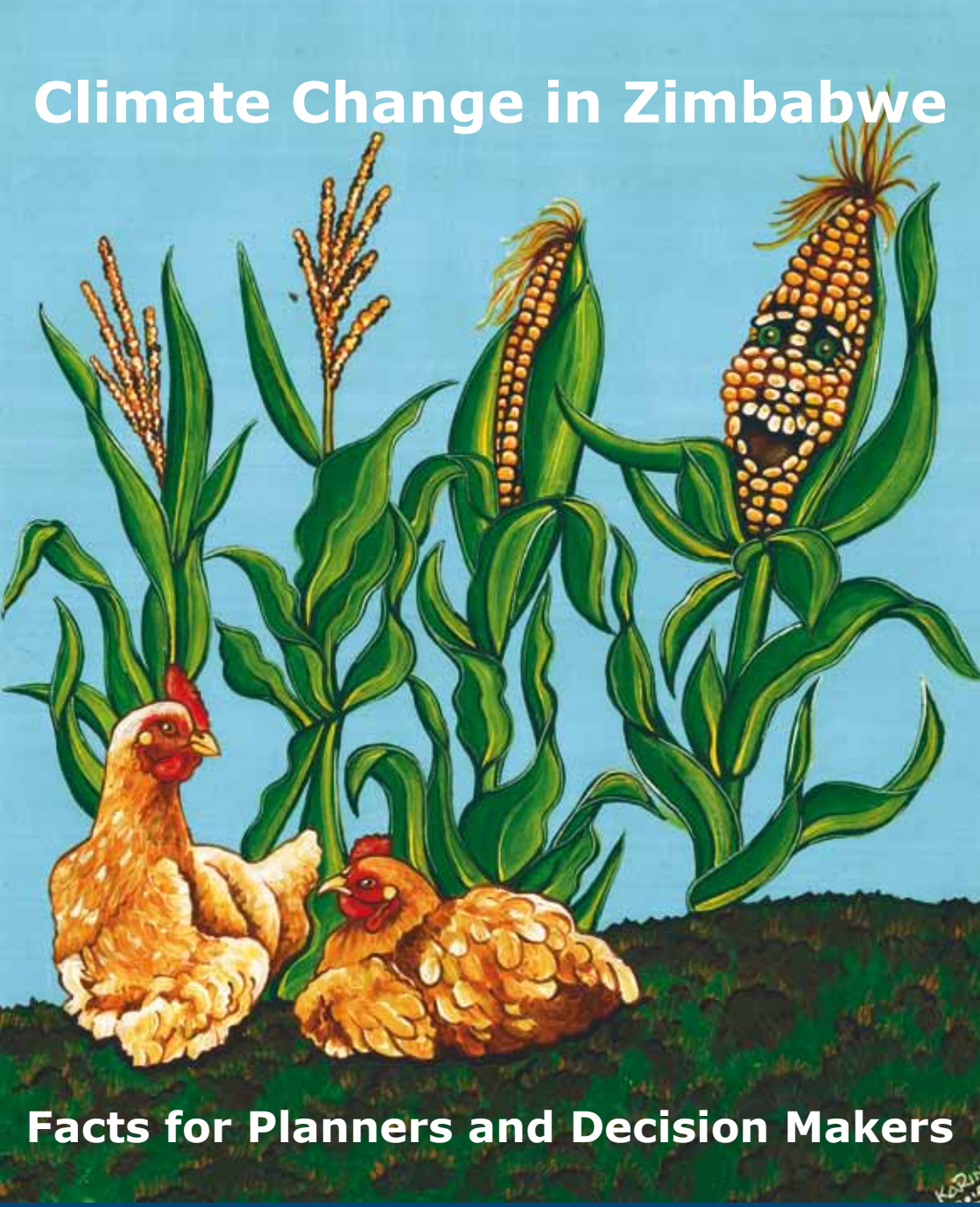
Climate Change in Zimbabwe



Facts for Planners and Decision Makers

Konrad
Adenauer
Stiftung

Anna Brazier

Climate Change in Zimbabwe

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RAU RESEARCH AND ADVOCACY UNIT

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Acronyms and abbreviations

AIDS	Acquired immune deficiency syndrome
AGRITEX	Department of Agricultural Technical & Extension Services
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
GDP	Gross domestic product
GoZ	Government of Zimbabwe
HIV	Human immunodeficiency virus
IPCC	Intergovernmental Panel on Climate Change
MSD	Meteorological Services Department of Zimbabwe
NAMA	Nationally appropriate mitigation actions
NAPA	National Adaptation Programme of Action
NCCRS	National Climate Change Response Strategy
NGO	Non-governmental organisation
REDD	Reducing emissions from deforestation and forest degradation
UNDP	United National Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WFP	World Food Programme
ZINWA	Zimbabwe National Water Authority
ZimAsset	Zimbabwe Agenda for Sustainable Socio-economic Transformation
ZimStat	Zimbabwe National Statistics Agency

Foreword

Threats and opportunities

There is no doubt that climate change will affect the lives of every person on this planet no matter who they are or where they live. It will threaten food and water security and human health as well as social, economic and political stability. It will reshape societies and change the natural world as we know it. By degrading and depleting the very resources on which life depends, climate change could reverse many of the development gains made by African countries during recent decades and could hamper development efforts.

Zimbabwe's National Climate Change Response Strategy (NCCRS) states that "Climate change is the biggest threat to humanity today", and this at a time when many parts of the world already experience environmental degradation, water shortages, poverty, hunger and inequality. However, many citizens, activists, scientists and policy makers hope that if we rise to the challenge of climate change, it could become our best chance to make the world a better place.

This book aims to provide planners and decision makers with concise, user-friendly information to help them design future projects with climate change in mind. It will help implementers to build resilient communities, raise awareness of the current and potential impacts of climate change and develop strategies to prepare for the future.

The first chapter gives a situational analysis of Zimbabwe, highlighting different sectors that could be affected by climate change. The second chapter gives a brief overview of the causes of climate change. The third discusses the future impacts of climate change globally, on Africa and on Zimbabwe. Chapter 4 looks at ways in which we can adapt to the impacts of climate change. The fifth chapter looks at ways in which we can mitigate climate change by reducing greenhouse gas emissions. The final chapter gives recommendations. Appendix 1 gives an overview of key legislation and policies related to climate change. Appendix 2 lists resources, including organisations involved with climate change issues, and useful websites. Appendix 3 reviews finance options for adaptation and mitigation projects.

Climate change in brief

Climate change is the long-term change in the Earth's climate caused by the release of greenhouse gases – such as carbon dioxide [CO_2] and methane [CH4]) – which trap heat in the atmosphere, causing the planet to become hotter (global warming). Greenhouse gases are released by human activities which use of fossil fuels (coal, oil and natural gas) as well as by large-scale commercial agriculture and deforestation (This is explained in more detail in chapter 2).

How will it affect us?

The average atmospheric and ocean temperatures across the Earth will rise due to climate change. This will cause widespread melting of snow and ice at the poles. The extra water from this melting will cause sea levels to rise and weather patterns to change across the planet. Extreme events, including storms, droughts and floods, will be more frequent. Everyone will be affected especially people in developing countries due to their location, their economic status and the burdens which they already bare including hunger, poverty and disease (This is explained in more detail in chapter 3).

In Zimbabwe, climate change will cause average temperatures to rise by about 3°C before the end of this century. Annual rainfall could decline by between 5% and 18%, especially in the south. Rainfall will become more variable. There will be an increase in droughts, floods and storms. This will affect Zimbabwe's food

security, health, energy supply and the economy (This is explained in more detail in chapter 3).

What can we do about it?

Even if greenhouse gas emissions are stopped or reduced through concerted international efforts, many of the impacts of climate change will still affect us for decades. We must therefore develop strategies now to adapt to climate change. Primarily, we must protect the natural resources on which our lives and livelihoods depend by introducing better land management practices and increasing biodiversity (This is explained in more detail in chapter 4).

At the same time we must work together as a global community to reduce the concentration of greenhouse gases. It is hoped that this will prevent the most devastating impacts of future climate change and help us to repair some of the damage which has already been done (This is explained in more detail in chapter 5).

"Is it the end of the world as we know it, or our best chance to improve the future?"

1

The Zimbabwean context

Chapter summary

"There are no environmental problems, only human problems."

In this chapter we look at the current state of people, land and economy in Zimbabwe, allowing us to see how climate change will impact on these sectors later in chapter 3.

Climate[1]

Zimbabwe is endowed with abundant human and natural resources, and these resources are interdependent. For example, since the economy is heavily reliant on agriculture and electricity, its strength and stability are linked to the climate and particularly the state of the country's water resources.

The country is situated in central southern Africa and most of its land area is on a plateau between 1200 m and 1600 m above sea level, which gives it a relatively mild subtropical climate with seasonal rainfall. Around 20% of its land area, including the Zambezi and Limpopo river valleys, lies below 900 m. The climate is strongly influenced by the Intertropical Convergence Zone, which develops as a result of the collision of warm moist air masses from the north and cool air masses from the south, producing the main rainfall season. Zimbabwe has four seasons:

- Hot season from mid-August to mid-November
- Main rainy season from mid-November to mid-March
- Cool season from mid-May to mid-August
- Post rainy season from mid-March to mid-May

Rainfall

Zimbabwe has one of the most variable rainfall patterns in the world in terms of distribution across time and space, although dry spells and droughts are part of a normal cycle. Figure 1 shows the variation in rainfall in an average year. The higher-altitude districts in the north and east typically experience greater amounts of rain (above 1,000 mm per year) than low-lying areas in the south and west of the country (350–450 mm per year). The western parts usually receive the first rains of the season, while the southern and south-eastern parts occasionally experience drizzle (*guti*) brought by south-easterly air masses. Figure 2 shows the average rainfall distribution across the country in an average year.

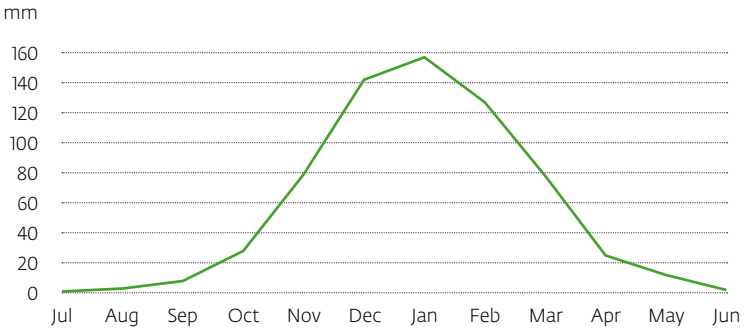


Figure 1: Zimbabwe average monthly rainfall

Source: Meteorological Services Department of Zimbabwe (MSD)[2]

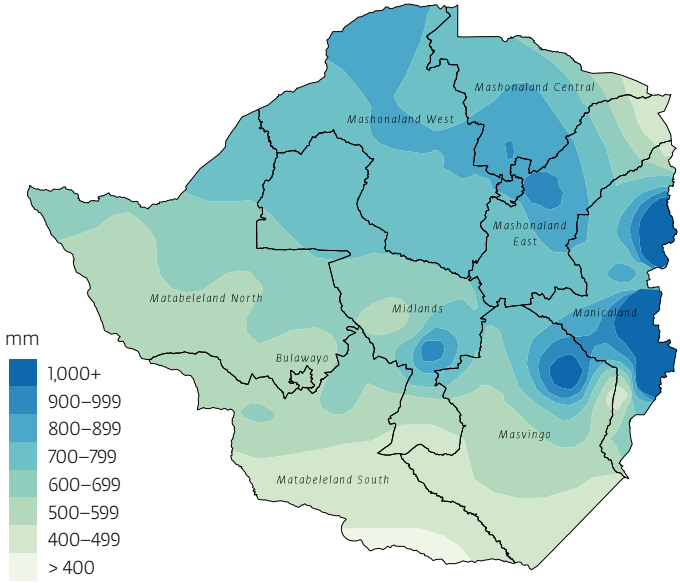


Figure 2: Zimbabwe average annual rainfall map

Source: MSD

Temperatures

On average, the higher-altitude areas in the north and east experience lower temperatures than low-lying areas in the west and south. Figure 3 shows the average maximum temperatures across the country, with the coolest maximum temperatures being experienced in the eastern highlands and the hottest in the low-lying areas in the west and extreme south.

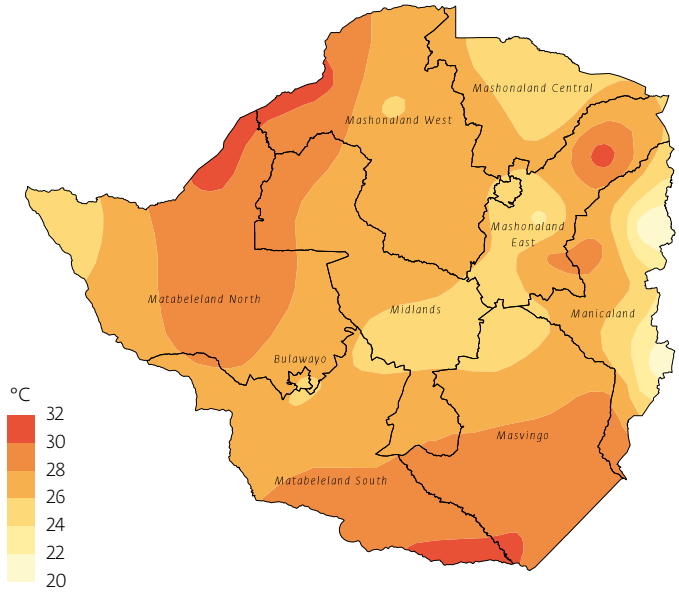


Figure 3: Zimbabwe average maximum temperatures map

Source: MSD

Climate-related hazards

Normal weather hazards experienced in Zimbabwe include tropical cyclones causing intense rainfall (more than 100 mm in 24 hours) and thunderstorms sometimes leading to hailstorms, floods and flash flooding. The country is often affected by droughts lasting from one to three years and occurring every five to seven years.[3] This is a natural cycle, partly influenced by a climate pattern called the El Niño-Southern Oscillation, which originates in the Pacific Ocean. During some years of the cycle, temperatures in the Pacific Ocean rise and this causes rainfall fluctuations across the southern hemisphere. An El Niño can last nine months. The correlation between El Niño events and droughts in Zimbabwe is very high. The past 10 drought years in southern Africa were all El Niño years.[4]

Figure 4 shows the variability in average seasonal rainfall since records began in 1901. As can be seen 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 declining. The decline is attributed to climate change. During an average rainy season it is normal for the country to experience four to five dry spells.

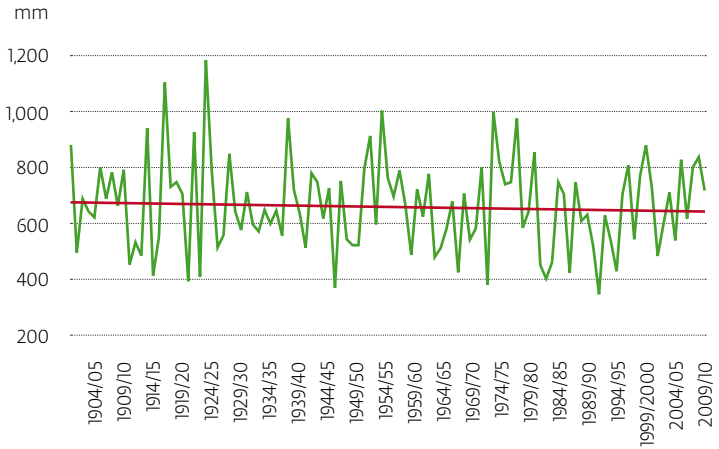


Figure 4: Zimbabwe average seasonal rainfall (mm) 1901/02 to 2009/10

Source: MSD

Temperature extremes cause ground frost during the cold season and heat waves during the hot season. Climate change is expected to bring an increase in average temperatures across the country of between 1°C and 3°C.[5] A moderate decrease in average rainfall is expected.[6] Rainfall variability and distribution are expected to increase and climate-related hazard events, such as droughts

and floods, are likely to become more frequent. These impacts are described in more detail in chapter 3.

Natural resources

Zimbabwe has abundant natural resources, including minerals, agricultural land, water, natural vegetation and wildlife. The population in both urban and rural areas depends heavily on ecosystem services that provide a clean, regular water supply, fertile soils and trees for fuel, building construction and fencing. In addition, many rural Zimbabweans draw on important food sources in the form of wild foods during times when agricultural produce is out of season. These vital resources and services have been degraded over the years through various human activities. Climate change will accelerate the degradation and its impacts will be felt more strongly. Zimbabwe's soils, for example, have been increasingly eroded through annual ploughing, burning for land clearing, deforestation and poor grazing management. Lack of control of water run-off on slopes and uncontrolled open-cast mining in some areas have added to the degradation. Deforestation has become a major problem in recent years as forests have been cleared in preparation for agriculture, for fencing and for use as firewood mainly for tobacco curing and brick making. Between 1990 and 2015 Zimbabwe lost 36% of its forest cover at a rate of 9% per decade.[7] Destruction of natural habitats, pressure from human settlements and poaching have decimated wildlife populations, particularly those of endangered species.

Natural regions

Zimbabwe is divided into natural regions based on soil types, vegetation and climate. The five regions shown in Figure 5 were mapped to help planners identify the optimum types of agricultural land use for each part of the country.

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, rock, air and water. Ecosystem services are the benefits that humans get from ecosystems. These include food, clean water and air, waste disposal (through decay), fertiliser, fuel, control of pests and diseases, and climate regulation.

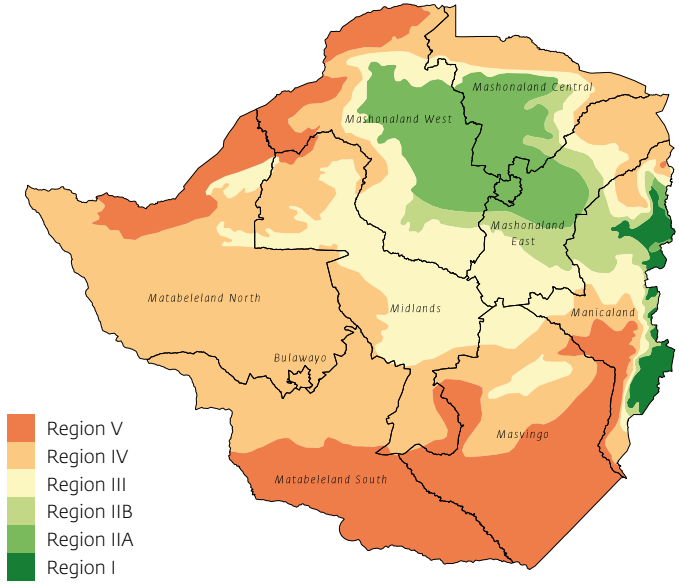


Figure 5: Zimbabwe's natural regions

Source: MSD

Natural Region Descriptions

Natural region I: High rainfall (over 1,000 mm per year), low temperatures and steep slopes. It is suitable for high-value arable farming, diary, horticulture and forestry.

Natural region II: Medium rainfall (750–1,000 mm per year). Temperatures are not extreme and soils are generally good. It is suitable for intensive farming, including horticulture and dairy.

Natural region III: Low rainfall (500–750 mm per year), with mid-season dry spells and high temperatures. This is a semi-intensive farming region suitable for field crops such as maize, soya, tobacco and cotton as well as livestock.

Natural 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.

Natural region V: Very low rainfall (less than 650 mm per year) and highly erratic. Suitable for livestock, wildlife management, beekeeping and non-timber forest products.

Communities living in natural regions IV and V (which make up about 64% of the land area) are at the mercy of climatic extremes, with few livelihood options. They tend to be the most vulnerable to poverty. These regions are already feeling the impacts of climate change and will be the hardest hit in the future. Many scientists propose that the natural region map be redrawn because of climate change, with regions IV and V taking up more area and I, III and IV less.[8]

Water[9]

Figure 6 explains the water cycle in Zimbabwe, showing the atmospheric, surface and underground water stores and the links between them. The total available water for Zimbabwe today is

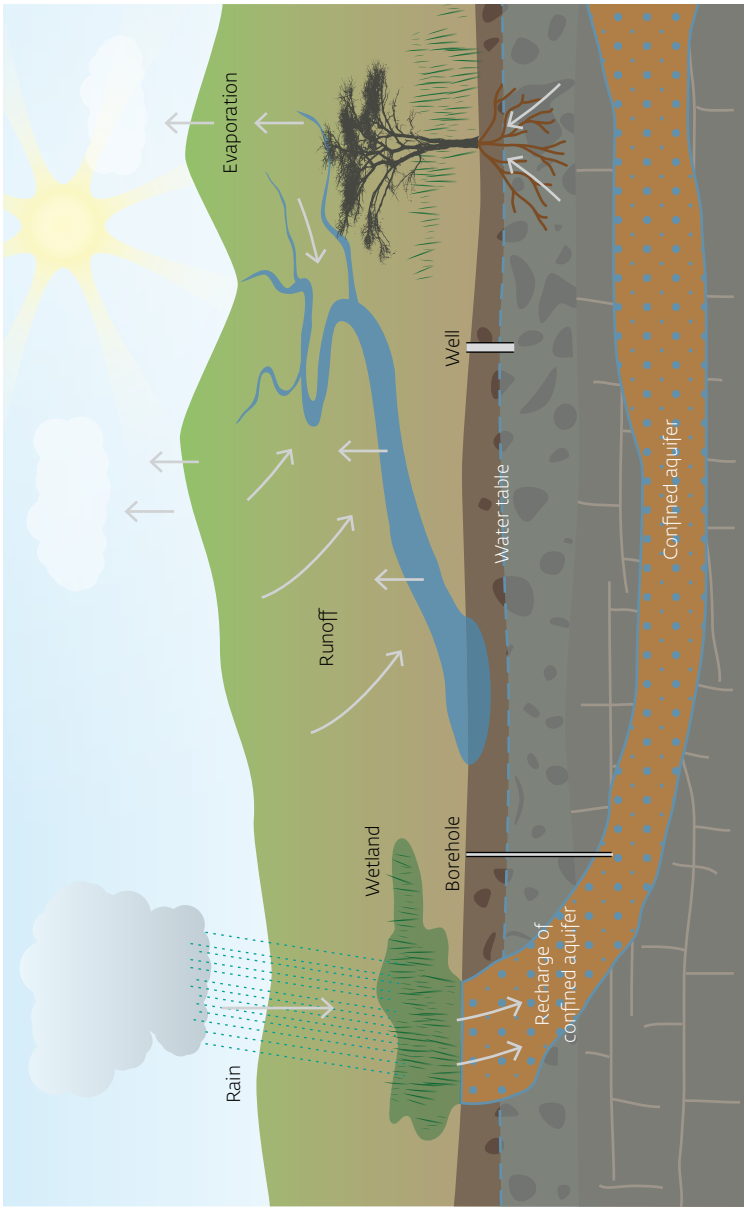


Figure 6: The water cycle showing surface and underground water stores and the role of wetlands

around 20 million megalitres (1 megalitre = 1 million litres). 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. Electricity generation will be affected by climate change since lower rainfall means less water in Kariba and hence less generating capacity.

The water cycle

Figure 6 shows the water cycle. Water occurs 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 in aquifers.

Underground water

It is estimated that 8 million megalitres of underground water is available through wells and boreholes.[10] 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 7. Shallow wells, which serve most families in rural areas, draw on water stored in the soil. These 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. Depending on the amount of water in an aquifer, boreholes provide a more reliable water source. Depending on the rock type, some underground aquifers are also recharged by rainfall. However, others become permanently dry once the water has been extracted from non-rechargeable aquifers.

The vital role of wetlands

Wetlands play a vital role in the water cycle. They allow water to sink into the soil, reducing run-off and thus flooding, while recharging underground water. They also filter many toxins from water. Protection of wetlands is fundamental to adapting to climate change. Any land-use activity taking place on wetlands should be carefully planned to ensure that it does not diminish the role of the wetland in the water cycle. Most forms of building and many forms of agriculture are likely to damage the proper functioning of wetlands.

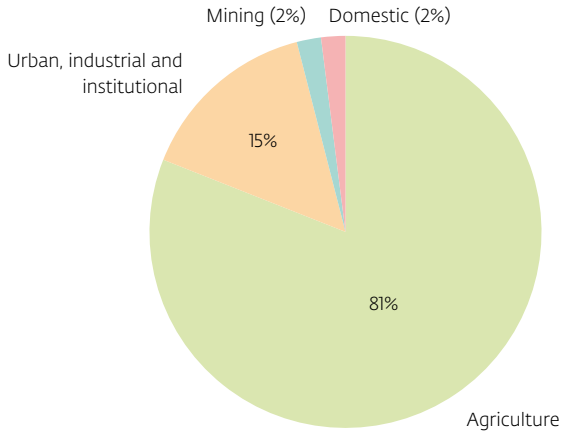


Figure 7: Water use by sector in Zimbabwe

Adapted from GoZ 2014 data

Water quality

The quality of the water for both urban and rural communities has deteriorated due to population pressure, climate fluctuations, cultivation and construction on watercourses and wetlands, and pollution from agriculture, industry and mining. This has led to increased health hazards, including diarrheal diseases and a cholera outbreak in 2008/2009, which was the worst in African history.[11]

Climate change is predicted to have a negative effect on Zimbabwe's water resources both in terms of the quantity and quality of water available.

People [12]

Climate change will exacerbate hardship and poverty among the people of Zimbabwe. Women, children and the disabled, especially those living in rural areas, will be the worst affected. The renowned resilience of Zimbabweans will be put to the test to develop effective coping strategies.

The national census of 2013 put Zimbabwe's total population at 13,061,239, of which 41% were under the age of 15.[13] 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. The average household size is 4.2 people and 67% of the population lives in rural areas.

Health

The main health issues in the country are high child mortality and poor maternal health. A survey in 2010 found that 39% of children in the country were suffering from chronic undernutrition in the form of stunting.[14] Food insecurity is a constant problem – Zimbabwe is ranked 156 out of 187 countries on the Global Hunger Index.[15] The most prevalent diseases are the human immunodeficiency virus (HIV) and acquired immune deficiency syndrome (AIDS), malaria, tuberculosis and diarrhoeal infections. Over half of the population lives in areas populated by malaria-transmitting mosquitoes. 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 provinces.

Resilience and vulnerability

Zimbabweans are a resilient and adaptable people, but also acutely vulnerable. The variable climate and turbulent history of the country have bred a population that is familiar with adversity. People have developed both positive and negative strategies for coping with long-term hardship and acute shocks due to a wide range of factors, including:

- 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
- The HIV and AIDS pandemic in the 1990s

- Recent economic and political instability

The country boasts the most highly educated population in Africa, with an overall literacy rate of 96% (94% for women).[16] In addition, there is a vast wealth of local traditional knowledge that has enabled Zimbabwean communities to adapt to a fluctuating climate for centuries. However, the past and present challenges have created vulnerability. According to recent figures, 72% of Zimbabweans live below the national poverty line (less than us$ 1.25 per day).[17] Poverty is higher in rural areas, with around 76% of rural people affected.[18] The causes of rural poverty relate to the adverse climate and environmental conditions that disrupt agriculture, the main livelihood activity in areas where most people live.

Women, children, the elderly and the disabled have been identified in several studies as being the most vulnerable to shocks.[19] Cultural norms burden women with the responsibility to provide food, fuel and water, a responsibility that will be made increasingly difficult by climate change.

Urban drift and cross-border migration have increased the range of families' sources of income, but, like 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.

Economy[20]

Zimbabwe has a diverse economy thanks to its amenable climate, abundant resources and highly educated population. However, the economy is heavily dependent on water availability. Figure 8 shows how gross domestic product (GDP) has been strongly affected by rainfall fluctuations in the past. During years where rains have been good, GDP has increased proportionally. During drought years GDP has fallen.

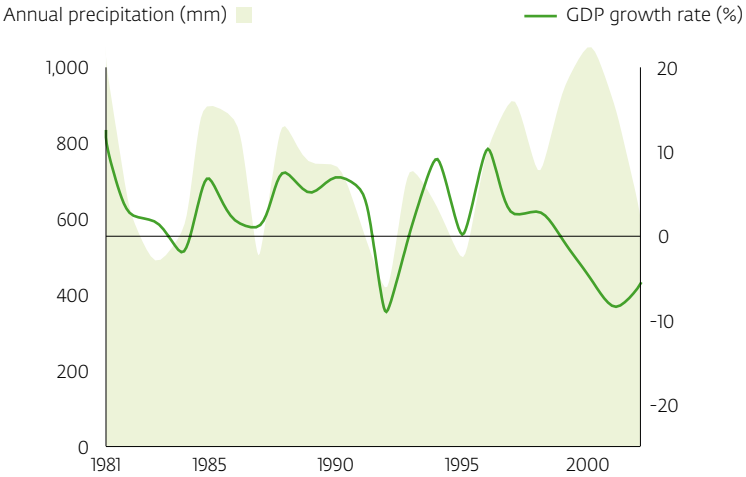


Figure 8: Correlation between GDP and rainfall in Zimbabwe 1979–1993

Source: Hugo Ahlenius 2006

Figure 9 shows the contributions to GDP of the major economic sectors. About 60% of the population is employed in agricultural activities, and agriculture contributes about 15% to the GDP.

Most agriculture is carried out by smallholder farmers, most of whom 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.

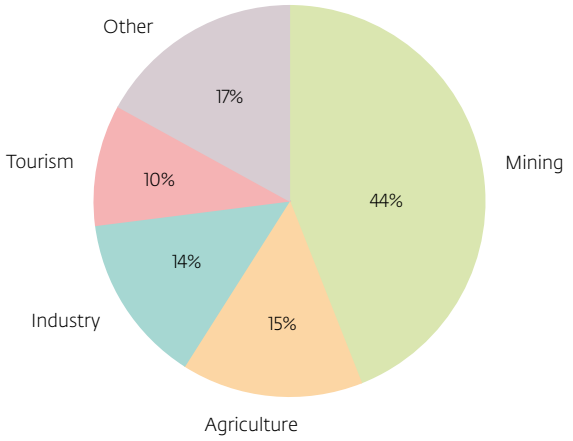


Figure 9: Contribution to national GDP by sector in Zimbabwe

Adapted from GoZ 2014 data

Energy

Most energy for industry, commerce and urban domestic activities in the country 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 fuelled by petrol or diesel.

Zimbabwe has suffered 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.[21]

Climate change is likely to set back economic production in Zimbabwe in two main ways: increasing degradation of the natural environment on which so many of its people depend for their livelihoods, and fluctuating rainfall in Zimbabwe and beyond its borders, reducing the volume of water in Kariba dam and so restricting 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.[22] As crops fail, people are likely to turn to other sources of income, including activities such as brick moulding and sale of firewood, which add to the demise of forests.

Endnotes

1 This section is based on information from Zambuko 2011

2 MSD http://weather.utande.co.zw/climate/climatechange.htm.

3 Davis and Hirji 2014

4 Ibid.

5 GoZ 2014

6 IPCC 2014a

7 FAO 2015a

8 Mugabe *et al.* 2013; Brown *et al.* 2012

9 Most of the information in this section is from Davis and Hirji 2014

10 GoZ 2014

11 IPCC 2014b p. 1222

12 Most information from this section is taken from GoZ 2014

13 ZimStat 2013a

14 GoZ National Nutrition Survey 2010

15 WFP 2015a

16 ZimStat 2013b

17 WFP 2015b

18 ZimStat 2013b

19 See Manjengwa *et al.* 2014 and Chagutah 2010

20 Most information from this section is taken from GoZ 2014

21 Manjengwa *et al.* 2014

22 This section is based on based on information from Zambuko 2011.

2

What we need to know about climate change

Chapter summary

"If we ignore it, maybe it will become someone else's problem"

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

Weather, variability and climate change

The Earth's climate has always been changing, but it is changing faster today than it has for thousands of years. Most scientists agree that the very rapid changes that have been recorded in the past century have been caused by human activities. Climate change is the long-term change in the climate as a result of human activities that alter the composition of the atmosphere and causes warming.

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. Meteorologists can produce a fairly accurate forecast of what the weather is going to be like two weeks into the future.

Climate, on the other hand, describes the long-term conditions that exist in a particular place or region over a lengthy period. 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-November and mid-March.

Climate variability

It is normal for a climate to vary in time and space. As we have already noted in chapter 1, Zimbabwe's rainfall varies according to the time of year and between years. Some years are wet and others have droughts. The amount of rainfall received in different parts of the country also varies. However, until recently the long-term average climate had remained more or less the same for centuries. As global climate change has begun to have an impact, the "average climate" has begun to change in an unpredictable way.

Weather and climate variability follow patterns and can be predicted. Climate change impacts are hard to predict or forecast, but scientists are improving their methods of doing so all the time.

The Intergovernmental Panel on Climate Change (IPCC)

The change in the climate that is being observed is monitored by the Intergovernmental Panel on Climate Change (IPCC). This 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. The fifth assessment report was published in 2014 and much of the information in this book is taken from it.

What causes climate change?

A greenhouse is a glass building that allows light and heat in, but prevents heat from escaping. Its function is to enable plants to be grown in cold countries during winter. 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. The gases that trap the heat are called greenhouse gases. Figure 10 shows how greenhouse gases become trapped in the atmosphere and cause global warming. The heating of the atmosphere leads to many other changes, including the melting of ice and snow on mountains and at the north and south poles. As the ice melts, the extra water causes sea levels to rise. 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.

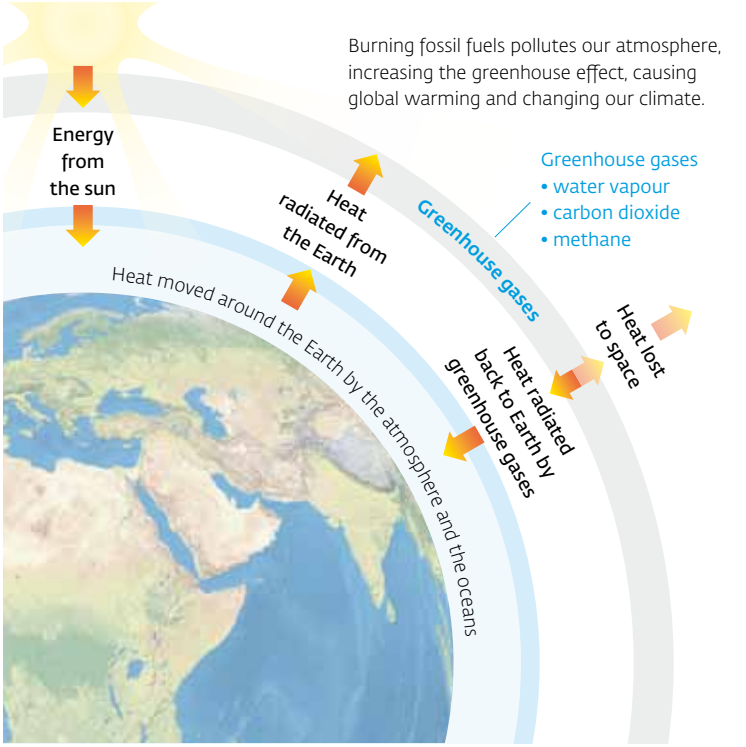


Figure 10: The greenhouse effect

Greenhouse gases

Human activities, such as burning coal or oil (known collectively as fossil fuels) for industry and transport and to produce

electricity, release greenhouse gases into the atmosphere. Large-scale commercial agriculture and forest clearing also contribute to greenhouse gas emissions. Figure 11 shows the main greenhouse gases and their percentage of 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. Methane (CH_4) mainly comes from livestock farming and waste management. Nitrous oxide comes from agricultural activities mainly related to fertiliser use. Fluorinated gases come from industrial processes, refrigeration and some consumer products.

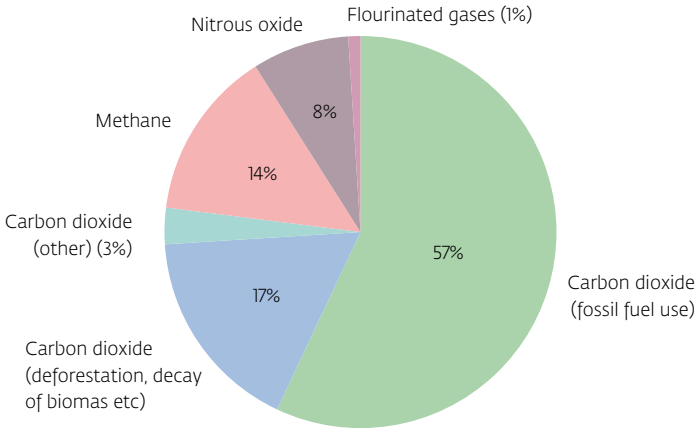


Figure 11: The main greenhouse gases responsible for climate change

Source: Environmental Protection Agency 2015

Figure 12 shows the main activities that cause the release of the greenhouse gases and the percentage contribution of these activities to climate change. Methane and carbon dioxide contain carbon, the main element in the climate change story. In order to understand climate change it is useful to know about the natural cycle of carbon and how human activities have altered it. Figure 13 in the box shows the main processes involved in the carbon cycle.

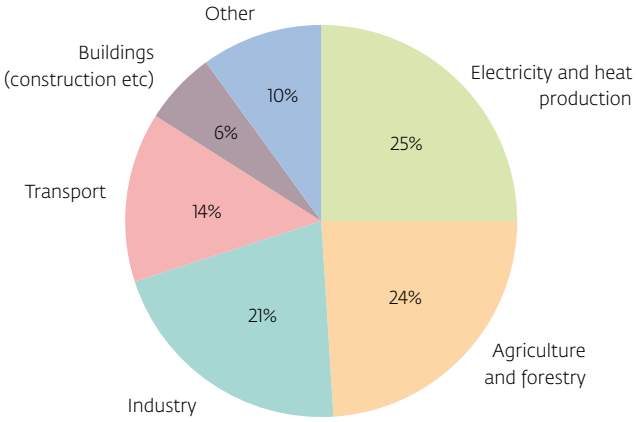


Figure 12: The main human activities that release greenhouse gases

Adapted from IPCC 2014a

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 CH4, in plants and soils (5%), in fossil fuels underground (8%) and in 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% 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 managed to absorb 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.

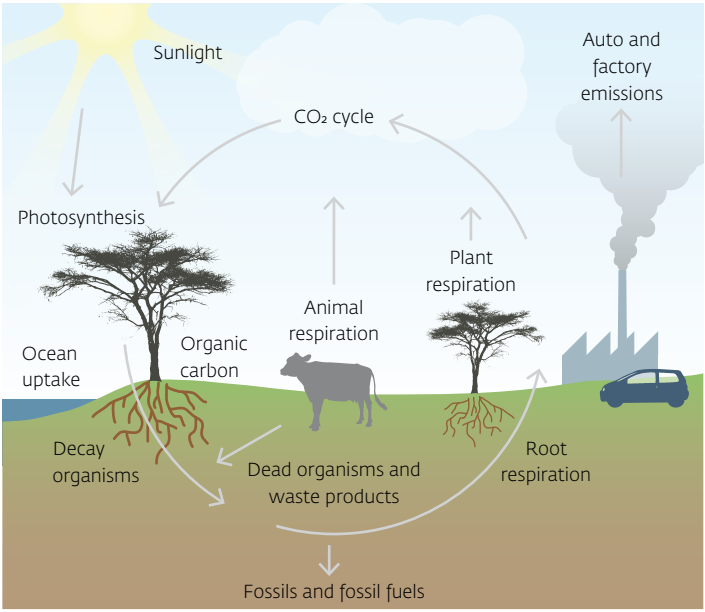


Figure 13. The main processes in the global carbon cycle

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

As countries have developed and economies and populations have expanded, more and more greenhouse gases have been released into the atmosphere. Figure 14 shows how the concentration of CO_2 (in red) has risen as global average temperatures (in orange) have increased.

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

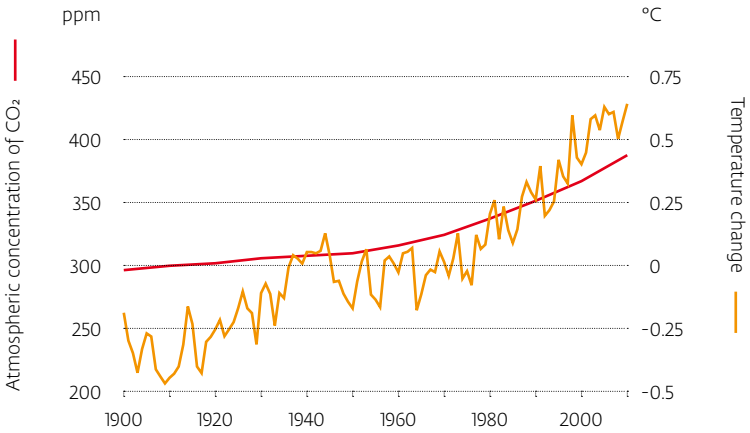


Figure 14: World atmospheric concentration of CO_2 (in parts per million) and average temperature change in degrees Celsius

Source: International Energy Agency 2013

Who is causing it?

The countries responsible for releasing the largest amounts of greenhouse gases into the atmosphere are also the richest and the most industrially developed. Figure 15 shows the top 20 countries emitting the most greenhouse gas in 2012. China currently produces around 22% of global greenhouse gas emissions, while the United States is responsible for 12%. When we leave out the figures for South Africa and Nigeria, the whole of the rest of the continent of Africa contributes to only 4.6% of total average global greenhouse gas emissions. Although China is currently the largest emitter as shown on the graph, this is a recent trend. In terms of historical emissions, the U.S. and Europe have contributed the most to climate change.

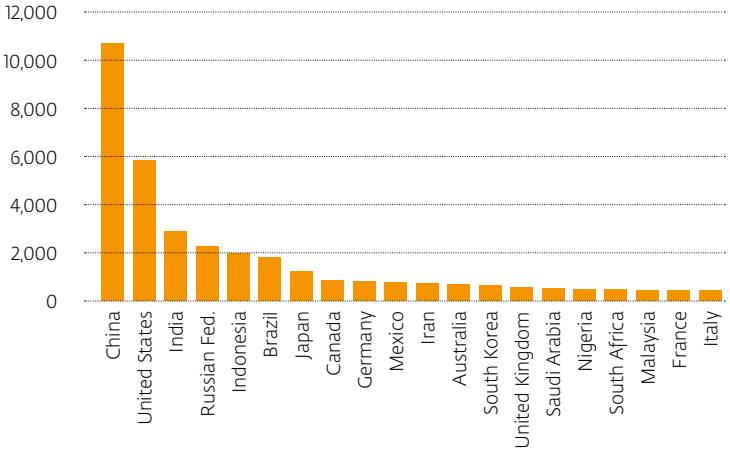


Figure 15: Total greenhouse gas emissions ($MtCO_2$ equivalent) in 2012 for the top 20 biggest emitters

Adapted from World Resources Unit 2015

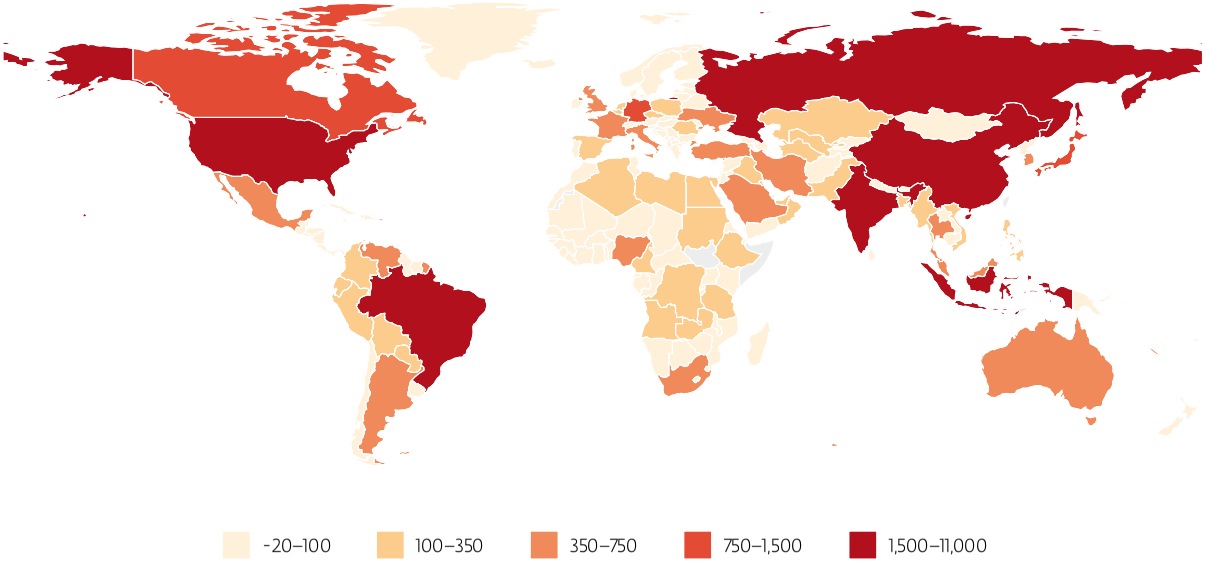


Figure 16: Greenhouse gas emissions (in millions of tonnes of CO_2 equivalent) per capita

Source: United Nations Statistics Division 2010

Figure 16 shows the CO_2 emissions per capita for the countries around the world. The countries shown in pale pink are producing the lowest emissions per capita.

Who will be affected?

Everyone on Earth will be affected by climate change, but the countries and communities that will experience the most severe impacts are in the developing world. This is due to their location, their economic status and the burdens that they already bear including hunger, poverty and disease (see chapter 3 for more details).

Climate injustice

If less economically developed countries try to develop in the same way as rich countries, their industries will release more

greenhouse gases into the atmosphere, leading to more climate change. In global climate change negotiations, rich countries insist that less developed nations reduce their greenhouse gas emissions, but they are not offering to help them continue to develop in a way that contributes less to climate change. The choice for developing countries is either to stop developing or to continue to develop and contribute to climate change, paying fines for the extra emissions under the global climate change treaties. Thus, poor countries are expected to pay for a problem that they did not cause. This argument is causing paralysis of the negotiations to mitigate climate change and a failure for countries to agree on emission reduction levels. For more on this issue see chapter 5.

Evidence for global climate change[23]

The greenhouse effect was first described by scientists 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 change in the global climate and consequent rises in atmospheric and ocean temperatures have been caused by human activities.

Scientists have been measuring the amount of CO_2 that has been entering the atmosphere from human activities every year since 1958. The increased levels in CO_2 strongly mirror the increased temperatures experienced by the planet (as shown in Figure 14).

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. It is important to note that 97% of scientists around the world agree that climate change is happening and that it is due to human activities. A vast amount of evidence has been collected to support this view.

Evidence from temperature measurements

Scientists can get an impression of the Earth's climate in the past by studying tree rings, ice cores, coral growth rings and sediments at the bottom of lakes. These studies show that in the past century, the planet has experienced an extreme and unusual increase in temperatures that is unlike anything experienced in the last 1,000 years. Detailed global temperature information collected when records began in 1850 shows a sharp rise that strongly correlates with the increasing levels of greenhouse gases in the atmosphere due to human activities. Most of the increase in temperatures has occurred since the 1970s. The warmest atmospheric and ocean temperatures have been measured in the past 10 years: 2014 was the hottest year on record, but it seems likely that 2015 will be even hotter.

Evidence from the oceans

Scientists have measured many other effects that are correlated with the increase in greenhouse gas emissions. The oceans absorb a great deal 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 for food and income.

Melting snow and ice in the Himalayas threaten 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 these 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 these areas of snow and ice melt too quickly and do not reform due to warmer winters, the result could be avalanches, floods and landslides followed by major rivers running dry leaving billions of people with drastic water shortages.

Evidence from snow and ice

Global warming has caused melting of glaciers, 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 cities worldwide with flooding. In addition, because snow and ice are an important water store for many countries, this melting has led to a decrease in the quantity and quality of water available in many parts of the world.

Evidence from plants and animals [24]

Plants and animals in many countries 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. As temperatures have risen, plants and animals have moved to cooler areas in order to survive. 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.

Evidence of extreme events

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

Evidence from Zimbabwe

Climate change, in the sense of altered long-term changes in the average state of the atmosphere, is already occurring in Zimbabwe. There is evidence from records since 1900 that average annual surface temperature has increased by 0.4°C. There are now more hot days and fewer cold days than in the past, as shown in Figure 17. The temperature increase has been most pronounced during the dry season. The five warmest years on record have occurred since 1987.[25]

The total amount of rainfall received during a rainy season has decreased by about 5% since 1900, as shown in Figure 18. These graphs, along with other evidence, show that while temperatures are increasing, the rainfall pattern seems to be changing. More rain than the average is occurring at the beginning of the season, in October, and less rain than the average is being received between January and March. More dry days have been recorded during the rainy season. Droughts and floods have increased in frequency since 1990, often occurring back to back with a flood year immediately following a drought year.

The impacts of climate change in Zimbabwe, particularly the increase in rainfall variability, make it difficult for people who depend on rainfall and water resources – including those involved with agriculture, tourism and industry – to plan their activities. These and other problems relating to the impacts of climate change will be discussed in more detail in the next chapter.

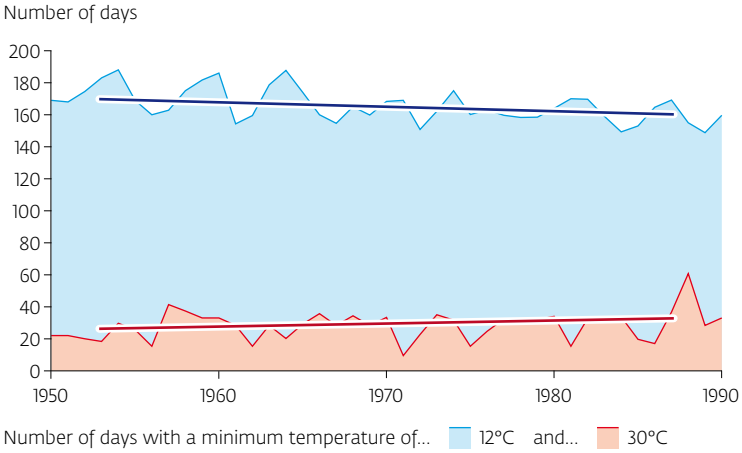


Figure 17: Decline in frequency of cool days and increase in the frequency of warm days in Zimbabwe

Source: Rekacewicz 2005

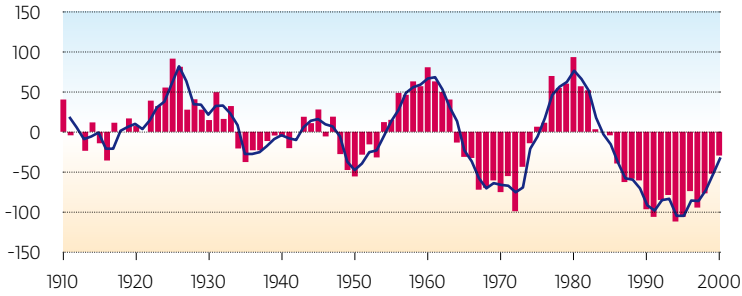


Figure 18: Changes in annual average rainfall since 1900

Source: Rekacewicz 2005

Farmers and others in rural communities in Zimbabwe are already living with the impacts of climate change. Case study 1 describes changes seen by community members in Muzarabani and how people are using traditional strategies to cope.

Case study 1: Coping with climate change in Muzarabani

In hot, dry Muzarabani 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 general community contributes to a grain store to help needy families during times of hardship. In addition *nhimbe*, or collective work, is carried out by community members.

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 4.

Source: Chanza 2015

In this chapter we looked at the causes of climate change and discussed some of the evidence that has been collected by scientists from around the world. It is clear that climate change is already making an impact in Zimbabwe. In the next chapter we will discuss how climate change will affect us in the future. We look at predictions made by the IPCC about climate change on a global scale, for Africa and specifically for Zimbabwe.

Endnotes

23 Most of the information in this section has been taken from IPCC 2014a. A readable summary is available at http://climate.nasa.gov/evidence/

24 For more information about the impact of climate change on plants and animals, see wwf.panda.org/about_our_earth/all_publications/living_planet_report/

25 MSD

3

How climate change will affect us in future

Chapter summary

"It is hard to care about the future when times are tough today"

"But many of today's problems are caused by environmental degradation, which is leading to poverty and climate change"

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

Future global impacts [26]

It is difficult for us to know exactly how climate change will affect the future. Leading experts in the field of climatology have developed many powerful computer models to help predict how climate will change across the world. The models draw on data that are routinely collected by meteorological departments in most countries. The computer predictions are adjusted to match real, observed changes to increase their predictive power and accuracy. The models have been developed for different scenarios relating to whether greenhouse gas emissions increase and at what levels.

How climate change affects us in the future will depend on:

- The rate at which we increase greenhouse gas concentrations in the atmosphere and our mitigation efforts
- How strongly these increases in greenhouse gas emissions affect temperature, rainfall and sea level changes, among other aspects of climate
- The occurrence of natural climate fluctuations due to phenomena such as volcanic activity, changes in the sun's intensity and changes in ocean circulation patterns [27]

Climate scientists now know that many of the harmful effects of climate change will persist for decades because of the complex nature of the Earth's natural systems, even if greenhouse gas emissions are stopped today.[28] Figure 19 summarises some of the major impacts. The map shows that most of the worst effects will be felt in the tropical and subtropical regions – the "crisis belt". This is mainly due to the fact that temperatures there are already high, soils and water systems are variable, degraded and vulnerable and their governments have less income for adaptation measures.

The Earth for the rest of the century

The latest report of the IPCC, issued in 2014,[29] predicts that by the end of the century the average global temperature is very likely to have risen by 2°C. There will almost certainly be more hot and fewer cold extremes across the globe on a daily and seasonal basis, with more frequent and longer heat waves.

Rainfall changes

The IPCC report also foresees that rainfall is likely to increase in some high- and mid-latitude areas: the Arctic and Antarctic, northern Europe, northern Asia, northern U.S. 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.

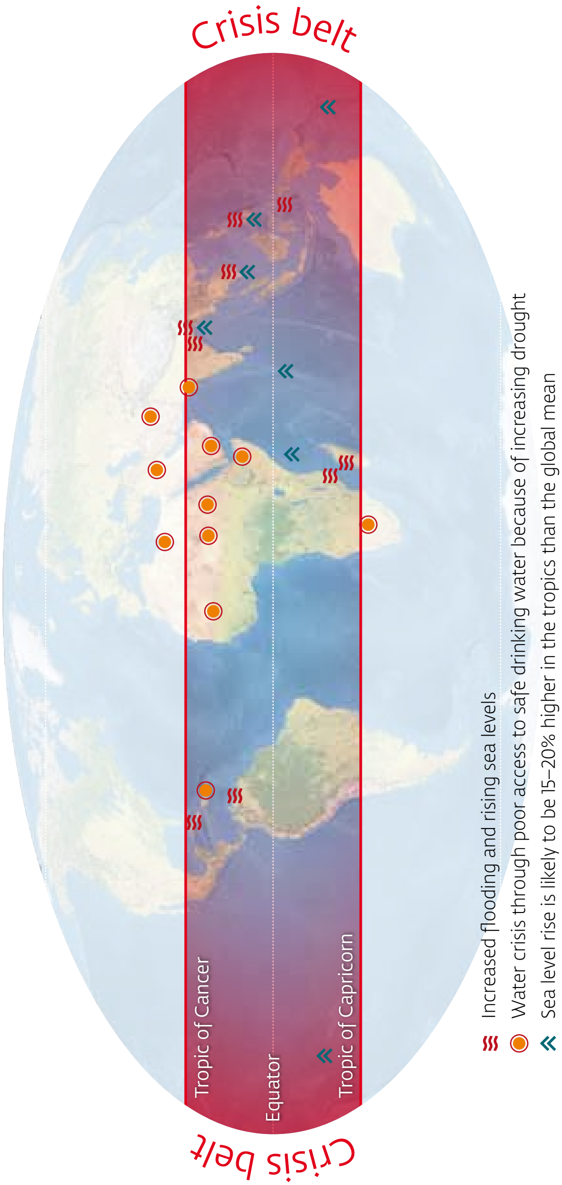


Figure 19: The global impacts of climate change

Source Adapted from Canali 2013

Changes in the oceans

The oceans will become more acidic by the end of the century decimating sea life and causing extinctions and severely reducing the catches of global fisheries on which millions of people depend for food and jobs.

Melting ice and sea levels

Snow and ice on mountains will continue to melt at rapid rates. Since these are important stores of water, communities which rely on them in many parts of the world, particularly in Asia and north and south America will suffer water shortages. The ice caps at the poles will continue to melt rapidly and sea levels will rise at a faster rate than they already are. This 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.[30] By 2100, sea levels could be up by 98 cm and could continue to rise for centuries even if greenhouse gas emissions are stopped.[31]

Impacts on natural systems

It is predicted that by 2050 one-quarter of the Earth's species risk extinction if the warming continues.[32] During the past decade, scientists have observed instances of animals and plant species that are suited to cooler climates occurring in areas closer

to the north or 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 territories northwards.[33] Plants are particularly vulnerable as they are unable to move quickly to new areas in order to escape warming and drying. Many animals will lose their habitats as vegetation patterns change. Water shortages will also threaten animal species. Animals which are particularly threatened by climate change are polar bears, sea turtles, whales, pandas, orang-utans, elephants and tigers.[34]

Impacts on human communities

Global food security is likely to be severely threatened. Production of all of the major food staples (maize, rice and wheat) will be disrupted by rising temperatures, water shortages and increases in pest and disease attacks.[36]

As water resources are stressed, competition for water between different geographical regions and economic sectors, such as domestic, agriculture and industry, will increase. Other resource pressures and extreme weather events caused by climate change are likely to bring about increased migration and escalate the threat of violent conflicts.

The most recent IPCC report predicts that climate change will increase health problems, particularly among low-income communities in developing countries.[36]

Because built-up environments are hotter, urban communities will experience increased risks from extreme events, including heat waves, water scarcity and flooding. Rural communities will face water shortages, crop failures and loss of livestock, leading to health problems, food insecurity and threats to lives and livelihoods.

Future impacts on Africa [37]

Africa is predicted to be the continent that will be worst affected by climate change mainly because of its global position, its vulnerable populations and its poor land-use practices. However, it is important to understand that many of Africa's problems result from factors other than climate change. In fact, the most recent IPCC report notes that in comparison to the increasingly severe stresses on future water resources such as population growth, urbanisation, agricultural growth and land-use change, climate change will have a modest effect overall.[38] This reinforces the idea that Africa needs to address resource management issues urgently in preparation not just for climate change but also for a generally hazardous future.

The IPCC predicts that average temperatures across most of Africa will increase more quickly than the global average and by the end of the century much of Africa could see temperature increases of between 3 and 6°C. Rainfall is likely to reduce over North Africa and the south-western parts of southern Africa by the end of the

21st Century. Figure 20 summarises the major impacts foreseen in Africa in the future as a result of climate change.

Summarising the data from several recent reports,[39] 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 such as droughts, heat waves, wildfires, storms, intense rain and floods, causing damage to natural systems, crops, transport networks and human settlements
- Threats to soil fertility from erosion and increased temperatures
- Rising sea levels threatening coastal communities
- Accelerated expansion of deserts, especially in Namibia and Botswana and into 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
- Faster growth of dry and desert areas and heat and water stress, and shortened growing seasons, leading to declines in crop yields
- Shifts in ecosystems, with the reduction of grassland 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

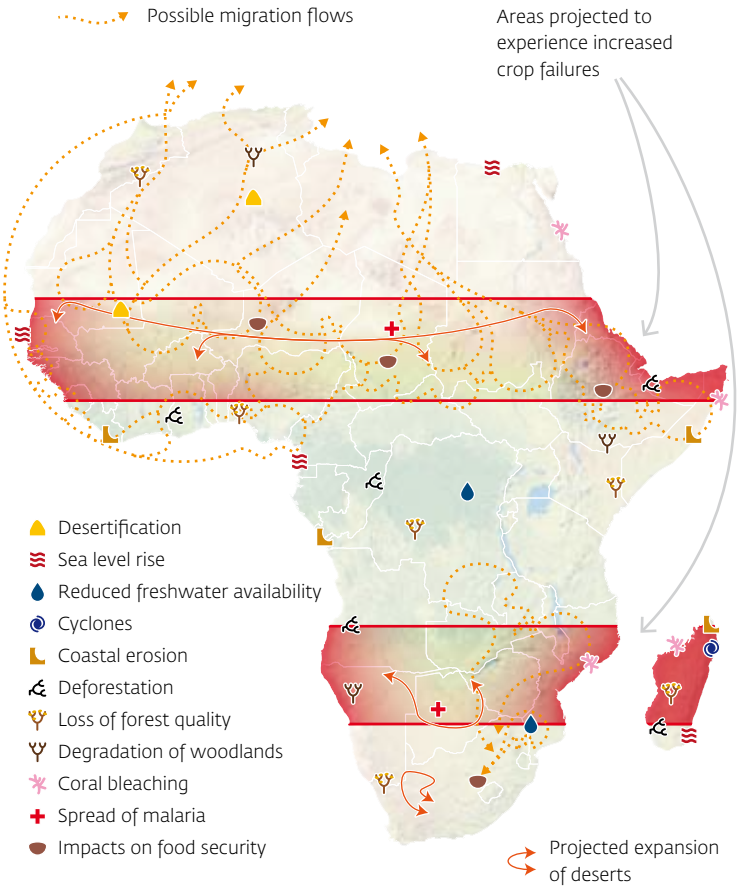


Figure 20: The expected impacts of climate change on Africa

Adapted from Canali 2013

- Increases in pest infestations and diseases of crops and livestock
- Increases in malnutrition and human diseases
- An upsurge in migration and displacement of human populations due to extreme events such as drought, floods, and rising sea levels (as shown in Figure 20), as well as social conflicts as people begin to compete for dwindling resources

Future impacts on Zimbabwe

As we found in chapter 1, Zimbabwe already has an extremely variable rainfall pattern and climate change will intensify the variability, making it hard to predict the availability of water for human activities, particularly agriculture. The future impacts of climate change in Zimbabwe will exacerbate the harmful effects of poor land-use practices, notably deforestation, soil degradation and water pollution. Communities that have been made vulnerable by economic hardship and disease will find it even harder to cope.

According to an analysis of several studies[40] on the impacts of climate change, it is likely that by 2050 and until the end of the century there will be:

- A modest decrease in total amount of rainfall[41]
- Changes to the onset and end of the 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
- Temperature increase of between 1°C and 3°C, which is greater than the global average

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 and the shrinking of Natural Region I and shifts in the areas covered by natural regions III and IV (see Figure 21 for a comparison between the old and new natural regions)[42]
- Degradation of natural resources, especially soil, water, natural vegetation, crop, livestock and wildlife species
- Reduced food security because of the impacts on agriculture possibly leading to increased undernutrition, particularly in children

- Increases in the incidence of diseases such as diarrhoea, malaria and cholera due to reduced water quality, temperatures and flooding and cholera due to increased flooding

Impacts on natural resources

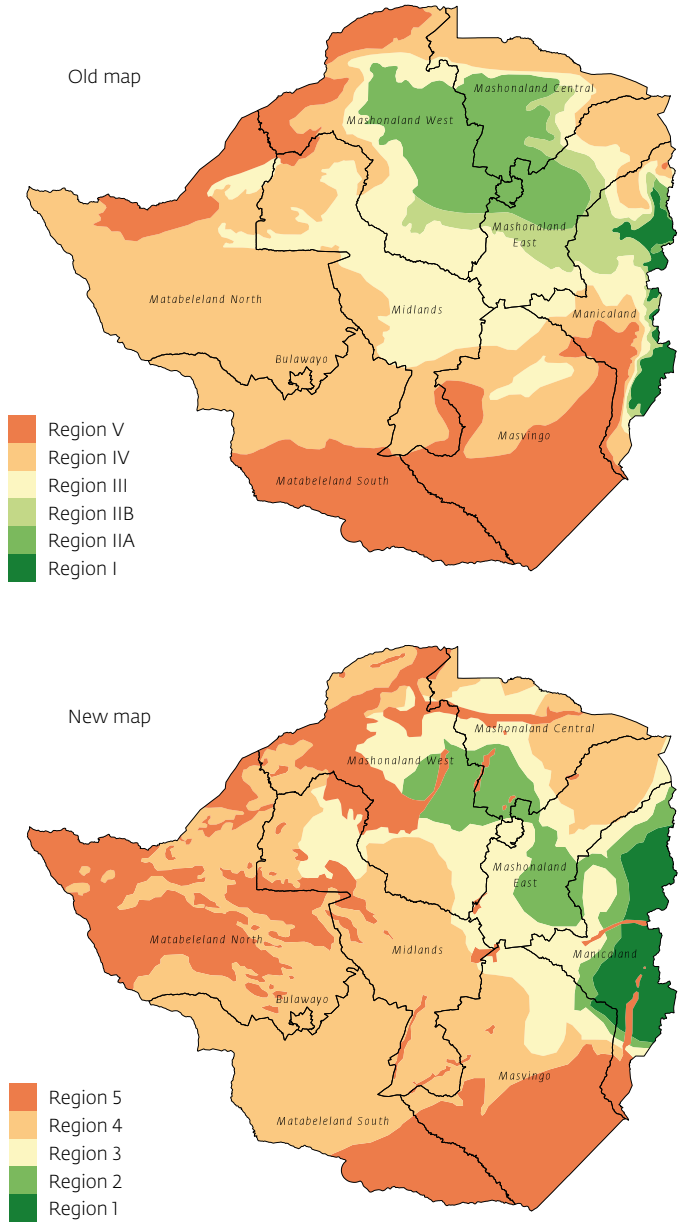
As mentioned in chapter 1, Zimbabweans depend heavily on ecosystem services that provide, among other things, clean water, fertile soils, timber and fuelwood and nutritious wild foods. These ecosystem services are already under pressure from overexploitation and poor resource management and they will become further depleted through climate change. Losses and even extinction among many plant, animal and other species are indicated as parts of the country dry up and temperatures increase. 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 be degraded as vegetation loss and erosion are exacerbated by changing rainfall patters, droughts, floods and wildfire.

Water resources

The most serious impact will be on the country's water resources. The World Bank in partnership with the Government of Zimbabwe has produced a report [43] predicting that climate change is likely to cause an annual rainfall decrease in all Zimbabwean catchments, except Mazowe and Manyame. The largest decline, it states, will be in the Runde and Mzingwane catchments where average rainfall could decrease by between 12% and 16% by 2050.[44] The

report predicts that climate change will also reduce the recharge rates of wetlands and aquifers. For an explanation of the role of wetlands and aquifers in the water cycle, refer to chapter 1.

The decrease in water availability will affect irrigation for agriculture, energy generation for mining, manufacturing and commerce, and tourism and human health. Even with 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.[45] Urban and rural communities in the south and west of Zimbabwe could be seriously affected by water stress. The report also notes that climate change will cause increasing dependence on groundwater sources in Zimbabwe and management of groundwater therefore needs to be improved.


Old map
Mashonaland Central
Mashonaland West
Mashonaland East
Matabeleland North
Midlands
Manicaland
Bulawayo
Masvingo
Matabeleland South
Region V
Region IV
Region III
Region IIB
Region IIA
Region I
New map
Mashonaland Central
Mashonaland West
Mashonaland East
Matabeleland North
Midlands
Manicaland
Bulawayo
Masvingo
Matabeleland South
Region 5
Region 4
Region 3
Region 2
Region 1

Redrawing the natural regions

A rise in temperature of one degree has already made itself felt in Zimbabwe. Figure 21 shows the results from a recent study that argues that the natural regions of Zimbabwe must be modified to take into account changes that have already 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.

Impacts on people and the economy[46]

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 agricultural systems are already insecure as they depend mainly on seasonal rainfall. In addition, ruinous land-use practices in the form of poor soil and water management, reduced biodiversity and poor choice of crops to plant 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 in Zimbabwe.

Figure 21: 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

It is predicted that rising temperatures will lead to a greater incidence of heat stress and increased infestations of pests and outbreaks of diseases, thus reducing productivity of crops and livestock and driving up expenditure on pesticides, herbicides and veterinary drugs.

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.[47] 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.

High temperatures also reduce the nutrient content and storage capacity of the soil, leading to reduced soil fertility, and farmers will have to spend more on fertilisers.

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 as well as low fodder availability due to changes in rainfall and lack of crop residues. Dairy farming may decline in the face of water shortages and diseases among dairy 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[48] and notes that sorghum yields could also decline. Areas suitable for growing maize are forecast to decrease by 2080. One study predicts that the south and west of the country will become less suitable for sorghum and maize cultivation, while the north, central and eastern areas will favour maize, sorghum and cotton.[49] Crops such as groundnuts, roundnuts and cassava may benefit from increased CO_2 levels,[50] while areas suitable for growing sorghum and cotton are likely to increase by 2080.[51]

Tourism

Zimbabwe's wilderness areas are already under threat from population pressures, poor resource management and poaching. Most of its national parks are in areas that will likely be most severely affected by 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 a regular supply of water and electricity, both of which are disrupted by climate change. 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.

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 provide the main labour for agricultural activities. The impacts of climate change will mean more work and greater hardship for women and children[52] 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 increasingly scarce, affecting household hygiene and nutrition and undermining the health of pregnant and

breastfeeding women and their children. Women and children may be exposed to emotional and physical abuse.

Children, the elderly and the disabled are less mobile than other people 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. 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.[53] The incidence of less common diseases such as guinea worm and dysentery are likely to increase. Warmer temperatures could increase the spread of meningitis.[54]

Half the population of Zimbabwe is already at risk from malaria. Figure 22 shows the results of a study by Ebi *et al.* 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 top map 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 bottom map 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.

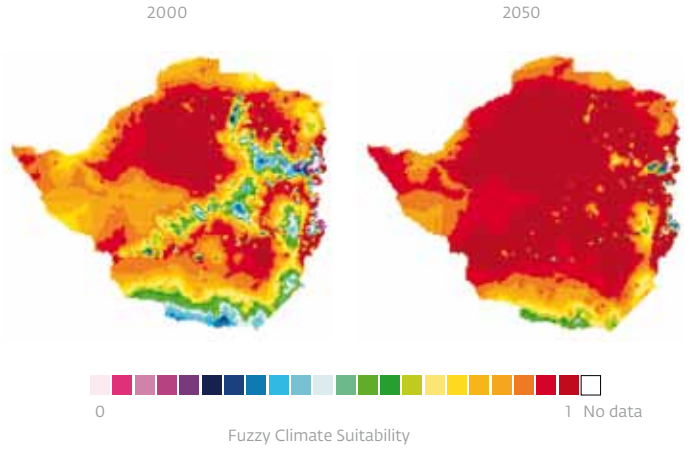


Figure 22: Changes in malaria transmission areas of Zimbabwe with projected temperature increases (using an average emissions scenario) due to climate change

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 occasioned by rising temperatures, creating greater demand for air conditioning, which contributes to greenhouse gas emissions. Air quality is likely to deteriorate, leading to more respiratory illnesses.[55] 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 onto wetlands destroys this flood-control ability and reduces the recharge of underground reservoirs. 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 such utilities provision under strain, urban dwellers could be left more helpless than their rural counterparts who are at least be able to dig wells and fetch firewood for cooking.

Living standards for both urban and rural households 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

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. The growth of informal settlements with inadequate housing and poor sanitation will likely lead to new health hazards and drive up the crime rate.

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 and declining availability of water. Some of these measures are discussed in the next chapter. Second, we can work together as a global community to reduce greenhouse gas emissions and mitigate the effects of climate change in order to avoid some of its more hazardous impacts. Some mitigation measures for Zimbabwe are discussed in chapter 5.

Endnotes

26 Most of the information from this section is taken from IPCC 2014a

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

28 IPCC 2014a

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

30 CDKN 2014 p. 16

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

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

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

34 Ibid.

35 IPCC 2014a p. 15

36 IPCC 2014a p. 15; Climate and Development Knowledge Network 2014 p. 20

37 For a comprehensive summary of the main impacts on Africa, see IPCC 2014b, https://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Chap22_FGDall.pdf and CDKN 2014 http://cdkn.org/resource/highlights-africa-ar5/

38 IPCC 2014b p. 1217

39 IPCC 2014b; Davis and Hirji 2014; Lesolle 2012; Shanahan *et al.* 2013

40 Davis and Hirji 2014; Lesolle 2012: Mugabe *et al.* 2013; IPCC 2014b

41 IPCC 2014b

42 Mugabe *et al.* 2013

43 Davis and Hirji 2014

44 Ibid. p. 27

45 Ibid. p. 33

46 Most of the information in this section is summarised from Davis and Hirji 2014, IPCC 2014b and Brown *et al.* 2012

47 Lesolle 2012

48 CDKN 2014 p. 20

49 Muriwa *et al.*, in Brown *et al.* 2012

50 IPCC 2014b p. 1219

51 Brown *et al.* 2012

52 Manjengwa *et al.* 2014

53 GOZ 2014

54 Ibid.

55 GOZ 2014

4

How Zimbabwe can prepare for climate change

Chapter summary

This chapter discusses ways in which Zimbabweans can prepare for future climate change by building the resilience and adaptive capacity of human communities and ecological systems. The different roles of communities and governments are discussed and adaptation measures for specific sectors identified.

Adaptation and resilience

As was mentioned in chapters 2 and 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. The IPCC predicts that if greenhouse gas emissions continue to rise, there will be cataclysmic results for human societies and natural systems.

We know that climate change is going to affect Zimbabwe's future, but we do not know exactly what the effects will be. 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 which we use.

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".[56]

The fifth assessment report of the IPCC states that we have potential to significantly reduce some of the effects of climate change through effective adaptation measures.[57] 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.[58]

Building resilience

Resilience is the ability to withstand and recover from hazards or shocks and is an important part of adaptation. Resilience is increased when a person or system can learn from past disasters in order to reduce future risks.[59] 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.

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 people 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.

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.

Zimbabwe has several things in its favour when it comes to adaptation. It has abundant natural resources and a well-educated, resilient population. The social networks that exist 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 into. 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 are present in a system, the stronger the system; if one element of the system is damaged – for instance, through drought, fire or disease – 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.

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 adaptation measures are the foundations of sustainable development and will go towards achieving many of the new Sustainable Development Goals[60] and many objectives of the government's blueprint for sustainable economic development, Zimbabwe Agenda for Sustainable Socio-economic Transformation (ZimAsset).

Because these measures will benefit communities, whether or not climate change happens, they are called "win-win", "no regrets" or "low regrets" 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, reducing, or mitigating, the effects of future climate change. For example, planting trees and protecting existing 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.

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).

Different levels of adaptation

Adaptation can occur at many different 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.

Building on indigenous knowledge systems such as those described in case studies 2 and 3 below 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 government NGO 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.[61] However, important lessons have been learnt from these initiatives. One is that successful adaptation strategies need to come from the community, or bottom-up, while being supported by national coordination, policies, strategies and legislation.

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 during dry years than conventional methods.

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

Community-based adaptation (CBA)

Using this method, communities work with government agencies or NGOs to analyse their vulnerabilities and assess their risks of climate change hazards. They then develop ways to build their adaptive capacity, increase their ability to predict potential hazard events and develop resilience to enable recovery from them. Several projects in Zimbabwe have used this approach, including those shown in table 1:

Table 1: Some successful CBA projects in Zimbabwe

Name of project and area	Implementing agencies	Main features
Coping with drought and climate change in Chiredzi	GoZ, UNDP and GEF [62]	• 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	• Raise awareness of climate change and building community capacity • Promoting sustainable use of woodland for energy and 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 [63] in Munyawiri Ward, Domboshawa area of Goromonzi District	ZERO	• Community members identify the impacts of climate change and note their current strategies to deal with it while developing recommendations for future adaptations.
Strengthening weather and climate change information dissemination [64] in Chirumanzu, Zvishavane and Gutu	Oxfam in partnership with MSD and AGRITEX	• AGRITEX officers and farmers improved their knowledge on weather, agro-meteorology and climate change adaptation. • Weather stations were set up in the target districts. • Farmers gained improved access to local level weather, climate and agro-meteorological information services.

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

In Munyawiri ward, farmers use knowledge of weather systems such as 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 use 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 at which birds build 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 diversification of livelihood activities away from agriculture. Traditional leaders advocate time-honoured resource management practices, including protection of riverine vegetation and forests and prevention of wildfires. Unfortunately in this community, many no longer respect the traditional leaders and ignore their policies. 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

The role of government

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

- Policies and strategies that support adaptation and makes resources available
- Enforcing laws that protect vulnerable and marginalised groups and natural resources, and prevent environmental degradation. Appendix 1 gives an overview of some key laws
- Facilitating the development of local adaptation plans, including disaster risk-reduction measures, information dissemination and capacity building
- Raising awareness of climate change issues through the local media and extension staff
- Disseminating climate information from national and local meteorological stations to farmers through extension agents
- Facilitating the sharing of information about successes and learning between different communities

The national response strategy

A major step towards this support is in the form of the National Climate Change Response Strategy (NCCRS),[65] which was released in 2015. 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 other vulnerable groups, children and youth

Many of the observations in the next section are built on the suggestions in the NCCRS and on recommendations from various global and local studies.

Adaptation options for Zimbabwe

Table 2 summarises some of the specific adaptation measures that have been proposed for Zimbabwe. Some of these are described in detail in the following section.

Table 2: Adaptation measures for some of the main sectors which 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 of deforestation • Managing grazing areas • Reducing fires • Water-harvesting • Conservation 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 • 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

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 • Improving infrastructure including roads, bridges and buildings • Diversifying livelihoods

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.

Before developing water management strategies, we need to understand the factors influencing the water cycle in Zimbabwe, which are described in chapter 1, notably the vital role of aquifers and wetlands in the section on water.

In Zimbabwe, the evaporation of water from plants and surface stores exceeds the amount of water from rainfall. Climate change will increase the rate of evaporation. Thus the most effective way to conserve water is by improving underground stores rather than expanding surface stores such as dams and reservoirs. Besides being protected from evaporation, underground water is usually cleaner than water stored on the surface as it better protected from contamination by pollutants.

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

Increasing infiltration

This can be done 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; reducing 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[66] 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
- Protecting vegetation along streams, rivers and wetlands and around the edges of dams
- Introducing drip irrigation and bottle-watering methods
- Using wells, boreholes and sand abstraction methods rather than constructing surface water stores

Using mulch

Mulch is any material that is used to cover the soil. The most effective types of mulch are organic materials that increase 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.

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.[67] 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.

Agriculture

The main land-use activity in Zimbabwe is agriculture. Agriculture can harm the soil, water and vegetation systems through land clearing and uncontrolled livestock grazing, leading to erosion and pollution of soil and water by agricultural chemicals. 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 of 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. Conservation agriculture is seen as an important climate change adaptation method.

Conservation agriculture (CA)

In the last two decades there has been a global campaign to promote CA, which discourages these soil-damaging activities. Case study 4 looks at experiences in Zimbabwe.

Improved agricultural methods that reduce soil degradation and improve its organic content 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.

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.

Case study 4: Experiences with CA in Zimbabwe

CA recognises that care of the soil is fundamental to successful and drought-resilient agriculture. It incorporates three principles: minimum 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. Proponents argue that after the second or third season, farmers can use the same planting holes as in the previous season rather than having to dig new ones. Moreover, as mulch builds up, fewer weeds emerge. Mechanical planters have been introduced and gradually the idea has spread.

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 Food and Agriculture Organisation estimates that over 300 000 farmers are practising CA in Zimbabwe today.

Source: ICRISAT

Vegetation management

We depend directly on vegetation for food, fuel and other products. So do livestock and wildlife, which make an important contribution to livelihoods and the economy. Vegetation provides communities with other important ecosystem services, including protection of the soil, increasing soil fertility, improvement of 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, 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
- Encouraging integrated pest and disease management[68] to reduce pest infestations and diseases using cultural, biological and physical methods rather than simply depending on chemicals that may exacerbate pest problems in the long term

Agroforestry

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

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.

Case study 5: Barriers to agroforestry adoption in Zimbabwe

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 improved 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

Human communities

Strengthening the resilience of human communities to cope with climate change depends on increasing their capacity to function as self-supporting units. In the past, Zimbabwean communities were 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 was shown in case study 2, over

the years these traditional social systems have become eroded and a more individualistic mentality has prevailed that has led to exploitation and degradation of communal resources.

New systems will have to be devised and developed in order to replace these old systems. The new systems can encourage the participation and empowerment of groups that were left out of decision making processes in the past, particularly women. The following measures can help:

- Raising awareness, informing and educating people about the causes and impacts of climate change are a crucial first step, with schoolchildren, teachers and community opinion leaders such as pastors, chiefs and headmen and business executives playing an important role

- Strengthening community-based decision making and collective action while destroying 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 infrastructure, such as roads, bridges and buildings, that may be susceptible to climate change hazards

- Diversify livelihoods into climate resilient-areas, including animal husbandry, horticulture and off-farm activities

In this chapter we looked at ways in which Zimbabwean communities can build resilience and develop ways to adapt to climate change as well as improve progress to achieving sustainable development. In the next chapter we examine ways in which Zimbabweans can contribute to climate change mitigation. If you would like the contact details of organisations involved with adaptations projects please refer to appendix 2. Appendix 3 gives details on finance options for adaptation projects.

Endnotes

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

57 CDKN 2014

58 Brown *et al.* 2012

59 Davis and Hirji 2013

60 Which have been put in place by the UN to replace the Millennium Development Goals at the end of 2015

61 Brown *et al.* 2012

62 For more information on this project, visit http://www.undp-alm.org/sites/default/files/downloads/focus_on_climate_change_zimbabwe_-_april_2013.pdf

63 For more on this project visit, http://www.acts-net.org/programmes-projects/projects?id=35

64 For more on this project visit, http://oxfaminzimbabwe.org/index.php/strengthening-weather-and-climate-change-information-dissemination-systems-in-zimbabwe/

65 GOZ 2014 www.ies.ac.zw/downloads/draftstrategy.pdf

66 See also http://www.fao.org/ag/ca/Training_Materials/CA_toolbox_Zimbabwe.pdf for more information

67 Zimbabwe Environmental Lawyers Association: www.zela.org

68 An effective, environmentally sensitive approach to controlling pests and diseases through cultural, biological and mechanical methods in order to reduce dependence on pesticides. See http://www.epa.gov/agriculture/tipm.html

5

Zimbabwe and mitigation

Chapter summary

In this chapter we look at ways in which Zimbabweans can work with the global community to reduce not only Zimbabwe's greenhouse gas emissions but also the global greenhouse gas load in the atmosphere through removal of CO_2 from the atmosphere, a process known as carbon sequestration.

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. Thus all future strategies in Africa should involve energy-efficient, low-emission technologies.

What does mitigation entail?

Mitigation of climate change involves minimising the future impacts and risks of climate change by reducing greenhouse gas emissions. Since the dangers of climate change were first highlighted, there have been decades of international discussions and negotiations about how to mitigate climate change, which countries should reduce their emissions and by how much. The following section gives an overview of the international negotiations.

International negotiations [69]

The main negotiations began in 1994 with the UNFCCC. There are currently 200 signatories to this treaty, including Zimbabwe.

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 the extent to which they support their obligations with finance and emission-reducing technology.
- Economic and social development and poverty eradication are the priorities of the developing countries.

Each year a UNFCCC conference of parties (COP) session is held in a different country to assess progress towards addressing climate change. Developing countries are disadvantaged by the way that these sessions are set up. They tend to be under-represented and have therefore formed coalitions to negotiate common positions. Zimbabwe belongs to the Africa Group. There is also a least developed countries block, but Zimbabwe is not a member.

The Kyoto Protocol

The UNFCCC signatories adopted the Kyoto Protocol at the COP3 in 1997. This provides legally binding targets for developed nations to reduce their emissions and mechanisms to enforce compliance. This protocol required developed nations to reduce their emissions to an average of 5.2% than their 1990 levels by 2012. The United

States refused to sign the Kyoto Protocol because it did not require major growing economies such as China and India to reduce their emissions. The Kyoto Protocol has been extended with a second commitment period running from 2013–2020. Fewer developed nations signed up for the second period.

Least developed countries and NAPAs

In 2007 at the COP7 parties to the UNFCCC agreed that the least developed countries would receive funding to produce national adaptation programmes of action (NAPAs).

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. The units can be traded and sold to industrialised countries to a meet a part of their emission reduction targets under the Kyoto Protocol.[70]

Carbon emissions trading

Countries, companies and individuals can meet their mitigation obligations through carbon trading, that is, by purchasing, from another entity 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). Emissions trading has expanded beyond the Kyoto Protocol.

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

- Quantified "commitments" from developed nations to reduction of 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 both adaptation and mitigation
- Finance and investment to pay for all of the above

The Bali Action Plan was not agreed at the 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.

Since then, limited progress has been made at the COP sessions in the form of a climate adaptation framework, a "green climate fund" and a technology transfer mechanism. However, no legally binding agreements have been set on emissions limits. The COP21, held in Paris in 2015, was projected to be a milestone session at which UNFCCC parties were expected to agree on a comprehensive, legally binding global agreement for the post-2020 period.

In preparation, for COP21, countries agreed to publicly state the climate actions that they intend to implement (post 2020) under the Paris agreement. These actions are known as Intended Nationally Determined Contributions (INDCs). The INDCs will determine whether the world achieves a effective agreement which will herald a low-carbon, climate-resilient future.

Global emission reductions

As mentioned in chapter 2, Figure 12, most greenhouse gas emissions come from power generation. Therefore clean energy production plays a major role in helping to reduce emissions.

Renewable energy

There has been growing global interest in renewable energy technology, such as solar, wind and wave energy, hydroelectricity and biofuels, which have low or no emissions. The technology for these systems is improving and the cost (particularly for solar) has dropped dramatically in the last five years. However, developing ways to store energy during times 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.

Biofuels are made from fresh plant or other organic material, including human and animal waste. They include bioethanol, 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.

In 2013, renewable energy sources, notably wind power, contributed 44% to new electricity generation capacity, showing a pleasing growth in this sector. However, coal-burning power stations, which account for the largest greenhouse gas emissions of all energy production processes, are still the fastest-growing means of power generation.[71]

Alternatives to coal

Apart from renewables, the main alternatives to coal power are electricity generated from natural gas or nuclear power. Although these methods 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 health impacts through potential pollution of underground water reserves by fracking chemicals.[72]

Nuclear power became increasingly unpopular after a nuclear power plant in Fukushima, Japan, was severely damaged in March 2011 by a tsunami, causing radiation leaks that forced more than 100,000 people to leave their homes and are still affecting the Pacific Ocean. This highlighted the danger which nuclear power plants face from extreme events which are likely to worsen due to climate change.

Increasing efficiency

New coal power plants are being developed that are more energy-efficient, release fewer emissions and also remove CO_2 from the atmosphere.

Meanwhile, governments in many developed countries have offered financial incentives to industry and business, including agribusiness, to reduce emissions. Mechanisms have been put in place to reduce demand for travel and make a wider range of options for low-emission private and public transport available to their citizens. Urban planners are becoming more emissions-conscious and building standards are being improved to help reduce emissions. Individuals are being encouraged to reduce their energy demands, their consumption patterns and waste.[73]

Zimbabwe's emission sources

As mentioned in chapter 2, Zimbabwe's contributions to greenhouse gas emissions are modest. However, we are part of a global fight against climate change and every country has to play its part. Moreover, if Zimbabwe is to develop sustainably, as is proposed under ZimAsset, it is important to adopt development strategies and technologies that help Zimbabweans not only to achieve a decent standard of living, but also to adapt to and mitigate climate change.

Zimbabwe as a signatory to the UNFCCC and the Kyoto Protocol is committed to reduce its contribution to greenhouse gas emissions in international agreements. The nation currently contributes around 0.13% to global greenhouse gas emissions and most of these are from energy production and use. Because it is relatively industrialised, Zimbabwe emits about half of the global per capita average in greenhouse gases, but twice the average of the rest of Africa.[74] Figure 23 shows the main sectors of the economy that contribute to greenhouse gas emissions.

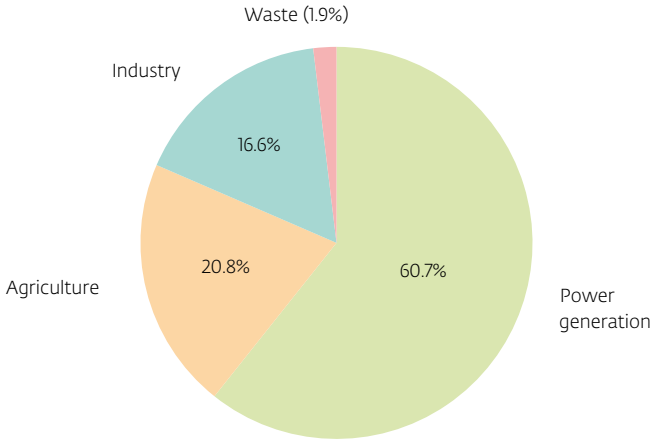


Figure 23: The contribution of different sectors to Zimbabwe's greenhouse gas emissions

Based on data from GoZ 2014

Several factors affect Zimbabwe's greenhouse gas emission levels. Population growth 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. The land reform programme, which has led to the clearing of extensive forested areas, has also brought increases in emissions.

Power production

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. 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 out-dated equipment and lack of maintenance, leading to inefficiency and unnecessary greenhouse gas emissions.

Rural energy supply

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.

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, runaway wildfires play a major role in destruction and degradation of forests.

Urban energy

Most urban families use electricity for cooking, heating and lighting, but due to the erratic supply, many households have turned to 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 runs on petroleum derivatives. Imported petrol is blended with ethanol produced by a biofuel plant attached to the main sugar refinery in Chiredzi. The plant also 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.

Reducing emissions through forests

Like most other African countries, Zimbabwe has no binding emissions targets. However all UNFCCC signatories are expected to develop NAMAs, which will be financed through instruments such as the CDMs 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 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 of land and cutting down of forests for fuel, timber and other resources release CO_2 into the atmosphere.

Forests and other vegetation affect climate and weather patterns in other ways, for example by reducing wind speed, cooling surface temperatures and increasing atmospheric humidity. When vegetation is cleared on a large scale it can also lead to changes in weather patterns and local climate. The more land that is cleared for agriculture, mining, residential areas, fuel and timber, the more we contribute to climate change. The more forests and other vegetation we plant or preserve, the less we advance climate change.

Tree growing, not tree planting

While admirable, national tree-planting campaigns and reforestation projects at schools and other community institutions often do not go far enough. Trees need to be looked after by being watered and protected from fire, livestock and wild animals, especially during the first two years of their life. Simply planting trees is highly unlikely to guarantee that they survive to maturity.

REDD+

The UNFCCC mechanism called REDD permits developed countries to pay developing countries to offset their emissions by giving financial rewards for conserving existing forests. There has been considerable criticism of such payment schemes 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 – and releasing huge amounts of CO_2 – and replanting them with exotic trees. Other problems associated with the REDD schemes are:[75]

- 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"
- Challenges in monitoring the actual rate of forest degradation and comparing it to situation where the project activities are not undertaken

Case study 6: 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 hectares 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 prevent the emission of 52 million tonnes of CO_2 into 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 methods

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 prevent emissions of 1000 tCO_2e by preserving the 15.6 million hectares 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 2014

These challenges have been discussed at international climate negotiations and it was hoped that an effective REDD+ mechanism could be launched at the COP21 in December 2015.

As this new opportunity presents itself, 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. If you would like to know more

about funding available for REDD+ and other mitigation projects please refer to appendix 3.

Future energy sources

For a sustainable, climate-resilient future, Zimbabwe should invest in large-scale forest protection and regeneration while alternative fuel sources for rural communities are sought and promoted nationwide. A new official policy to promote clean and renewable energy would facilitate the uptake of innovative energy technologies across the nation.

Reducing dependence on coal-fired power generation and precarious hydroelectricity generation by investing substantially in renewable energy alternatives is the obvious way forward, although wind energy, small-scale hydroelectricity plants, solar power, 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. However, all such alternatives require considerable financial investment.

Macpherson Photographers

Solar power

Zimbabwe's warm, dry climate offers tremendous potential to exploit solar power for electricity production 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. In many countries (including South Africa) building grid-scale solar farms is already cheaper than building coal power plants. The price of solar PV has dropped 80% in the last five years.

Energy-efficient stoves

As has been noted, most rural families and many urban families in Zimbabwe rely on fuelwood for cooking. Given the important role of forests in both mitigation and adaptation to climate change, it is crucial that the amount of trees harvested for fuel is reduced by promoting energy-efficient stoves. Several organisations have been promoting such stoves in the developing world in order to improve the lot of countless women who walk several kilometres each day to fetch firewood, to reduce deforestation and land degradation and to mitigate the health risks of women and children exposed to excessive wood smoke. Case study 7 looks at some of the barriers to the adoption of improved stoves in Zimbabwe.

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 8 looks in more detail at a recent programme to promote biogas as a domestic fuel source.

Case study 7: 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 Nation 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 *et al.* 2011

Case study 8: Zimbabwe domestic biogas programme

The ministries of Energy and Power Development, and Agriculture, Mechanisation and Irrigation Development, the Rural Electrification Agency, the Netherlands Development Organisation (SNV) and Humanist Institute for Cooperation (HIVOS) 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 made up of methane and carbon dioxide. It is created as a by-product when organic material decomposes in airless conditions. A basic biogas digester 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 as fuel for cooking and lighting. The digested slurry of dung and water is pushed out of one end of the digester and can be used as high-quality fertiliser. Biogas burns with minimal carbon dioxide emission and uses products that are readily available locally. The project digesters cost between $800 and $2000 to build.

Source: Biriwasha 2015

Increasing efficiency and reducing demand

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, inadequate financial resources 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, changing mindsets is making slow progress in developed countries and scant effort has been made to reduce energy consumption in Zimbabwe.

Barriers to action

A major recommendation of the NCCRS is to raise awareness about climate change in local communities and to build the capacity of Zimbabweans through training in adaptation and mitigation strategies. We need to act now to prepare for climate change, but climate change policy makers and activists worldwide have found it difficult to persuade people to change their attitudes and behaviour. Some of the reasons for this resistance are listed in table 3[76]. Identifying the barriers to change will facilitate awareness-raising and education programmes.

Table 3: Barriers to action on climate change in Zimbabwe.

Adapted from Gifford 2011

Barrier	Explanation
Lack of knowledge	Zimbabweans in towns and cities seem to be more informed about climate change than their rural cousins. Zimbabweans generally know more about the global impacts of climate change, including rising sea levels and melting polar ice caps, than about local impacts.
We have a victim mentality	When questioned, many farmers and development workers blame most problems in rural areas on climate change when they are really the result of poor land-use practices and environmental degradation.
We like to focus on the present issues	People generally disregard long-term, gradual change or problems that do not affect them directly.
Uncertainty	Equivocal information is widely distrusted and scientists cannot make exacting predictions.
Why should I act?	If only a minority is concerned about climate change, the argument goes, why should one bother to act? And besides, what difference can one person make?
Denial	Few people trust the warnings of climate scientists or believe that the situation is as bad as the scientists say.
Perceived risk	A commonly expressed concern is that climate change adaptation or mitigation actions may put them at a disadvantage. Some people fear that it will cost them time or money. They are afraid to act because of what others may say about them.
Habit	Most people are set in their ways and resistant to change.
Fatalism	Few believe that anything can be done about climate change.
Disempowerment	Some people feel that they are not intelligent, powerful or rich enough to act.
Waiting for opinion leaders	Many wait for powerful influential people to act before copying them.
Individualist mentality	Few Zimbabweans heed traditional leaders or put community interests first.

This list shows the need to offer simple, clear and positive messages about climate change. Fears and doubts should be elicited and addressed in meetings. People should be involved in planning and decision-making processes so that they can feel empowered to take action. Opinion leaders should speak out in their communities. The media should be employed to back national awareness-raising campaigns.

It is generally easier for urban households and business enterprises to reduce their carbon emissions – rural communities have fewer lifestyle choices.

In this chapter we looked at ways to reduce, or mitigate, the amount of greenhouse gases released into the atmosphere and some methods to remove carbon dioxide from the atmosphere (carbon sequestration). We summarised the international climate change negotiations and their achievements. We surveyed the options for renewable energy and alternatives to coal-fuelled power generation. We examined Zimbabwe's emission sources and ways to reduce emissions through forests and future energy sources including solar, energy-efficient stoves and biogas. We discussed ways to increase energy efficiency in power production and industry as well as ways to reduce energy demand. We identified barriers to behaviour change and a useful way to overcome it. If you would like to know more about funding available for climate change mitigation please refer to appendix 3.

Endnotes

69 Most of the information in this section is adapted from Shanahan *et al.* 2013

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

71 http://journalistsresource.org/studies/environment/climate-change/united-nations-ipcc-working-group-iii-report-climate-change-mitigation

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

73 For more information on these emissions reductions, visit http://journalistsresource.org/studies/environment/climate-change/united-nations-ipcc-working-group-iii-report-climate-change-mitigation

74 Chagutah 2010

75 For more on REDD issues, see www.redd-monitor.org/redd-an-introduction/ and http://www.coderedd.org/about-redd/

76 For more information on this study, see http://www.scp-knowledge.eu/knowledge/dragons-inaction-psychological-barriers-limit-climate-change-mitigation-and-adaptation

6

Conclusions and recommendations

Chapter summary

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 the nation.

Climate change and its impacts in Zimbabwe

Zimbabwe is a country of abundant natural resources and highly educated, resilient people. Most of its people live in rural areas and are highly dependent on natural resources for their lives and livelihoods. Due to a naturally variable climate and turbulent history, the country has experienced many hardships. This has left the economy weak, the environment degraded and many of its people economically vulnerable. Climate change is already having a profound effect throughout the world. In Zimbabwe, average temperatures have risen, rainfall appears to be declining, the rainy season is 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:

- A modest decrease in total amount of rainfall
- Changes to the onset and end of the 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
- Temperature increase of between 1°C and 3 °C

These changes are likely to lead to

- Reduced water supply for domestic and agriculture from both surface and groundwater sources
- 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, natural vegetation, crops, livestock and wildlife
- Reduced food security, possibly leading to increased undernutrition, particularly among children

- Increases in the incidence of diseases such as diarrhoea, malaria and cholera due to declining water quality, warmer temperatures and flooding
- The rural poor, particularly women, children and the elderly, and the disabled will most likely bear the brunt of the impacts

The NCCRS details mechanisms for addressing climate change in the following sectors: natural systems, economic sectors and physical and social infrastructure.

Recommendations

These recommendations are drawn from chapters 4 and 5 on adaptation and mitigation followed by some general recommendations for Zimbabwe as a nation. Many are already proposed in the NCCRS.

Adaptation recommendations

Zimbabweans will have to adapt to survive the changes in the climate. Adaptation should involve building the resilience of human communities and ecosystems to environmental shocks as well as implementing sustainable development measures that focus on improved natural resource management and strengthening of social networks.

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 structures. Local adaptation initiatives should be built 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.

- In water management, priority should be given to protecting and conserving underground water resources by reducing soil erosion and conserving wetlands and aquifers.
- In land management, the focus should be on soil protection by controlling mining activities and improving agriculture. The promotion of CA is a powerful measure that can have far-reaching benefits.
- In vegetation management, it is vital to conserve forests since vegetation has beneficial impacts on weather, soil and water systems. Agroforestry, control of wildfires and encouraging crop diversification are equally important.
- Human communities can be strengthened by raising awareness about climate change and building capacity for adaptation strategies that build on indigenous knowledge. Strengthening 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.

Mitigation recommendations

- Zimbabwe needs stronger representation in international climate change negotiations in order to secure technical support and funding for adaptation.
- At a national level, Zimbabwe needs to explore options for more efficient and cleaner power generation and encourage the use of renewable energy, particularly solar power 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 the energy efficiency of their operations and reduce emissions.
- Companies that emit harmful gases should be encouraged to invest in mitigation and adaptation measures through corporate social responsibility projects.
- REDD+ and other forestry conservation and expansion measures need to be expanded to conserve all of our national forests. A concerted nationwide campaign to promote energy-efficient stoves needs to be launched.

General recommendations

- A national climate change policy should be developed as a matter of urgency in tandem with updating of key policies and legal instruments as highlighted in Appendix 1.

- Collection of meteorological and water resource data should be improved; the data should be disseminated widely to enable communities to plan their adaptation and mitigation strategies.
- AGRITEX officers, village health workers and other community workers should be trained in climate change adaptation measures. Ideally, climate change officers should be deployed in each district to help communities to monitor climate change and the state of natural resources and advise on adaptation and mitigation measures.
- Nationwide awareness-raising campaigns supported by government and civil society should be conducted in the mass media.
- Education ministries should introduce climate change training for all teachers and teaching materials made available in primary and secondary schools.

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 the biggest threat to humanity today. For the sake of future generations of Zimbabweans, we cannot afford to delay.

However, Zimbabwe has begun to act through its NCCRS, and the task for future generations is to turn this strategy into concrete action. The biggest immediate threat is that policy makers do not act and that citizens do not appreciate the risks so that they might support policy makers in their task to deal with the threat of climate change. It will be the synergies between citizens and policy makers that may change the future for Zimbabwe.

Appendix 1: Zimbabwean legislation and policy overview

The legal and governance frameworks regulating environmental protection in Zimbabwe are fragmented and sprawl over a wide range of laws and policies falling under the mandates of the ministries of 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.

Zimbabwe has no specific policy or legislation for climate change beyond the NCCRS.[77] 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. The strategy 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.[78]

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, but its regime has been criticised as being weak.

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

- The removal of private ownership of water, which grants communities freer access to water, a measure that will be important as climate change makes rainfall patterns more variable[79]
- 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 (1998)

Appendix 2: 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/Takawira avenues, Harare
263 4 791287
eprzim@eprzim.co.zw
Director: Mrs Ndlovhu

Environmental Management Agency
Makombe Complex, Harare Street/Herbert Chitepo Avenue, 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 Avenue, Belvedere, Harare
263 4 778176
www.weather.co.zw/
Director: Mr Makarau

Ministry of Environment, Water and Climate
Climate Change Unit
11 Floor Kaguvi Building, Corner 4th Street/Central Avenue,
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 Street/Jason Moyo Avenue, Harare
263 4 797 610–3/ 797 604–7
e-mail: pr@zinwa.co.zw
www.zinwa.co.zw/

Zimbabwe Parks and Wildlife Authority
Botanical Gardens
Corner Sandringham Drive and Borrowdale Road, Harare
263 4 707624–9, 792796–9, 706077/8
www.zimparks.org/

Academic/ Research institutions [80]

Chinhoyi University of Technology's School of Agricultural Sciences and Technology: Research on impact of conservation agriculture on greenhouse gas emissions and carbon sequestration and climate change impacts on crops
www.cut.ac.zw/

Department of Chemical and Process Systems Engineering:
Research relating to adaptation and mitigation
Harare Institute of Technology (HIT)
Ganges Road, Belvedere, Harare
263 4 741422–36
communications@hit.ac.zw

Department of Research and Specialist Services
Matopos Research Station
Bulawayo, Zimbabwe
263 383311/15, 263 383307
www.drss.gov.zw/index.php/2013-02-12-12-32-56/matopos-research-station

International Crops Research Institute for Semi-arid Tropics (ICRISAT): Research on drought-resistant crop varieties and community-based adaptation
Matopos Research Station
Bulawayo, Zimbabwe
263 3 83311 to 15, 263 383307
icrisatzw@cgiar.org
www.icrisat.org/icrisat-globalpresence.htm

Lupane State University
Agricultural Sciences: Animal science and rangeland management; crop science research focusing on improving quality of drought-tolerant sorghum varieties
2nd Floor, CBZ Building, Corner Fife Street/10th Avenue, 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, Zimbabwe
http://ww4.msu.ac.zw/

The following are institutions of the University of Zimbabwe, 630 Churchill Avenue, Mount Pleasant, Harare (263 4 30321; www.uz.ac.zw/)
Institute of Environmental Studies: Involved with 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 (CASS), 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 Street/Jason Moyo Ave, Harare
263 4 793002/3/7/9, 791983, 796464, 796469, 794737, 797154
http://www.zou.ac.zw/

NGOs involved with climate change in Zimbabwe

Climate change adaptation programmes

Environment Africa
76 Queen Elizabeth Road, 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 Road (off Enterprise Road), Newlands, Harare
263 4 776 107, +263 4 776 631
Hopewell Zheke
info@practicalaction.org.zw
http://practicalaction.org/wherewework_zimbabwe

ZERO Regional Environmental Organisation (ZERO)
158 Fife Avenue, Harare
263 772347769
Director: Shepherd Zvigadza
szvigadza@gmail.com

Conservation

Birdlife Zimbabwe
35 Clyde Road, Eastlea, Harare
www.birdlifezimbabwe.org/
263 4 481496

Campfire Association
Mukuvisi Woodlands
Corner Hillside Road and Glenara Ave South, Harare
www.campfirezimbabwe.org/

263 4 747429–30

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 Road and Glenara Ave South, Harare
263 4 747648
www.zimwild.org/

World Wide Fund for Nature (WWF) Zimbabwe
10 Lanark Road, Belgravia, Harare, Zimbabwe
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 Avenue 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 Road, Mt Pleasant, Harare
263 4 339512/ 339503 fax: 263-4-333811
Director: Linda Kabaira
scopezimbabwe@gmail.com
http://scopezimbabwe.org/
http://permaculturegloba.org/projects/2208-schools-and-colleges-permaculture-programme-scope-zimbabwe

UNICEF (Zimbabwe)
Climate change department
Amy Wickham
6 Fairbridge Avenue
Belgravia
Harare, Zimbabwe
263 4 703881, 731840, 703941, 799232
http://www.unicef.org/zimbabwe/

Climate change activism

Action 24
African Youth Conference on Climate Change
158 Fife Avenue, Greenwood Park, Harare
263 4 772991697
Programme co-ordinator: Archieford Chemhere
achemhere@gmail.com

Climate change advocacy

Environment Africa
76 Queen Elizabeth Road, 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/

Zimbabwe Environmental Lawyers Association
26B Seke Road, Hatfield, Harare
263 4 573601–3
www.zela.org/

ZERO Regional Environmental Organisation (ZERO)
158 Fife Avenue, Harare

263 772347769
Director: Shepherd Zvigadza
szvigadza@gmail.com

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 National Framework 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 3: Climate change finance

International funding

The Climate Funds Update[81] website is a useful place to find information about international finance targeted 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% mostly from the Climate Investment Fund, which approved $2.3 billion for projects.
- The Standing Committee on Finance of the UNFCCC identified $40–175 billion in climate change finance flowing from developed countries to developing countries annually between 2010 and 2012.
- In 2014 the UN Secretary General's climate summit in New York marshalled over $200 billion in financial commitment to help address climate change from governments, business and the financial sector.
- A global movement initiated by local governments, philanthropic foundations, universities, faith-based organisations, non-governmental organisations (NGOs) and individuals aims to divest from (withdraw investment from companies associated with) fossil fuels.
- In 2014 The Clean Technology Fund, 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 the largest portion of which ($54.6 million), went towards incorporating climate risk and resilience measures into national development planning focussing on Disaster Risk Reduction.
- The Adaptation Fund was set up offering developing country based institutions direct access to its finance and 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 4 shows some of the main climate change funds noting the source, organisation administering the fund, the area of focus and date operational.

The NCCRS[82] states that the most important sources of multinational funding for Zimbabwe are the World Banks carbon funds, the Global Environment Facility, the African Development Bank, African Sustainable Forestry Fund, the UNFCCC's Adaptation Fund, and the Kyoto Protocol's Clean Development Mechanism. The document notes that Green Climate Fund, (a financial mechanism of the UNFCCC), is expected to be a major source of climate finance for developing countries.

Local funding

The NCCRS notes that in the past Zimbabwe has not been able to take full advantage of these international funding mechanisms

due to lack of capacity and lack of accredited financial institutions. For example the Ministry of Environment, Water and Climate needs to be accredited in order to access the UNFCCC's 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. The strategy 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 capitalised from budgetary allowances, environmental levies and carbon tax donations. It is expected that the fund will provide grants and loans to local authorities, adaptation and mitigation projects, environmental extension, research training and technology transfer; rehabilitation of degraded areas and environmental awareness programmes. The NCCRS notes other local funds which relate to climate change, including the Water Fund, the Rural Electrification fund and the Zimbabwe Energy Fund (a multidonor trust fund).[83]

Table 4: Major sources of climate change funding.

Source: http://www.climatefundsupdate.org/

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 (IFAD)	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
Global Environment Facility Trust Fund – Climate Change focal area (GEF 4)	Multilateral	The Global Environment Facility (GEF)	Adaptation, Mitigation – general	2006
GEF Trust Fund – Climate Change focal area (GEF 5)	Multilateral	The Global Environment Facility (GEF)	Adaptation, Mitigation – general	2010
Global Climate Change Alliance	Multilateral	The European Commission	Adaptation, Mitigation – general, Mitigation – REDD	2008
Global Energy Efficiency and Renewable Energy Fund	Multilateral	The European Commission	Mitigation – general	2008

Name	Source	Administered by	Area of focus	Date operational
Green Climate Fund	Multilateral	GCF to be confirmed	Adaptation, Mitigation – general, Mitigation – REDD	Not yet operational
UK's International Climate Fund	Bilateral	Government of the United Kingdom	Adaptation, Mitigation – general, Mitigation – REDD	2011
Germany's International Climate Initiative	Bilateral	Government of Germany	Adaptation, 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, Mitigation – general, Mitigation – REDD	2008
Japan's Fast Start Finance – public sources	Bilateral	Government of Japan	Adaptation, Mitigation – general, Mitigation – REDD	2008
Least Developed Countries Fund	Multilateral	The Global Environment Facility (GEF)	Adaptation	2002
MDG Achievement Fund – Environment and Climate Change thematic window	Multilateral	United National Development Programme (UNDP)	Adaptation, Mitigation – general	2007
Norway's International Climate and Forest Initiative	Bilateral	Government of Norway	Mitigation – REDD	2008

Name	Source	Adminis-tered by	Area of focus	Date opera-tional
Pilot Program for Climate Resilience	Multilateral	The World Bank	Adaptation	2008
Scaling-up Renewable Energy Program for Low-income Countries	Multilateral	The World Bank	Mitigation – general	2009
Special Climate Change Fund	Multilateral	The Global Environment Facility (GEF)	Adaptation	2002
Strategic Climate Fund	Multilateral	The World Bank	Adaptation, Mitigation – general, Mitigation – REDD	2008
Strategic Priority on Adaptation	Multilateral	The Global Environment Facility (GEF)	Adaptation	2004
UN-REDD Programme	Multilateral	UNDP	Mitigation – REDD	2008

Endnotes

77 GoZ 2014 p. 64.

78 Ibid.

79 Chagutah 2010 p. 13

80 Adapted from Lotz-Sisitka and Urquhart 2014

81 www.climatefundsupdate.org/about-climate-fund/10-things-to-know-about-climate-finance-in-2013

82 GoZ 2014 p. 66

83 GoZ 2014 p. 68–9

Glossary

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 adapt to climate change.

Agroforestry Agriculture incorporating the growing of trees.

Aquifer Permeable rock which stores water.

Biofuel Ethanol, diesel and methane made from fresh plant or other organic material, including human or animal waste.

Carbon dioxide (CO_2) One of the main greenhouse gases in the atmosphere that is causing climate change. It is produced by the burning of fossil fuels, cutting down or burning of forests and various other sources.

Carbon sequestration Methods for taking CO_2 out of the atmosphere, for instance by conserving and planting forests.

Carbon trading A mechanism by which developed countries can meet their mitigation obligations. A country with high carbon emissions can purchase, from a less developed country that has low emissions, the right to emit more carbon.

Catchment area (of a river) The land uphill from a river from which rainwater runs off.

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 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.

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.

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.

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.

Global warming The heating of the planet caused by climate change.

Greenhouse effect A greenhouse is a glass building that allows light and heat in, but prevents heat from escaping. Its function is to enable plants to be grown in cold countries during winter. 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 gases 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.

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.

Mitigation Actions that reduce greenhouse gas emissions which lead to climate change.

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 upheld definition.

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 exposed to risk of harm.

Wetland An area that is permanently or seasonally saturated with water and that contains characteristic plants.

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communication, senior lecturer, Department of Geography, Bindura University of Science Education: nchanza@gmail.com

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