wetlands

As mentioned in previous chapters, plants and trees in particular are important natural sinks of CO_2, but they become sources of

atmospheric CO_2 when they are cut down or burnt. Therefore, clearing land and cutting down trees for fuel and timber releases CO_2 into the atmosphere.

Forests and other vegetation affect climate and weather patterns in other ways too, for example by reducing wind speed, cooling surface temperatures and increasing atmospheric humidity.

Case study 9: Termites teach us how to build solar air-conditioned cities

As temperatures rise in Zimbabwe's cities due to climate change, there will be greater requirements for ways to cool buildings to enable people to live and work comfortably. Conventional air conditioning requires a huge amount of electricity – three times more than that needed to heat buildings in cold countries. The extra power needed to drive air conditioners and the HFC gases used as refrigerants are major contributors to global warming.

But there are other ways to cool buildings that save huge amounts of energy and do not require conventional air conditioning. Award-winning Zimbabwean architect Mick Pearce designed the Eastgate complex in Harare in 1995 using a groundbreaking passive-cooling approach that he adapted by observing the way that termites cool their nests. Like termite mounds, Eastgate uses chimneys to expel heat from the building at night while drawing cool night air into the building through a system of cavities and air passages. The uneven surface of the building, small windows, low wattage lighting systems and thick walls help prevent the building from heating up too quickly during the day. The design of

Eastgate has reduced external power consumption by 90% compared with full air conditioning.

Pearce says that "at present buildings are responsible for 40% of humanity's total energy consumption, mainly from air conditioning. This percentage can be reduced by at least half using adaptive building design systems. Planting trees along our streets, painting our buildings and roads with light-reflective colours and by giving up our obsession for glass facades could reduce the ambient temperatures outside the buildings by 7°C to 10°C. By using our built forms as solar energy collectors, each building could become a power generator by day, feeding into an integrated network supply grid where power is needed."

Today Pearce is working on buildings that combine passive cooling, energy production and water-harvesting systems. He is also involved in promoting building materials with a low carbon footprint.

Eastgate complex, Harare

REDD+

The UNFCCC mechanism called "reducing emissions from deforestation and forest degradation" (REDD+) permits developed countries to pay developing countries to offset their emissions by giving financial rewards for conserving existing forests. Such payment schemes have been criticised because it is difficult for enforcers to see how loopholes can be plugged. For example, some of the schemes would conceivably allow people to earn money by cutting down natural forests, releasing huge amounts of CO_2, and replanting them with exotic trees. Other problems associated with the REDD+ schemes are:[11]

- The difficulty of measuring how much carbon an area of forest can store and calculating how the level would change if emission levels continued to increase
- Difficulties in designing effective conservation and management projects that ensure that less carbon is emitted
- Ensuring that communities that live in and off the forests are not exploited
- Ensuring that preventing deforestation in one place does not encourage it in other areas instead, a problem known as "leakage"

These challenges have been discussed at international climate negotiations and it is hoped that an effective REDD+ mechanism will come out of it. Some examples of REDD+ programmes around the world can be found at www.un-redd.org/ and www.coderedd.org/about-redd/

When vegetation is cleared on a large scale it can lead to changes in weather patterns and local climate. The more land that is cleared for agriculture, mining, housing, fuel and timber, the more we contribute to climate change. As trees are cut down, large amounts of carbon that were stored in their tissues are released into the atmosphere. The more forests and other vegetation we plant or preserve, the less we advance climate change.

As noted in chapters 2 and 5, wetlands play a crucial role in maintaining the quantity and quality of water and in flood reduction. The conservation of natural wetlands is also an important mitigation measure as they have been shown to be important natural sinks for carbon dioxide, methane and nitrous oxide.[10]

Agriculture

Transforming agricultural systems through practices already mentioned in the adaptation chapter, such as climate-smart agriculture and agroforestry, can lead not only to reduced carbon emissions but can also transform agricultural systems into carbon sinks.

Another approach, regenerative agriculture, encourages zero tillage, a diversity of cover crops, improved soil fertility, avoidance of pesticides and synthetic fertilisers, and multiple crop rotations.[12] The emphasis on adding organic matter to the soil in these ways helps to sink carbon in the soil and reduce emissions. Other farming methods that can sequester carbon are the burial of crop residues and biochar. Biochar is a type of charcoal that is made by burning crop residues in the absence of oxygen. In this way biochar locks up carbon in a stable structure that can act as a soil fertiliser and a carbon sink.[13]

Artificial trees

"Carbon scrubbers" are devices that capture carbon dioxide from the atmosphere and store it using various technologies. Commonly known as artificial trees, these devices have already been installed in some cities across the globe. The technology is extremely expensive at around $350,000 per tree, but the cost is expected to drop rapidly as the uptake increases.[14]

Geo-engineering

Geo-engineering involves large-scale interventions in the Earth's climate system to reduce global warming. Its proponents justify various technologies to manipulate the climate by pointing to evidence that a dangerous tipping point may be reached that leads to an irreversible change in global climate. One trigger for such a tipping point would be the shrinking of sea ice, releasing huge amounts of methane stored beneath the ice. Geo-engineering is seen by some as a quick way to buy us time until we can put longer-term measures in place. Others argue that geo-engineering itself could have unforeseen side-effects that are irreversible and could cause more damage than they address.

Because there are substantial economic costs and risks associated with these methods, most scientists see geo-engineering as a last resort rather than as a substitute for other types of mitigation. Some geo-engineering methods are likely to be used in combination with other measures.

Geo-engineering can be divided into two categories: carbon dioxide removal and solar radiation management.

All Zimbabweans need to recognise the value of trees and cultivate a culture of tree planting

Carbon dioxide removal

Carbon dioxide removal involves large-scale reforestation, large-scale burial of biochar and ocean fertilisation, a method of using iron, urea and other nutrients to feed the growth of microscopic marine organisms that absorb carbon from the atmosphere.

Solar radiation management

Solar radiation management takes the form of reducing the amount of sunlight –and thus heat – reaching the Earth's surface. Such methods can include creating large surfaces that reflect sunlight away from the Earth – for example, a space-based sunshade using mirrors or dust – using pale-coloured roofs or road materials and growing pale-coloured crops. Other suggestions are to brighten clouds with sea-water spray or to spray reflective chemicals into the atmosphere.

Social and economic transformation

Governments in many developed countries have offered financial incentives to industry and business, including agribusiness, to reduce emissions. This marks the beginning of structural transformations to society that have become known as the green economy. The United Nations Environment Programme has defined the green economy as "one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. It is low-carbon, resource-efficient, and socially inclusive."[15]

The green economy

The green economy is taking off in developed countries. Measures have been put in place to reduce demand for travel and make available a wider range of options for low-emission private and public transport. Batteries and fuel cells are powering vehicles and the appetite for the new technologies is increasing. Urban planners are becoming more emissions-conscious and building standards are being improved to help lower emissions. Individuals are being encouraged to reduce their energy demands, their consumption patterns and waste.[16]

The circular economy

Economists realise that a focus on economic growth has caused many social and environmental problems and are starting to rethink the basic principles on which societies are based. One approach is the circular economy, which focuses on renewable energy sources and aims to build economic, natural and social capital. It avoids the conventional linear industrial model of exhausting resources in the manufacturing process and creating waste as a by-product. Instead, the circular economy restores and

Baobab tees grow in arid areas and produce nutritious, high value fruit

regenerates resources, keeping materials in use for as long as possible, while re-using waste as a basic raw material for other processes.[17]

Empowering women

Other structural changes to society that have been shown to make great contributions to reducing greenhouse gas emissions are educating girls and improving access to family planning services. Both methods help reduce population growth, which in turn reduces greenhouse gas emissions.[18]

Zimbabwe and economy-wide mitigation

The energy sector is the biggest contributor to the emissions that drive climate change, yet it is key for economic development and the welfare of populations. Like many developing countries, Zimbabwe submitted an energy-sector INDCs mitigation target to the UNFCCC, which will be upgraded to an economy-wide target in the future. This option was offered to developing countries, while developed countries were required to submit economy-wide targets.

A baseline analysis of the energy sector greenhouse gas emissions revealed that Zimbabwe's annual emissions declined between 2000–2008, due to difficulties of extracting and delivering coal. The energy sector emissions were dominated by energy industries, which contributed around 50%. Agriculture and commercial and residential contributions accounted for 20%, with manufacturing industries and construction contributing 14% and transport contributing 12%. Based on this, mitigation options were investigated that are in line with national development plans and affordable. For a detailed look at some of Zimbabwe's mitigation options, visit "Climate Change Mitigation Studies in Zimbabwe" at www.climatechange.org.zw/sites/default/files/publications/Mitigation.pdf.

Zimbabwe's INDCs

In September 2015 Zimbabwe submitted its INDCs, with a mitigation target to reduce energy sector greenhouse gas per capita by 33% below business-as-usual by 2030. This submission was conditional, subject to the availability of cheaper, better funding. For details about Zimbabwe's NDC strategy, download

the INDCs submission from the Climate Change Management Department website at www.climatechange.org.zw/. The document explains that Zimbabwe is seeking to build resilience to climate change while ensuring sustainable development in recognition of its climate change vulnerability and national circumstances. It highlights Zimbabwe's commitment to a low-carbon development pathway, instituting mitigation actions that will help reduce emissions while enhancing socio-economic growth and improving livelihoods. The document also notes that Zimbabwe has a vast potential for renewable energy, such as hydropower and solar, which, combined with energy efficiency and other environmentally sound projects, constitute Zimbabwe's INDCs.

The document contains an adaptation component which includes:

- Implementing climate-smart agriculture in the form of technologies and support, merging indigenous and scientific knowledge, sustainable intensification[19] of crop and livestock systems and commercialisation
- Developing resilience to hazards through early warning systems, an integrated approach to the economy, climate-indexed insurance and enabling markets
- Better water management through water-harvesting, improved surface and groundwater storage, better monitoring, efficient water use and conservation, better research and extension and biodiversity management
- Reducing agricultural risk through vulnerability assessments, response models and strengthening meteorological and hydrological services
- Cross-sectoral approaches – research, education and awareness, gender-responsive policies, support for vulnerable groups, promoting sustainable agroforestry, enhancing hydroelectric power capacity and diversifying livelihoods away from agriculture

The mitigation component states that:

- Zimbabwe's goal for emission through mitigation is to reduce energy-sector GHG emissions per person by 33% below projected business-as-usual by 2030
- In 2000 national emissions were 26,996 $GtCO_2.e$, or 0.045% of global emissions
- Zimbabwe is a net carbon sink with high sequestration capacity from its forests that cover 45% of total land area

Tables 8a and b list some measures proposed in the INDCs document to reduce emissions and their estimated cost.

Table 8a: Main actions intended to reduce emissions in $GtCO_2.e$ by 2030 and their implementation cost

Project	$GtCO_2.e$ in 2030	Indicative cost ($ millions)
Ethanol blending	202	100
Solar water heaters	179	1,230
Energy-efficiency improvement	1,278	60
Increasing hydro in our energy mix	15,316	5,000
Refurbishment and electrification of the rail system	341	1,106
Sub-total 1	**17,316**	**7,496**

Table 8b: Other key actions and their implementation cost

Project	Indicative cost ($ millions)
Coal-bed methane power	1,000
Solar-powered off-grids	3,000

Project	Indicative cost ($ millions)
Integrated waste management	500
Changing thermal power station technologies	5,000
Reviewing the transport system	37,000
REDD+ implementation	1,000
Sustainable energy alternatives to curing tobacco	1,050
Sub-total 2	**48,550**
TOTAL FOR MITIGATION	**55,796**

Some clean energy initiatives mentioned in the INDCs document are:

- Replacing incandescent bulbs with compact fluorescent lamps in over 164,654 houses, saving 42 MW
- Rewarding companies for improving energy efficiency and reducing carbon footprint
- Increase in Kariba power station generating capacity from 666 MW to 750 MW in 2003 and is expected to be 1,050 MW in 2018
- Promoting the use of liquefied petroleum gas as an alternative to electricity
- Constructing institutional biogas digesters, a target of at least 1,250 digesters by 2030
- Developing micro-hydro projects
- Introducing solar street lighting

Figure 27, taken from the INDCs document, shows the projected emissions trajectories with a business-as-usual scenario compared to one with strong mitigation measures.

Zimbabwe needs to prepare an economy-wide mitigation target involving greenhouse gas emissions from all sectors – industry,

agriculture, waste and forestry. Categories with potential are:

- Transformations in agriculture (climate-smart agriculture) relating to alternative energy sources, soil management and livestock management
- Improved solid waste disposal
- Improved mining processes for metals and mineral products

In order to implement these measures, everyone in the nation must take responsibility for the problem. Thus, the private sector, public sector and communities must begin to implement the various policies, strategies and options available. Zimbabwe must also find ways to mobilise cheaper and better finance (green finance), required for green growth. See chapter 7 for details of green finance.

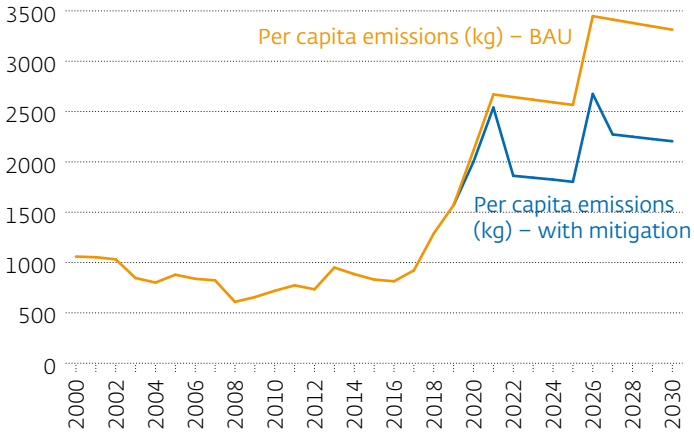


Figure 27: Zimbabwe's mitigation INDCs target

Source: Climate Change Management Department website: www.climatechange.org.zw/

Solar energy is becoming affordable for many rural families

Photo: Macpherson Photographers

Future energy sources for Zimbabwe

The national power supply

Reducing dependence on coal-fired power generation and precarious hydroelectricity generation by investing substantially in renewable energy alternatives is the obvious way forward.

However, wind energy, small-scale hydroelectricity plants, solar power (both solar PV and solar thermal used to heat water), biogas and similar energy solutions are beset with technical problems and cannot compete with conventional power generation methods on many levels. At the very least, switching from coal-fired power to natural gas would be a more climate-friendly option given that Zimbabwe has large methane deposits. Other fuel sources investigated are large hydropower and coal-bed natural gas. However, all such alternatives require considerable financial investment.

Solar power

Zimbabwe's warm, dry climate offers tremendous potential to exploit solar power for electricity generation and heating water in urban and rural households. The major disadvantage is that the equipment is imported and prohibitively expensive. However, the cost of solar appliances is declining steadily and could be made more affordable if the government were to scrap import tariffs. Large solar farms have recently been developed in several African countries, notably Mauritania, Ghana and South Africa. The auction bidding system has seen energy prices fall as low as 2.5 cents/kWh in the Middle East and 6 cents/kWh in Zambia.

Biogas

Biogas, or methane, is another source of renewable energy. Although biogas is not as clean as solar power, the advantage is that the digesters run on waste products. The technology is slowly being taken up in Zimbabwe, but has yet to reach its full potential. Case study 10 looks in detail at a recent programme to promote biogas as a domestic fuel source.

Case Study 10: Zimbabwe's domestic biogas programme

The ministries of energy and power development, and agriculture, mechanisation and irrigation development, the Rural Electrification Agency, the Netherlands Development Organisation and HIVOs, the Humanist Institute for Cooperation, are collaborating in a programme to promote domestic biogas digesters. The aim is to provide sustainable, clean and reliable energy for cooking and lighting in 67,000 households. The project is being rolled out in 2015 and uses a market-driven approach in promoting and disseminating biogas technology.

How it works: biogas is a mixture mainly of methane and carbon dioxide. It is created as a by-product when organic material decomposes in airless conditions. A biogas digester basically consists of a tank in which organic material such as cow dung is mixed with water and fermented to produce methane that can be used for cooking and lighting. The digested slurry of dung and water is pushed out at one end of the digester and can be used as high-quality fertiliser. Biogas burns with minimal carbon dioxide emissions and uses products that are readily available locally. The project digesters cost between $800 and $2,000 to build.

Source: www.newsday.co.zw/2015/05/08/with-biogasnothing-goes-to-waste/

Improved stoves

Since most rural families and many urban families in Zimbabwe rely on fuelwood for cooking, ideally we need to equip rural homes with facilities to cook using electricity, biogas or solar methods.

However, these methods have disadvantages for the Zimbabwean context. Most rural homes do not have access to electricity. Rural families are not used to paying for fuel or for stoves, and it will take some time to introduce such systems. While solar cookers are good for boiling, frying and roasting food, they are not ideal for cooking sadza, the staple. Besides, solar cookers work only when there is sunlight and are no good for producing evening meals. The biogas systems available today need large amounts of material to produce biogas and thus are better suited to institutions such as schools or hospitals. They are also expensive. Modern technological options are being investigated in an initiative on energy and water efficiency being run by the Climate Change Management Department in partnership with the Climate Technology Centre and Network and the United Nations Industrial Development Organisation (UNIDO).[20]

Improved stoves are being promoted in the short term, although they also have disadvantages (see case study 11). Given the important role of forests in both mitigation and adaptation to climate change, it is crucial that fewer trees are cut down for fuel. Several organisations have been promoting such stoves in the developing world to improve the lot of countless women who walk far each day to fetch firewood, to reduce deforestation and land degradation and to lower the health risks of women and children exposed to excessive wood smoke.

Case Study 11: Challenges with improved stoves in Zimbabwe

A notable advance in promotion of energy-efficient stoves in Zimbabwe was the development by the Development Technology Centre of the University of Zimbabwe in the 1980s of the Tsotso stove. This efficient metal stove uses less firewood, improves cooking time and produces less smoke than a cooking fire. However, the stove tends to damage cooking pots and did not become popular.

Since then a number of other stoves have been promoted, including the Chingwa stove, which was widely disseminated by the Department of Energy and NGOs, but whose uptake was limited. Mud stoves such as the Yugen, which was introduced in Plumtree and is built outside the kitchen, also failed to catch on. A survey for the United Nations Energy Programme found that most of these stoves are no longer in use and most Zimbabweans have reverted to using open fires.

The main obstacle to uptake of improved stoves appears to be that they cost twice as much to make as conventional stoves and that they lack spare parts. Moreover, many housewives who use stoves regard wood as a freely available resource and see greater advantage in cooking speed than in energy efficiency. It would seem that a social marketing campaign would need to be adopted in tandem with more efficient design and greater availability of spare parts to achieve wider acceptance of improved stoves.

Source: Makonese, T., Chikowore, G. & Annegarn, H.J. 2011. "Potential and Prospects of Improved Cookstoves in Zimbabwe". Paper presented at the Domestic Use of Energy conference, Cape Town, South Africa: https://ujdigispace.uj.ac.za/bitstream/handle/10210/10759/Makonese,%20Chikowore%26%20Annegarn,%202011.pdf?sequence=1

Case study 12: Rapid uptake of industrial energy and water efficiency in Zimbabwe

Zimbabwe has already started to experience water scarcity, which affects industrial production and energy sectors. Although most Zimbabwean companies claim to be energy- and water-efficient, there is limited monitoring and measurement of water and energy use. The practices of energy auditing, water footprinting and systematic emission reduction programmes are rare in most companies except for the purposes of meeting regulations.

A green industry initiative by the UNIDO in collaboration with the Business Council for Sustainable Development Zimbabwe and the government of Zimbabwe offers opportunities for achieving inclusive and sustainable industrial development through minimising energy intensity and water consumption in manufacturing enterprises.

The project will address both climate change mitigation and adaptation by promoting industrial energy and water efficiency, emissions reduction and renewable energy technologies, including waste-to-energy projects.

To facilitate the project, the Climate Technology Centre and Network will:

- Give technical assistance in chemical and waste-water management
- Support industrial energy and water audits for 10 demonstration companies to determine resource productivity of Zimbabwean firms
- Help assess needs for development and implementation of ISO 50001 energy management systems

- Raise awareness of the importance of water and mainstreaming water management and resource efficiency in business strategy
- Establish a green industry networking facility to enable information exchange and knowledge management in industrial energy efficiency and efficient water utilisation

The project is intended to improve corporate capacity to develop and implement energy efficiency, bringing about a significant reduction in greenhouse gas emissions and minimising the impacts of climate change on selected industries. It also aims to improve the competitiveness of small and medium enterprises in selected industrial sectors and increase their profitability as a result of resource savings.

For details of the project, visit www.ctc-n.org/technical-assistance/projects/technical-assistance-piloting-rapid-uptake-industrial-energy

Case study 13: United Refineries leads the way towards a circular economy

United Refineries Limited (URL) Bulawayo is a leading innovative producer of brands in personal care, hygiene and value-added agriculture products. Part of its corporate ethos is the belief that it can do business successfully without harming the environment. URL is committed to an environmental management system based on:

- Implementing and maintaining an environmental management system
- Complying with legislation and statutory requirements

pertaining to the environment
- Engaging in strategies and research to conserve both renewable and non-renewable natural resources
- Minimising waste and re-using and recycling as much as possible
- Applying the principles of continuous improvement to minimise air, water, noise and land pollution at its premises and reducing impacts from its operations on the environment and local community
- Communicating openly on environmental issues with employees and relevant stakeholders
- Ensuring that employees at all levels receive appropriate training in reducing waste, separating waste materials and in other aspects of environmental management
- Assessing in advance the environmental impacts of any new processes or products it intends to introduce

Turning waste into riches

In 2015 the safety and health manager of the company introduced waste separation. Cardboard waste is collected by National Waste Collectors, a recycling company, and Petricozim collects plastics for recycling. Some of the leftovers from the company canteen are given to employees as pet food. The rest of the degradable matter is composted and used to fertilise lawns and trees on the premises. This helps to reduce greenhouse gas emissions.

URL is the country's second largest cooking oil firm and can process 8,000 tons of cotton and soya oil seeds per month. The protein-rich seed cake, a by-product, is sold as livestock feed. Product synergy between production companies is an important measure in curbing waste and increases the

company's income. The company also reduces its waste by re-using much of it. Caustic soda is added during the oil refining and the residues removed when the neutral oil is washed with hot water. The resulting effluent is used to clean the tarred walkways and machinery on the premises rather than being released into municipal drains. A water interceptor filters the effluent, ensuring that water that flows into the Phekiwe River is free of oil residues and harmful chemicals. The small amount of water that flows back to the municipal treatment plant is filtered and inexpensive to treat.

The refining process produces a by-product called soap stock, which is used as a raw material to make soap. The soap waste, contained in dams on the premises contains lye, a substance rich in corrosive caustic soda, that is harmful to humans and the environment. In the dams the lye settles and liquid soap residues remain at the top to be collected and re-used to make cooking oil. Some lyes are used to make industrial detergents and to help clean the URL plant.

Applications of URL's energy-saving policy

Fluorescent lights and bulbs have been replaced with LEDs to reduce energy usage. LEDs emit light in a specific direction, unlike fluorescent illumination, which emits light and heat in all directions. LEDs use light and energy more efficiently. Most of the gangway switches were replaced with automatic day-night switches, further reducing energy and electricity expenses. Factory motors draw a high current when starting, so URL is installing soft starters that use much less energy. The warehouses and plants have transparent roofing sheets to improve lighting without the need for additional electric lighting.

All these measures aid in climate change mitigation as they drastically reduce the amount of greenhouse gases released into the atmosphere. The company continues to improve operations to lessen environmental impacts.

Sibonisiwe Ngubeni, third-year environmental science and health student, National University of Science and Technology, and an intern at URL Bulawayo

Energy efficiency improvement

There is great potential in Zimbabwe to upgrade power generation and industrial equipment and machinery. The main obstacles are a lack of enforcing legislation and financial incentives, a lack of finance and uncertainty about the future of the economy. Part of a sustainable approach to mitigating the effects of climate change is to reduce the global demand for energy by drawing attention to how much energy is wasted and how excessive energy consumption harms the environment and climate. However, mindsets are slow to change in developed countries and scant effort has been made to reduce energy consumption in Zimbabwe.

Reducing emissions through forests

Like most other African countries, Zimbabwe has no binding emissions targets. However, all UNFCCC signatories are expected to develop nationally appropriate mitigation actions, or NAMAs, which will be financed through instruments such as the clean development mechanisms set up by developed nations.

One way that Zimbabwe and many other developing countries contribute to mitigation is through addressing land-use change and forestry issues. As this new opportunity presents itself,

Conserving our forests is an important mitigation measure

Zimbabweans should be encouraged to see their forests as a valuable asset that not only mitigates the effects of climate change but is also a means to generate income. In support of REDD+ in Zimbabwe it is vital to review the national forestry policy. A REDD+ country needs assessment has been carried out and can be downloaded from the Climate Change Management Department website at www.climatechange.org.zw/our resources

Case Study 14: Zimbabwe's REDD+ pilot

Zimbabwe joined the REDD+ programme in 2011 and has begun building capacity to exploit opportunities from conserving its 15.6 million ha of forests to limit emissions, create income and improve livelihoods. Carbon Green Africa in partnership with South Pole Carbon Asset Management has implemented an ambitious private REDD+ project covering 750,000 ha of forest in Binga, Mbire, Nyaminyami and Hurungwe. The project aims to remove 52 million tonnes of CO_2 from the atmosphere in 30 years. In return the communities involved are meant to benefit from:

- Support for conservation agriculture
- Sustainable honey production and links to markets
- Education and awareness campaigns
- Fire prevention programmes
- Alternative, low-emission brick-making production

Rural district councils in the project areas are given direct funding, a portion of which is conditionally tied to community development projects and aimed at mitigating disasters. However, the project is hamstrung because benefits are not reaching the target communities and a lack of buyers on the international carbon trading market has led to low prices for REDD credits, known as offsets or carbon units measured in tonnes of CO_2 equivalents.

Based on the Carbon Green Africa's estimates, Zimbabwe could sequester 1,000 tCO_2e by preserving its 15.6 million ha of national forest. This puts the value of Zimbabwe's forests at between $1 billion and $4 billion depending on the average unit price of CO_2 equivalents, which has fluctuated between $7.4 per tonne in 2011 to under $1 per tonne today.

Source: Gogo, J. "Zimbabwe: Kariba REDD+ Removes Tonnes of Carbon Emissions", *The Herald*, 3 November 2014

Siliniwe Moyo, a locally trained technician at Mashaba solar minigrid, which is powering irrigation, small businesses, a school and a clinic in Gwanda. Installed through the Sustainable Energy for Rural Communities Project by Practical Action Zimbabwe

In this chapter we looked at ways in which we can limit the amount or rate of long-term climate change through mitigation. We investigated global and local emissions sources. We looked at technological and socio-economic mitigation measures. We then discussed Zimbabwe's international mitigation commitments and options. The next chapter examines ways that green finance can be accessed to implement climate change adaptation and mitigation measures.

Endnotes

1 IPCC 2014a. "Climate Change 2014: Synthesis Report". Contribution of Working Groups I, II and III to the Fifth Assessment Report IPCC, Geneva: www.ipcc.ch/report/ar5/syr/, accessed August 2015

2 https://coastadapt.com.au/sites/default/files/infographics/15-117-NCCARFINFOGRAPHICS-01-UPLOADED-WEB%2827Feb%29.pdf

3 IEA 2017. "World Energy Investment Outlook" :www.iea.org/publications/wei2017/

4 British Petroleum 2017. "BP Statistical Review of World Energy": www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/renewable-energy.html

5 Renewable Energy Policy Network 2017. "Advancing the Global Renewable Energy Transition: Highlights of the REN21 Renewables 2017 Global Status Report in Perspective"

6 Project Drawdown: www.drawdown.org/solutions/materials/refrigerant-management

7 Ibid.

8 Ibid.

9 Hawken, P. 2017

10 Bergkamp and Orlando 1999

11 http://unfccc.int/national_reports/non-annex_i_natcom/items/10124.php

12 Regeneration International: http://regenerationinternational.org/why-regenerative-agriculture/

13 Biochar International: www.biochar-international.org/biochar

14 *The Guardian* 2013: www.theguardian.com/environment/2016/jan/12/artificial-trees-fight-climate-change

15 UNEP 2011: www.unep.org/greeneconomy/sites/unep.org.greeneconomy/files/publications/ger/ger_final_dec_2011/1.0-Introduction.pdf

16 IPCC 2014:https://www.ipcc.ch/report/ar5/; http://journalistsresource.org/studies/environment/climate-change/united-nations-ipcc-working-group-iii-report-climate-change-mitigation

17 For more on the circular economy, see www.ellenmacarthurfoundation.org/circular-economy

18 Project Drawdown: www.drawdown.org/solutions/women-and-girls/educating-girls

19 For more information on sustainable intensification approaches, see www.sciencedirect.com/science/article/pii/S0264837715000332

20 www.ctc-n.org/technical-assistance/projects/technical-assistance-piloting-rapid-uptake-industrial-energy

7 Financing mitigation and adaptation

This chapter was written by Elisha Moyo with contributions from Tendayi Marowa

This chapter gives a background to climate finance and describes some domestic and international finance opportunities and enablers such as the technology and capacity required to tap these resources. Appendix 2 offers a summary of finance options.

Chapter summary

The Paris Agreement and climate finance

COP21 in Paris (2015) introduced a new era for climate finance and policies, defining a global action plan to put the world on track to avoid dangerous climate change. Parties to the agreement have accepted the following, among other obligations: to set more ambitious targets every five years as required by science through their nationally determined contributions (NDCs); to report to each other and the public on how well they are doing in meeting their targets; to track progress toward the long-term goal through a robust transparency and accountability system; and to strengthen their abilities to deal with the impacts of climate change.

The Paris Agreement reiterated that developed countries shall provide finance to assist developing countries with mitigation and adaptation. Zimbabwe can draw on these multilateral and international financial sources. The agreement has therefore sent a strong signal for increasing ambition through scaling up efforts to mitigate the effects of climate change and adapt to it, and to bring finance flows in line with a pathway towards lower greenhouse gas emissions and climate-resilient development.[1]

The agreement thus recognises the urgent need to make finance, technology and capacity building available in a predictable way to enable enhanced action before 2020. COP21 also invited UN agencies and international, regional and national financial institutions to provide information on how their development assistance and climate finance programmes incorporate climate-proofing and climate resilience measures.[2] This shows that climate finance is recognised as a critical enabler of global climate aspirations and fulfilment of obligations.

What is climate finance?

Climate finance refers to local, national or transnational financing, which may be drawn from public, private and other sources to address climate change. This covers reducing emissions, notably in sectors that emit large quantities of greenhouse gases, and adaptation to the adverse effects of climate change. Industrialised countries grouped in Annex II of the UNFCCC are required to provide financial resources to assist developing country parties in implementing the objectives of the UNFCCC in accordance with the principle of common but differentiated responsibility and capabilities set out in the convention.[3]

All developing country climate players – governments and other stakeholders – must understand and assess their financial needs, the sources of this financing and how these resources will be mobilised. They must also demonstrate their ability to receive and use the resources effectively, and with utmost transparency, for mitigation and adaptation. The effective measurement, reporting and verification of climate finance are key to building trust between parties to the convention and external actors.

NDCs and finance

The UNFCCC synthesis report[4] shows that while NDCs represent a major step forward in that they are expected to deliver sizeable emission reductions and slow down emissions growth in the coming decade, they will not be sufficient to reverse the upward trend of global emissions by 2025 and 2030.

Despite the NDCs' emission reduction efforts, the Earth will continue to warm well into the century; hence all parties need to scale up their mitigation and adaptation efforts. For developing countries this will require finance, technical capacity and adaptation technology.

Financing Zimbabwe's NDCs

The Constitution of Zimbabwe (2013) gives every person environmental rights, including the right to an environment that is not harmful to health or well-being and to have the environment protected for the benefit of present and future generations. This is to be actualised through legislative and other measures that, among others, secure development and use of natural resources that are ecologically sustainable while promoting economic and social development. The Constitution stipulates that the State must take measures, within the limits of the resources available to it, to achieve the progressive realisation of these rights.

Zimbabwe's national economic blueprint, ZimAsset, aims to achieve sustainable development and social equity. The policy acknowledges that the country faces multiple environmental challenges, including susceptibility to floods and droughts, that it is reliant on climate-sensitive economic sectors and that it needs investment in climate-proofing these sectors as a priority.

Zimbabwe submitted its INDCs in 2015.[5] They quantify and cost the priority climate actions, climate-related policies and socio-economic sector inputs necessary to increase climate resilience and reduce per capita emissions by 33% by 2030. They focus on the most climate-sensitive sectors of the economy: agriculture and energy, the main source of emissions. Zimbabwe's INDCs seek to build resilience to climate change while ensuring sustainable development in recognition of its climate change vulnerability and national circumstances. They also seek to contribute to the ambitious global goal of limiting temperature rise to below 1.5°C and set the finance required to implement the actions at $90 billion.

The INDCs are subject to the availability of affordable international financial support, investment, the ability to access our resources, technology development and transfer, capacity development and continued improvement to develop a national enabling environment Accessing our own resources is in line with ZimAsset, which identified key financing mechanisms: tax and non-tax revenue, leveraging resources, sovereign wealth fund, issuance of bonds, public-private partnerships, securitisation of remittances, re-engagement with the international and multilateral finance institutions and other financing options.

Access to the various arms of the UNFCCC finance and technology mechanisms, such as the Green Climate Fund (GCF), Climate Technology Centre and Network (CTCN), Adaptation Fund and Global Environmental Facility (GEF), and continued investment by developmental partners are critical for Zimbabwe. Some of the main climate finance options are listed in appendix 2.

Global climate finance flows [6]

Total global climate finance flow from developed to developing countries has increased by almost 15% since 2012. In dollar terms this ranges from around $650 billion for 2011/2012 to $687 billion for 2013 and $741 billion for 2014. This growth is shown in figure 28.

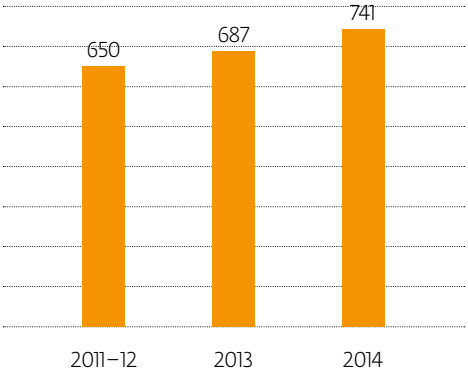


Figure 28: Increase in global climate finance ($ billions) from all sources between 2011 and 2014

Source: "Global Climate Finance: An Updated View on 2013 & 2014 Flows, October 2016": http://climatepolicyinitiative.org/wp-content/uploads/2016/10/Global-Climate-Finance-An-Updated-View-on-2013-and-2014-Flows.pdf

Where does the finance come from?

The world's six largest multilateral development banks have committed over $158 billion in climate finance during the past six years to developing countries and emerging economies. They are:

- African Development Bank (AfDB)
- Asian Development Bank (ADB)
- European Bank for Reconstruction and Development (EBRD)
- European Investment Bank (EIB),
- Inter-American Development Bank Group (IDBG)
- World Bank Group (WBG)

They have been jointly tracking and reporting climate finance, as shown in figure 29.

Figure 29: Reported climate finance commitments (in $ millions) from 2011–16

Source: "Climate Finance 2016 Joint Report on Multilateral Development Banks": www.ebrd.com/2016-joint-report-on-mdbs-climate-finance.pdf

The highest pledge of $28,345 million was made in 2014. The World Bank Group made the largest commitment (42%) over the six-year period while the AfDB made the lowest (6%).

Private investment in renewable energy and energy efficiency represents the largest share of the global total. However, the energy efficiency data are much less certain than the renewable energy data. Levels of finance have increased as the costs of clean technology have continued to fall. In most developing countries domestic public finance significantly exceeds the inflows of climate finance from bilateral and multilateral sources.

Where is the money going?

The 2016 figures shown in table 9 show that 77.3% of the climate finance flows in 2016 were dedicated to mitigation, 22.3% to adaptation and 0.4% to measures that addressed both mitigation and adaptation at the same time (dual-benefit finance). At COP22 developing countries strongly advocated a balance between mitigation and adaptation finance.

Table 9: Adaptation, mitigation and dual-benefit climate finance (in $ millions) from multinational development banks in 2016

MDB	Adaptation finance	Mitigation finance	Dual-benefit finance	Total
ADB	1,187	3,250		4,437
AfDB	388	673		1,061
EBRD	154	3,269	71	3,495
EIB	290	3,976		4,266
IDBG	551	2,109	29	2,689
WBG	3,555	7,939		11,494
Total	**6,125**	**21,216**	**100**	**27,442**

Source: "Climate Finance 2016 Joint Report on Multilateral Development Banks": www.ebrd.com/2016-joint-report-on-mdbs-climate-finance.pdf)

Private sector finance

Private firms make investment decisions based on commercial viability. That means that investments must cover the full costs of the project, including the cost of capital, and achieve a return to balance the associated risks. This principle can often lead to under-investment in activities promising strong environmental and social benefits but lacking in reliable returns.

In the climate change businesses in most parts of the world the cost of carbon emissions is not yet integrated into decision making in any meaningful way. Thus, policy makers have experimented with alternative strategies to encourage investment. In some countries these investments are undertaken by the public sector through taxpayers' finance. Governments are increasingly looking to approaches that involve the private sector – private companies, local, regional and global commercial banks, non-bank financial institutions, leasing companies, private equity investors and institutional investors.[7]

Finance for Zimbabwe

Zimbabwe's domestic climate finance vision is captured in the National Climate Policy (2017) which proposes to:

- Establish a national climate fund supported by a 10% allocation in the national budget
- Channel funds to support climate projects in every district
- Develop, review and implement policies to enhance the country's capacity to engage in carbon market activities
- Build capacity to access international climate funds by scaling up projects financed through REDD+, CDM, GCF and GEF
- Ensure the accreditation of national institutions as national implementing entities for direct access to GCF and the Adaptation Fund
- Provide an analysis of the annual budget expenditure on climate-related interventions to determine its impacts on vulnerable groups
- Establish a 0.005% levy of net profit for industries for national green growth

Other strategies for domestic climate financing could be: taxes such as the carbon tax, rebates and incentives; levies and fees, for

instance for ozone licences; and local public-private partnerships to complement Treasury efforts to fund climate actions. Levies, fees and taxes from non-climate-smart practices and payments from the implementation of the "polluter-pays principle" could also support climate actions. Zimbabwe has proposed introducing a climate change levy on natural resources such as timber and mineral and agricultural products which are exported.

Zimbabwe's citizens are also called upon to provide climate finance for their local and household-level climate actions.

International finance for Zimbabwe

There has been an increase in dedicated climate finance over the years as the detrimental impact of industrialisation on the climate system and humans becomes unequivocal. Relevant climate funds established are:

The Global Environmental Facility

The GEF started in 1991 as a $1 billion pilot programme of the World Bank to assist the protection of the global environment and promote environmentally sustainable development. The GEF serves the UNFCCC and several other international environmental agreements. It is now an operating entity of the convention's financial mechanism and is entrusted to operate the Special Climate Change Fund, as well as the Least Developed Countries Fund. COP21 decided that GEF shall serve the Paris Agreement and decisions agreed before its adoption. Zimbabwe has been implementing various projects under the GEF, including the Hwange-Sanyati biological corridor project and the development of the INDCs.

Special Climate Change Fund

The SCCF was established under the UNFCCC in 2001 to

finance projects relating to: adaptation; technology transfer and capacity building; energy, transport, industry, agriculture, forestry and waste management; and economic diversification, complementing other funding mechanisms.

The Adaptation Fund

The AF was established in 2001 to finance concrete adaptation projects and programmes of developing country parties to the Kyoto Protocol. Finance is drawn from carbon credits.

The Least Developed Countries Fund

The LDCF finances the preparation and implementation of NAPAs in response to urgent and immediate adaptation needs in least developed countries.

Climate Investment Funds

CIF was established in 2008 by G8 Leaders who recognised the increased costs of climate change and set up CIF with a sunset clause to transfer to the Green Climate Fund once it was established.

The Green Climate Fund

The GCF is a dedicated climate change fund established in 2010. It is the largest climate financing source to date, having attained more than $10 billion in its initial mobilisation cycle. It aims to achieve an equal balance between mitigation and adaptation investments over time and has allocated 50% of the adaptation funds to vulnerable countries, including African states.

The GCF governing instrument established a board with 12 developed and 12 developing country members. The fund is accountable to and is guided by the COP to support projects, programmes, policies and other activities in developing countries through thematic funding windows.

The fund has "readiness and project preparation" finances whose funding proposals are approved by the secretariat. Full project funding proposals are approved by the GCF board. The Paris Agreement states that the institutions serving the agreement, including the operating entities of the financial mechanism, such as GCF and GEF, shall aim to ensure efficient access to financial resources through simplified approval procedures and enhanced readiness support for developing countries. Country negotiations through the COP and GCF focal points are therefore critical in ensuring that there is efficiency and simplified approval procedures.

Engaging with the GCF is possible through the following:

- Establishing and maintaining a national designated authority or focal point
- Development of country programmes to determine which priorities identified by country strategies – NCCRS, NCP, INDCs, LEDs, NAPAs and NAMAs, for instance – are the best match for GCF support
- Identify and seek accreditation of entities to access resources from the fund
- Develop projects and programmes to bring forward funding proposals through accredited entities

Disbursements by the GCF for developing countries have been slow and application procedures are cumbersome, especially for the most vulnerable countries and communities. Furthermore, the rate of the fund capitalisation remains low and unlikely to meet the agreed target of raising $100 billion per annum by 2020. It is therefore critical for developing countries to diversify their resource mobilisation strategies and financial sources beyond the GCF.

Climate technology focal points from Africa with members of the Climate Technology Centre and Network and its partners pictured at a side event at the 22nd Conference of Parties to the UNFCCC held in Marrakech, Morocco, in November 2016

Photo Moyo, 2016

Other funds

Other sources of finances, enablers and support that could be used to enhance climate financing are the clean development mechanisms (CDMs), Climate Technology Centre and Network, International Fund for Agriculture Development, the REDD+ Forest Carbon Partnership Facility, Global Framework for Climate Services, National Adaptation Plan , nationally appropriate mitigation actions (NAMAs), Technology Needs Assessment, the REDD+ Capacity Needs Assessment, the German development organisation (GIZ), the International Renewable Energy Agency, Kuwait Fund and several UN agencies. including the UN Environment Programme, the Food and Agriculture Organisation, the World Food Programme, the UN Development Programme, the UN Industrial Development Organisation and the UN

Economic Commission for Africa. Regional sources include the African Union Commission, the African Development Bank's climate development fund, Africa Climate Change Fund, the New Partnership for Africa's Development (NEPAD) and Climate for Development in Africa (ClimDev-Africa). Figure 30 summarises funds available from some of these sources.

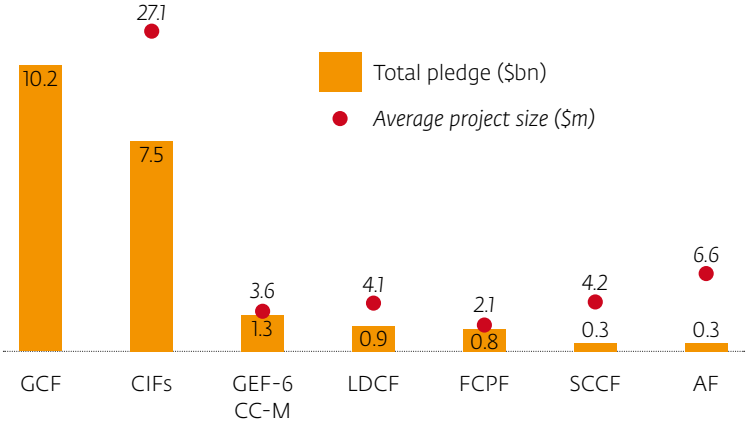


Figure 30: Some key milestones of climate finance in the global response to climate change

Source: presentation by R. Kelly, regional advisor on GEF to UNDP 2014

Barriers to accessing climate finance

Most climate funding seems to be going to south and east Asia, the Pacific and the Caribbean and non-EU Europe, while sub-Saharan Africa is one of two regions receiving the least funding.

Developing countries need to overcome various barriers to access finance, capacity building, technology enhancement and creation of an enabling environment. A range of issues can present challenges, including:

- Low levels of technical capacity to design and develop projects and programmes and to monitor and evaluate progress
- Difficulties in following procedures to access finance and
- Lack of awareness of the need for action and available sources of funding

Several efforts to improve access to climate finance are under way and the GCF in particular has stepped up its efforts in this regard. Investment in building the capacity of local business planners to attract finance from a range of sources is needed. Ownership of climate finance and alignment of this finance with national climate change priorities, policies and strategies are crucial. Zimbabwe has held numerous capacity-building workshops, including sessions with the CDM and Access to Green Finance in 2016 and 2017 respectively.[8]

Carrying out comprehensive financial, technology, policy and capacity needs assessments is crucial to identify the actions to be taken to access finance. Proponents also need to understand the engagement procedures and financiers' priority areas and align them with their countries' proposed project areas. Engagement of key stakeholders across government, particularly ministries of finance and planning, and across society, including civil society and the private sector, is also important.

Finance enablers

To catalyse domestic climate financing, there is a need for more awareness and greater capacity in project development and implementation phases. This could include:

- **Detailed sectoral case studies** documenting the socio-

economic value of climate investments such as better competitiveness in product pricing and improved food security. This could attract investments by government, local authorities, local businesses and individuals.

- The creation of **an institutional and policy environment** which enables consistent collection, mobilisation, use, monitoring and evaluation of climate finance.
- **Capacity building** for climate actions, covering resilience, mitigation, financing and technology provision as envisioned in the Paris Agreement. This would unlock climate finance through re-alignment of budgets and allocation of resources to climate-resilient and low- carbon actions.

Quick actions for finance access

To facilitate access to finance policy makers should:

- Familiarise themselves with the national and sector climate-related policies highlighted in chapter 4
- Identify climate financing benefits and threats from non-climate-proofing finance
- Mainstream climate change into programming and budgeting
- Quantify and monitor finances allocated to and used for climate change activities
- Internally fund socio-economically beneficial climate actions
- Identify and understand external funding opportunities before requesting climate finance
- Re-design the budgetary allocation to be climate-sensitive

"Mwana asingacheme anofira mumbereko" – a Zimbabwean proverb meaning "Resources are not allocated to those who need them but to those who ask."

Finance criteria

As climate takes centre stage, developmental finance is also increasing and often being tied to climate resilience, low-carbon technologies and sustainable development. Successful finance applications require that project proponents understand the guidelines, eligibility criteria and expected outputs of projects. Emphasis should be on the impact potential of the project as specified in various financing models, among them **results-based climate financing**, i.e. funding to achieve specific climate mitigation or adaptation results.[9]

It is crucial for anyone wanting to access climate finance to understand the project in regard to climate impact, target investors and national priorities investors' eligibility criteria, and to consult key stakeholders. It is critical to focus on finance, technology, governance and institutional frameworks, but there must also be a deliberate effort to ensure that there is investment in human capital, especially the youth as critical players, if climate project funding is to be sustainable. The efforts must also be sensitive to the country's strategic interest, climate vision and national circumstances.

Quick actions for implementers

Decision makers and implementers wanting to access these funds should:

- Identify various international funds, enablers and support mechanisms
- Identify relevant funds for the specific programmes or climate activities
- Familiarise themselves with each funder's access processes and national priorities and align these with their proposals
- Assess the proposed climate impact, alignment with

national priorities and assessment criteria
- Identify and contact the designated focal points or contact point to initiate the process
- Review and submit a funding proposal request

Climate Technology Centre and Network

Inability to mobilise climate finance is sometimes the result of technology challenges. It is therefore important to promote technology transfer and development when addressing climate finance issues. Investors often require finance proposals to be developed at scale, packaged in a specific format and offer feasibility studies that include climate impact, paradigm shift potential and transformation to climate resilience and low-carbon development.

This often entails forging public-private partnerships, submitting innovative ideas and catalysing the use of technology plans that respond to the needs of countries. The operational arm of the UNFCCC technology mechanism, the Climate Technology Centre and Network (CTCN) can help countries to package their requests and match them with financing institutions.

Governance and institutional frameworks

Effective climate finance mobilisation and utilisation require good governance and institutional frameworks. The following are some key developments in these areas at local and international levels as well as recommendations for effective climate action.

The National Climate Policy (NCP) recognises that climate funding is crucial to its successful implementation and management of climate change. The policy acknowledges that despite Zimbabwe's vulnerability, several sector-specific adaptation and mitigation options have been constrained by the lack of funding. Zimbabwe

has recently established governance and institutional structures to ensure that climate finance issues are better coordinated and that the country taps the available international, regional and local climate regime opportunities such as the REDD+, clean development mechanisms and the GCF.

The NCP also provides for the establishment of a national climate fund to develop, review and implement policies to enhance Zimbabwe's capacity to engage in carbon market activities and build capacity to access international climate funds.

Role of focal points

The COP established focal points, who are links between country stakeholders and the financiers, to catalyse climate finance access. Stakeholders should therefore use these offices to increase their chances of successfully mobilising finance.

Recommended roles and capacities of focal points:

The roles of focal points are:

- Convening national stakeholders
- Strategic oversight aligned with national priorities
- Approval of readiness support
- Issuance of "no objection" letters for projects and programmes
- Nomination of direct access entities

The recommended capacities of focal points are:

- Oversight and awareness: ability to monitor and evaluate fund-related activities and familiarity with related activities
- Knowledge of national priorities, strategies, plans,

adaptation and mitigation efforts and needs
- Coordination functions: facilitating multi-stakeholder consultations and other country coordination mechanisms
- Drive: ability to drive strategic engagement

Table 10: Key climate finance-related focal points in Zimbabwe

Institution	Focal points and addresses	Contact persons	Email addresses
GCF	Climate Change Management Department, Ministry of Environment, Water and Climate, 11th Floor Kaguvi Building, Central Ave/4th Street, Harare	Washington Zhakata (director and National Delegated Authority) Elisha N. Moyo, alternate focal point (principal climate researcher)	washingtonzhakata@gmail.com; climatechange@environment.gov.zw enmoyo@gmail.com
GEF	Dept of Environment and Natural Resources, Ministry of Environment, Water and Climate, 11th Floor Kaguvi Building, Central Ave/4th Street, Harare	Tanyaradzwa Mundoga (acting director and GEF focal point)	tmundoga@gmail.com
AF	Climate Change Management Department	Washington Zhakata Veronica Gundu-Jakarasi (alternate)	climatechange@environment.gov.zw verogundu@gmail.com
CTCN	Climate Change Management Department	Elisha N. Moyo (National Delegated Authority)	enmoyo@gmail.com
NAMA	Climate Change Management Department	Lawrence Mashungu	lawrencemashungu@gmail.com

This chapter has provided critical background to climate finance and possible opportunities and enablers for successful resource mobilisation in Zimbabwe. Stakeholders and decision makers can use the chapter to understand the basics of climate finance and increase their knowledge of eligibility criteria for Zimbabwe's climate funding proposals.

Endnotes

1 UNFCCC. "The Paris Agreement": http://unfccc.int/paris_agreement/items/9485.php

2 United Nations Sustainable Development Knowledge Platform: https://sustainabledevelopment.un.org/topics/finance/decisions

3 UNFCCC. "Parties and Observers": http://unfccc.int/parties_and_observers/items/2704.php

4 UNFCCC 2015. "Synthesis Report on the Aggregate Effect of the Intended Nationally Determined Contributions": https://unfccc.int/resource/docs/2015/cop21/eng/07.pdf

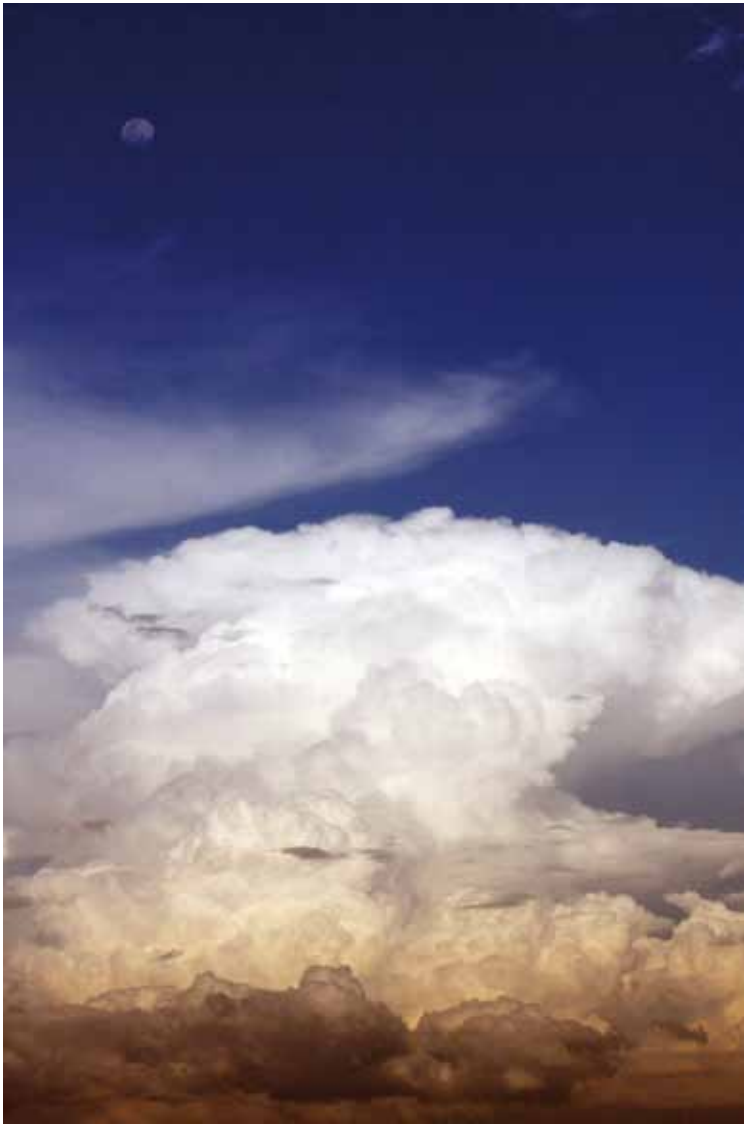
5 Zimbabwe's INDCs: www4.unfccc.int/submissions/INDC/Published%20Documents/Zimbabwe/1/Zimbabwe%20Intended%20Nationally%20Determined%20Contribution%202015.pdf

6 http://unfccc.int/files/cooperation_and_support/financial_mechanism/standing_committee/application/pdf/2016_ba_summary_and_recommendations.pdf

7 IFC 2011. "Climate Finance: Engaging the Private Sector": www.climateactionprogramme.org/images/uploads/documents/ClimateFinance_G20Report.pdf

8 Ibid.

9 World Bank 2017. "Results-based Climate Finance in Practice: Delivering Climate Finance for Low-Carbon Development". Washington, DC: World Bank Group: http://documents.worldbank.org/curated/en/410371494873772578/Results-based-climate-finance-in-practice-delivering-climate-finance-for-low-carbon-development



All Zimbabweans must start working together to ensure a resilient future

8 Conclusions and recommendations

In this, the final chapter, we bring together the main messages from this book and provide recommendations for specific adaptation and mitigation activities as well as general recommendations for Zimbabwe.

Chapter summary

Zimbabwe's vulnerability and adaptive capacity

As we have seen, climate change caused by excessive greenhouse gas emissions from the burning of fossil fuels is already having a profound effect throughout the world. Although Zimbabwe has advantages that contribute to its adaptive capacity, many Zimbabweans are vulnerable to shocks and hazards which climate change is bringing and will increasingly exacerbate.

Factors contributing to Zimbabwe's vulnerability:

- The climate is naturally variable
- Most Zimbabweans depend on rain-fed agriculture
- Energy production is partly dependent on hydroelectricity
- Much of industry is climate-sensitive
- Industry and agriculture depend on human labour
- Natural resources have been degraded due to poor land management
- Most Zimbabweans live in rural areas
- Poverty, malnutrition and poor health are widespread
- There is physical and economic water scarcity in parts of the country
- Many communities lack the means to put adaptation plans and disaster risk reduction measures into practice

Factors that improve Zimbabwe's adaptive capacity:

- Abundant natural resources
- Basic infrastructure – roads, settlements, health and educational facilities
- A diverse economy
- High literacy levels
- A relatively low fertility rate so the population is growing gradually

- Extensive indigenous knowledge in some communities
- Availability of indigenous crops that are drought-resilient and tolerant to high temperatures
- High levels of social capital and strong social networks

Summary of climate impacts on Zimbabwe

Meteorologists in Zimbabwe have recorded average temperature rises and rainfall declines in parts of the country. The rains are starting later and mid-season dry spells are more common. Extreme events such as droughts, floods and storms appear to be becoming more frequent and less predictable.

By 2050 and until the end of the century it is likely that Zimbabwe will experience the following effects of climate change:

- A modest decrease in the total amount of rainfall
- Changes to the onset and end of the rainy season
- More frequent and longer mid-season dry periods
- Reduced groundwater recharge
- Erratic rainfall distribution throughout the country
- More droughts and floods, which may occur year after year
- A temperature increase of 4°C

These changes are likely to lead to reduced water supplies from surface and groundwater sources and the expansion of natural region V, shrinking of natural region I and shifts in the areas covered by natural regions III and IV. Degradation of natural resources, especially soil, water, vegetation, crops, livestock and wildlife, are likely to occur. There is likely to be reduced food security, increasing under-nutrition among children and a greater

incidence of diseases such as diarrhoea, malaria and cholera. The rural poor, particularly women, children, the elderly and the disabled will most likely bear the brunt of the impacts.

Government action on climate change

International agreements, notably the United Nations Framework Convention on Climate Change (UNFCCC), have been put in place to address the problems of climate change through adaptation to the effects and reduction of greenhouse gas emissions (mitigation). The landmark Paris Agreement aims to keep global temperature rises well below 2°C above pre-industrial levels. In support, Zimbabwe has developed a climate policy and a climate response strategy as well as submitting our nationally determined contributions (NDCs) to the UNFCCC which pledge a 33% per capita emissions reduction.

Recommendations for action

These recommendations are drawn from chapters 5, 6 and 7 of this book. Many are already proposed in the National Climate Policy, the National Climate Change Response Strategy and our communications to the UNFCCC relating to the NDCs.

Adaptation recommendations

Zimbabweans will have to adapt to survive the changes in the climate. Adaptation is about building the resilience of human

communities and ecosystems in the face of environmental shocks and taking sustainable development measures that improve natural resource management and strengthen social networks. Some steps to take in an adaptation process are:

1. Learn about the components of your system (social, ecological and economic)
2. Identify potential threats, hazards and shocks
3. Identify areas of vulnerability
4. Identify factors that could increase adaptive capacity
5. Develop a disaster risk reduction plan
6. Put measures in place to reduce vulnerability
7. Put measures in place to increase adaptive capacity

Adaptation should be tailored to specific environments and communities. It should be driven by local communities in participation with development agencies supported by local and national government agencies. Local adaptation initiatives should draw on indigenous knowledge in combination with scientific research and technological advances. Communities should be helped to prepare disaster risk reduction plans.

Water, land, vegetation and communities

Sectoral adaptation measures for Zimbabwe should focus on management of water, land use and vegetation, and on strengthening human communities.

Priority should be given to protecting and conserving underground water resources by reducing soil erosion and safeguarding wetlands and aquifers. Expanding irrigation is also important. In land management the focus should be on soil protection by controlling mining activities and improving agriculture. The promotion of climate-smart agriculture is a powerful measure that can have far-reaching benefits.

It is vital to conserve forests since vegetation has beneficial impacts on weather, soil and water systems. Agroforestry, climate-smart agriculture, control of wildfires and encouraging crop diversification are equally important.

Raising awareness about climate change and building capacity for adaptation strategies that build on indigenous knowledge can strengthen communities. Improving the abilities of communities to deliberate and act collectively by encouraging participation is a way to achieve this. Protecting the most vulnerable individuals and diversifying livelihoods are crucial for building community resilience. Climate-proofing infrastructure including buildings, roads and bridges, is also crucial.

Business adaptation measures

Climate-proofing businesses will be an important step in reducing the risk of financial losses due to climate change. The following steps can be taken:

1. Raise awareness of climate change and possible impacts on sector-specific operations
2. Identify climate risks such as water scarcity and floods and assess their potential severity
3. Identify adaptation solutions such as efficient use of water and power
4. Prioritise and develop budgets
5. Implement adaptation measures
6. Spread the risks through insurance
7. Commission monitoring and evaluation to find out if measures are working and adjusting when necessary

Mitigation recommendations

Zimbabwe has made commitments to reduce emissions under the

Paris Agreement, but the country needs stronger representation in international climate change negotiations to secure technical support and funding for adaptation and mitigation measures.

Mitigation needs to be achieved through technological solutions and structural changes to the social and economic systems on which our societies are based. The following steps can be taken when developing a mitigation plan for any system such as a home, business, or community.

1. Conduct an energy audit of your system
2. Analyse the processes used in your system, for instance for heating, lighting, cooking, manufacturing, transport and waste
3. Identify ways to generate and use energy more efficiently
4. Identify ways to use less energy and introduce renewable energy technologies, including waste-to-energy projects
5. Identify materials that can be replaced with non-greenhouse gas alternatives (like refrigerants) and low-energy measures such as using compost instead of inorganic fertiliser
6. Identify elements in your system that could be developed as carbon sinks – tree planting, composting of organic waste etc.
7. Institute the mitigation measures

Apart from reducing greenhouse gas emissions, mitigation also involves carbon sequestration (removal of carbon dioxide from the atmosphere).

Mitigation options for Zimbabwe

Since the energy sector is most responsible for emissions, Zimbabwe needs to find ways to generate power more cleanly and efficiently and adopt renewable energy solutions, particularly solar power, wind and biogas. Coal-fired power generation needs

to be made more efficient, preferably with some form of carbon capture.

Mining, manufacturing and other industrial enterprises should be encouraged to improve energy efficiency and reduce emissions. Companies that emit harmful gases should be encouraged to invest in mitigation and adaptation measures through corporate social responsibility projects. They should look at substituting materials for refrigerants and cement that do not cause greenhouse gas emissions.

Switching to climate-smart agriculture methods will reduce emissions, sequester carbon dioxide and help farmers adapt to the uncertainty of the future climate.

REDD+ and other forestry conservation and expansion measures need to be expanded to conserve all of our national forests. A concerted nation-wide campaign to promote energy-efficient stoves and rural electrification needs to be launched.

Accessing climate finance

Although climate change funding for developing countries has increased, more money is going towards mitigation than adaptation. Sub-Saharan Africa is one of the regions receiving the least amount of funding. This is because of:

- Lack of technical capacity to design and develop projects and monitor and evaluate progress
- Difficulties in following procedures to access finance
- Lack of awareness of the need for action and available sources of funding

Several efforts to improve access to climate finance are under way and Zimbabwe has held many capacity-building workshops in this regard.

To facilitate access to finance policy makers should:

- Familiarise themselves with the national and sector climate-related policies highlighted in chapter 4
- Identify climate financing benefits and threats from non-climate-proofing finance
- Mainstream climate change into programming and budgeting
- Quantify and monitor finances allocated to and used for climate change activities
- Fund socio-economically beneficial climate actions
- Identify and understand external funding opportunities before requesting climate finance
- Re-design the budgetary allocation to be climate-sensitive

Those looking to apply for funding for climate-change related projects should:

- Identify various international funds, enablers and support mechanisms
- Identify relevant funds for specific programmes or climate activities
- Familiarise themselves with each funder's access processes and national priorities and align these with their proposals
- Assess the proposed climate impact, alignment with national priorities and assessment criteria
- Identify and work with the designated focal points or contact point to initiate the process
- Review and submit a funding proposal request

Conclusion

It is hoped that the information in these pages will persuade planners and decision makers of the urgent need to prepare Zimbabweans to face up to climate change and its attendant risks. The most important message of this book is that we must act now to address this, the biggest threat to humanity today. For the sake of future generations of Zimbabweans, we cannot afford to delay.

Appendix 1: Resources

Useful organisations

Government departments:

AGRITEX
Ministry of Agriculture, Mechanisation and Irrigation Development
Ngungunyana Building
1 Borrowdale Rd, Harare
263 4 706081–9
www.agritex.gov.zw/

Department of Civil Protection
Ministry of Local Government, Rural and Urban Development
Makombe Building
Corner Herbert Chitepo/Leopold Takawira avenues, Harare
263 4 791287
eprzim@eprzim.co.zw
Director: Mrs Ndlovhu

Environmental Management Agency
Makombe Complex, Harare St/Herbert Chitepo Ave, Harare
eep@ema.co.zw
263 4 705671–3, 705661–2; toll-free 08080028
0779565707 (WhatsApp)
www.ema.co.zw

Meteorological Services Department
Corner Bishop Gaul and Hudson avenues, Belvedere, Harare
263 4 778176
www.weather.co.zw/
Director: Mr Makarau

Ministry of Environment, Water and Climate
Climate Change Management Department
11th Floor Kaguvi Building, Corner 4th St/Central Ave, Harare
263 4 701681–3
www.environment.gov.zw/
Director: Washington Zhakata

Zimbabwe Forestry Commission
1 Orange Grove Drive, Highlands, Harare
263 4 498 4369
www.forestry.co.zw/

Zimbabwe National Water Authority
8th Floor Old Mutual Centre, 3rd St/Jason Moyo Ave, Harare
263 4 797 610–3, 797 604–7
pr@zinwa.co.zw
www.zinwa.co.zw/
Zimbabwe Parks and Wildlife Management Authority
Botanical Gardens
Corner Sandringham Drive and Borrowdale Rd, Harare
263 4 707624–9, 792796–9, 706077/8
www.zimparks.org/

Academic and research institutions

Chinhoyi University of Technology
School of Agricultural Sciences and Technology
Several research studies, including impact of conservation agriculture on greenhouse gas emissions and carbon sequestration, climate change impacts on crops and climate change adaptation for livestock.

School of Wildlife, Ecology and Conservation
Research in the following areas: building climate resilience for

the City of Harare in partnership with Harare City Council and Zimbabwe National Water Authority; climate adaptation and green economy; and fish health in a changing climate in Lakes Chivero and Manyame.
www.cut.ac.zw/schools/

Lupane State University
Agricultural sciences: animal science and rangeland management, and crop science research to improve drought-tolerant sorghum varieties
2nd Floor, CBZ Building, Corner Fife St/10th Ave, Harare
263 9 73770–1, 63546, 64458
www.lsu.ac.zw/index.php/en/

Midlands State University
Faculty of Natural Resources Management and Agriculture
Department of Agronomy: capacity building for adaptation to climate change
Gweru
263 8677000234
http://ww4.msu.ac.zw/

National University of Science and Technology
Institute of Development Studies
Corner Gwanda Rd, Cecil Ave, Bulawayo
263 9 282842, 288413, 289557
www.nust.ac.zw

University of Zimbabwe
630 Churchill Ave, Mount Pleasant, Harare
263 4 30321
www.uz.ac.zw/
Institute of Environmental Studies: Several climate change-related studies and development of the National Climate Change

Response Strategy
Director: Prof. S.B. Feresu
Institute of Development Studies: Research on the economics of climate change and agricultural adaptations to climate change.
Lead climate change researcher: Dr Medicine Masiiwa
Centre for Applied Social Science, Faculty of Social Studies: Research on climate change adaptation, community-based natural resource management and indigenous knowledge
Chairperson: Dr B. Mukamuri
University of Zimbabwe and Soil Fertility Consortium for Southern Africa: Enhancing the adaptive capacity of local communities to respond to climate change
Department of Agricultural Economics: Studies on climate change adaptation among smallholder farmers
Faculty of Education: Education for sustainable development and climate change education research and outreach
Faculty of Humanities and Social Studies: Sociological and multidisciplinary research and teaching on human-environment and natural resources concerns, including climate change

Zimbabwe Open University
Nursing Science: Health threats of climate change
Centre for ODL Research and Scholarship: Climate-compatible waste management research
Stanley House, Corner 1st St/Jason Moyo Ave, Harare
263 4 793002/3/7/9, 791983, 796464, 796469, 794737, 797154
http://www.zou.ac.zw/

Scientific and Industrial Research and Development Centre (SIRDC)
1574 Alpes Rd, Hatcliffe, Harare
263 4 860320/2
Public relations: Mrs Tarisayi Zvoma

Department of Research and Specialist Services
Harare Agricultural Research Centre
Fifth St Extension, Harare
263 4 7045341–9

Matopos Research Institute
Criterion Mine, Bulawayo
263 (0383) 320
mtri@drss.gov.zw

International Crops Research Institute for Semi-arid Tropics (ICRISAT)
Research on drought-resistant crop varieties and community-based adaptation
Matopos Research Station, Bulawayo
263 383311 to 15, 263 383307
icrisatzw@cgiar.org
www.icrisat.org/icrisat-globalpresence.htm

Department of Chemical and Process Systems Engineering
Research relating to adaptation and mitigation
Harare Institute of Technology (HIT)
Ganges Rd, Belvedere, Harare
263 4 741422–36
communications@hit.ac.zw

Private sector

Business Council for Sustainable Development Zimbabwe
c/o Chemplex Corporation Ltd,
93 Park Lane, Harare
263 4 251800/8
www.bcsdz.co.zw/
Contact person: Dingane Sithole

Green Buildings Council Zimbabwe
185 Second St Extension, Mount Pleasant, Harare
Chairman: John Chiwara
263 77 6366958
chiwarajn@gmail.com

Comprehensive Energy Solutions,
2925 Mainway Meadows, Waterfalls, Harare
263 77 464 2989, 263 4 2003771
Director: Tendayi Marowa
tendayimarowa@yahoo.com

NGOs involved in climate change in Zimbabwe

Climate change adaptation programmes

Environment Africa
76 Queen Elizabeth Rd, Greendale, Harare
263 4 492148/55
Climate change officer: Collen Mutasa
collen@environmentafrica.org

Oxfam GB (Zimbabwe)
Arundel Office Park, Norfolk Rd, Harare
263 4 369603, 369564, 369873
Climate change officer: Dr Leonard Unganai
http://oxfaminzimbabwe.org/

Practical Action (Zimbabwe)
4 Ludlow Rd, Newlands, Harare
263 4 776 107, +263 4 776 631
Contact person: Hopewell Zheke
info@practicalaction.org.zw
http://practicalaction.org/wherewework_zimbabwe

United Nations Development Programme (UNDP)
Zimbabwe Resilience Building Fund
Block 7 Arundel Office Park
Norfolk Rd, Mount Pleasant, Harare
263 4 338836–44
www.zrbf.co.zw/

ZERO Regional Environmental Organisation (ZERO)
158 Fife Ave, Harare
263 772347769
Director: Shepherd Zvigadza
szvigadza@gmail.com

Conservation

Birdlife Zimbabwe
35 Clyde Rd, Eastlea, Harare
263 4 481496
www.birdlifezimbabwe.org/

Campfire Association
Mukuvisi Woodlands
Corner Hillside Rd and Glenara Ave South, Harare
263 4 747429–30
www.campfirezimbabwe.org/

The World Conservation Union (IUCN)
6 Lanark Rd, Belgravia, Harare
263 4 705714
www.iucn.org/

Wildlife and Environment Zimbabwe (WEZ)
Mukuvisi Woodlands
Corner Hillside Rd and Glenara Ave South, Harare
263 4 747648
www.zimwild.org/

World Wide Fund for Nature (WWF) Zimbabwe
10 Lanark Rd, Belgravia, Harare
263 4 252533/34
wwfzimbabwe@wwf.org.zw
wwf.panda.org/who_we_are/wwf_offices/zimbabwe/

Climate change communications and information

Africa Centre for Climate Change Knowledge Foundation Trust (ACCCKF)
6210 Bloomingdale Drive, Mabelreign, Harare
263 772433116
Director: Foster Dongozi
fosterdongozi@yahoo.com

Development Reality Institute
Climate Change Virtual School
21 Glenara Ave South, Eastlea, Harare
263 773460466
Director: Verengai Mabika
www.driafrica.org/virtual-school/

Children and climate change

Schools and Colleges Permaculture (SCOPE) Programme
Education Services Centre Building
Upper East Rd, Mount Pleasant, Harare
263 4 339512, 339503

Director: Linda Kabaira
scopezimbabwe@gmail.com
http://scopezimbabwe.org/
http://permacultureglobal.org/projects/2208-schools-and-colleges-permaculture-programme-scope-zimbabwe

UNICEF (Zimbabwe)
Climate Change Department
6 Fairbridge Ave, Belgravia, Harare
263 4 703881, 731840, 703941, 799232
Contact person: Amy Wickham
www.unicef.org/zimbabwe/

Climate change activism

Action 24
African Youth Conference on Climate Change
158 Fife Ave, Harare
263 4 772991697
Programme co-ordinator: Archieford Chemhere
achemhere@gmail.com

Climate change advocacy

Environment Africa
76 Queen Elizabeth Rd, Greendale, Harare
263 4 492148/55
Climate change officer: Collen Mutasa
collen@environmentafrica.org

Zimbabwe Environmental Lawyers Association
26B Seke Rd, Hatfield, Harare
263 4 573601–3
www.zela.org/

Useful Websites

Climate change issues and science

BBC News Global Climate Change: http://newsvote.bbc.co.uk/hi/english/static/in_depth/sci_tech/2000/climate_change/
Climate Development Knowledge Network: http://cdkn.org/
Climate Funds Update: www.climatefundsupdate.org/
Global Climate Change: Vital signs of the planet (NASA): http://climate.nasa.gov
Intergovernmental Panel on Climate Change: www.ipcc.ch/
United Nations Framework Convention on Climate Change Newsroom: http://newsroom.unfccc.int/
World Wide Fund for Nature Climate Change: wwf.panda.org/about_our_earth/aboutcc/

Climate change in Africa

Know Climate Change Impacts on Africa: http://know.climateofconcern.org/index.php?option=com_content&task=article&id=105
Union of Concerned Scientists: Global warming Africa: www.climatehotmap.org/global-warming-solutions/africa.html
World Bank: Climate Change and Africa: http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEXT/0,,contentMDK:22410211~pagePK:146736~piPK:146830~theSitePK:258644,00.html

Climate change Zimbabwe

Climate Development Knowledge Network: Zimbabwe: http://cdkn.org/regions/zimbabwe/
Famine Early Warning Systems Network: www.fews.net/southern-africa/zimbabwe

SADC Climate Services Centre: www.sadc.int/sadc-secretariat/services-centres/climate-services-centre/

Adaptation

Africa Climate Change Resilience Alliance: http://community.eldis.org/accra/
Climate Action Network International: www.climatenetwork.org/about/about-can
UNDP Africa Adaptation Programme: www.undp-aap.org/
UNEP Climate change adaptation: www.unep.org/climatechange/adaptation/

Mitigation

Carbonfootprint Ltd: www.carbonfootprint.com/minimisecfp.html
Carbonfund.org: www.carbonfund.org/reduce
Global Environment Facility: www.thegef.org/gef/climate_change/mitigation
Environmental Protection Agency: www.epa.gov/greeningepa/ghg/

Appendix 2: Climate finance resources

International funding

The Climate Funds Update website[1] is a useful place to find information about international finance aimed at helping developing countries address the challenges of climate change. The site reports that:

- Since 2013 finance approved for new projects to address climate change has increased by almost 50%. Most of it was sourced from the Climate Investment Fund, which approved $2.3 billion for projects.
- The standing committee on finance of the UNFCCC estimated that $40 billion-$175 billion in climate change finance flowed from developed countries to developing countries annually between 2010 and 2012.
- In 2014 the UN Secretary General's climate summit in New York mobilised over $200 billion in financial commitments from governments, business and the financial sector to help address climate change.
- A global movement initiated by local governments, philanthropic foundations, universities, faith-based organisations, NGOs and individuals aims to withdraw investment from companies associated with fossil fuels.
- In 2014 the Clean Technology Fund, the Scaling-Up Renewable Energy Programme and the Global Environment Facility approved $900 million for mitigation activities.
- Finance for REDD+ projects in developing countries reached $1.9 billion in 2014.
- Adaptation finance reached $2 billion in 2014, most of which ($54.6 million) went towards incorporating climate risk and resilience measures into national development plans

focusing on disaster risk reduction.

- The UNFCCC's Adaptation Fund was established in 2001 and launched in 2007 to offer institutions in developing countries direct access to its finance. It now has 21 institutions accredited as national or regional implementing entities.
- The Green Climate Fund is now the largest and fastest-growing climate fund, with $9.7 billion pledged.

Table 11 shows some of the main climate change funds, noting the sources, organisations administering the fund, the areas of focus and the dates they became operational.

Zimbabwe's National Climate Change Response Strategy (NCCRS)[2] states that the most important sources of multinational funding for Zimbabwe are the World Bank's carbon funds, the Global Environment Facility, the African Development Bank, the African Sustainable Forestry Fund, the Adaptation Fund, and the Kyoto Protocol's clean development mechanism (CDM). The document notes that the UNFCCC's Green Climate Fund is expected to be a major source of climate finance for developing countries.

Local funding

The NCCRS notes that Zimbabwe has not been able to take full advantage of these international funding mechanisms because it lacks capacity and accredited financial institutions. For example, the Ministry of Environment, Water and Climate needs to be accredited in order to access the Adaptation Fund.

The strategy suggests that additional funding could be sourced from mechanisms such as the UN Sustainable Energy for All fund, private sector carbon funding, REDD+ and international conservation foundations and funds. It recommends that

Zimbabwe set up a designated national authority which can be authorised by UNFCCC to approve Zimbabwe's participation in CDM projects.

The government has established an environment fund that is not yet operational and which can be financed from budgetary allowances, environmental levies and carbon tax donations. It is expected that the fund will provide grants and loans to the following: local authorities; adaptation and mitigation projects; environmental extension; research training and technology transfer; rehabilitation of degraded areas; and environmental awareness programmes. The NCCRS mentions other local funds which relate to climate change, including the Water Fund, the Rural Electrification Fund and the Zimbabwe Energy Fund, a multi-donor trust fund.[3]

Table 11: Major sources of climate change funding

Name	Source	Administered by	Area of focus	Date operational
Adaptation Fund	Multilateral	Adaptation Fund board	Adaptation	2009
Adaptation for Smallholder Agriculture Programme	Multilateral	The International Fund for Agricultural Development	Adaptation	2012
Clean Technology Fund	Multilateral	The World Bank	Mitigation – general	2008
Forest Carbon Partnership Facility	Multilateral	The World Bank	Mitigation – REDD	2008
Forest Investment Programme	Multilateral	The World Bank	Mitigation – REDD	2009

Name	Source	Administered by	Area of focus	Date operational
Global Environment Facility Trust Fund – climate change focal area (GEF 4)	Multilateral	The Global Environment Facility (GEF)	Adaptation and mitigation – general	2006
GEF Trust Fund – climate change focal area (GEF 5)	Multilateral	GEF	Adaptation and mitigation – general	2010
Global Climate Change Alliance	Multilateral	The European Commission	Adaptation and mitigation – general Mitigation – REDD	2008
Global Energy Efficiency and Renewable Energy Fund	Multilateral	The European Commission	Mitigation – general	2008
Green Climate Fund	Multilateral	GCF to be confirmed	Adaptation and mitigation – general Mitigation – REDD	Not yet operational
UK's International Climate Fund	Bilateral	Government of the United Kingdom	Adaptation and mitigation – general Mitigation – REDD	2011
Germany's International Climate Initiative	Bilateral	Government of Germany	Adaptation and mitigation – general Mitigation – REDD	2008
Australia's International Forest Carbon Initiative	Bilateral	Government of Australia	Mitigation – REDD	2007
Japan's Fast Start Finance – private sources	Bilateral	Government of Japan	Adaptation and mitigation – general Mitigation – REDD	2008
Japan's Fast Start Finance – public sources	Bilateral	Government of Japan	Adaptation and mitigation – general Mitigation – REDD	2008
Least Developed Countries Fund	Multilateral	GEF	Adaptation	2002

Name	Source	Administered by	Area of focus	Date operational
MDG Achievement Fund – Environment and Climate Change thematic window	Multilateral	United National Development Programme (UNDP)	Adaptation and mitigation – general	2007
Norway's International Climate and Forest Initiative	Bilateral	Government of Norway	Mitigation – REDD	2008
Pilot Programme for Climate Resilience	Multilateral	The World Bank	Adaptation	2008
Scaling-up Renewable Energy Programme for Low-income Countries	Multilateral	The World Bank	Mitigation – general	2009
Special Climate Change Fund	Multilateral	GEF	Adaptation	2002
Strategic Climate Fund	Multilateral	The World Bank	Adaptation and mitigation – general Mitigation – REDD	2008
Strategic Priority on Adaptation	Multilateral	GEF	Adaptation	2004
UN-REDD Programme	Multilateral	UNDP	Mitigation – REDD	2008

Source: www.climatefundsupdate.org/

Endnotes

1 www.climatefundsupdate.org/about-climate-fund/10-things-to-know-about-climate-finance-in-2013

2 GoZ 2014:66

3 GoZ 2014:68–9

Glossary [1]

Adaptation The process through which societies increase their ability to cope with an uncertain future, which involves taking appropriate action and making the adjustments and changes to reduce the negative impacts of climate change (United Nations Framework Convention on Climate Change [UNFCCC] 2007).

Adaptive capacity The ability of a system (such as a forest, a community or a nation) to adjust to climate change (including variability and extremes).

Agroforestry Agriculture incorporating the growing of trees.

Aquifer Permeable rock which stores water underground.

Atmosphere The layer of gases surrounding the Earth. The dry atmosphere consists almost entirely of nitrogen (78.1% volume mixing ratio) and oxygen (20.9% volume mixing ratio), together with a number of trace gases, such as argon (0.93% volume mixing ratio), helium, radiatively active greenhouse gases such as carbon dioxide (0.035% volume mixing ratio), and ozone. The atmosphere also contains water vapor, whose amount is highly variable but typically 1% volume mixing ratio. The atmosphere also contains clouds and aerosols.

Biodiversity The variety of life, including the number of plant and animal species, life forms, genetic types, habitats, and biomes (which are characteristic groupings of plant and animal species found in a particular climate)

Biofuel Ethanol, diesel and methane made from fresh plant or other organic material, including human or animal waste.

Biogas gaseous fuel (usually methane) produced by the decay of organic matter including manure.

Carbon cycle Carbon reservoirs in the atmosphere, land (includes soil, plants and animals and freshwater systems), oceans, and sediments (includes fossil fuels) and the movement

of carbon between them through chemical, physical, geological, and biological processes. The ocean contains the largest pool of carbon near the surface of the Earth, but most of that pool is not involved with rapid exchange with the atmosphere.

Carbon dioxide (**CO_2**) A naturally occurring gas and one of the main greenhouse gases in the atmosphere that is causing climate change. It is released during the burning of fossil fuels, cutting down or burning of forests and various other sources.

Carbon sequestration technologies developed to reduce carbon dioxide emissions from new and existing sources. It includes capture of carbon dioxide from power plants or industrial sources; transport of the captured and compressed carbon dioxide (usually in pipelines); and permanent storage, of that carbon dioxide in rock formations that contain tiny openings or pores that trap and hold the carbon dioxide.

Carbon trading A mechanism by which developed countries can meet their mitigation obligations. A country with high carbon emissions can purchase the right to emit more carbon from a less developed country that has low emissions.

Catchment area (**of a river**) The land uphill from a river from which rainwater runs.

Circular economy An alternative to a traditional linear economy (make, use, dispose) in which we keep resources in use for as long as possible, extract the maximum value from them while in use, then recover and regenerate products and materials at the end of each service life (See WRAP UK: www.wrap.org.uk/about-us/about/wrap-and-circular-economy).

Clean development mechanisms (**CDMs**) Mechanisms developed under the Kyoto Protocol to allow industrialised nations to

earn emission reduction units by investing in projects that reduce emissions, such as forest conservation in developing countries.

Climate The "average weather", or the statistical description of quantities (such as temperature, precipitation and wind) over a period of time ranging from months to thousands of years.

Climate change The long-term change in the Earth's climate caused by the release of greenhouse gases – notably carbon dioxide and methane – that trap heat in the atmosphere. Climate change includes major changes in temperature, rainfall or wind patterns, among others, that occur over several decades or longer.

Climate-smart agriculture Agricultural practices that sustainably increase productivity and system resilience while reducing greenhouse gas emissions.

Conference of the Parties (COP) The 180 nations that have ratified the United Nations Framework Convention on Climate Change (UNFCCC) have met annually in a different place since 1995. The role of the COP is to promote and review the implementation of the convention in light of the objectives, new scientific findings and the effectiveness of national climate change programmes.

Conservation agriculture A farming method that involves minimum tillage and encourages mulching with crop residues. It has been shown to give higher yields than other methods during low rainfall years and increases long-term soil fertility.

Desertification Land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities.

Ecosystem A community of plants, animals and other living organisms and the environment – soil, rocks and water – in which they live.

Ecosystem services Services provided by ecosystems that benefit humans, such as purification of air and water, food and fertile soil.

El Niño – Southern Oscillation (ENSO) El Niño, is a warm water current that periodically flows along the West coast of South America, disrupting local fishing industries. This event is linked to fluctuations in the circulation of the Indian and Pacific oceans called the Southern Oscillation. This has great impact on the wind, sea surface temperature and on precipitation patterns in the tropical Pacific and many other parts of the world. The opposite of an El Niño event is called La Niña.

Emissions The release of a substance (usually a gas in relation to climate change) into the atmosphere.

Food security The state in a family, community or nation when all people at all times have sufficient nutritious food in order to lead healthy, active lives.

Fossil fuel A fuel formed from decayed plants and animal material that have been converted to crude oil, coal, natural gas or heavy oils by exposure to heat and pressure in the earth's crust over hundreds of millions of years.

Global warming The heating of the planet caused by climate change.

Greenhouse effect The gases in the Earth's atmosphere act like a greenhouse, forming a layer to keep the planet warm. Without the natural greenhouse effect the Earth would be too cold for life. However, human activities have caused excessive greenhouse gases to build up in the atmosphere, causing the planet to heat up too much, an effect known as global warming.

Greenhouse gas Any gas that absorbs infrared radiation in the atmosphere or gases that contribute to the greenhouse effect. The main gases responsible are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO) and fluorinated gases.

Groundwater recharge The process by which underground water stores are replenished by rain and other sources of water.

Hazard Anything that poses a threat or danger to humans.

Heat waves A prolonged period of excessive heat, often combined with excessive humidity.

Infiltration The permeation of rainwater in the soil.

Integrated pest and disease management An environmentally sensitive approach to controlling pests and diseases through cultural, biological and mechanical methods in order to reduce dependence on pesticides.

Intended nationally determined contributions (INDCs) Targets for greenhouse gas emissions reductions set by all countries that are signatories to the UNFCCC. INDCs become nationally determined contributions (NDCs) when a country ratifies the Paris Agreement.

Low-emission development strategies Strategies to implement climate-resilient, low-emission development and support transitions to a low-carbon economy through coordination, information exchange and cooperation among countries and programmes working to advance low-emission economic growth. For more information, visit https://sustainabledevelopment.un.org/index.php?page=view&type=400&nr=708&menu=151

Mid-season dry spell At least 10 consecutive days of dry weather after the onset of the rains.

Mitigation Actions that reduce greenhouse gas emissions which lead to climate change.

Methane (CH4) A hydrocarbon that is a greenhouse gas with a global warming potential most recently estimated at 25 times that of carbon dioxide (CO_2). Methane is produced through anaerobic (without oxygen) decomposition of waste in landfills, animal digestion, decomposition of animal wastes, production and distribution of natural gas

and petroleum, coal production, and incomplete fossil fuel combustion.

Reducing emissions from deforestation and forest degradation (REDD+) A mechanism "to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development", according to a widely acknowledged definition.

Renewable energy Energy resources that are naturally replenished, such as biomass, wave and tidal action, and hydro, geothermal, solar, wind and ocean thermal power.

Resilience The ability of an entity such as a family, community, forest or farm to recover from shocks and hazards, enabling it to adapt better to hazards and shock in the future.

Species Any living organism.

Sustainable development Development that meets the needs of the present without compromising the ability of future generations to meet their needs.

Vulnerability The degree to which an individual, household or community is sensitive to or is exposed to risk of harm.

Wetland An area that is permanently or seasonally saturated with water and that contains characteristic plants.

Biographies

Washington Zhakata is the director of the Climate Change Management Directorate in the Ministry of Environment, Water and Climate. He previously worked for Meteorological Services Department, was a lecturer in the geography and environmental science department of the University of Zimbabwe and was national programme coordinator for climate change with the United Nations Development Programme. He is a seasoned Africa Group lead climate change negotiator and has experience in the following areas: greenhouse gas inventorying, environmental management, early warning systems for food security, environmental policy, clean development mechanisms and carbon markets, and impact assessments in the agriculture, biodiversity, health and other sectors. He has been a member of the UN's clean development mechanism executive board on carbon trading since 2012.

Professor Francis Themba Mugabe holds a BSc in soil science and PhD in water resources management, both from the University of Zimbabwe, and an MSc in agricultural water management from Reading University in the UK. For 10 years he was with the Department of Research and Specialist Services where he did extensive research on the efficient utilisation of water resources in the south-eastern Lowveld. He has been dean of faculties of agriculture at both Midlands State University and Chinhoyi University of Technology. He is presently the director of innovation and technology transfer at Chinhoyi University of Technology. His research interests are water resources management and climate-smart agriculture.

Elisha Nyikadzino Moyo is a principal climate researcher in the Climate Change Management Department of the Ministry of Environment, Water and Climate. He is also the climate

technology focal point for Zimbabwe with the UNFCCC's Climate Technology Centre and Network and alternate focal point for the Green Climate Fund. Mr Moyo is a chartered meteorologist and holds an MSc in applied meteorology and climate with management from the University of Reading in the UK. He is reading for a doctorate in climate dynamics and impacts on maize production. He has worked for the Meteorological Services Department, Bindura University of Science Education and the SADC Climate Services Centre. He interacts with climate service players at all levels and is passionate about the linkages between climate and development.

Dr Mzime Ndebele-Murisa is a lecturer and researcher and the deputy dean in the School of Wildlife, Ecology and Conservation at Chinhoyi University of Technology. She has been an academic for more than 10 years. She is a freshwater ecologist and has worked with several multidisciplinary and transdisciplinary research projects focusing on climate vulnerability, impacts and assessment, modelling, freshwater ecology and conservation as well as fisheries management. Dr Ndebele-Murisa has a PhD in biodiversity and conservation biology from the University of the Western Cape in South Africa, an MSc in tropical resource ecology and a BSc (Hons) in biological sciences from the University of Zimbabwe.

Dr Nqobizitha Dube is an economist with a keen interest in environmental governance livelihoods and sustainable development. He lectures at the Institute of Development Studies at the National University of Science and Technology. He also leads the Ali-Douglas Research Network and the Ali-Douglas Development Consultancy through which he has conducted research, evaluation and organisational transformation projects with UN agencies, NGOs, the private sector and local government organisations. Dr Dube holds a PhD in economics, (environmental

and natural resources) from Rhodes University in South Africa, an MSc and BSc in agricultural economics, both from University of Fort Hare in South Africa, and a BSc (Hons) in economics from the University of Zimbabwe.

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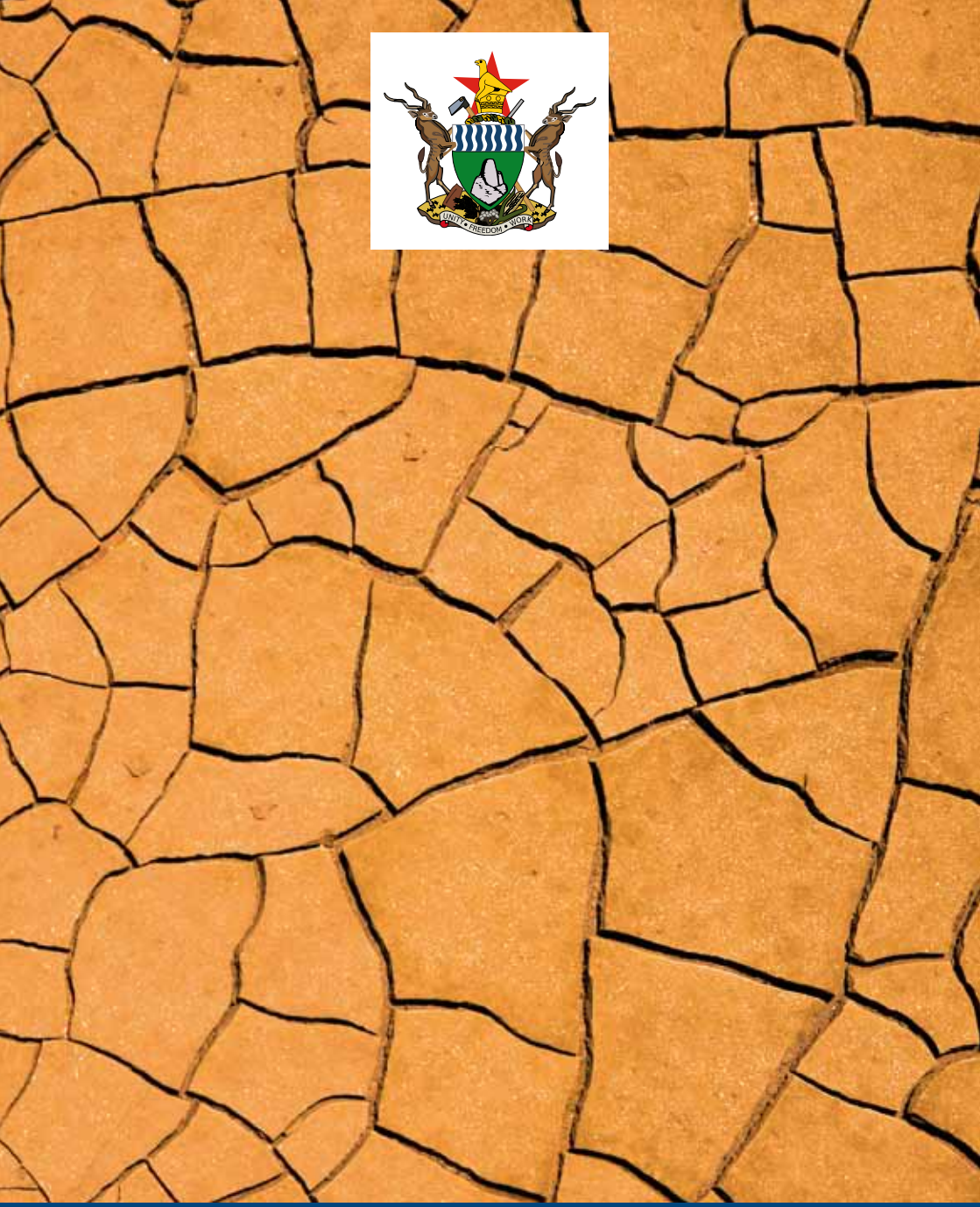

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