RESPONDING TO CLIMATE CHANGE IMPACTS

Adaptation and mitigation strategies as practised in the Zambezi River Basin

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Climate Change and the Zambezi River Basin Project funded by the Heinrich Böll Stiftung (HBS)

Southern African Research and Documentation Centre (SARDC)
I. Musokotwane Environment Resource Centre for Southern Africa (IMERCSA)

2010

SARDC
Southern African Research and Documentation Centre

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REGIONAL OFFICE FOR SOUTHERN AFRICA

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ISBN: 978-1-77910-035-3

Citation: SARDC and HBS, 2010. Responding to Climate Change Impacts: Adaptation and mitigation strategies as practised in the Zambezi River Basin, SARDC and HBS, Harare and Cape Town

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CONTENTS

ACRONYMS

AFOLU	Agriculture Forestry and Other Land Uses
AIACC	Assessments of Impacts and Adaptations to Climate Change
AIDS	Acquired Immune Deficiency Syndrome
APF	Africa Partnership Forum
CBA	Community Based Adaptation
CBD	Convention on Biological Diversity
CCAA	Climate Change Adaptation in Africa
CDM	Clean Development Mechanism
COP	Conference of Parties
CTDT	Community Technology Development Trust
DNA	Designated National Authority
EC	European Commission
ET	Emission Trade
EU	European Union
FACE	Forest Absorbing Carbon Emissions
FAO	Food and Agricultural Organisation
GECHS	Global Environment Change and Human Security
GEF	Global Environment Fund
GHG	Green House Gas
GWP	Global Water Partnership
HBS	Heinrich Böll Stiftung
HIV	Human Immunodeficiency Virus
ICRAF	International Centre for Research in Agro-Forestry
IFPRI	International Food Policy Research Institute
IFRC	International Federation of Red Cross and Red Crescent Societies
IIED	International Institute for Environment and Development
IMERCSA	I Musokotwane Environment Resource Centre for Southern Africa
INGC	Instituto Nacional de Gestão de Calamidades (National Institute for Disaster Management)
IPCC	Inter-Governmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
IWRM	Integrated Water Resources Management
LCA	Linking Climate Adaptation
LDCF	Least Developed Countries Fund
MEAs	Multilateral Environmental Agreements
NAMAs	Nationally Appropriate Mitigation Activities
NAPAs	National Adaptation Plan of Action
ProBEC	Programme for Basic Energy Conservation
PV	PhotoVoltaic
RANET	Radio And Internet
RCCP	Regional Climate Change Programme
REDD	Reduced Emissions from Deforestation and Land Degradation
SACORF	Southern Africa Climate Outlook Regional Forum
SADC	Southern African Development Community
SANF	Southern African News Features
SARDC	Southern African Research and Documentation Centre
SAVI	Southern Africa Vulnerability Initiative
SCCF	Special Climate Change Fund
SMEs	Small and Medium Enterprises
SPI	Solar Panel Information
TaTEDO	Tanzania Technology Development Organisation
UNCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Education Fund
WIDSAA	Women in Development Southern Africa Awareness
ZRA	Zambezi River Authority
ZRBI	Zambezi River Basin Initiative

ACKNOWLEDGEMENTS

Responding to Climate Change Impacts: Adaptation and mitigation strategies as practised in the Zambezi River Basin was produced with the I Musokotwane Environment Resource Centre for Southern Africa (IMERCSA) which is part of the Southern African Research and Documentation Centre (SARDC).

Production of this report was made possible with the support of many people, both in their individual capacities and as representatives of various organisations whom SARDC works with as partners.

The report was produced with financial support from Heinrich Böll Stiftung (HBS). To Sakile Koketso, the Sustainable Development Programme Manager, we acknowledge your spirit of partnership and efficient response to our requests.

The methodology of the report draws on the United Nations Framework Convention on Climate Change (UNFCCC)'s 2007 Fourth Assessment Report which discussed impacts, adaptation and mitigation strategies as well as policy responses.

The preparation process of this report benefited from the network of National Collaborating Centres (NCCs) in the Zambezi River Basin created during the production of the State of Environment Zambezi Basin 2000. The NCCs made many documents available to make this report as current as possible. The NCCs include Development Workshop, Angola; Forum for Sustainable Agriculture, Botswana; Coordination Unit for the Rehabilitation of the Environment, Malawi; Gabinete do Plano de Desenvolimento da Região do Zambeze (GPZ), Mozambique; Integrated Rural Development and Nature Conservation, Namibia; National Environment Management Council and Tanzania Gender Network Programme, Tanzania; Environment Council of Zambia, Zambia; and CAMPFIRE Association in Zimbabwe.

The 2007 Rapid Assessment Report for the Zambezi River Basin carried out under the Zambezi Action Plan, Project 6 Phase II (ZACPRO 6.2), provided useful information especially on water resources and climate change.

Some background information was drawn from the Southern Africa Environment Outlook 2008 produced by SARDC in collaboration with the Southern African Development Community (SADC), IUCN World Conservation Union, and United Nations Environment Programme (UNEP).

This publication also benefited from the Basic Energy Report, a SARDC Regional Economic Development Information (REDI) initiative led by Munetsi Madakufamba, the Deputy Director of SARDC.

Clever Mafuta, the former Director of IMERCSA, coordinated the preparation of the report, and Egline Tauya compiled the report and assisted with coordination of the process. Leonnisah Munjoma, the Acting Head of IMERCSA, oversaw the review and editing of the report. Backstopping support and encouragement provided by Phyllis Johnson, the Executive Director of SARDC, is greatly appreciated.

Many members of the SARDC Team reviewed the manuscript, among them, Admire Ndlovu, Mukundi Mutasa, Israel Dabengwa, Neto Nengomasha, Monicah Nyamakura, and Maxwell Mupita.

The presentation of the publication benefits from the creative support of Tonely Ngwenya and Paul Wade, both very special artists and designers, for the cover and text design. To Gamuchirai Ziramba, thank you for coordinating production.

There were many organisations and individuals who contributed directly and indirectly to this process. While every effort has been made to acknowledge their input, it may be that not everyone has been credited by name. Please accept this acknowledgement of your role in this important process.

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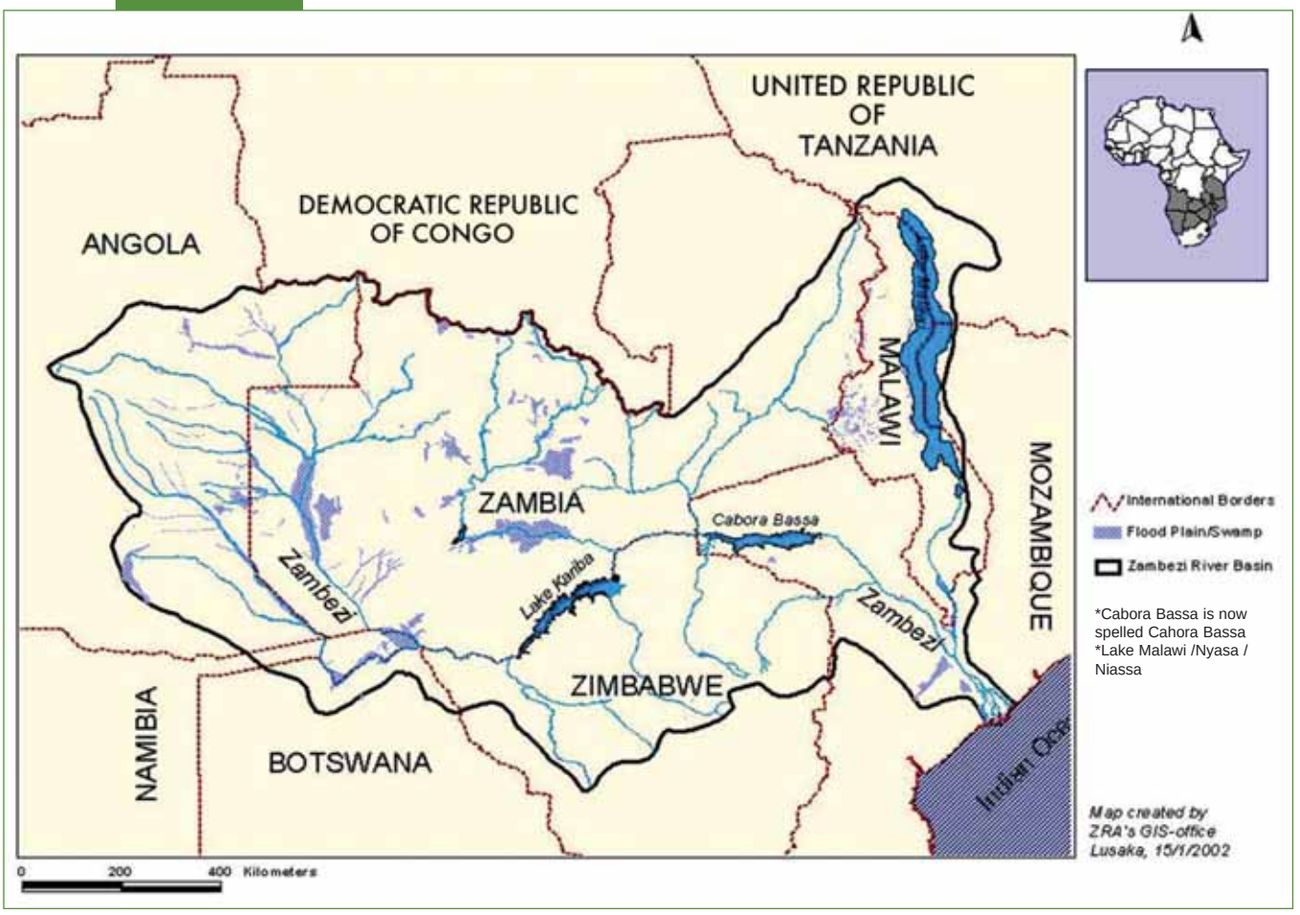
MAP OF ZAMBEZI RIVER BASIN



1 INTRODUCTION

The Zambezi River Basin, like the rest of southern Africa, is embarking on various climate change adaptation and mitigation strategies following the realisation that the region is severely impacted by climate change, and facing severe and frequent floods and droughts, among other negative effects.

The warming of the climate system is evident from increases in global averages of air and ocean temperatures, and widespread melting of snow, ice and glaciers resulting in rising global average sea levels, and this has prompted the need to step up efforts towards adaptation and mitigation strategies.

According to the Southern Africa Environment Outlook (SADC, SARDC, IUCN, UNEP 2008), climate change is well underway, with average temperatures in southern Africa having risen by 0.5^{o}C over the last century, and the 1990s deemed the warmest and driest decade ever.

While much of the sea level rise will be due to the melting of ice cover in Greenland, mountain glaciers around the world continue to melt. This will impact on the Zambezi basin, and the Zambezi delta in Mozambique will be affected by sea level rise.

The Southern Africa Environment Outlook notes that the total area covered by snow on Mount Kilimanjaro decreased by six-fold from 12 square kilometres in 1900 to two sq km in the year 2000. A recent study by Thompson (2009) indicates that some 85 percent of the ice that made up the Mount Kilimanjaro top glaciers in 1912 was gone by 2007, and more than a quarter of the ice present in 2000 was gone by 2007.

According to UNEP (2009), a climate expert study now estimates a sea level rise of between 0.8 and 1.5 metres in the coming century from outflows of ice from Greeland alone. A one-metre rise in sea levels worldwide would displace millions of people, including several million living in coastal areas in Africa.

Much of mainland southern Africa is semi-arid, so much that any increase in droughts worsens an already fragile agricultural sector. The region has already started to experience extreme weather events with disastrous effects on livelihoods and the environment. Thus, the need to increase awareness on climate change impacts, as well as adaptation and mitigation strategies is imperative.

A schematic framework in Figure 1 shows human-induced climate process drivers, impacts of and responses to climate change, as well as indicating linkages, and illustrates what this report is about.

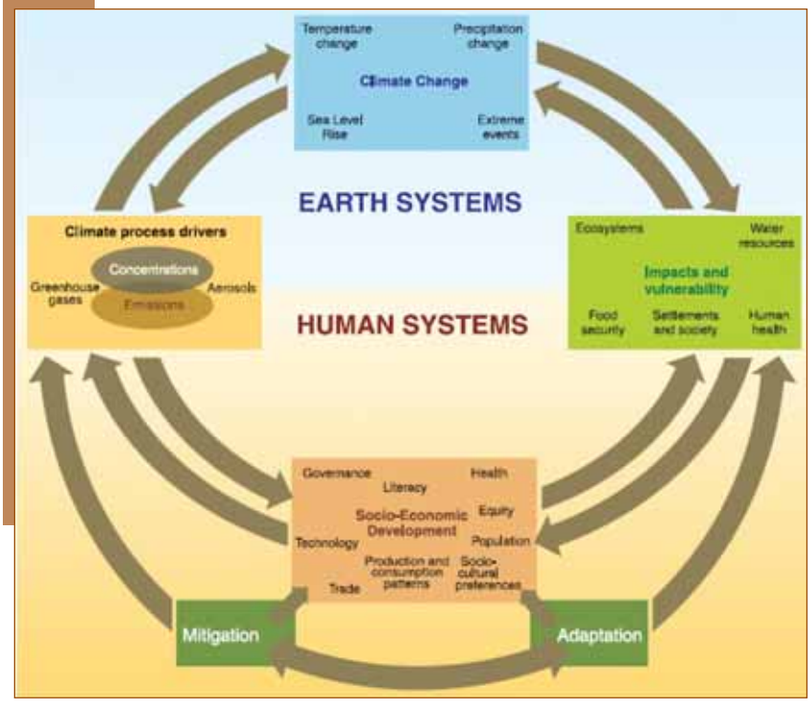
1.1 Purpose of the Report

This report seeks to improve access to information on climate change mitigation and adaptation strategies, and climate change impacts on livelihoods in the Zambezi River Basin. It describes the strategies crucial to addressing the many impacts of climate change on communities. It is hoped that the report will contribute to creating awareness on climate change and assisting riparian states to formulate policies and positions which can further their development objectives in the context of climate change negotiations.

The publication is intended for use by various groups of people including the media, researchers, parliamentarians and other policy makers, and civil society including the private sector and the general community.

The report is divided into five sections. The first section is this Introduction which provides an overview describing the target groups, geographical scope and differential vulnerability to climate change. The second section explains what climate change is, with definitions and explanations, and also shows the extent of impact of climate change, both regionally and globally. In southern Africa, the effect that frequent droughts and floods have on the population has been examined. Effects of the melting ice on sea levels, and changes in cyclonic activity are also addressed in this section.

Fig 1 **Schematic Framework of climate drivers, impacts and responses**



Source, Bernstein L. 2007. Climate Change: Synthesis Report. An assessment of the Inter-governmental Panel on Climate Change

The third section shows the impact of climate change in the Zambezi River Basin, and highlights the socio-economic, cultural and environmental impacts on livelihoods. There are implications on settlements and societies where lives have been lost, and people have been displaced due to heavy flooding. Climate change has implications on health, and the report shows the increase in the occurrence and spread of water-borne, respiratory and vector-borne killer diseases including malaria and cholera.

Food security is also addressed in this report. There has been drought-induced crop failure which has reduced farmers to beggars with the collapse of the traditional credit delivery systems. Crop pests thrive in drought situations and these have contributed to reduced yields. Livestock has been affected as have been fisheries.

The report gives a detailed assessment of the impacts of climate change on the environment, emphasising the threat to sustainability of the rich environmental and water resources that are crucial for human livelihoods in the Zambezi basin. Communities rely on water and water resources including wetlands, coral reefs, and wildlife for food, as well as vegetation for medicines and firewood, and anything that disturbs this process is sure to have negative effects.

In its gender analysis of the impacts of climate change, the report highlights the impact of climate change, especially on the marginalized and poor women, men, girls and boys as their capacity, skills and resources to adapt are already reduced. Women and men have been noted as having differences in their experiences in times of flooding and drought. More women die in flood situations while during drought, women spend more time fetching water for their families.

Section four provides a comprehensive report on how the people of the Zambezi river basin are responding to climate change. Faced with the reality of climate change, there is no choice but to adapt, and the report recommends that societies in the Zambezi basin can respond to climate change by adapting to its impacts, as well as by implementing mitigation measures. Climate change adaptation reduces the magnitude of change. The report gives a description of climate change adaptation and mitigation measures being taken to counter the impacts. These include adaptation strategies at national, basin, regional and global levels. This section demonstrates the strong will around the river basin to deal with climate change and minimise its impacts.

The report ends with a concluding section stating that observation records and climate projections provide evidence that the Zambezi River Basin is vulnerable and has potential to be strongly impacted by climate change, with wide-ranging consequences for communities living in it.

1.2 Who are the Communities?

The term community has different meanings to different people. In most literature there is an assumption that a community is a social entity concerned with ensuring equal distribution of resources amongst its members. Terms such as community participation, community management, and community-based organisations, are often used to describe community interactions.

Elton Laisi

Children in a flood situation.

A community is also taken to mean a group of people living in the same area, such as rural, urban, peri-urban, village or river basin, as well as a group of people or social entity interacting, but not necessarily living in the same geographic area. Examples of the latter may include a network of environmental organisations or a group of industries with the same interests but in various locations.

It is important to note that a community in a river basin may not necessarily be homogeneous with similar interests and living standards. Some groups of people are more vulnerable to climate change impacts than others due to their marginal geographical positions, and their inability to cope due to being economically disadvantaged.

While communities in the context of the Zambezi River Basin refers to all stakeholders in the basin, including business, village and NGO communities, this report has a special focus on vulnerable communities – the youth, women, orphans, single-headed households, child-headed households, the elderly, HIV and AIDS affected and infected, persons living with disabilities, and people living in fragile parts of the basin, including arid and flood-prone areas.

Illustrative Options

The Zambezi river at Victoria Falls.

1.3 Geographical Scope of the Report

The Zambezi River Basin drains an area of almost 1.4 million square kilometres, stretching across eight of the 15 Member States of the Southern African Development Community (SADC). These are Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe.

The Zambezi River flows over a distance of almost 3,000 km, dropping in altitude from its source in the Kalene Hills in the north-western district of Solowezi in Zambia at 1,585 metres above sea level, to its delta in the Indian Ocean, 200km north of the Mozambican port of Beira. Its catchment is the most shared river basin lying wholly within the SADC region, and the fourth largest river basin in Africa after the Congo, Nile and Niger basins.

Juda Ngwenya, AFP

A city under flood waters in Mozambique.

The Zambezi basin covers almost all of the territory of Malawi and a large part of Zambia. It covers almost half of Zimbabwe and significant areas of both Mozambique and Angola. Small parts of Tanzania, Botswana and Namibia are situated inside the basin. The Zambezi river basin's population is estimated at over 40 million people. Approximately 7.5 million live in the urban centres. The population is expected to increase to 47 million by 2025 with urbanization steadily increasing according to the same report. A summary of the socio-economic indicators of the countries in the Zambezi basin is shown in Table 1 to put the climate change impact on vulnerable communities into context.

1.4 Differential Vulnerability of Communities

Considering the socio-economic status of the basin, as Table 1 shows, an increase in the frequency, complexity and magnitude of natural disasters and epidemics would exacerbate the vulnerability of the communities in the basin.

However, it is important to note that vulnerability levels to climate change are not the same for all the people and areas in the basin. Vulnerability to climate change varies greatly among riparian states, sectors and social groups in the basin. For example in the water sector Angola, Malawi, Mozambique, Tanzania and Zambia are not as vulnerable to water scarcity in comparison with Botswana, Namibia, and Zimbabwe, although Malawi and Namibia have sufficient resources, much is inaccessible in most of the country (SADC, SARDC, WB, 2002). See the vulnerable context and sectors shown in Table 2.

Vulnerability may vary due to differences in the provision of services and access to alternative livelihoods between villages and even between households in the same village. The majority of the Zambezi river basin farmers are smallholders who engage in low-input farming, in addition to other livelihood activities.

This report notes that poverty and vulnerability are not synonymous. Within any area, it is not always the poorest

Table 1 Socio-economic indicators for countries in the Zambezi River Basin

Country	Population total (000) 2007	Life expectancy at birth 2007	Infant mortality (per 1000 live births) 2007	Literacy rate (% age 15 and older)	Per capita GDP (US$) 2007	HIV prevalence among 15 -20 yr olds 2007	Population using improved water source % 2008
Angola	17 024	42.7	116	63	3,574	2.1	50
Botswana	1 745	50.7	46.5	82.9	6,603	23.9	95
Malawi	13 188	48.3	89.4	71.8	268	11.9	80
Mozambique	20 366	47.6	95.9	48.3	423	12.5	47
Namibia	2 074	52.9	42.3	88.	3,526	15.3	92
Tanzania	39 816	52.5	72.6	72.3	387	6.2	99
Zambia	12 160	42.4	92.7	80.6	941	15.2	60
Zimbabwe	13 349	43.5	58.0	91.2	354	15.3	82

Source, SADC Facts and Figures 2007, African Statistical Yearbook 2009

that are the most vulnerable, as explained by Coertzee (2002). However, some of the factors that increase vulnerability to climate change are closely associated with poverty. Poor people are often the ones to suffer injury, loss, death, or harm from droughts, floods, or other extreme events and they have less capacity to recover. This is due to lack of resources to cope with the climatic challenges. Vulnerability to climate change is therefore not simply a question of poverty, but of a combination of factors that render some vulnerable to even small changes. The most vulnerable are often those who are unable to diversify to other means of survival. Also vulnerable are those who lack access to forests or productive land, and those who have been displaced from their homes due to floods, conflicts, or famine without receiving adequate humanitarian assistance (Coetzee 2002).

People who are vulnerable often live in areas that are marginal in terms of basic services, such as health, access to clean water and sanitation, a situation that also affects crop production and livestock-rearing because of disease. They are also often exposed to a breakdown of security in terms of theft and crime during periods of climate-related stress. Households that are affected by HIV and AIDS, malaria, and other infectious diseases are often more vulnerable to climatic events, as they may experience labour shortages during critical periods or a break-up in their families. The table below provides a summary of vulnerable sectors and vulnerability context for each country in the basin. The shaded areas indicate countries experiencing a particular climate challenge.

Table 2 **Summary of climatic challenges, vulnerable sectors and vulnerability context by country**

		Angola	Botswana	Malawi	Mozambique	Namibia	Tanzania	Zambia	Zimbabwe
Climatic challenges	Increase of temperature	■	■	■	■	■	■	■	■
	Increased incidence of droughts	■	■	■	■	■	■	■	■
	Decrease in rainfall		■	■	■			■	■
	Seasonal shifts in rainfall	■	■	■	■	■	■	■	■
	Cyclones				■				
	Localised floods	■	■	■	■	■	■	■	■
	Overflowing of large rivers				■				
	Lakeshore flooding						■		
	Decline in lake levels						■		
	Decreased/Varying river flows	■	■	■	■	■	■	■	■
	Wildfires	■	■	■	■	■	■	■	■
	Sea level rise	■			■	■	■		
	Salt water intrusion	■			■	■	■		
	Coral reef bleaching				■		■		
	Landslides in Mountainous areas			■					
Vulnerable sectors	Water scarcity		■			■			■
	Biodiversity loss	■	■	■	■	■	■	■	■
	Health/Disease outbreaks	■	■	■	■	■	■	■	■
	Coastal ecosystems, cities				■	■	■		
	Infrastructure	■	■	■	■	■	■	■	■
	Fisheries	■		■	■	■	■	■	
	Agriculture and food security								
	Livestock		■		■	■	■		■
Vulnerability context	Urbanisation	■		■	■		■		
	Poor infrastructure	■		■	■		■	■	
	Gender inequality	■	■	■	■	■	■	■	■
	Dependence on climate sensitive resources	■	■	■	■	■	■	■	■
	Poor water access by population	■			■		■	■	
	Poor health status	■		■	■		■	■	■
	HIV and AIDS		■	■	■	■	■	■	■

Source, Adapted from Global Environment Change and Human Security 2008. Based on assessment of available information, which varies in quality between countries. There may also be large geographical variations in the variables within countries.

2

WHAT IS CLIMATE CHANGE

Climate change is an alteration in the state of the climate that can be identified by changes in the mean and/or the variability of its properties (mainly temperature, rainfall, radiation, wind and cloud cover) and that persists for an extended period, typically decades. According to the Inter-governmental Panel on Climate Change (IPCC), this refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

Illustrative Options

Emissions such as this contribute to green house gases.

Illustrative Options

Green house gases are a major factor in climate change.

Increased greenhouse gas emissions from human activities over the past 60 years have caused increases in global average temperatures, according to expert reports (Boko and others, 2007).

Human activities that lead to the warming of the earth's atmosphere include the burning of fossil fuels such as oil, coal and petroleum. The use of some agricultural and industrial chemicals also leads to the build-up of greenhouse gases. Greenhouse gases such as carbon dioxide, methane and nitrous oxide as well as water vapour, trap heat in the atmosphere, causing global warming. Atmospheric concentration of GHGs increases when emissions outweigh the removal processes.

On emissions, the Copenhagen Diagnosis report (2009) finds that if emission trends continue unabated, even with zero emissions worldwide after 2030, the risk of a 2ºC or higher increase in global average temperatures, over pre-industrial levels, will go up. Such an increase would have climate destabilizing effects that are beyond most "worst-case scenario" projections.

The report also finds that the melting of ice is accelerating, with summer-time melting of Arctic sea-ice having exceeded expectations of climate models by far. This area of sea-ice melt during 2007-2009 was about 40 percent greater than the average prediction from IPCC Fourth Assessment Report climate models. The melting of ice shelves in Greenland and Antarctica is also speeding up, as is the melting of glaciers in North America, Africa and the Himalayas. A glacier is a large mass of ice which persists throughout the year, and moves slowly down slope by its own weight. Glaciers are formed in areas where the winter snow does not have a chance to melt, and consecutive snowfalls accumulate and compress into ice.

The melting of ice and glaciers is visible in satellite imagery and is contributing to the accelerating rise in sea levels worldwide. The 2005 IPCC report had foreseen an average annual sea-level rise for the period 1993-2008 of 1.9 millimetres per year (mm/yr). The Copenhagen Diagnosis 2009 report reveals that up-to-date scientific research shows an actual 3.4 mm/yr rise in global sea levels. According to the report, this acceleration is consistent with a doubling of contribution from melting of glaciers, ice caps and the Greenland and West-Antarctic ice-sheets.

Emissions of greenhouse gases in one region may result in temperature rise with the associated effects in another region. Temperature rise in southern Africa has averaged 0.5ºC over the past century, resulting in the 1990s being the warmest and driest ever in the Zambezi river basin (IIED 2006).

According to a study by the Mozambique's National Disaster Management Institute (INGC) (2009), between 1960 and 2005, during the winter season, increases of up to 1.6°C are apparent over central Mozambique, whereas maximum temperatures during the March-April and the September to November months have increased by approximately 1.1°C. By 2081-2100 increases in temperature are projected to be as

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Desert conditions as a result of climate change.

much as +5-6°C over central Mozambique during the September to November months (Tadross 2009).

Similar to increases in temperature, the interior areas of Mozambique will also suffer greater evaporation increases than those nearer to the coast. The largest increases occur during the September to November months, particularly over the Zambezi river valley. This suggests that evaporation will increase significantly in this area before the onset of rains, which, depending on changes in rainfall, could result in decreases in soil moisture before the main cropping season starts (Tadross 2008).

While countries in the Zambezi river basin and most developing countries are not major emitters of greenhouse gases, a significant contribution to climate change through thermal power stations such as in Chichiri, Lilongwe and Mzuzu in Malawi, the Copperbelt gas turbines in Zambia, and in Hwange, Harare and Munyati in Zimbabwe (Chenje 2000), should not be ignored. The basin's emissions are projected to rise as economies develop, including a threefold increase in Zimbabwe over the next 50 years (SADC, SARDC, IUCN, UNEP 2008).

Also to note are the methane emissions from livestock and wildlife in the basin as well as forest fires, coupled with deforestation in the entire basin. The expansive mature forests in the basin store large quantities of carbon so much that when they are cut and burned the carbon dioxide that is released contributes to the greenhouse effect. Forests can also absorb carbon dioxide as "carbon sinks".

Communities in the Zambezi river basin, as in most developing countries rely heavily on firewood, which accounts for nearly 80 percent of the total energy requirements among the basin's rural population and urban poor. Experts predict that wood use in Africa will double by 2020 (ProBEC website October 2009).

The Herald, Zimbabwe

Floods are a reality in the region.

2.1 Precipitation Extremes – Floods and Droughts

The rain season for the Zambezi basin is largely dependent on the inter-tropical convergence low-pressure system, which moves to the southern part of Zambia in November and reaches its peak in January or February. Many of the riparian states are partially or largely semi-arid with low annual rainfall reliability.

Rainfall ranges from 10mm in some parts of Namibia to about 2,800 mm in some parts of Angola, Malawi and Tanzania. In Angola, Namibia, Mozambique, Malawi and Zambia a significant increase in heavy rainfall events has been observed including evidence of changes in seasonality and weather extremes (New and others, 2006)

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Wilting crops due to frequent droughts cause suffering among farming communities.

Although year-to-year droughts have been experienced, especially in the last decade, the current decade has seen floods of unprecedented magnitudes (WMO/GWP 2007). Historical records indicate that extensive droughts affected the Zambezi basin in 1981-82, 1986-87, 1991-92, 1994-95 and 2001-02, while floods ravaged parts of the basin in 1999-2000, 2005-06 and 2007 (SARDC IMERCSA 2009).

Storms due to tropical cyclones from the Indian Ocean also affect the Zambezi River Basin, and cyclone-induced floods have become more frequent. This is in line with the IPCC predictions based on a range of models indicating that tropical cyclones will become more intense, with larger peak wind speeds and heavier precipitation associated with increases in tropical sea surface temperatures (IPCC 2008). While the Zambezi basin experiences seasonal and variable rainfall, resulting in cyclical spells of drought and intermittent floods, the recent increase in the variability and intensity of drought and floods is attributed to climate change.

The IPCC Fourth Assessment Report (2007) indicates that southern Africa is expected to experience increased flooding and more intense drought as a result of the warming temperatures. By 2080 an increase of 5-8 percent of arid to semi-arid land in southern Africa is projected under a range of climate scenarios.

Table 3 Rainfall Trends in the Zambezi River Basin

2008 – 2009	The basin experienced flooding, affecting and displacing thousands of people in Angola, Botswana, Malawi, Namibia and Zambia.
2007	Cyclone Favio-induced floods affect Mozambique and parts of Zimbabwe
2005 – 2006	Parts of Mozambique, South Africa and Zimbabwe received very heavy rains resulting in flooding that caused considerable infrastructural damage, destroying schools, crops, telecommunications and roads.
2001 – 2003	Southern Africa experienced abnormally high rainfall and disastrous flood causing damage to infrastructure and loss of lives and property, followed by a severe drought particularly from Zimbabwe northwards.
1999 – 2000	Cyclone Eline hit the region and widespread floods devastated large parts of central Mozambique and eastern Zimbabwe.
1994 – 1995	Many countries in the SADC were hit by a severe drought, surpassing the impact of the 1991 – 1992 drought.
1991 – 1992	Worst drought in living memory experienced in southern Africa, excluding Namibia.
1986 – 1987	Drought conditions returned to the region.
1983	This year saw a particularly severe drought for the entire African continent.
1982	Most of sub-tropical Africa experienced drought.
1981 – 1982	Severe drought occurred in most parts of southern Africa.
1967 – 1973	This six-year period was dry across the entire region. Some records show a severe drought in 1967.

Source, SADC, *Southern Africa Environment Outlook, SADC, SARDC, IUCN, UNEP, 2008; Data for 2008-2009 from FAOStat, FewsNet*

At the local level, communities have also observed changes in the rainfall patterns. A long-term resident in Mulanje district of Malawi had this to say, "From January to June every year, there were heavy rains in Mulanje and the hot dry season lasted from August till October, when the first rains started, known as chizimalupya (Nyanja vernacular expression for 'the fire extinguisher'). Chizimalupya no longer precedes the main rains because the rain season starts late, sometimes as late as December. June and July were extremely cold months with frequent fog, but it is now difficult to tell between the cold and hot seasons. Many rivers that rise from Mount Mulanje never dried up, most of them with large pools. They are frequently drying now as early as June (IIED 2008)."

Practical Action

Land degradation in Zimbabwe.

While flooding in some areas, such as the Barotse plains in western Zambia, are regular events providing vital water for irrigation and replenishing soil fertility, the frequency, timing, intensity and duration of flood hazards is changing in the basin. Often the extent of flooding is intensified due to poorly maintained embankments and structural measures, and in urban areas, poor land-use planning and inadequate drainage.

In addition to destruction of homes and infrastructure, as well as loss of crops, livestock and seed, flooding also inundates land, decreases soil fertility and destroys fodder resources, limiting agricultural production.

2.2 Sea Level Rise

The current sea level rise is partly linked to human-induced global warming (IPCC 2007). Increasing temperatures result in sea level rise by the thermal expansion of water and through the addition of water to the oceans from the melting of continental ice sheets. Thermal expansion, which is well quantified, is currently the primary contributor to sea level rise ahead of the melting glaciers (Randall, and others 2007).

Due to very little sea level data for Mozambique and the Zambezi river delta, recent trends in global rates of sea level rise can be used as the best estimates available. These global rates have risen since 1961 at an average of 1.8mm per year

and since 1993 at an accelerated average rate of 3.1mm per year (IPCC 2007).

The IPCC High Sea Level Rise Scenario shows a rise of 10mm by 2030, 100mm 30 years later by 2060 and 500mm 40 years later by 2100. It is the permanent flooding of the coast and the low-lying areas which forms the principal threat, particularly to large estuaries and subsiding deltas. Coastal set-back by erosion will reach approximately 500m. This scenario is likely to be catastrophic to Mozambique.

Sea level rise also represents a threat to the basin through saltwater intrusion. In the Zambezi delta, more than 240 sq km of land could be impacted with inland saltwater penetration of about 28 km by 2030 (Brundrit and Mavume 2009).

John Readu, APG

Ice cliffs on northern glacier, Mt. Kilimanjaro

An increase in the penetration of seawater into the delta will further degrade agricultural water quality and alter ecosystem conditions. Drinking water supplies for coastal communities will be affected due to the intrusion of seawater into coastal aquifers.

Marshland vegetation in the delta could provide some natural resistance to this intrusion. High flows from annual flooding of the Zambezi could also help to wash back some of the salt water. Conservation of marshland vegetation and eco-hydraulic management of the Cahora Bassa reservoir releases are required to ensure that these restorative processes occur.

2.3 Changes in Cyclonic Activity

Recent trends in IPCC observations and long-term modelling outcomes suggest that climate change will affect the characteristics of tropical cyclones in the south-western Indian ocean. Through the models and observations there is an indication of an increase in both frequency and intensity of cyclones.

According to the INGC study in 2009, of the 56 tropical cyclones and storms that entered the Mozambique Channel in the period 1980-2007, a total of 15 (25 percent) affected the coast of Mozambique. Only four occurred in the period 1980-1993, whilst the other eleven occurred in the later period from 1994-2007. Two cyclones in the period 1980-1993 were classified as category 3-5 compared to seven in the period 1994-2007.

Observations also suggest a recent southward shift in their trajectories and landfall locations. With cyclones becoming more intense, damage tends to increase exponentially.

South African Tourism

Increased vulnerability to storms is likely to be a threat to coastline towns.

The changing climatic aspects of temperature, precipitation, radiation and wind have great socio-economic, cultural and environmental implications on livelihoods in the Zambezi River Basin. The main impacts of floods and droughts are on human lives, settlements, infrastructure, health, food security, water, fisheries, wetlands, livestock and biodiversity, and these are all crucial to the wellbeing of communities in the Zambezi basin.

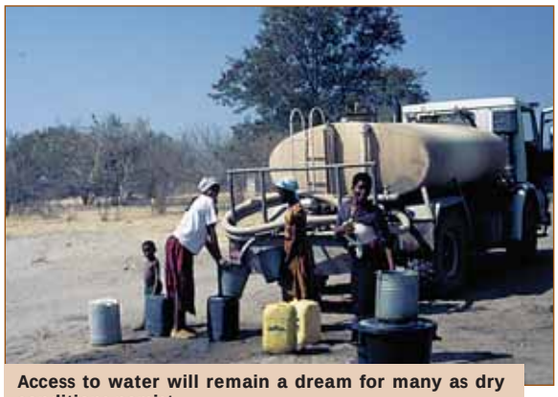
3.1 Implications for Settlements and Societies

Disasters induced by climate change cause loss of life for people, livestock and wildlife. For example, Cyclone Favio which hit Mozambique and parts of Zimbabwe in 2007 killed 700 people and drove more than half a million people from their homes (SANF 2007 No.16). The 2005-2006 floods that hit the same two countries killed at least 22 people in Mozambique while 1,500 families were left homeless and up to 9,000 others affected (SANF 2007 No. 17). In January 2008, at least 334 families (about 1670 people) were forced into displacement camps in neighbouring Malawi, after flooding of the Shire River, one of the main tributaries of the Zambezi River (INGC Climate Change Report 2009).

One-third of the people in the basin live in drought-prone areas and are vulnerable to impacts of droughts (Pandey and others, 2003). The frequency of droughts due to climate change has contributed to increased human migration, cultural separation, and dislocation, and there has been a growing culture to rely heavily on relief handouts. Even in the event of a good season the dependency syndrome that has been cultivated has made people to be less creative. The capacity for innovations and creativeness seems to be dwindling (UNEP and SARDC 2009).

Juda Ngwenya. AFP

Flooding in a settlement in Mozambique



SARDC IMERCSA

Access to water will remain a dream for many as dry conditions persist.

3.2 Health Implications on Communities

The health status of millions of people is under threat through an increase in malnutrition, as well as increased occurrence and spread of water-borne, respiratory and vector borne diseases resulting from climate change (Boko and others 2007).

The Zambezi River Basin is the hottest part in each of the eight countries that share the basin. This, coupled with stagnant water in the wake of floods, implies that the incidence of vector-borne diseases are high – particularly malaria. By 2100 the geographical range of vector-borne diseases such as malaria is expected to expand. Studies by Hartman and others (2006) show that by 2100 changes in temperature and precipitation could alter the geographical distribution of malaria in Zimbabwe, with previously malaria-free but densely populated settlements such as Harare, becoming suitable for transmission. Other examples of areas already affected where no malaria vectors had been recorded previously are the southern highlands in Tanzania (Chen and others 2006).

According to a 2006 World Malaria Report, Namibia is experiencing a steady increase in the number of reported malaria cases. In 1993, 380,500 patients were affected by malaria, and by 2003 the number of cases had risen to 444,000. The Caprivi and Kavango are Namibia's high-risk malaria areas.

Floods can also trigger malaria epidemics in arid and semi-arid areas. By 2080, up to 320 million more people in Africa could be affected by malaria because of these new transmission zones. The disease would then be spreading to people whose immune systems may not have been exposed to malaria, and who may be more vulnerable as a result. Due to sea level rise, the Mozambican coast could be threatened by increased abundance of mosquitoes that breed in brackish water.

ZACPRO 6.2 Project

Disease outbreaks are set to increase due to rising temperatures, with children the most affected.

On the other hand, increased temperatures in already hot regions such as the Kariba area could reduce the spread of malaria mosquitoes by pushing temperatures higher than the ranges at which mosquitoes can survive. Most mosquitoes cannot survive above 40^{O}C. In addition increased rainfall in wet regions could reduce malaria by washing away immature mosquitoes (Chen and others (2006).

Medical experts say the occurrence of waterborne diseases such as cholera, diarrhoea, and dysentery, while already common to the Zambezi river basin, may increase further due to climate change. This observation follows a study carried out in Lusaka, between 2003 and 2006, which concluded that rainfall, temperature and other climate variables were related to the increase in cholera cases during the epidemic period. The study notes that the rise in temperature six weeks before the rainy season increased the number of people affected by cholera by almost five percent (SARDC IMERCSA 2009).

The cholera bacteria Vibrio cholerae can live on some species of plankton. Warmer sea temperatures mean more plankton blooms, which could mean the cholera bacteria flourishes, spreading to populations on the warm coasts of countries such as Mozambique (Shetty 2009).

Some studies are underway to determine whether the recent cholera epidemics in the basin states including Zimbabwe, Zambia, Malawi and Botswana could be linked to effects of climate change, as the severity and spread broke historic records. The cholera claimed more than 4,000 lives and affected more than 100,000 people in Zimbabwe alone (UNICEF 2009).

According to studies by Shetty (2009) not only malaria and cholera are linked to climate change, but also non-water related diseases. Due to the greenhouse effect, higher concentration of ground level ozone in urban areas results in increased cardio-respiratory diseases. Large cities in the basin including Harare, Lusaka and Lilongwe are likely to be affected.

Other diseases are also important to consider with respect to climate variability and change, as links between variations in climate and other diseases such as meningitis have also been observed. About 162 million people in Africa live in areas with a risk to meningitis (Molesworth and others 2003).

While factors that predispose populations to a certain type of meningitis called meningococcal, are still poorly understood, dryness, very low humidity and dusty conditions are factors that need to be taken into account. A recent study has demonstrated that wind speeds in the first two weeks of February in southern Africa explained 85 percent of the variation in the number of meningitis cases (Sultan and others 2005).

It is not only human lives that are at risk due to an increase in the occurrence of diseases. Livestock on which the communities depend for food, income and draught power, are also at risk. African livestock productivity has been severely affected by vector-borne livestock diseases such as trypanosomiasis (nagana), (Niggoll 2008). For example, nagana is transmitted to people and animals by the tsetse fly and affects approximately 20 percent of Africa's 160 million cattle and comparable numbers of small ruminants. These diseases are known to be climate sensitive and with the rise in temperatures due to climate change the severity of such diseases will increase (Sultan and others 2005). While large portions of the Zambezi basin have been cleared of the tsetse fly, the risk of a resurgence of the pest is high due to climate change.

3.3 Impacts on Food Security

The agricultural sector is a critical mainstay of local livelihoods and national GDP for the Zambezi basin riparian states. Agriculture contributes an average of 35 percent towards national GDP for the eight basin countries, and is a major foreign exchange earner, employing 70-80 percent of the total labour force (UNEP and ICRAF 2008). The productivity of agriculture, forest and fishery systems depends critically on the temporal and spatial distribution of precipitation and evaporation as well as availability of freshwater.

Changes in water demand and availability under climate change will significantly affect agricultural activities and food security in the 21st century as the areas suitable for agriculture, the length of growing seasons, and yield potentials are expected to decrease (particularly along the margins of semi-arid and arid areas). IPCC assessments project that southern Africa would be likely to experience notable reductions in maize production under possible El Niño conditions, and wheat production is likely to disappear from Africa by 2080 (Stige and others 2006).

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Changes in water demand and availability will affect agriculture and food security.

Practical Action

Destruction of crop fields and livestock increases the likelihood of a food gap.

In Zambia drought-induced crop failures have been the most common disasters experienced in the recent past. On a local scale recurrent droughts have led to the collapse of the traditional credit delivery system, which focused mainly on maize and fertilizer inputs, crop diversification and contract farming arrangements, especially for cotton, tobacco, paprika and castor oil (UNEP, SARDC 2009).

Crop failure due to increased severity of floods has also affected Mozambique. In December 2007, following early season flooding, more than 31,000 hectares of arable land were rendered unfit for agriculture, according to the National Disaster Management Institute (UNEP and ICRAF 2008).

Furthermore, a slight rise in temperature affects crop yields. A UNDP simulation of the impact of climate change on crop yields and output in the Zambezi basin, produced in 2006, estimates a 10 percent fall in the yield of wheat, rice and maize for every 1°C rise in temperature (SADC 2007). The simulation also shows cereal production falling by up to 25 percent over most of the Zambezi River Basin between 2000 and 2080. In addition, an experiment in Zimbabwe showed that a 2–4°C increase in temperature caused a reduction in maize yield at all experimental sites (Magadza 2003).

Apart from the decline in crop yields due to dry conditions, floods, and high temperatures, outbreaks of pests such as locusts are likely to affect yields. Such outbreaks are linked to climate, as they typically occur when a dry period is followed by good rainfall. Changes in El Niño frequency would have an effect on the timing, location and extent of locust outbreaks in ways that are presently unpredictable (IPCC 2007).

Even though climate change issues are difficult for most people to understand, smallholder farmers in Seke rural district about 40km south-east of Harare, in Zimbabwe say the most persuasive evidence that global warming is happening is the change in the rainfall pattern as well as the frequency of droughts threatening food security. Box 1 highlights their views regarding climate change.

3.4 Environmental Implications

While the basin is rich in environmental and water resources crucial for human livelihoods, their sustainability is under threat due to the effects of climate change. Communities rely on water and water resources including wetlands, mangroves, and wildlife for food, as well as vegetation for medicines and firewood.

Changes induced by climate change are likely to result in shifts in species range, as well as in changes in tree productivity, adding further stress to forest ecosystems (UNEP 2004). For example, ambient temperatures and precipitation in Lengwe National Park in Malawi will probably increase under climate change conditions, precipitated by high temperatures, and equally high evaporation rates. The consequences are low vegetation productivity, habitat degradation and increased mortality among large mammals (Boko 2007). The arid highlands of Botswana, Namibia and Angola will become unsuitable for springbok and Hartmann's mountain zebra (SADC, SARDC, IUCN, UNEP 2008).

Box 1 **Community views regarding impacts of climate change**

"We used to eat plenty of wild fruits – matohwe, tsambatsi, mazhanje, matamba, tsenza and other herbal plants. The rain pattern was predictable – we had Madzura Chando (winter rains in June) followed by Gukurahundi rains in August, Bumharutsva rains in September and the Kutemera Gwati rains which signaled the start of the new rain season," said Mrs Rose Chamboko, who is 78 years old.

She said the rainfall pattern then was predictable and smallholder farmers knew exactly when to plant their crops. "But now things have changed. It's now difficult to plan. We don't know when to plant. Timing is now a big headache for us. Our crop harvest has fallen significantly and our soils now require more fertilizers which we can't afford. Rains are erratic and I think this has more to do with climate change." (CTDT 2009).

On the other hand, climate impacts on food security are not always negative. The 2002/03 floods in the northern province of Zambia brought both negative and positive significant impacts. The positives included increased rice yields in the Chambeshi river flats; growth in fish stocks; better pastures for livestock and increased groundwater recharge for the aquifers (UNEP, SARDC 2009). People in the Barotse floodplain have long relied on nutrient-rich silt brought in by the floods. In addition to that, predictions by Thornton and others (2006) indicate that agriculture and growing seasons in certain areas such as Mozambique may lengthen due to a combination of increased temperature and rainfall changes.

Apart from crops, livestock production contributes to the food basket for communities in the basin. Climate can affect livestock both directly and indirectly. Direct effects from air temperature, humidity, wind speed and other climate factors influence animal performance such as growth, milk production, and reproduction. Climate change can also affect the quantity and quality of livestock feed such as pasture, forage and grain, and the severity and distribution of livestock diseases and parasites (McCarthy and others 2001).

A decrease in mean annual precipitation in the Zambezi river basin is expected to have a negative impact on grassland. However a temperature increase is also expected to have a positive effect on the amount of grassland as forests shift to grassland. Studies by Seo and Mendelsohn (2006) show that a warming increase of 2.5ºC could expand the production of small livestock such as goats, which are heat tolerant.

Communities in the basin also rely on fish as a source of food. In Malawi, for example, fish provides 60–70 percent of the animal protein consumed and contributes 36–40 percent protein to people's diet. The fisheries sector provides direct employment for some 300,000 people.

In Malawi, fish production has decreased over the years as a result of water level variations in natural water bodies, lake water temperatures, surface wind and rainfall. Shallower lakes such as Chilwa often dry out completely as happened in 1914/15, 1966/67, 1993/94. The warming and declining wind speeds have reduced the mixing, nutrient enrichment, and the primary productivity of surface waters, affecting fisheries of Lake Malawi/Nyasa/Niassa, Cahora Bassa and Kariba (SADC 2008).

David Martin, APG

Destruction of mangroves would be a great loss to coastal communities.

The changing climatic patterns have also resulted in loss of habitats such as mangroves. In Angola and Mozambique the aerial roots of the mangrove rhizophora are a privileged refuge where fish can spawn, and they play an important role in the economic life of the surrounding inhabitants. Mangroves represent an essential source of income and means of subsistence providing fishing, firewood, timber, various foodstuffs, shellfish, medicines, and tourism. Additionally, mangroves regulate the tides and sedimentation and act as a protective barrier against storms and coastal erosion (Rocha and others, 2005). Thus their destruction would be a great loss to the communities around.

David Martin, APG

High temperatures result in increased evaporation rates.

It is recognised that a significant reduction in rainfall or increase in evapo-transpiration due to climate change would threaten the wetlands in the basin. Wetland areas, such as peat bogs, have stored enormous amounts of organic carbon for thousands of years. But wetland zones are increasingly drained for agricultural or logging purposes in the basin. The stored carbon then reacts with oxygen, producing carbon dioxide, one of the most significant greenhouse gases contributing to climate change.

According to the International Conservation Group report (2009), Africa's peat bogs (dead plant matter) hold 10 giga tonnes of soil carbon. Peat bogs are carbon sinks and lock up huge quantities of carbon that would otherwise end up in the atmosphere. While much of the continent's wetland zones remain intact, Zambezi basin wetland areas in the Kafue flats, Lukanga and Bangweulu swamps in Zambia, the Caprivi Strip in Namibia, as well as the Mozambique delta, and Lake Chilwa in Malawi are in danger of shrinking. As these wetlands shrink carbon emissions will increase.

As for water flows, negative impacts of climate change on freshwater systems outweigh its benefits. According to Magadza (2003), the Zambezi river has the worst case scenario of decreased rainfall (about 15 percent), increased potential evaporative losses (about 15–25 percent) and diminished runoff (about 30–40 percent).

Areas in which runoff is projected to decline face a reduction in value of services provided by water resources. For example, the Zambia National Heritage Conservation Commission (2007) warns that significant changes in water flows at the Victoria Falls since the 1970s will affect the plants that have adapted to the spray from the falls, and a change in the length of dry spells may result in the loss of some species in the "rain forest" around the falls.

Similarly, reduced river flow will lower the "smoking" sight of the Victoria Falls, making it less attractive to tourists. Communities dependent on tourists for marketing of their local goods and services will be greatly affected.

Reduced runoff will exacerbate current water stress, reduce the quality and quantity of water available for domestic and industrial use, and limit hydropower production in the basin states. The above predictions are supported by the IPCC reports which state that, due to the overall drying of the continent, between 75 and 250 million people are to be

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Wetlands are at risk of drying up.

exposed to additional water stress by the year 2020 (IPCC Reports 2007).

3.5 Climate Change and Gender

The climate related events compounded by poverty, environmental degradation, and inadequate disaster management, have profound impacts on poor women, men and children who may have less capacity, skills and resources to adapt. Women and men have different vulnerability levels and capacities to adapt to climate impacts due to differing roles, opportunities and access to resources.

Women and men face different risks to extreme climate events such as flooding. The Women's Manifesto on Climate Change (WEN/NFWI, May 2007) states that women make up 70 percent of the world's poor making them more vulnerable to environmental damage, while they also make up 85 percent of people who die from climate-induced disasters.

In the devastating cyclone Eline-induced floods of 2000, which affected Mozambique and parts of Zimbabwe, the death rate was higher among women (Brekke and others, 2009). This was blamed on cultural norms inhibiting women's movement without a man present, women not having learned how to swim, and women's lack of access to early warning information.

As women constitute the largest percentage of the world's poorest people, they are most affected by these changes. Children and youth – especially girls – and elderly women, are often the most vulnerable.

While estimates vary in different basin countries, women in Mozambique spend an average of 15.3 hours each week during the dry season and 2.9 hours during the wet season, drawing and carrying water. In Malawi, each household spends five percent of their active time collecting water (SARDC WIDSAA 2008).

According to a study by Mehretu and Mutambira (1992), fetching water for domestic consumption in a Zimbabwean family showed that women contributed 91 percent to this task with men spending one hour of the total household time on this chore while women spend 9.3 hours.

Gender inequalities are also exacerbated in the aftermath of disasters such as floods. The household workload may increase substantially in the face of disasters, forcing many girls to drop out of school to assist with household chores. Traditionally, household chores are left for women and girls to carry out.

A study by Ritchie (2007) from seven communities in Zambia, provides a snap shot of how human livelihoods are affected by climate change (see Table 4).

R.J. Boroto, SARDC

Access to clean water can be a challenge in dry conditions.

africanwater

Women and children spend more time fetching water.

Table 4 Main impacts of climate change

Droughts	Floods	Extreme heat	Sea level rise
F Crop damage/loss, leading to food scarcity and hunger F Water shortages F Reduced fish stocks F Income loss F Reduced charcoal business F Increase in diseases (affecting humans and animals) F Decreased water quality F Increased soil erosion F Decreased soil fertility F Increased honey production (if drought is not too severe)	F Crop damage/loss, leading to food scarcity and hunger F Loss of crop land and grazing ground F Decline in fish catches F Increase in diseases (malaria, dysentery, cholera, etc.) F Destruction of infrastructure (houses, roads) F Loss of life (humans and livestock)	F Increase in diseases affecting animals, crops and humans (especially malaria) F Decreased human capacity to do work F Loss of life (animals and humans) F Crop damage/loss F Reduced fish stocks F Decreased livestock feed F Reduced water quality	F Salt water intrusion, loses of coastal wetlands and mangroves, flooding of coastal sites

Source, Ritchie 2007

Table 5 **Establishing the linkages between MDGs, climate change and gender**

MDGs	Threats due to climate change	Gender implications
MDG 1 Eradicate extreme poverty and hunger	-Reduction of agricultural production for survival and commercial ends -Food security at risk -Less access to safe water	-Loss of domestic species of plants and animals used by women to ensure food security of their families. -Reduction, mobilization, or extinction of marine species used by women for household consumption or for productive activities. -Increase in women's workload due to decline in availability of water and other resources.
MDG 2 Achieve universal primary education	-Increases the workload for agricultural production and subsistence activities -Environmental changes are likely to drive migration	-Generally, girls and women are responsible for the collection of water and fuelwood. If the time they invest in these tasks increases, their capacity to attend school is at risk. -According to UNHCR, 80% of refugees in the world are women and children. Migration of populations, given extreme changes and disasters, could interrupt and limit the opportunities for education. -Men are more likely to migrate, either seasonally or for a number of years. Female-headed households left behind are often the poorest. -The workloads of these women, their children and the elderly increase significantly as a result of male emigration.
MDG 4 Reduce child mortality	-Environmental effects can aggravate the risk of contracting serious illnesses	-Increase in women's workload due to their role as primary carers in the family. -Loss of medicinal plants used by women.
MDG 5 Improve maternal Health	-Increased prevalence of some vector-borne diseases	-Pregnant women are particularly susceptible to water-borne diseases. Anaemia – resulting from malaria – is responsible for a quarter of maternal mortalities. -Women and children are fourteen times more likely to die than men during a disaster.
MDG 6 Combat VIH/SIDA, malaria and other diseases	-Increase in temperatures (heat waves)	-The high mortality rates of mothers/women/spouses during disasters result in an increase in: the numbers of orphans and mortality rates; early marriages for young girls causing them to drop out of school; trafficking and prostitution which in turn increase exposure to HIV and AIDS. -Migration enhances the risk of getting HIV and AIDS, given that families are separated and they are forced to live in overpopulated spaces. In developing countries, the poorer households affected by HIV and AIDS have less resources to adapt to the impacts of climate change. The need to adopt new strategies for crop production or mobilization of livestock is harder for female-headed households and for houses with HIV infected people.
MDG 7 Ensure environmental sustainability	-Extinction of species, change in species composition, changes in the quantity and quality of natural resources could reduce the productivity of ecosystems. -Floods, droughts, rising sea levels, melting of glaciers and icecaps.	-Without secure access to and control over natural resources, women are less likely to be able to cope with climate change impacts. -Less available drinking water means women have to spend more effort to collect, store, protect and distribute water. -Adaptation measures, related to anti-desertification, are often labour-intensive and women often face increasing expectations to contribute unpaid household and community labour to soil and water conservation efforts. Women often rely on a range of crop varieties to accommodate climatic variability, but permanent temperature change will reduce agro-biodiversity and traditional medicine options.

Source, IUCN 2008. *Gender and Climate Change*, IUCN World Conservation Union , Gland

Faced with the reality of climate change, societies can respond to climate change by adapting to its impacts, as well as by reducing greenhouse gas emissions (mitigation). Climate change adaptation reduces the magnitude of change. Both climate change adaptation and mitigation require policy reforms.

The IPCC defines adaptation as adjustment to natural or human systems in response to actual or expected climatic stimuli or the effects, with such adjustment moderating harm or exploiting beneficial activities (McCarthy and others, 2007). Mitigation refers to reducing emissions or increasing the carbon sinks.

4.1 Adaptation Strategies

Due to the vulnerability nature of the Zambezi river basin to climate change, adaptation is a necessity. Climate change impacts on the Zambezi basin are exacerbated by stresses such as poverty, unequal access to resources, and diseases such as HIV and AIDS (Bernstein 2007).

Adaptation to climate change is not new in the basin. Communities have always been at risk from climate hazards and people have continually sought ways of adapting. However, variations and extremes regularly exceed coping ranges, resulting in devastating effects.

Residents of the Zambezi river basin have a long history of adapting and reducing their vulnerability to the impacts of weather and climate related events such as floods, droughts and storms. These may need to be revived and strengthened. New adaptation measures in the form of new technologies suitable to the vulnerable communities need to be introduced.

The strategies in use in the Zambezi River Basin are at community, national and basin levels (Leary and others, 2007). These include:

- increasing the capacity to bear losses by accumulating food surpluses, livestock, financial savings and other assets;
- hedging risks by diversifying crops, income sources, food sources and locations of production activities;
- reducing exposure to climate hazards by relocating, either temporary or permanent;
- sharing risks through kinship networks, pooled community funds, insurance and disaster relief;
- reducing the sensitivity of production and incomes derived from natural resources by restoring degraded lands, using drought resistant seed varieties, harvesting rainfall, adopting irrigation and using seasonal forecasts to optimise farm management;
- preventing climate impacts through flood control, building standards and early warning systems; and,
- increasing the capacity to adapt through public sector assistance such as extension services, education, community development projects, and credit services.

A range of factors including wealth, technology, education, information, skills, infrastructure, and access to resources modify adaptive capacity (Brooks 2005).

L Munjoma, ZACPRO 6.2

Effective water management strategies are needed to promote water security.

4.1.1 Community level adaptation practices

Use of Indigenous Knowledge Systems

Climate change adaptation practices by communities living in the basin include diversification of livelihood activities, institutional reforms, adjustment in farming operations, income generation projects, seeking employment, new technologies, migration and moving off-farm livelihood incomes.

Incorporating indigenous knowledge into the climate change policies can lead to the development of effective adaptation strategies that are cost-effective, participatory and sustainable (Robinson and Herbert 2001). Local communities in the Zambezi River Basin have developed systems of gathering, predicting, interpreting, and decision-making in relation to weather.

A study in Malawi and Zimbabwe, for example, shows that farmers are able to use knowledge of weather systems such as rainfall, thunderstorms, and sunshine to prepare for future weather. Elderly farmers formulate hypothesis about seasonal rainfall by observing natural phenomena, while cultural and ritual specialists draw predictions from visions or dreams (Roncoli and others, 2001).

Other forecasting indicators include the timing of fruiting by certain local trees, the water level in streams and ponds, the nesting behaviour of small quail-like birds, and insect behaviour. The enhancement of this indigenous capacity is a key to the empowerment of local communities and their effective participation in the development process. People are better able to adopt new ideas when these can be seen in the context of existing practices. A study in Zimbabwe observed that farmers' willingness to use seasonal climate forecasts increased when the forecasts were presented in conjunction with and compared with the local indigenous climate forecast (Patt and Gwata 2002).

As predictions indicate that climate change will alter the ecology of disease vectors, use of indigenous plant material such as agrochemicals to combat pests that normally attack food crops would be useful adaptation strategies. Apart from the crops, traditional vegetables have been consumed for countless generations signifying their value and importance

in local cultures. However with the advent of the highly promoted exotic vegetables, there has been erosion on the traditional vegetable genetic resource base. With the effects of climate change at the fore, indigenous vegetables will definitely play a significant role in household food and nutrition security both in the rural and urban settings. In comparison with the exotic vegetables (the brassicas, crucifers), indigenous vegetables grow widely in any environment and require little attention. Spider flower (Cleome gynandra or nyevhe in the Shona language) for example, will germinate and thrive even in the worst of rainfall situations, be it drought or very wet conditions (CTDT 2009).

Organic manure, fertile land and adequate moisture levels are all that is required for optimum production of traditional vegetables. Farmers have explained that chemical fertilizers distort the taste of the vegetables. Chemical fertilizers also make the vegetables susceptible to pests and diseases.

Other indigenous strategies that local farmers adopt include restoring land by using organic manure, constructing stone dykes, managing low-lying lands and protecting river banks (Ajibade 2003).

Through traditional knowledge of the flooding regime of the Zambezi river, the Lozi people in Zambia use an old survival strategy, the Kuomboka ceremony, in which the Lozi King leads the people in an annual migration out of the plain at the height of the flood (Flint 2007).

Box 2 **Kuomboka ceremony in Zambia**

The ceremony is called Kuomboka, meaning "moving out of the water". Every year the king of the Lozi people journeys from the flooded plains to higher ground. Thousands gather to dance, feast and watch the royal barge rowed by dozens of oarsmen beneath a giant replica elephant.

The Kuomboka is traditionally the cue for local people to follow the king in escaping the rising waters, but the reality of climate change is catching up with this colourful ritual. The most recent flood came too soon and too strong, killing at least 31 people in Zambia's western province. The devastating aftermath left people hungry and homeless. "Flooding here is an annual event, but it came earlier than expected and people were caught off guard," said Raphael Mutiku, a public health engineer in Mongu.

Source, Oxfam 2007

Apart from the cultural aspect, the Kuomboka ceremony practised by the Lozi brings to Mongu, the provincial capital of Western province of Zambia, some US$30,000 in food and hotel accommodation for three days in a year (Oxfam 2007).

Adaptation in the agricultural sector

Adaptation options in the agriculture sector include crop diversification, mixed crop and livestock farming systems, using different crop varieties, changing planting and harvesting dates, and mixing less productive, drought-resistant varieties and high-yield water sensitive crops (Bradshaw and others, 2004). Crop diversity can serve as insurance against rainfall variability as different crops are affected differently by climatic events.

L Munjoma, ZACPRO 6.2

Laying the pipes in preparation for irrigating the crop

A study by Nhemachena and Hassan (2007), indicates that farmers in Zambia and Zimbabwe, are using crop management practices that include use of irrigation, water and soil conservation techniques and varying planting and harvesting dates to ensure that critical sensitive growth stages do not coincide with very harsh climatic conditions in the season.

Diversifying from farming to non-farming activities is a common option for both Zambia and Zimbabwe. Sale of poultry and livestock, informal trade and casual employment are some of the alternative activities common in the basin. The combination of activities in which a household engages depends both on the options available locally and the labour availability, education, skills, and access to capital. In addition to resource access, strong local links between and within social groups and local knowledge of environmental processes are important for coping and adapting.

Changing farming areas is not common in the Zambezi River Basin, although it plays an important role in managing climatic variability and change. In Mozambique, for example, people have plots on high ground for use when there is a lot of rain and on low ground for use when there is little rain (GECHS 2008). The people also use wetlands or depressions for cultivation in the aftermath of rains. The adaptation in the basin is also in the form of technology transfers in community areas. This includes use of new irrigation techniques such as the treadle pump which allows water to be distributed evenly and used efficiently.

Other strategies include use of fast-growing varieties in times of drought. In most parts of Malawi for example farmers have switched to fast-maturing varieties of favoured crops. They are also now planting a minimum of two crops in their fields and gardens, mixing cereals with pulses and tubers, often intercropping with nitrogen-fixing pigeon peas. Diverse crops and relay cropping through the rainy season are effective means of ensuring at least some harvest (IIED 2008).

Seasonal movement of livestock, splitting herds, changing herd composition and distributing livestock among relatives

and friends in different areas minimize risks from drought, floods or diseases. This option is restricted due to inadequate water sources for the livestock and lack of fencing in the alternative areas.

It is important to note that without support from governments, or other sponsors, some options like switching crop types or promoting irrigation, are often inappropriate or simply unavailable to low income groups because they entail high capital, technological and labour inputs and may close off other coping options.

From the drought assessments undertaken in Malawi, Zambia and Zimbabwe (UNEP, SARDC 2009), farmers are advised that the adaptation measures should not be taken as independent strategies but should be used in a complementary way. For instance, the use of irrigation technologies needs to be accompanied by other good crop management practices such as use of crops with better use of water, use of efficient irrigation systems, growing crops that require less water and using improved irrigation water-use practices. However, in all these strategies smallholder farmers should be supported.

Box 3 Coping strategies for women in Zimbabwe

Community Technology Development Trust (CTDT) is assisting women in the rural communities with adaptation and mitigation strategies to combat the effects of climate change. One method that is being applied is conservation farming. The story of Agnes below, is a case study of a woman benefiting from conservation farming.

"Ever since I joined the CTDT Conservation Farming three years ago, my harvest has increased remarkably. Conservation farming basically taught us on ways to use a little piece of land with a little amount of fertilizer and manure to produce the highest yields. For the past three years my harvest is increasing greatly with each year. They viewed both men and women as equals, they did not discriminate anyone on the basis of sex.

"The beneficiary assessment and selection was on the basis of need. The community participated in compiling the beneficiary list. It was the people who live with me everyday that see it befitting for me to be a beneficiary, together with other women whether single or married that were suffering like me. Every year I get fertilizer and seeds from CTDT and I was taught on good and conservative farming in which I can use manure and seed without disturbing the soil structure to produce the maximum harvest.

"Before I joined the conservation programme I harvested only 3 bags of maize which is about 150 kilograms. My harvest has remarkably improved to about 16 to 18 bags. I now can afford to sell some of the maize. I get money to pay school fees and I have more time to work in my own fields. There is no need for me to toil in other people's fields for money anymore.

"I am so impressed with the results of conservation farming that I actually started equipping my neighbours who are not necessarily beneficiaries of the programme with the knowledge that I have gained from CTDT. Most of my neighbours are women whose husbands have either died or are working in the city. CTDT has not helped only me but indirectly these families too. We are moving to a point where we could actually be food secure."

Source, CTDT News climate Change 2008

In a study in Malawi, Osgood and Warren (2007) report about a drought insurance scheme introduced for the small farmers. The insurance contracts are written against an index that, for example, describes an established relationship between lack of rainfall and crop failure, verified by long historical records of both rainfall and yields. If rainfall turns out to be low, falling below an agreed trigger point, the farmers receive payouts. But whether the insurance pays out or not, farmers still have the incentive to make productive management decisions.

The main advantage over crop insurance is that when rainfall is low enough to cause crops to fail, insurers will pay out farmers quickly, so that farmers do not need to sell off their assets to survive. The money will see them through the drought period, and will be able to continue farming when the rains resume.

The farmers are however insured only against drought. If crops fail due to other reasons such as pests, diseases and floods there is no compensation. Furthermore the study noted that while the index-based insurance is the key to raising production and incomes in the smallholder farming community, it does not protect the poor, most of whom do not have access to land and/or are too marginalized or vulnerable to be economically active.

The Malawian farmers preferred signing up for the insurance scheme as a way of adapting to climate variability and change. Recently the insurance scheme was introduced in Tanzania.

Community-based adaptation strategies

Community-Based Adaptation (CBA) is emerging as a key response to the challenges of climate change. Tailored to local cultures and conditions, CBA supports and builds on other adaptation strategies to climate variability, such as the traditional Kuomboka ceremony and the floodwater dryland farming in the lower Shire valley, which helps small farmers' crops survive climate-driven floods (Flint 2007).

The CBA is participatory, involving both local stakeholders and development and disaster risk reduction practitioners. As such, it builds on existing cultural norms while addressing local development issues that contribute to climate vulnerability. CBA is now gaining ground in many parts of the basin.

In the upper Zambezi basin CBA involves cultivation of fruits and vegetables, harvesting of reeds and grass for use in house-building, mat-making and basketry, some of which is for sale outside the valley. The communities have also introduced growing of crops that are not likely to be adversely

SARDC

Growing drought-resistant crops such as sorghum is one of the adaptation strategies for climate change.

affected by climate change. These include cassava and cashew nuts. The two crops can survive in sandy soil and withstand drought, and are commercially viable.

In order to stimulate cultivation of crops, adaptation incentives such as processing plants where local growers could trade their crops have to be encouraged. These have been lacking, resulting in communities abandoning crops such as cashew nut orchards.

Apart from crop-related activities, community-based early warning systems are effective in parts of the basin. In the past, local knowledge about early warning signs had been largely dismissed as unscientific, but it is increasingly clear that such knowledge can complement technical warnings. For example, in Mozambique, downstream communities watch the colour of the river water and the size and type of debris floating to judge the magnitude of a potential flood. Communities monitor many other warning signs, especially animal behaviour (Howell, 2003). Instead of dismissing this local knowledge, it should be studied and integrated into warning systems.

Local authorities and communities clearly have a major role to play in the communication and dissemination of warnings. Not only can they assist in the actual dissemination of messages, such as volunteering to go from house to house or transmitting warnings via local radio broadcasts, they can also feed information back to the warning providers such as the Civil Protection Unit or the meteorological offices, about how they might be made more actionable or comprehensible.

According to a survey by the International Federation of Red Cross and Red Crescent Societies (2007), community-based, wind-up and solar-powered, Freeplay Lifeline radios eliminate the need for batteries or electricity and can provide poor households with reliable access to disaster warnings and other lifesaving information. The radios can withstand dust, water and harsh temperatures. These radios can ensure dependable and free access to information broadcast over AM, FM or shortwave frequencies.

The Mozambique Red Cross Society has integrated Freeplay Lifeline radios into its cyclone and flood early warning activities (IFRC, 2007), and the radios have been credited with dramatically improving the country's ability to prevent a repeat of the devastation caused by the 2000 flood and cyclone disaster. Disaster preparedness volunteers are charged with guarding the radio on behalf of the community and listening to broadcasts. When a warning is sounded, the activists alert village leaders and a pre-planned response is launched. Such radios are also being used in Zambia under the project called RANET (Radio And InterNet). (Box 4)

Box 4 RANET in Zambia

RANET-Zambia project, which is a joint initiative of the Zambia Meteorological Department and community radio stations, was conceived with a mandate to disseminate accurate and timely weather/climate information on behalf of the Zambia Meteorological Department to users in a precise and easy-to-understand manner. Its aim is to rise to the challenge of exchanging vital developmental information by introducing new information and communication technologies using Worldspace Foundation digital satellite radio broadcast. The objective of the project is to enhance the living standards of rural communities by increasing their access to vital information on weather, climate, agriculture, health, environment, natural calamities and other vital developmental information.

The National Information Centre (NIC), based at the Zambia Meteorological Department Headquarters collects relevant information from stakeholders and prepares this information for the RANET website. The content is then sent to the uplink station in Pretoria, South Africa and Niamey, Niger, where it bounces to the satellite. The Worldspace satellite then broadcasts this content and can be received and viewed by a RANET community radio station. The broadcaster at any RANET radio station browses through the contents and selects the desired information for translation into a local language and then broadcasts on FM radio to the community. The RANET radio station also provides a forum for discussion by the community of issues affecting their livelihood.The RANET-Zambia project plans to reach all the 72 districts with developmental information.

Source, Proceedings of SACORF 13 meeting (2009)

Warning messages that are broadcast on radio can quickly reach isolated rural communities where no other form of communication can. However, in the poor communities, even radio ownership is rare. A radio may often be the first "luxury" good procured by a household, yet the need to purchase disposable batteries means that regular radio use is expensive.

Another related community-based strategy is the Community Based Risk Management of climate change-related diseases, which was established in 2005 in Mozambique (World Disasters Report 2009). This people-centred risk and resilience approach starts with motivation of the individual and their desire to achieve well-being. Community risk and resilience strategies can help stimulate that process for local groups. The infectious disease risk reduction programme in Mozambique found that area-specific risk committees were able to assess and intervene in health hazards and vulnerability in relation to various types of health threats. (Box 5) An established community group or committee is empowered to communicate, on behalf of the people it represents, with other institutions such as local government or non-governmental organisations that then help to facilitate targeted risk reduction.

The health risks discussed in the Box below are due to use of contaminated water and poor hygienic methods such as not washing fruits before eating and not washing hands after visiting the toilet.

4.1.2 National and basin adaptation strategies

Flood management

The Zambezi River Basin has some communities living in flood-prone areas. Examples of such areas include the lower Shire in Malawi, Caprivi in Namibia, the Zambezi delta in Mozambique, the Muzarabani district in Zimbabwe and the Kazungula district in Zambia. As water crosses national boundaries, the impact from climate-induced floods requires flood management at national and regional levels.

Flood management consists of both structural and non-structural measures. In most parts of the basin the former consists of dams and weirs. Although these were put in place to improve water security, they also serve as flood control structures (Madamombe 2006).

The non-structural measures range from flood forecasting to rescue operations, as well as defining areas to settle. Data collection of rainfall and discharge from rivers is done by the relevant national agencies. Other sources of information are satellite observations, forecasts from other institutions, information from the local communities and local authorities. Dissemination of information is normally through newspapers, radio, television, telephone, internet, and awareness programmes by government and non-governmental organizations. Multi-sectoral meetings on flood management, coordinated by the civil protection agencies are well attended and positive contributions are made (Madamombe 2006).

Topics which are normally covered during the meetings include information about where floods normally occur, that people should be aware of the normal behaviour of their rivers, identifying areas to relocate to in the event of floods, the need to work as a community when floods occur, survival tactics, what to do after the floods, as well as the type of house to construct, and materials to use in order to reduce the impact of floods on shelter.

While other places face significant impacts during floods, Mozambique is always hit the hardest due to its geographical position being at the lower receiving end of the river basin.

Recognising the increase in frequency and severity of climate-change-related floods, Malawi, Mozambique, and Zambia established National Disaster Management programmes in

Box 5 Community-based risk management

In 2005, the local health department in Beira, Mozambique, and the infectious disease risk established a community-based risk management unit. The main aim was to reduce diarrhoeal disease risk through community-based risk management. This was achieved through establishing a coordinated network of risk committees in key disease risk areas. These would be effective in the reduction of diarrhoea disease risk, through a 'system-supported community-based risk management' approach. This was a practical, low-cost strategy to enable management of diarrhoeal disease risk at the local level and to become the first stage of a community-based early warning system. The approach places emphasis on avoiding disease epidemics through effective risk management, rather than expensive emergency aid interventions once epidemics occur.

The specific objectives of the community-based risk management unit were to:

- improve community-based risk management through the establishment of area-specific risk committees
- improve communication channels between community risk committees and stakeholders in order to facilitate appropriate and timely risk reduction
- improve cholera risk management at the 'central' level through monitoring of risk information produced by risk committees.

The committees consist of a core membership, which identifies and monitors the risk areas and, most importantly, encourages community members to manage and reduce diarrhoeal disease risk. The committees disseminate risk information to key service providers and health institutions such as city health authorities and the city council. These groups in turn provide committees with technical information and support where appropriate and possible. The work of the committees is flexible, as it must adapt according to changing hazards and vulnerabilities in the population and environment. Participatory community-based assessments encouraged community responses, with the committees being run and managed as unique entities by the community. This approach builds organizational capacity to respond to disease risk by increasing civic knowledge of disease risks and risk reduction measures. It develops advocacy skills at the local level to enable the community to mobilize interventions and lobby the authorities and other stakeholders to address identified disease risks. Some of the disease risks are also, at the request of the community, confirmed through laboratory analysis provided by the local health authority.

Source, World Disaster Report 2009

1996, 1999 and 1991 respectively. In Mozambique, the establishment of the National Disaster Management Institute was a change in approach to disaster management, from reaction to preparedness. A National Policy on Disaster Management was formulated in the same year (IRI 2007).

Under the Mozambique disaster policy, preparedness for floods is facilitated by a flood early warning system. This provides forecasts of flood risk, detects and monitors flooding, and puts out flood warnings when necessary, paving the way for a coordinated response. The flood early warning system is coordinated by the National Directorate of Water, together with the National Institute of Meteorology and the National Disaster Management Institute. This collaboration reflects the essential integration of hydrologic and climate information needed to understand and predict floods and to manage an effective response.

If flooding is expected, a flood team is mobilized. When a flood occurs, the team's role is to monitor the situation, receive and analyze information, recommend responses, ensure collaboration between the different bodies involved, and coordinate activities at central and local levels.

The National Disaster Management Institute works closely with the Drought Monitoring Centre for Southern Africa and the Southern Africa Regional Climate Outlook Forum (SARCOF). These bodies work with Regional Water Administrations (RWAs), which monitor water levels and provide data to the National Institute of Meteorology.

The RWAs issue flood warnings when necessary, to district governments and local authorities and also to the media (radio, television, and newspapers). District governments and local authorities, civil protection units, in collaboration with the Red Cross and other non-government organizations (NGOs), are responsible for the dissemination of information, and in particular warnings, at the local level, and for the evacuation of people before floodwaters rise.

According to the World Disaster Report (2009), Mozambique now has a tropical cyclone warning system, distinct from the flood early warning system. This informs people of the probable arrival of a tropical cyclone at least 48 hours in advance. Colour-coded messages, including flags, are used to warn the people. A TV studio devoted to weather forecasting is also in use.

In other parts of the basin, flood management also includes harnessing floods. A case in point is the demonstration in Malawi's Dzimphutsi district through projects implemented by the SADC Water Division in collaboration with the Malawi government. Harnessing floodwater to improve people's livelihoods is done through activities such as irrigation, fish farming, livestock production and flood control. The initiative involved carrying out a feasibility study towards the use of floodwater for dry-land agricultural production and increasing food security. This included the construction of a small dam on Mkuzi stream near Dzimphutsi village to trap floodwater. Through the support from the Danish International Development Agency (Danida), SADC Water Division initiated four other demonstration projects at regional level.

Some basin states now have structures in place for domestic flood management, but a country cannot address its water-related climate challenges alone, since weather events outside the country often largely determine the internal situation. To take care of this gap and recognising the increased frequency and severity of climate-change-related disasters such as floods, droughts, and diseases, a Zambezi River Basin Initiative for disaster reduction was established in 2008 by International Federation of Red Cross and Red Crescent Societies [see Box 6].

Box 6 IFRCS Zambezi Basin Initiative

International Federation of Red Cross and Red Crescent Societies (IFRC) have launched a long-term, basin-wide initiative to support vulnerable people living in the Zambezi basin in seven countries.

The Zambezi River Basin Initiative (ZRBI) is a joint programme involving Angola, Botswana, Malawi, Mozambique, Namibia, Zambia and Zimbabwe. Red Cross Societies seek to support about 600,000 people living in villages and towns in the basin over the next eight years. The initiative targets three categories of people who are most vulnerable to the threat of floods and drought. These include the extremely poor (i.e. those who are unable to make a living in normal times without some form of assistance); chronically vulnerable (classified as poor and fall below the accepted poverty line but are economically productive and can respond to interventions aimed at supporting their livelihoods); and the transitory vulnerable (i.e. those who are normally able to make an independent livelihood, but need support in hard times) (IFRC 2009)

The ZRBI is aimed at reducing vulnerability and building community resilience against hazards and threats focussing on disaster preparedness, response and risk reduction, food security, HIV and AIDS, malaria and cholera prevention, water and sanitation, and capacity building.

At national level, the National Red Cross Societies and other humanitarian organisations are embarking on disaster preparedness and response strategies in the vulnerable communities of the Zambezi basin.

Source, IFRC 2008 Zambezi River Basin Initiative

Strategies for health implications of climate change

Malaria

Malaria, a major illness causing as many as three million deaths each year in the world, remains one of the greatest health and developmental challenges in the Zambezi basin (IRI 2007). The majority of people living in the basin reside in malaria zones. Climate experts predict an expansion of malaria cases to zones which are too cool for malaria such as the Highveld of Zimbabwe and the Highlands of Zambia, due to climate-change-related rises in temperature.

In response to the threat, partners in the Roll Back Malaria initiative (WHO, UNICEF, UNDP and the World Bank) developed a new early warning and response approach that includes seasonal forecasts and climate monitoring as well as vulnerability assessment, case surveillance, and response planning (Connor and others, 2007). The four components allow planning and preparedness for epidemics, so that response activities can be implemented in the right place at the right time.

The Roll Back Malaria initiative aims to identify stakeholders, consolidate research, and deliver concerted support to malaria control through the development of strong national and regional health systems. Under the initiative's targets endorsed by African States in 2000, national malaria control services are expected to detect 60 percent of malaria epidemics within two weeks of onset and to respond to 60 percent of epidemics within two weeks of their detection.

The Malaria Early Warning System has been introduced in Botswana, Mozambique, Namibia and Zimbabwe of the eight riparian states. In Botswana, routine vulnerability monitoring and regular assessments of drug efficacy are done at key sites. With this early warning system, if an epidemic looks likely ahead of the malaria season, emergency containers with mobile treatment centres and necessary medical supplies are prepared.

Zambia is witnessing reduced incidences of reported malaria cases due to the revival of the indoor residual spraying programme as well as provision of insecticide-treated nets.

Current malaria control strategies rely mostly on individuals and communities taking action themselves to reduce mosquito breeding sites, sleep under mosquito nets, welcome spray teams, and treat symptoms of malaria with anti-malarial drugs, either at home or at nearby health facilities. These strategies succeed only when communities understand the causes of malaria and how to prevent and treat the disease.

Decentralization of health services has been a huge challenge to the control of epidemics where rapid responses are required with resources that are often not available at community level.

USAID

Bed-nets are widely promoted for malaria control and are especially effective when treated with insecticides.

Cholera

Due to the increased number of cholera cases in recent years, the Ministries of Health in all the Zambezi riparian states have intensified monitoring and surveillance for the disease. As part of the cholera preparedness activities, local level Emergency Preparedness Plans have been revised along with the establishment of and improvements in the configuration of Emergency Management Committees and Rapid Response Teams.

The World Health Organisation (WHO 2009) reports that public education efforts on cholera have been intensified across the basin. Community mobilisation campaigns focussing on personal hygiene, food safety and sanitation, have been initiated in all districts. Whilst sensitization and training of health workers on the prevention and control of cholera cases is happening in all basin states, this is being intensified in districts close to the Zambezi river which include Mutarara, Zambezia, Tete, in Mozambique and Muzarabani in Zimbabwe where floods are frequent.

Adaptation strategies for water resources

Water is the primary medium through which climate change impacts are felt. As such it is appropriate to have effective water management strategies involving both supply- side and demand-side approaches during climate-change-induced disaster episodes such as drought and floods.

Supply-side options generally involve increases in storage capacity, rain water harvesting, water transfer or extraction from ground water. Demand-side options involve improvement of water-use efficiency by recycling, reduction in water demand by efficient irrigation technologies, use of virtual water through importing agricultural products, improved water management to prevent waterlogging, erosion and leaching, reallocating water to high-value-water use and encouraging water conservation through pricing water (Bates and others, 2008).

In the Zambezi basin the most common approach to improve local water supply is rain water harvesting, either by practices that aim at enhancing soil infiltration at the site, improving rain-fed cultivation, or collecting and diverting rainwater to reservoirs. Modern rainwater harvesting projects are usually based on traditional practices.

Related to these options, a coherent approach of promoting water security that will address current climate variability as well as the challenges of climate change is that of Integrated Water Resources Management (IWRM). IWRM is a process that promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (GWP 2004). Successful IWRM strategies include capturing society's views, reshaping planning processes, coordinating land and water resources management, recognizing water quantity and quality linkages, conjunctive use of surface water and groundwater, and protecting and restoring natural systems, including consideration of climate change.

World Agricultural Forum

This treadle pump is used to access groundwater.

If properly implemented, an IWRM approach is inherently adaptive as it should inform water users about water challenges and provide a framework through which such challenges can be addressed. The Zambezi riparian states have formulated an IWRM Strategy for the Zambezi River Basin. It is expected that once in force, the ZAMCOM secretariat will operationalise the Strategy.

Box 7 Principles of IWRM

IWRM is founded on the Dublin Principles, which assert that:

1 Freshwater is a finite and vulnerable resource, essential to sustain life, development and the environment.
2 Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels.
3 Women play a central part in the provision, management and safeguarding of water.
4 Water has an economic value in all its competing uses and should be recognized as an economic good.

Table 6 Main adaptation activities, interventions and delivery methods

Adaptation goal/ Expected outcomes	Main line of intervention and delivery
Minimize physical exposure to climatic hazards	o Flood control measures such as dams, levees, early warning systems, improved drainage, river re-routing, improved land management, e.g. watershed afforestation to manage runoff, preservation of wetland systems to manage runoff o Coping with drought measures such as improved water management/water harvesting o Frost control measures such as watering or covering crops/plants at night o Migration or relocation away from flood zones, coastal areas
Avoid or reduce potential for adverse impact	o Improved water treatment to avoid contamination from flood waters, salinization o Reducing dependence on rain-fed agriculture o Drought Insurance o Manipulate systems (such as ecosystems and infrastructure) to withstand new climatic conditions through crop/tree breeding or genetic manipulation
Enhance adaptive capacity and resilience (address determinants of adaptive capacity)	o Increase wealth/income especially of rural poor through economic diversification, access to micro-finance o Modify climate-system relationship such as through manipulation of thresholds or coping ranges, dependence on climate (e.g. reducing dependence on rain-fed agriculture), etc. o Improve ecosystem integrity through reduced siltation and erosion control, fire control, eradication of invasive species, avoid overgrazing, rehabilitate degraded areas
Improve planning to take changing climate into account to avoid an adaptation deficit and to remove any barriers to adaptation	o Modify planning processes to integrate climate change and adaptation into sectoral and national plans (mainstreaming) o Remove barriers through policy review and/or development of new policies to facilitate adaptation
Create and manage information to facilitate adaptation	o Build knowledge bases through research, monitoring, extension and outreach, early warning systems, etc., to improve adaptation planning and implementation o Build capacity in communities to take climate change into account.

Source, GEF 2007, Assessment of Impacts and Adaptation to Climate Change Project

4.2 Mitigation Strategies

Mitigation of climate change is a human intervention strategy aimed at reducing the sources or enhancing the sinks of greenhouse gases (IPCC 2007). For the most vulnerable communities such as in the Zambezi River Basin, the potential for implementation of mitigation measures is low. Adaptation is the major concern, unless the mitigation option enhances adaptation at the same time.

Some mitigation measures may disrupt traditional food production systems thereby compromising food security. For example, increasing dependence on energy crops may compete with food crops for water and land, and reduce biodiversity while increasing vulnerability to climatic extremes. FAO (2008) states that evaluation standards are needed to ensure mitigation strategies have no negative impacts on food security. For instance, clear guidelines would help to resolve some of the conflicts between rural income from bioenergy and food security.

4.2.1 Mitigation options in the agriculture sector

Agriculture and land-use change resulting in deforestation are major contributors to climate change. The IPCC Fourth Assessment Report found that agriculture, which consists of cropland, pasture and livestock production, contributes 13 percent of total human induced greenhouse gas emissions.

Cropland mitigation measures remain unexplored although many adaptation options also contribute to mitigation. Among these measures are soil management practices that reduce fertilizer use and increase crop diversification; restoration of peaty soils and degraded lands; promotion of legumes in crop rotation; increasing biodiversity; avoiding burning of crop residues; promotion of low energy production systems; and promoting efficient energy use by commercial agriculture and agro-industries.

Mitigation options in livestock include improving livestock waste management through covered lagoons to reduce methane emissions; improving ruminant livestock management through improved diet, nutrients and increased feed digestibility; improving animal genetics; and increasing reproductive efficiency.

SARDC

Crop diversification helps in mitigating the effects of climate change on food security.

4.2.2 Wetlands restoration as a mitigation option

Wetlands International, a global organisation based in the Netherlands, says preventing the loss of wetlands and their stored carbon is a challenge, but is possible and at a relatively low cost. What is needed is a mechanism similar to the one set up to stop forest carbon emissions. "The huge carbon losses of wetlands are totally overlooked. Climate change talks should call for a similar scheme where developed countries support developing countries such as those in Africa to maintain their wetlands, and restore their wetlands and get credits – money – for the carbon they prevent from reaching the atmosphere," (Wetlands International 2009).

Parties to the Ramsar Convention on Wetlands have agreed to protect and restore wetlands and watersheds, and to prevent and mitigate damage by natural disasters on such ecosystems. Six of the eight Zambezi basin states are party to the Ramsar Convention, and these are Botswana, Malawi, Mozambique, Namibia, Tanzania and Zambia.

4.2.3 Mitigation options in the forestry sector

The IPCC reports state that deforestation contributes 20 percent of the annual global carbon dioxide emissions and constitutes the main source of human-induced greenhouse gas emissions from many developing countries. Three of the 10 largest forest losses in southern Africa are in Zambezi basin states, namely Tanzania, Zambia and Zimbabwe (SADC 2009).

Although the riparian states have put in place programmes and policies aimed at making modern energy services available to the rural and urban poor through electrification of public facilities such as schools and clinics, traditional biomass remains the predominant source of energy for cooking and heating needs of the majority of the population.

Biomass is the primary source of basic energy and accounts for 80 percent of total energy consumption for families and informal businesses particularly among the rural and urban poor. This includes the use of woodfuel, charcoal, agricultural residue and animal dung. In response to massive use of wood fuel, a Programme for Basic Energy and Conservation (ProBEC) implemented by the German Agency for Technical Co-operation (GTZ), stimulates the establishment of various projects based on basic energy conservation in nine SADC member states. Six of these are Zambezi river basin states – Botswana, Malawi, Mozambique, Namibia, Tanzania and Zambia. ProBEC promotes the use of improved fuel efficient stoves such as rocket and clay stoves and promotion of efficient tobacco rocket barns to reduce wood fuel use.

In Zambia ProBEC has constructed nine rocket barns in the Southern Province and conducted user training workshops. In the Manica province of Mozambique, ProBEC is promoting the fixed mud stove (Poupa Lenha fixo); the portable clay stove (Poupa Lenha movel); the Mangi-Mangi or institutional portable stove; the institutional rocket stove (fixed) and ovens for bakeries (ProBEC).

In other parts of the basin, the Tanzania Technology Development Organisation (TaTEDO) in collaboration with district and municipal councils, NGOs, and Community-Based Organisations (CBOs), performed capacity building activities in efficient use of wood fuel in villages called Laela, Mtibwa, Matai, Kisumba and others in Sumbawanga municipality. The capacity building included training on how to bake using TaTEDO ovens, construction of Okoa improved woodfuel stoves, and sustainable charcoal production practices using improved charcoal production methods, and multi-purpose energy tree growing.

REDD and AFOLU programmes

The 13th Conference of Parties of the UNFCCC held in 2007 put forward a concept of Reduced Emission from Deforestation and Degradation (REDD) in which developing countries would be provided with financial incentives for reducing emissions from deforestation. This step has opened an opportunity for the basin countries to work on a carbon credit mechanism for the forestry sector. However, the REDD approach does not seem to benefit the basin, as it favours rainforests such as the Congo. Most parts of the Zambezi basin have sparse woodland which may not be suitable for such initiatives and thus not eligible for the financial incentives. In addition it is not clear how to ensure that compensation from REDD is distributed fairly in countries where many people are subsistence farmers. There is also a possibility that rich people would buy up land in order to claim the compensation, thereby not benefiting the poor (RCCP 2009).

In view of these shortcomings of the REDD programme, southern Africa calls for an approach which is inclusive of agriculture, forestry and other land uses (AFOLU) (World Agroforest Centre 2009). Already the Uchindile-Mapanda reforestation project in Tanzania has secured exclusive access to carbon credits from the first AFOLU project validated to the Voluntary Carbon Standards. The project involves the reforestation of degraded grassland across the Uchindile-Mapanda districts, to create a sustainable forest, which delivers income to the local community and conservation area designed to ensure that local indigenous species are protected. On 18,379 hectares of land at the project, four varieties of trees will be planted. Eucalyptus and pine will be planted on 7,252 hectares at Uchindile and 3,562 hectares at Mapanda while the remaining area will be used to conserve natural forests, wetlands, blue swallow habitats and native plant species (World Agroforest Centre 2009). In many other parts of the basin, eucalyptus, which is not indigenous, are being removed due to heavy water usage.

Harvesting of the eucalyptus (blue gum) and pine trees will occur every 13 and 21 years, respectively, ensuring a base forest cover and that capacity for regeneration is constantly maintained. A range of exotic and indigenous tree species and local fruit crops has also been planted on the project sites to improve species diversity, ensuring the forest's health and resilience.

Box 8 The Uchindile-Mapanda AFOLU Project

How is the local community involved and benefiting from the project?

The Uchindile-Mapanda project followed a strict process of local approvals before receiving permission to proceed. In order to acquire the land, Green Resources had to obtain permission from the village following a presentation of how the project could work and the local community investment that would be generated from it. Once the village gave its approval, the request to acquire the land went up through the district government and then on to the Ministry of Lands for final permission to be granted.

Ten percent of the carbon revenues from the forests have been allocated to initiatives which will benefit the local communities. The project managers have established, a list of their priorities in consultation with village members. These include education, health and infrastructure. So far the investment has built seven classrooms, a dispensary and a teacher's house. A community hall and a nurse's house have been planned. Infrastructure improvements include the construction of about 200 kilometres of new roads and 100 kilometres of road renovations, plus improved road signaling and signs. Portable water pumps have been installed wherever water quality was a problem.

The project is important to Tanzania for many reasons. Between 1990 and 2005, Tanzania lost 14.9 percent – or just over six million hectares – of forest cover through deforestation. The Tanzanian government has responded with numerous policies to stem further degradation. However, with limited public funds these policies lack the financial incentives to be widely effective. This project will supply carbon finance to an African country, which will enable the creation of local employment, wealth, and development of capacity and expertise.

Source, World Agroforest (2009)

Carbon sequestration

Carbon sequestration is a policy for long-term storage of carbon dioxide to mitigate global warming, and it has both economic and environmental benefits relevant for the basin states. Efforts to mitigate climate change through carbon sequestration projects could bring in funds to raise local incomes and regenerate natural resources.

Carbon sequestration through afforestation and reforestation can often generate locally valued ecosystem services such as improved water quality and reduced soil erosion and sedimentation. It further encourages adoption of agro-forestry and other land management techniques that store carbon and pay local communities for carbon credits. In the Zambezi basin efforts are being made to encourage such projects.

In addition, many international private organizations are promoting carbon sequestration projects to balance their carbon emissions. The World Bank's Bio Carbon Fund is currently the biggest investor for carbon sequestration projects (APF 2008)

4.2.4 Community mitigation options to replace fossil fuels

There is global consensus that over-reliance on fossil fuels, unsustainable exploitation of bio-fuels and inefficient energy conversion methods contribute to climate change while energy from renewable sources, the sustainable use of bio-fuels and energy efficiency and conservation are central to the solutions for climate change.

Bio-energy produces mitigation benefits by displacing fossil-fuel use. The common source of such fuel is extracted from plants such as Jatropha, cotton seed, soya bean, sugar and sunflower. These plants are also known as Straight Vegetable Oils (SVOs) (Jones et al, 2002). The SVOs are a renewable fuel produced locally and can be used in unmodified diesel engines. The use of SVOs reduces greenhouse gas emissions such as hydrocarbons, carbon monoxide, particulates, soot and other air toxins, and at the same time, they are biodegradable. In Zimbabwe and other basin countries, bio-diesel used in small-scale industries is produced from Jatropha and ethanol in place of coal and diesel.

However, largescale bio-fuel production raises questions of high fertilizer and pesticides requirements, impact on nutrient cycling, energy balances, biodiversity impacts, hydrology and erosion, conflicts with food production, and the level of financial subsidies required.

Other community level, energy-related mitigation strategies include the use of solar power. There has been an increase in solar initiatives in the basin since the turn of the millennium. This is mainly due to the free and abundant sunshine in the region as well as the fact that products can stand alone with no connections required. Many of these have concentrated on solar water heaters, solar cookers, solar dryers, solar lanterns, solar streetlights, and the conversion to electricity using Photovoltaics.

UN FAO

The use of solar power can reduce deforestation.

Respondents to a survey carried out by Practical Action in Tanzania say that through the use of solar technology their working day is more productive and women are able to do some of their chores at night. "Since the solar panel came I have been getting four hours of lighting using the solar lantern. I have also managed to put light where I operate the poultry business," says one respondent.

Other successful solar initiatives that have worked for many communities include the SolarAid which has a project called Lighting Malawian Homes.

In 2004, BP Solar, a British company established a renewable energy source for 360 people living in the village of Paranhos, in Angola. The freestanding solar panels have been providing this village with clean, renewable solar energy to power community facilities such as the local school, medical facility, water-pumping facility, and vaccine refrigerator. According to a report by Solar Panel Information (SPI), Angola's Ministry of Energy and Water is exploring the feasibility of using the Paranhos project as a model for the rest of the country. Through solar power, use of fossil fuel such as diesel, paraffin, petrol and coal is reduced.

While solar power is a clean and renewable source of energy some researchers claim that it cannot provide sufficient power for more than basic necessities, such as lighting, heating and cooking. Largescale photovoltaic electricity is more expensive than that produced by coal, natural gas or hydropower (Drissen 2004) and is beyond the reach of many communities living in the basin.

4.2.5 Clean Development Mechanism

The Clean Development Mechanism (CDM), a programme under the Kyoto Protocol where rich countries pay developing countries to run emission reducing projects, is another mitigation strategy. The African continent has 71 of the nearly 2,156 CDM projects in the world. Of these, 33 are in southern Africa with only four in two countries of the Zambezi basin. Tanzania and Mozambique have three and one, respectively.

The CDM, which has emerged as the most lucrative source of "carbon financing", allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol to implement emission reduction projects in developing countries rather than in their own. It also enables developing countries to increase energy access while limiting greenhouse gas emissions by harnessing clean energy sources such as hydropower, wind, solar and bio fuels.

The CDM recognizes carbon sequestration through forestry as a way to mitigate global warming. The CDM allows industrialized countries to offset their carbon emissions by investing in forestry projects in developing countries rather than reducing their own emissions. Major developmental benefits for local communities from these projects include an increased number of timber and non-timber forest products from regenerated forests, employment opportunities from forestry activities, and potentially increased incomes from the sale of carbon credits.

The development potential of transactions under the CDM is constrained by a number of factors. This is because concluding deals under the CDM in low-income countries such as those in the Zambezi basin can be more expensive, time-consuming and risky than buying carbon credits elsewhere. Smallscale projects which have more potential for benefits for local livelihood are less likely to be targeted because of their high transaction costs. Bundling small projects into a programme of activities should help to reduce transaction costs and promote CDM projects in low-income countries.

Box 9

Carbon Finance and the Clean Development Mechanism (CDM)

Carbon finance is the general term applied to resources provided to purchase greenhouse gas emission reductions. Carbon finance is driven either by mandatory regulatory structures or by voluntary actions aimed at limiting the right to emit greenhouse gases into the atmosphere. Carbon finance permits governments, companies, NGOs or private foundations to generate, sell or buy emissions reduction credits.

There are two kinds of carbon trading. The first is emissions trading (sometimes called "cap-and-trade") whereby a company with savings in emissions (below specified quota) can sell its surplus allowances to another company that is short of its target. The second is trading in project-based credits where companies in developed countries can invest in projects abroad, mostly in developing countries, which "reduce" emissions of carbon dioxide "below what would have happened otherwise".

By providing additional incentives for investment in developing countries, when such foreign investments "count" towards meeting the Kyoto commitments of the countries from which they originate, the CDM provides a source of finance for climate-friendly investments in developing countries, such as in power generation.

CDM is one of two project-based mechanisms designed to promote investment in projects that reduce or sequester emissions of greenhouse gases in developing countries and is founded on the basic assumption that "creating" emissions reductions abroad is cheaper due to low labour costs, dirty factories in these countries, and subsidies provided under carbon funding by the World Bank and other agencies covering part of the costs of building the projects, rather than implementing costly new technologies and upgrades to reduce domestic emissions in the developed countries. CDM projects might include growing crops to produce bio fuels that can substitute oil; installing machinery at a chemical factory to destroy greenhouse gases; or building a wind-power generator.

Source, APF 2007

4.2.6 Mitigation options in the water sector

The Zambezi river basin has many opportunities for mini-hydroelectric generation, though the cost of setting up the schemes is high. The system uses water from the river, and in the process avoids damage to the environment as well as other social effects that large hydroelectric schemes cause. Besides providing power for practical needs, the mini-hydro schemes

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Fetching water is seen as the woman's role.

can be used for income generating activities such as grain milling. Organisations such as Practical Action Southern Africa are promoting rural-based mini-hydropower schemes in Mozambique, Zambia and Zimbabwe. The five-year energy project from 2008-2012 seeks to rehabilitate six existing micro-hydro schemes and establish nine new ones, targeting the Zambezi basin's Mulanje region in Malawi, as well the mountainous regions of Manica in Mozambique and Manicaland in Zimbabwe, both of which are outside the Zambezi basin.

Waste-water treatment

Wastewater has been known to emit methane during transportation and during sewage treatment processes. The methane emissions from wastewater alone are expected to increase by almost 50 percent between 1990 and 2020 (IPCC 4th Assessment Report 2007). Emissions from septic tanks, latrines, and uncontrolled discharges mainly in developing countries tend to go unrecorded.

As mitigation strategies, low water use toilets and ecological sanitation approaches are being encouraged in Malawi, Namibia, Zambia and Zimbabwe. These include ecological toilets, where nutrients are safely recycled into productive agricultural and the environmental uses,

4.3 National and Regional Institutional and Policy Responses

4.3.1 National Adaptation Programmes of Action

Numerous efforts are underway to facilitate adaptation to current and future climate change challenges. These efforts include National Adaptation Programmes of Action (NAPAs) supported by the Least Developed Countries Fund which aims to assess vulnerability and adaptation options at the national level. Five of the eight riparian states – Malawi, Mozambique, Tanzania Zambia and Zimbabwe – have developed plans for financial support under the fund, which is based on voluntary contributions from wealthy countries.

NAPAs have been criticized for being a little different from national development plans in general, as well as for failing to involve all line ministries and decision makers in the countries in question, and for being project-oriented. For exam-

ple, lack of a clear link in the content of NAPAs on one hand and Poverty Reduction Strategy, National Development Strategy, and IWRM plans on the other, has been identified as a main weakness in the NAPAs (Bjerklund 2009). In the NAPAs the frequency and intensity of droughts and floods are the climate-related issues most frequently mentioned, and yet the plans tend to be silent on how to deal with these climate-based extreme events.

However, the World Development Report 2008 found that those involved in building NAPAs were instrumental in creating awareness, and as a result urgent adaptation projects have been identified (Agrawal 2008). The NAPAs specify the adaptation needs for each country. Box 10 provides an example of the NAPA priority needs for Malawi.

Some ongoing or planned national adaptation projects have been funded through the Global Environmental Facility (GEF) Trust Fund, the Special Climate Change Fund (SCCF), the Least Developed Countries Fund (LDCF) and the Adaptation Fund under the Kyoto Protocol. Some funding that may also support adaptation is linked to other Multilateral Environmental Agreements (MEAs), such as the Convention on Biodiversity (CBD), the UN Convention to Combat Desertification (UNCD) and the Ramsar Convention on the Conservation of Wetland Resources. Some examples of ongoing or planned adaptation projects in the basin include:

- Incorporating climate change in Integrated Water Resources Management in Tanzania, funded by the SCCDF
- Coping with drought and climate change in Mozambique and Zimbabwe, funded by GEF;
- Integrating vulnerability and adaptation to climate change into sustainable development policy planning and implementation in Mozambique and Tanzania funded by GEF's Strategic Priority on Adaptation (SPA); and,
- Community-based adaptation programme in Namibia funded by GEF's SPA.

4.4 Policy and Legal Frameworks for Climate Change

4.4.1 The UNFCCC

Climate change adaptation and mitigation options are supported by a legal framework, the United Nations Convention on Climate Change (UNFCCC). Adopted in 1992 in New York by more than 185 member nations, the UNFCCC seeks to stabilize atmospheric concentrations of greenhouse gases at a safe level. Such a level should be achieved within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

The UNFCCC came into consideration in 1997, in Kyoto, Japan, when the Kyoto Protocol was approved by all countries except the USA. All basin states are party to the convention and all but Angola have ratified the protocol and deposited their ratification papers with the United Nations. (Table 8)

Box 10 Adaptation needs for Malawi as outlined in the NAPA

In most parts of Malawi, rural communities have tried to devise ingenious ways to cope with and adapt to the adverse impacts of extreme weather events, including shifting homes to higher ground, storing grain in local granaries, hunting small animals, gathering and eating wild fruits and vegetables, sinking boreholes, and using traditional medicines to cure various ailments and diseases. A list of proposed adaptive measures in the agriculture, water, forestry, fisheries, and wildlife sectors are given in Malawi's national communication to the Conference of Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC), and they include:

- Sustaining life and livelihoods for the most vulnerable communities;
- Enhancing food security and developing community based storage systems for seed and food;
- Improving crop production through the use of appropriate technologies;
- Increasing resilience of food production systems to erratic rains by promoting sustainable production of maize and vegetables in dambos, wetlands and along river valleys;
- Targeting afforestation and reforestation programmes to control siltation and the provision of fuelwood;
- Improving energy access and security in rural areas (e.g., through extension of the rural electrification programme, improved stoves and development of ethanol-based stoves);
- Improving nutrition among rural communities (e.g., through the promotion of fish farming, rearing of small stock, and nutritional supplements for children and the sick);
- Distributing mosquito bednets in high-incidence malaria areas;
- Developing food and water reserves for disaster preparedness and response;
- Developing community-based wildlife ranching and a breeding programme for Nyala;
- Developing and implementing strategies for drought preparedness, flood zoning and mitigation measures;
- Developing technologies to mitigate climate change;
- Providing standby power generation facilities;
- Managing forest fires in collaboration with communities; and
- Developing small dams, and other storage facilities to mitigate floods.

Source, Adapted from Malawi NAPA 2006

Table 7 Status of signature and ratification of the UNFCCC in the Zambezi River Basin

Country	Signature	Ratification
Angola	14 06 1992	08 05 2007
Botswana	12 06 1992	27 01 1994
Malawi	10 06 1992	21 04 1994
Mozambique	12 06 1992	25 08 1995
Namibia	12 06 1992	16 05 1995
Tanzania	12 06 1992	17 04 1996
Zambia	11 06 1992	28 05 1993
Zimbabwe	11 06 1992	28 09 2009

The Kyoto Protocol commits all countries to find ways to limit their emissions, gather relevant information, develop strategies for adapting to climate change, and cooperate with each other. It also requires developed countries, known under the UNFCCC as Annex 1 parties, to take measures aimed at reducing their emissions of six greenhouse gases by at least five percent compared to 1990 levels between 2008 and 2012.

The Protocol came into force in 2005. Now with 189 parties, the protocol has devised three flexible mechanisms to enable compliance with the commitments. These are: Joint Implementation, Clean Development Mechanism, and Emissions Trading. These "flexible mechanisms" allow developed economies to meet their greenhouse gas emission limitation by purchasing emission reductions from elsewhere. These can be bought from financial exchanges, or from projects that reduce emissions in developing economies under the CDM.

Developed countries that are party to the UNFCCC are required to help countries most at risk from the effects of climate change to meet the costs of adaptation. An Adaptation Fund for the benefit ofdeveloping countries has been created following the 15th Conference of Parties to the UNFCCC (COP 15) held in Copenhagen in December 2009.

Progress has been made in identifying vulnerable countries and regions and adaptation options, and there has been some capacity building to prepare for adaptation, but few adaptation measures are in place. In part this is due to limited funds. The costs of adaptation are likely to be high, running at several billion dollars a year for developing countries.

Several developed countries have made their commitments towards financially supporting Africa in climate change projects. The United States indicated that most of the US$1.2 billion committed for 2010 on climate change adaptation is likely to br for Africa (World Agroforestry Centre 2009).

The Convention obliges countries to,

- formulate, implement, publish and regularly update national, and where appropriate, regional programmes containing measures to mitigate climate change;
- cooperate in preparing for adaptation to the impacts of climate change;
- develop and elaborate appropriate and integrated plans for coastal zone management, water resources and agriculture, and for the protection and rehabilitation of areas, particularly in Africa, affected by drought and desertification, as well as floods.

The Kyoto Protocol has set some institutional mechanisms. It requires each developing country to establish a Designated National Authority (DNA) to promote carbon projects that are aligned with national development priorities beneficial to local communities, and support general sustainable development goals. Complying with the protocol, basin states have put in place several measures and strategies to deal with the adverse effects of extreme climatic events. For example, Zimbabwe has established the DNA with responsibility to assess the projects to ensure they were environmentally friendly (Climate Change Office Zimbabwe 2009).

Malawi, has established a Department of Disaster, Relief and Rehabilitation to handle extreme weather and other natural disasters. Non-governmental organisations and faith groups run similar programmes. Malawi also has a flood warning system housed in the Water Department. In addition, the Meteorological Department provides timely weather warnings to the general public. The Natural Disaster Management Plan for Malawi includes mitigation for drought and flood disasters but has no specific adaptation measures except for agricultural inputs and establishment of irrigation schemes in the rural areas. This is the case with most of the basin countries.

Table 8 Indicative scale of contributions from Parties to the Convention for 2008-2009

Party	United Nations scale of assessment for 2008	UNFCCC adjusted scale of assessment 2008	UNFCCC adjusted scale of assessment 2009
Angola	0.003	0.003	0.003
Botswana	0.014	0.014	0.014
Malawi	0.001	0.001	0.001
Mozambique	0.001	0.001	0.001
Namibia	0.006	0.006	0.006
Tanzania	0.006	0.006	0.006
Zambia	0.001	0.001	0.001
Zimbabwe	0.008	0.008	0.008

Source, Bali 2007 8th plenary meeting 14–15 December 2007

4.5 Negotiations Towards COP 15

In preparation for the COP 15 negotiations, a series of meetings were scheduled by Ad Hoc Working Groups under the auspices of the UNFCCC throughout the year 2009.

As the Kyoto Protocol will expire in 2012, the time has come for Kyoto signatories as well as non-parties to consider further commitments regarding mitigation of emission levels and technical adaptation to effects of global warming. The Kyoto Protocol sets binding targets for 37 industrialized countries and the European Community (EC) within the UNFCCC framework. Implementation of adaptation policies is not only urgent but vital for the international community as a whole.

The effects of global warming, such as the rise of ocean levels, loss of natural resources and biodiversity, affect the whole world, and consequently become a global issue. While an international regulatory framework approaches climate change comprehensively, unilateral action on a regional, basin, national and local level is also needed to implement commitments made at international level.

Until now the key missing player in climate change negotiations is the United States of America which has refused to accept the Kyoto Protocol because it imposed no pollution limits on China or other developing countries. The United States and China are responsible for almost half of the world's greenhouse gas emissions. China ratified the Kyoto Protocol but being a developing country, is not bound to limit its greenhouse gas emissions, but only to deliver accounts of its emissions to the UN.

In 2007, China overtook the USA as the world's leading carbon emitter, although per head of population, its pollution remains relatively low. China's emissions are largely due to the country's heavy reliance on coal.

China points to the historical responsibility of the world's wealthy countries for past emissions and argues that it has low per capita emissions and low energy use per capita. It refuses to commit to mandatory emissions reduction targets before the world's wealthy countries take the lead in addressing global climate change.

China points to its impressive improvements in energy efficiency and coal-plant cleanliness in recent years, and increasingly ambitious commitments to invest in renewable energy sources.

4.5.1 COP 15 negotiations position for southern Africa

Southern Africa, including the Zambezi basin states joined the rest of the African continent in presenting one position during the COP 15 in Copenhagen. The African position was that polluting countries should reduce their emissions drastically by a minimum of 40 percent below 1990 levels by 2020.

The African position endorsed Agriculture, Forestry, and Other Land Uses (AFOLU) (World Agro-forestry 2009).

Unlike the REDD which is most likely to benefit rich people when they buy up land in order to claim the compensation, AFOLU would ensure that small landholders are considered.

The approach would be consistent with Nationally Appropriate Mitigation Activities (NAMAs) and the UNFCCC principle of shared but differentiated responsibilities.

Linked to the AFOLU, southern Africa calls for a bio-carbon initiative, which would reward countries that adopt agricultural systems that store carbon, are climate-resilient and increase productivity. The bio-carbon initiative takes into account the full opportunities for reducing emissions and increasing carbon stocks in agriculture, forestry and other land uses.

Besides AFOLU, some other key African priorities that should be addressed by any post-Kyoto agreement include, but are not limited to:

- operationalising the Adaptation Fund;
- solutions to the energy, food and climate crises which should be comprehensive and interdependent;
- capacity building; and,
- technology transfer.

On finance, African leaders had agreed to seek US$200 billion by 2020 from developed countries to cushion the continent through implementation of climate adaptation technologies (RCCP 2009). This financing should be new, additional, predictable and grant based.

Africa was opposed to the replacement of the Kyoto Protocol by a new pact. The move to abandon Kyoto came in response to the pressure by some developed countries who are pushing emission reductions by the major emitters which include advanced developing countries such as China, India, Brazil and South Africa.

The advanced developing countries argue that words like "Advanced Developing Countries" and "Major Emitters" are not mentioned in the UNFCCC and Kyoto Protocol and therefore are not bound by the protocol. Their position is that discussion should be based on "Historical Responsibility and the principle of Common but Differentiated Responsibility" as enshrined in the protocol.

Africa reaffirms the UNFCCC principle of common but differentiated responsibilities and respective capabilities and says with one voice that should form the basis for the post-2012 regime. The UNFCCC provides a strong foundation for an inclusive, fair and effective international climate change regime. It effectively addresses the need to stabilize the climate system while recognising the importance and right of developing countries to develop and address poverty and food security.

In this context the intention of some developed countries to bring developing countries under binding commitment on emission reduction is conflicting with the Kyoto Protocol.

Africa says mitigation actions for Africa should be voluntary and nationally appropriate and must be fully supported and enabled by technology transfer, finance and capacity building from developed countries.

The provision of financial, technological transfer, and capacity building support by developed country parties for adaptation and mitigation in developing countries, the negotiators argue, is a commitment under the UNFCCC, that must be urgently fulfilled.

Box 10 Expectations not met in Copenhagen

Expectations for southern Africa and the rest of the African continent were not met at the UNFCCC Conference at Copenhagen in December 2009. The conference ended without a legally binding agreement but a political agreement termed the Copenhagen Accord.

Southern Africa expressed dissatisfaction with the contents of the Copenhagen Accord as expectations were not met, especially regarding binding emission targets and binding financial contributions to tackle the impacts of climate change due to rise in global average temperatures.

While the Accord states that developed countries committed to jointly mobilize US$100 billion a year by 2020 and an additional US$30 billion for the period 2010-12, for adaptation and mitigation in vulnerable countries, this falls far short of Africa's expectations. Africa favours an approach in which developing countries will be beneficiaries of technology transfer, capacity building and funding of US$200 billion a year by 2020.

The Accord makes reference to 50 percent reduction of emissions by developed countries by 2050 compared to 1990 levels with no immediate 2020 commitments.

"It does not give legally binding commitments for industrialized countries and has no mid-term targets," said the Zambian Environment Minister Cathrine Namugala

Africa and the rest of developing countries wanted the wealthy nations to cut emissions to at least 40 percent below the 1990 levels by 2020.

Africa also wanted deeper cuts by developed countries to reach at least 80 percent below 1990 levels by 2050.

While the Accord recognizes the need to keep global temperature rises below 2ºC, Africa says new climate studies show the dangers are even greater than thought just a few years ago.

Increased rate of melting glaciers including that on Mount Kilimanjaro, faster than recorded by the Intergovernmental Panel on Climate Change (IPCC), provides evidence to this effect. Africa argues global temperature rises should be kept below 1.5 degrees. This recognition also falls short of providing a credible pathway for reaching the objective. Instead the Accord inserts domestic pledges on emissions to be submitted by end of January 2010.

In an attempt to appease the demands of the poorest nations and small island states, the Copenhagen Accord, when reviewed in 2016 would include possible strengthening of the long-term goal to limit the increase in global average temperature to 1.5 degrees

The Accord commits developing countries to emission reductions, but only in the context of future development. These countries would have to report on their emissions cuts every two years.

"The developed countries will give the percentage of emission reduction while developing countries will give nationally appropriate mitigation action. By February we will have a fair idea what countries are willing to commit," remarked IPCC chairman Rajendra Pachauri. He said action will be taken soon after to use these submissions as a basis for creating a legally binding agreement within a reasonable period of time.

While the Accord is voluntary, there is an incentive that might encourage many developing nations to join as it promises funding to help poor nations deal with climate change.

Dr Batilda Burian from the United Republic of Tanzania said the conference reached promising stages and has laid a good foundation for the climate summit which will be held in Mexico in December 2010, although it failed to agree on most of the African recommendations. Burian said that, apart from the money, African countries requested that they should be empowered technologically so that they could effectively deal with the effects of climate change, but nothing was agreed upon.

While South Africa together with India, Brazil, China and USA contributed in drafting the Accord, South Africa's negotiator Alf Wills, said the resulting agreement was limited not only in terms of what it does to save the planet, but in the number of nations that accepted it. Will said it does not extend beyond the 28 represented at the late-night negotiations. However, he added that the Accord does have positive elements that can be built upon at the next round of talks.

Wills pointed to agreements on how the U.S. and other developed countries will record emission reduction targets, and on how emission reduction action by advanced developing countries like South Africa would be accounted for. South Africa is negotiating to reduce its emissions by 34-42 percent by 2020, depending on the amount of aid given.

The conference recognized the need to provide funds to save forests as carbon sinks and to create market mechanisms – a reference to carbon trading systems – to promote emissions reductions. This commitment was confirmed by the formation of Copenhagen Climate Change Fund which would sponsor environmental projects such as those for reforestation.

The Accord states that only developing countries that accept financial support for their reduction projects have to accept international monitoring and verification of their reductions.

While the outcomes were not satisfactory, some delegates to the conference said that outright failure to agree on anything at all would have been very much worse. The Parties agreed to "take note" of the Accord rather than formally adopt it and resolved to meet again in Bonn, Germany, for a preliminary meeting before COP 16 to be hosted by Mexico in December 2010.

Source, SANF 10 No 3, January 2010

5 CONCLUSION

Observation records and climate projections provide evidence that the Zambezi River Basin is vulnerable and has potential to be strongly impacted by climate change, with wide-ranging consequences for communities living in the basin. The rise in temperatures observed over several decades has been linked to changes in the hydrological cycle such as changing precipitation patterns, intensity and extremes, reduced snow cover, changes in soil moisture and runoff. The increased frequency and severity of droughts, floods, and cyclones, and the significant rise in average temperature of 0.5ºC over the past century are worth noting. The melting snow on Mount Kilimanjaro and the intrusion of saltwater in the Zambezi delta signify that climate change is a reality in the basin.

The resultant impacts of the rising temperatures such as a change in rainfall patterns and rise in sea level have socio-economic and environmental impacts affecting especially vulnerable communities living in the Zambezi basin.

Diseases such as malaria and cholera have increased and are expected to increase further during the course of this century. Areas that are not malaria zones are likely to be affected. This includes the densely populated areas of Zimbabwe such as Harare.

On food security, scientists say that a slight rise in temperature affects the crop yields. A UNDP simulation of the impact of climate change on crop yields and output in the Zambezi basin produced in 2006, estimates a 10 percent fall in the yield of wheat, rice and maize for every 1ºC rise in temperature. The simulation also shows cereal production falling by up to 25 percent over most of the Zambezi basin between 2000 and 2080. Rise in temperature is also linked to an increase in outbreaks of locusts affecting food production.

However, climate change impacts are not always negative. The climate change induced floods result in increased rice yields in flood plains, growth in fish stocks, better pastures for livestock and increased groundwater recharge for the aquifers. The negative impacts of future climate change on vulnerable communities are, however, expected to outweigh the benefits.

Societies can respond to climate change by adapting to its impacts, reducing greenhouse gas emissions (mitigation), thereby reducing the magnitude of change, and by reforming policies to support the adaptation and mitigation strategies.

Although a rich set of indigenous responses exist for coping with climate variability, these strategies are not sufficient in the face of societal transformations and climatic changes. Consequently, there may be some unexpected outcomes of climate change, which generate new vulnerable groups.

Ongoing negotiations for climate change adaptation strategies have noted the need to build on indigenous strategies with involvement of the communities.

Interventions may also create unplanned outcomes, and may even increase vulnerability for some, if the broader vulnerability context is not taken into account. There is currently a gap between local needs and ongoing and planned adaptation interventions. The most vulnerable groups of the Zambezi basin are generally not included in these projects, nor are the sources of their vulnerability being adequately addressed.

To ensure coping with climate impacts, most adaptation strategies take the form of integrated demand-side as well as supply-side strategies. For instance, to ensure water supply during average and drought conditions, the former may improve water use efficiency by, recycling, while the latter involves increases in storage capacity, abstraction from water courses and water transfers. An expanded use of economic incentives, including metering and pricing, to encourage water conservation and development of water markets and implementation of virtual water trade, hold considerable promise for water and re-allocation of water to high-value uses.

Mitigation measures can reduce the magnitude of impacts of global warming in turn reducing the adaptation needs. These include use of renewable energy sources such as solar power and bio-fuels and afforestation, to reduce carbon emissions as well as to increase carbon sinks.

Adaptation and mitigation strategies clearly impact on many policies for several sectors including energy, health, food security and environment. Therefore adaptation and mitigation strategies should be designed in the context of development, environment and health policies.

The next climate change conference (COP16) will be held in December 2006 in Mexico. This will further attempts to address issues which were not resolved at COP 15.

This report has examined climate change mitigation and adaptation strategies highlighting ongoing and planned activities and also constraints in implementing certain activities in the Zambezi River Basin. It has been noted that the challenge of climate change is too complex an issue to be dealt with by any one ministry or country. All relevant national sectors must be involved in climate actions and efforts must be linked.

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