Republic of Zimbabwe

Zimbabwe Second National Communication to the United Nations Framework Convention on Climate Change

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The Second National Communication of the Republic of Zimbabwe has been prepared in accordance with the United Nations Framework Convention on Climate Change (UNFCCC) Articles 4.1 and 12.1 on the basis of the Guidance for non-Annex I Convention Parties.

The national institution responsible for the preparation of the Second National Communication is the Climate Change Office, Ministry of Environment and Natural Resources Management in collaboration with key ministries and agencies.

The following government ministries and agencies participated in the preparation of the Second National Communication of the Republic of Zimbabwe under the United Nations Framework Convention on Climate Change:

- **Ministry of Environment and Natural Resources Management**
- **Ministry of Health and Child Welfare**
- **Ministry of Water Resources Development and Management**
- **Ministry of Agriculture, Mechanization and Irrigation Development**
- **Ministry of Energy and Power Development**
- **Ministry of Industry and Commerce**
- **Zimbabwe National Statistics Agency**
- **Zimbabwe Meteorological Services Department**
- **University of Zimbabwe**
- **Midlands State University**
- **Bindura University of Science Education**

Participant Non-Governmental Organisations (NGOs):

- **Southern Centre for Energy and the Environment**
- **Business Council for Sustainable Development Zimbabwe**

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Foreword

The Republic of Zimbabwe views ***climate change*** as a serious issue. Zimbabwe, through the years, has demonstrated its willingness to preserve the global climate for the good of the present and future generations. Zimbabwe was one of the first countries to sign and ratify the United Nations Framework Convention on Climate Change at the United Nations Conference on Environment and Development, held in Rio de Janeiro in June 1992. Zimbabwe acceded to the Kyoto Protocol on 28 September 2009. In accordance with the UNFCCC commitments, the Republic of Zimbabwe prepared and submitted its Initial National Communication (INC) on climate change to the UNFCCC in 1998.

Since signing the UNFCCC in March 1992, the Zimbabwe government, private sector, civil society and development partners have also undertaken a number of other initiatives under the climate change portfolio. Some of the initiatives include: US Climate Change Country Studies Programme, GEF/Small Grants Programme, Technology Transfer Needs Assessment, National Capacity Needs Self Assessment for implementation of the Multilateral Environmental Agreements, UNDP/GEF Medium Size Project on Coping with Drought and Climate Change, Climate Change Awareness Workshops and Climate Change training workshops for the media.

The Second National Communication of the **Republic of Zimbabwe** to the United Nations Framework Convention on Climate Change summarizes the up-to-date information on climate change issues in Zimbabwe, the process of UNFCCC implementation, and presents the general and specific data on climate change. The major objective of this Communication is to inform the Convention Parties, as well as decision-makers, specialists and the public at large of one of the most urgent issue facing mankind in this century. The Communication also provides information of Zimbabwe's emissions of greenhouse gases (GHGs) and information on the interventions undertaken to mitigate the adverse impacts of climate change.

It is important to note that the Second National Communication is an original document. However, results and findings from previous research carried out in the country have been incorporated. It is therefore important to refer to the sources and reports that were used by groups of experts. These reports which serve as the basis for this Communication are available in the Climate Change Office, Ministry of Environment and Natural Resources Management.

The results of research conducted within the framework of the Second National Communication revealed that the country's priorities are mainly on adaptation of vulnerable communities and ecosystems to climate change. Sustainable energy development has also been prioritized under mitigation. Other issues of importance include climate change research and systematic observation at local and regional scales.

The main chapters of the Second National Communication were discussed at workshops and working meetings during 2006-2011 with participation of representatives from more than 15 ministries and agencies, international organizations and the public at large. More than 20 experts, scientists and staff of different organizations participated in the preparation of this document.

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Executive Summary

INTRODUCTION

The Government of Zimbabwe views global climate change as a serious issue. The Government signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 at the Rio Earth Summit and ratified it in November of the same year. The driving forces behind Zimbabwe's effective participation in the climate change convention stem not so much from problems of reducing Zimbabwe's emission of greenhouse gases (GHGs), but rather the potentially serious impacts that global climate change might have on the country. By including climate change issues in the national environmental legislation, Zimbabwe intends to incorporate climate change policies in its national development plans.

The Second National Communication (SNC) to the UNFCCC has been prepared in fulfillment of Zimbabwe's obligations to the UNFCCC under articles 4 and 12 of the convention and builds on the Initial National Communication that was submitted in 1998 and several other climate change activities that have been ongoing in the country. The Second National Communication follows the UNFCCC guidelines and includes information on Zimbabwe's greenhouse gas inventory for the year 2000, measures to reduce emissions (mitigate) and adaptation to climate change.

The project was coordinated by the Ministry of Environment and Natural Resources Management. Funding for the project was provided by the Global Environment Facility (GEF), through the United Nations Environment Programme (UNEP).

NATIONAL CIRCUMSTANCES

Geographic Profile and Climate

Zimbabwe is situated in the southern part of Africa between latitudes 15^{0} 30" and 22^{0} 30" south of the Equator and between longitudes 25^{0}00" and 33^{0} 10" east of the Greenwich Meridian. The country is land locked and is bordered by Mozambique to the East, South Africa to the South, Botswana to the West and Zambia to the North and North-west. Zimbabwe has a total land area of approximately 390 757 square kilometres (km^{2}) and is divided into ten administrative provinces; Bulawayo, Harare, Manicaland, Mashonaland Central, Mashonaland East, Mashonaland West, Masvingo, Matabeleland North, Matabeleland South and Midlands. Harare is the capital city and it has the major administrative and commercial functions. As of 2002, Zimbabwe had an estimated total population of 11,6 million. The proportion of male and female population was 48 and 52 percent respectively.

The country's main topographical features include the central watershed, running from southwest to northeast and ranging from 1200m to 1500m above mean sea level. The watershed is 650 kilometres long and 80 kilometres wide. The highest elevation is along the eastern border with Mozambique where mountain peaks range from 2300m to 2500m. The Zambezi and Limpopo River Valleys found in the north and south respectively have the lowest altitude of around 500m.

Zimbabwe has four seasons; cool season from mid May to August, hot season from September to mid November, the main rainy season running from mid November to mid March and the post rainy season from mid March to mid May.The lowest minimum temperatures are recorded in June or July and the highest maximum temperatures in October, or if the rains are delayed, in November. The mean monthly temperature varies from 15°C in July to 24°C in November while the mean annual temperature varies from 18°C on the highveld to 23°C in the lowveld.

Natural Resources

The country has abundant natural resources that include beautiful scenery, arable land, forests, minerals, and surface and ground water. There are 12 national parks, one trans-frontier park (Trans Zambezi National Park), and other protected areas. The flora in the country is dry miombo woodland, with mopane woodland and other woodland types dominating while serpentine grasslands are found in the Great Dyke. Montane forest interspersed amongst high-altitude grasslands and heath is found in the Eastern Highlands. Zimbabwe's forestry resources cover approximately 66% of the total land area (257, 783km^2).

The country relies on surface water resources for 90% of its requirements while groundwater supplies the remaining 10%. At present, agriculture uses 60% of all the water in dams. Irrigation efficiencies range between 40% and 60%. In the urban areas, as much as 40% of water is lost during treatment and distribution. There are seven catchments in the country, namely Manyame, Mazowe, Gwayi, Runde, Sanyati, Save and Mzingwane.

Economic sectors

Agriculture: Zimbabwe has an agricultural based economy with the agriculture sector contributing about 15% each year to the GDP. The country is divided into five natural regions on the basis of soil type, rainfall, temperature and other climatic factors. Rainfall ranges from 650mm to above 1050mm per annum in regions 1 to 3 while in regions 4 and 5 it is below 650mm per annum. Zimbabwe's agriculture is divided into four major sectors namely; Large Scale Commercial Farms, Small Scale Commercial Farms, Communal and Resettlement Schemes. The country produces a variety of crops in its different sectors and zones. These include grain crops such as maize, sorghum, mhunga (pearl millet), rapoko (finger millet), oilseeds (sunflower, groundnuts and soyabeans) and other industrial crops which include tobacco, cotton, edible dry beans and paprika. The country rears a variety of livestock that include cattle, sheep, pigs and goats.

Industry: Zimbabwe's Gross Domestic Product (GDP) showed a market prices increase in nominal terms from 1994 to 1998 and then assumed a downward trend to year 2000. The decline is explained by poor performance of all sectors except agriculture, hunting and fishing; real estate and health. While nominal GDP per capita showed an increasing trend throughout the period, real GDP per capita has been on a decline. From 1998 to 2000, the growth rates were at 0.8%, -3.3% and -7.1%, respectively.

Energy: Zimbabwe generates about 1200MW of electricity from thermal and hydro-power plants. In the rural areas, energy needs are met basically with firewood, candles and in a few cases, paraffin. Energy demand is growing gradually, by over 2% annually. Local supply does not meet demand. The shortfall is made up with imports of electricity from Zambia, Mozambique and South Africa. However, with the rising demand of electricity regionally, Zimbabwe has been working on expansion projects of the existing plants and also initiating new hydro-power generation projects particularly in the major rivers that border the country. Solar power and bio-energy are also being looked at closely. Currently there are two biodiesel plants. Stability in the energy sector, encompassing liquid fuels, coal and electricity supplies is an indispensable pre-requisite for successful economic growth, as well as for household use.

Mining: The major minerals reserve deposits in Zimbabwe comprises asbestos, gold, copper, chrome, nickel, diamonds, platinum and iron. The mineral volume decreased towards the year 2000 except for black granite and platinum. Small-scale mining activities have been on the increase. These contribute significantly to employment creation and consequently poverty reduction. Mining activities have been seen to cause serious environmental problems as a result of the method used in extracting the ore i.e. underground or open cast. More coal deposits have been discovered in the country. Coal mining sites in Zimbabwe are concentrated in the Zambezi Basin.

Transport: Zimbabwe has a fairly modern transport service, dominated by road transport, and contributes about 7% to GDP. Other predominant forms of transport are railway and air, while boats are used in the man-made dams of the country. The international routes radiate from Harare and Bulawayo (the second largest city) to neighbouring countries. In the year 2000 there was a total of approximately 18 514km of road designated as state roads in Zimbabwe, of which 9 498,9km were gravel and earth. There has been a steady increase in the registered vehicle population in the country from 1980 to 2000, with the total number of vehicles rising by 8.7% over the period.

Tourism: Tourism in Zimbabwe is the seventh leading foreign exchange earner contributing about 16,3 % of the country's GDP. The country is richly endowed with a variety of tourist attractions. It has one of the Seven Wonders of the World and heritage site, the Victoria Falls. The scenic mystical beautiful eastern highlands is dominated by mountains, waterfalls and forests. The country accommodates a variety of national parks and trans-frontier parks with over 100 animal species and 400 bird species. Among the animal species are the big five, elephant; rhino; leopard; lion and buffalo. The country boasts of its tangible and intangible heritage. The tangible heritage consists of stone architectures such as the Great Zimbabwe monument and Rhodes Matopos monument while the intangible heritage is dominated by rich cultural diversity, inspiring musical sounds and mesmerising dances.

Trade: Total trade, sum of exports and imports, is a useful indicator of the level/volume of external trading activity. Zimbabwe's total trade has grown at the rate of 8 % from 1993 to 2000. Throughout the period under review, imports and exports rose by annual averages of 30.2% and 39.0%, respectively, and overall trade balance deficit grew from $1.6 billion in 1993 to $16.5 billion in 1998.

Environmental Protection: Zimbabwe, through the Ministry of Environment and Tourism led the process of developing a National Environmental Policy and Strategies in 2009. The policy compliments the Environmental Management Act (Chapter 20:27) promulgated in 2003, and other complimentary legislation pertaining to environmental protection, monitoring and sustainable management.

Education Development: Zimbabwe achieved the near universal primary education for all in the 1990s which laid a foundation towards the fulfilment of the Millennium Development Goal 2 (MDG 2). The education policy adopted soon after independence in 1980 contributed to increased primary education with an increase in the number of schools by 9.6% from 1990 to 2000. There has also been a rapid increase in the number of secondary schools as well as school attendance. Tertiary education also improved significantly after 1990, with numerous vocational centres, polytechnics and training colleges being established. To date, twelve universities have been opened in addition to the University of Zimbabwe to absorb the increasing demand for tertiary education. This has greatly improved the country's educational profile.

Healthcare Development: The major health issues in Zimbabwe relate to child mortality, maternal health and the top five killer diseases. The top five killer diseases are HIV and AIDS epidemic, malaria, TB and diarrheal diseases. Maternal mortality figures were estimated by the 1999 Zimbabwe Demographic and Health Survey at 283 deaths per 100 000 live births during 1984 to 1994 and rose sharply to 695 per 100 000 live births in 1995 to 1999. The sharp rise in child and maternal mortality rates are largely explained by the rapid spread of the HIV and AIDS epidemics. Whilst malaria is one of the major public health problems in the country, Zimbabwe has measures in place to control malaria and the most common one is the spraying programme done under the Ministry of Health and Child Welfare. This programme normally commences at the start of the rain season and is aimed at reducing the spread of mosquitoes. The Roll Back Malaria Campaign, which is being spearheaded by the World Health Organisation (WHO) also tries to reduce deaths attributed to malaria by half in Zimbabwe.

Political and Decision Making Structure: Zimbabwe is a sovereign state with a democratically elected executive President who is both head of state and head of government. The Zimbabwe legal system is based on Roman-Dutch Law and the 1979 Lancaster House Constitution which now has undergone 18 amendments**.**

NATIONAL GREENHOUSE GASES (GHGs) INVENTORY

Zimbabwe has a diverse economy with significant contribution from agriculture, industry and mining. Commerce is dominated by retail and service providers. Zimbabwe has an active Central Statistical Office which collects data on production on an annual basis. However, the Central Statistical Office was not until recently collecting information for the purpose of monitoring greenhouse gas emissions. Apart from the Central Statistical Office, line Ministries also collect data on production which was used to compile this inventory. The energy sector is the major source of greenhouse gases and till 2000 the Ministry of Energy and Power Development was compiling an annual energy balance. This data was published and delivered to the wider public through a periodic Energy Bulletin.

The Second National Communication Greenhouse Gas Inventory for the year 2000 is the second inventory to be prepared for Zimbabwe after the first one of 1994 which was used in the Initial National Communication. In compiling this inventory the team was organized according to sectors. Priority was placed on the key Intergovernmental Panel on Climate Change (IPCC) sectors being energy, industry, agriculture, waste and land use land use change and forestry (LULUCF). The experts were drawn from the key institutions in the respective sectors namely Forestry Commission, University of Zimbabwe, SIRDC, the Business Council for Sustainable Development Zimbabwe (BCSDZ). Coordination was done by Southern Centre for Energy and the Environment.

After provision of basic training, the sector experts relied on the IPCC guidelines to compute the emission estimates. Experts had the option to use the UNFCCC software (1996) or manual worksheets. Apart from the energy sector all other sectors used manual worksheets. As a result the summary table was compiled manually by extracting figures from the different worksheets.

Data was collected from official sources. For the industrial sector, various industries were contacted to provide production data. It was not always easy to get this data. Some of the companies did not keep the records required in a usable format. Others were reluctant to provide the information. Apart from cement and steel emissions, emissions from other industrial activities were difficult to estimate as they came from small players who were difficult to identify. Most companies switch between production and mixing or retailing of imported materials. In these instances the records were difficult to compile. Information on waste treatment was based on records kept by the major urban authorities. This data allowed estimation of local conversion factors before default emission factors were used. In agriculture data were compiled on the basis of the census of production. Data on animal populations and animal sizes was based on official estimates. Data on crop production and soils was also compiled from official statistics. Default emission factors were then used to estimate the emissions.

Quality assurance was done through periodic workshops where the data and findings were presented to key sector players. This process was perceived to give the best option for feedback.

During the time of the inventory there was a great movement of experts from the sectors and the country which may have affected the quality of data collected.

ES1: Summary of Greenhouse Gas Emissions for Zimbabwe/2000 (Gg)

National greenhouse gas inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol and greenhouse gas precursors								
Greenhouse gas source and sink categories	**CO_2 emissions (Gg)**	**CO_2 removals (Gg)**	**CH_4 (Gg)**	**N_2O (Gg)**	**NO_x (Gg)**	**CO (Gg)**	**NMVOCs (Gg)**	**SO_x (Gg)**
Total national emissions and removals	**25,805.7**	**88,034.6**	**335**	**60.22**	**148.64**	**798.86**	**82.23**	**1.38**
1. Energy	**23,832**	**0**	**47**	**4**	**148**	**770**	**76**	**0**
A. Fuel combustion (sectoral approach)	23,832		41	4	148	770	76	0
1. Energy Industries	7,488		0	0	24	2	0	0
2. Manufacturing industries and construction	13,012		0	0	11	5	0	0
3. Transport	1,071		0	0	19	121	0	0
4. Other sectors	2,255		41	4	94	642	76	0
Commercial and Institutional	362							
Residential	96		38	1	13	633	76	
Agriculture	1,797		3	3	81	9		
5. Other (please specify) Mining	6		0	0	0	0	0	0
B. Fugitive emissions from fuels	0		6		0	0	0	0
1. Solid fuels			6		0	0	0	0
2. Oil and natural gas			0		0	0	0	0
2 Industrial Processes	**1,973.7**					**0.37**	**6.23**	**1.38**
Mineral products	1,369.2							0.3
Chemical industry	117							0.17
Metal production	487.5					0.37		0.91
Other production Food Production Beverages and Tobacco							6.23	
Production of halocarbons and sulphur hexafluoride								
Consumption of halocarbons and sulphur hexafluoride								
Other								

ES1: Summary of Greenhouse Gas Emissions for Zimbabwe/2000 (Gg) *(continued)*

National greenhouse gas inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol and greenhouse gas precursors								
Greenhouse gas source and sink categories	**CO_2 emissions (Gg)**	**CO_2 removals (Gg)**	**CH_4 (Gg)**	**N_2O (Gg)**	**NO_x (Gg)**	**CO (Gg)**	**NMVOCs (Gg)**	**SO_x (Gg)**
3 Solvents and other product use								
4 Agriculture			**219.9**	**56.22**	**0.64**	**28.49**		
Enteric fermentation			212.43					
Manure management			7.47	0.04				
Rice cultivation								
Agricultural soils				56.16				
Prescribed burning of savannahs								
Filed burning of agricultural residues				0.02	0.64	28.49		
Other								
5 Land-use change and forestry		**88,034.6**						
Changes in forest and other woody biomass stocks		88,034.6						
Forest and grassland conversion								
Abandonment of managed lands								
CO2 emissions and removals from soils								
Other								
6 Waste			**68.1**					
Solid waste disposal on land			56.8					
Waste-water handling			11.3					
Waste incineration								
Other								
Memo items								
Aviation								
Marine								
CO2 emissions from biomass	**14,605**							

Using global warming potentials of:

(CO_2 = 1: CH_4 = 21: N_2O = 310; CO = 3: NO_x = 290: NMVOC = 10000),

Energy accounted for 68.51%, Industry 5.21%, Agriculture 22.35% and Waste 3.93% of total greenhouse gas emissions in CO_2 equivalent. However, with respect to carbon dioxide only energy sector accounted for 86.91% and industry 4.18% of emissions. Accuracy of non CO_2 emissions is dependent on the accuracy of technology information used to determine the emission factors. This is especially true for fuel combustion.

Key Categories

A key category analysis was carried out on the basis of level of emissions. A trend analysis was not carried out. The key categories were determined as indicated below.

ES2: Key Source Categories

IPCC Source Category	Sector	Source Categories to be Assessed in Key Source Category Analysis	Applicable Greenhouse Gas	Emission Estimate (current year, non-LULUCF) (Gg CO_2eq)	Level Assessment excl. LULUCF (%)	Cumulative level excl. LULUCF (%)
Sum				36,366.10		
1.A.2	Energy	CO_2 Emissions from Manufacturing Industries and Construction	CO_2	13,011.60	35.78%	35.78%
1.A.1	Energy	CO_2 Emissions from Stationary Combustion	CO_2	7488	20.59%	56.37%
4.A	Agriculture	CH_4 Emissions from Enteric Fermentation in Domestic Livestock	CH_4	4617.9	12.70%	69.07%
4.D	Agriculture	N_2O (Direct and Indirect) Emissions from Agricultural Soils	N_2O	3490.6	9.60%	78.67%
1.A.4	Energy	Other Sectors:CO_2: Agriculture/Forestry/Fishing	CO_2	1,796.70	4.94%	83.61%
6.A	Waste	CH_4 Emissions from Solid Waste Disposal Sites	CH_4	1192.8	3.28%	86.89%
2.A	Industrial Processes	CO_2 Emissions from Limestone and Dolomite Use	CO_2	870.7	2.39%	89.28%
1.A.4	Energy	Other Sectors: Residential CH_4	CH_4	797.6	2.19%	91.48%
1.A.3	Energy	CO_2 Mobile Combustion: Road Vehicles	CO_2	785.1	2.16%	93.63%
2.A	Industrial Processes	CO_2 Emissions from Cement Production	CO_2	541.2	1.49%	95.12%

Each sector expert projected emissions on the basis of sector parameters.

Mitigation Analysis

Mitigation analysis involves the determination of greenhouse gas emission reduction opportunities and the determination of the incremental cost of reducing the emissions. As such the analytical process involves determination of a baseline emission growth and the expected impact of the emission reduction options on the baseline emission growth. Such assessment requires the compilation of baseline information from the target sectors. In the Initial National Communication an industrial survey was carried out to determine the baseline information. In this case the target sectors had experienced a major economic shock hence data, if collected, would not show a logical continuity with reference to previous years. The energy sector was showing growth in emissions due to an increase in motor vehicles but other sectors were showing a decline in activity. As a result, determination of the steps and measures focussed on the development of programmes to enable implementation of known mitigation options which have not been implemented due to barriers. The programmes included; industrial energy management, reduction of nitrous oxide emissions from fertilizer production, waste composting as a way of reducing methane emissions, reforestation and afforestation. These programmes refer to options identified in the INC.

IMPACTS, VULNERABILITY AND ADAPTATION

The main objective of this study was to assess and predict the vulnerability, as well as adaptation capacity to climate change for the key sectors in Zimbabwe's economy i.e., agriculture, biodiversity, rangelands, water resources, health and the human settlements and tourism sectors. In addition, this study intended to establish the vulnerability of agro-ecological zones to climate change. In order to achieve this objective, regional climate change scenarios developed using the Global Circulation Models (GCM) projections were used. In this study the CSIRO MK3 model was used since it is more adapted to the climatic conditions prevailing in the southern hemisphere. Two scenarios were considered i.e., the business as usual case (A2a) hereafter referred to as the worst case scenario (WCS), and the environmentally conscious scenario (B2a) hereafter referred to as the best case scenario (BCS).

Agriculture

The vulnerability and adaptation assessment of the agricultural sector was carried out using three indicator crops i.e., small grain (sorghum), a staple food crop (maize) and a commercial crop (cotton). Results show that the area suitable for maize and cotton will decrease in the northern and southern parts of the country while sorghum shows less sensitivity to climate change throughout the country based on the worst case scenario. Based on these results we recommended for the adoption of small grains and cash crops such as cotton in place of maize by small holder farmers. Also we recommend the need to promote irrigation development through dam construction and the use of simple rainwater-harvesting technologies.

To assess whether there have been significant shifts in agro-ecological regions as a result of climate change, typical crops grown in each agro-ecological region were used. Results show that crop suitability varies with climate variability. For adaptation purposes, there is need for development and adoption of drought tolerant crop varieties.

Biodiversity

In the biodiversity sector, two components were considered namely, plant diversity and net primary productivity (NPP). Results demonstrate that plant diversity is sensitive to temperature and rainfall changes. The findings suggest that the expected rise in temperature accompanied by a decrease in rainfall amounts may have a negative effect on plant diversity and ecosystem function in Zimbabwe. This indicates that by year 2080 under the worst case climate scenario, plant diversity is projected to decline throughout the country and areas that currently harbour high diversity will shrink. In this regard, adaptation strategies in the biodiversity sector should include reduction of non-climatic stresses such as human disturbances, in particular, overexploitation of biodiversity.

Rangeland

Vulnerability assessment of the rangeland sector shows that net primary productivity (NPP) of rangelands in Zimbabwe will likely decrease. This is projected to result in reduced rangeland carrying capacity for both livestock and wildlife. The southwest and north-western parts of Zimbabwe will experience more reductions in NPP than in other parts of the country. Adaptation measures proposed may include the use of supplementary feeds in the livestock industry.

Water

In the water sector, the predicted run-off under both the worst case scenario (WCS) and best case scenario (BCS) indicate that runoff will decrease significantly in the Umzingwane, Shashe, Nata and Save catchments. One of the adaptation strategies that could be adopted is improving water use efficiency in the agricultural sector, as well as water harvesting through dam construction.

Health

Malaria was selected as an indicator disease that is closely related to climate. In this regard, the projected malaria hazard for Zimbabwe for the year 2080 under both the best case and worst case climate scenarios shows that the high malaria hazard will be concentrated in the low lying parts of the country including the Zambezi valley, and the south-east lowveld. A deliberate increase in the number of health centres could be one among many possible adaptive strategies.

Human Settlement and Tourism

In the human settlements and tourism sector, the negative effects of climate change on agriculture, health, water resources, rangelands, biodiversity and agro-ecological regions are likely to affect the vulnerability of the sector to climate change. The adaptation measures for this sector are likely to be more dependent on how the other sectors adapt to climate change.

OTHER INFORMATION

Integration of climate change into policies and development planning

Zimbabwe has embarked on a process to develop a National Climate Change Response Strategy (NCCRS). The issue of climate change has been elevated in status in the country after a Heads of Ministries Seminar on climate change came up with a recommendation to establish a National Task Team on Climate Change (NTT) that would lead the process of climate change response strategy formulation and reporting to the Office of the President and Cabinet. The NTT is a multi-stakeholder team that has expertise in various areas of interest to the climate change issue.

The NTT has also been tasked to develop a vision on climate change for the country, identify the specific roles of government and other sector organizations in achieving this vision, to advise the government on how the country should strategically position itself in response to the impacts of climate change and to guide in mainstreaming climate change in sector programmes. The National Task Team will also recommend the pillars of the National Climate Change Awareness and Communication Strategy, assist in raising awareness at higher levels of government and finally to launch the National Climate Change Response Strategy for Zimbabwe. Currently, the many legal and policy instruments of Zimbabwe do not adequately incorporate climate change issues, since many were developed before climate change became a serious security threat.

Zimbabwe is a member of the Southern African Development Community (SADC) as well as the Southern Africa Power Pool (SAPP). Being a signatory to the Multi-Lateral Environmental Agreements namely, United Nations Framework Convention on Climate Change (UNFCCC), United Nations Convention to Combat Desertification (UNCCD), and United Nations Convention on Biological Diversity (CBD), the country is ready to inform the appropriate responses to climate change.

Institutional Arrangements

The Office of the President and Cabinet has the overall responsibility of all decisions around Climate Change Policy. The Ministry of Environment and Natural Resources Management (MENRM) is responsible for all environmental issues in the country including climate change coordination through the Climate Change Office established within the MENRM. The Climate Change Office is supported by a multi-sectoral National Climate Change Committee (NCCC) for sector-specific and cross-sector implementation, coordination advice and guidance.

CONSTRAINTS AND GAPS, RELATED FINANCIAL, TECHNICAL AND CAPACITY NEEDS

Several studies that have been conducted in the country revealed some constraints and gaps and related financial, technical and capacity needs.

General Constraints

According to the Zimbabwe National Capacity Self-Assessment (NCSA) of 2008, only 18% of survey respondents ranked their level of awareness on climate change to be high while 42% ranked theirs to be very low. The statistics show that the level of awareness is still low in Zimbabwe. This limited awareness negatively affects climate change reporting and implementation of related initiatives.

Data gaps are a major issue for inventory preparation. Inadequacy of data can be attributed mainly to limited capacity (technical and financial) by key institutions to record or collect data. Loss of information from previous initiatives is also a challenge that needs to be addressed.

Inability to understand and properly apply complex UNFCCC methods and formulas used either in emission estimation amongst other climate change related methodologies is a challenge being faced by the country in trying to meet the convention's reporting requirements.

Climate change decisions are usually based on facts and figures through real time or recorded data. In Zimbabwe, systematic observations are mainly meteorological, hydrological and to a lesser extent agricultural. Some of the equipment used to make observations has reached the end of its life span making it obsolete and thus compromising data quality and availability.

Suggested solutions to the technological challenges include the need for technical capacity training for local technological institutions on technology adaptation and development. In addition, partnerships were suggested to be forged between local institutions and international technology developers so as to produce appropriate technologies.

Limited financial resources have been highlighted as one of the key barriers to successful reporting and implementation of the convention. The proposed mitigation and adaptation initiatives require funding for successful implementation. Funds should be mobilised both internally and externally to meet climate change needs.

Constraints specific to the Second National Communication

During the second national communication reporting process a number of constrains or challenges were identified in different sectors in relation to preparation of reports and implementation of climate change initiatives. The critical constraint in preparation of the GHG inventories for National Communications is the expertise in quantification of GHGs and also absence of a functional National Energy Information System (NEIS). The major constrain in reporting vulnerability and adaptation is limited access to and non availability of data for comprehensive analysis of vulnerabilities. There is data access constraint for research purposes and limited coverage for systematic observation systems to generate real time data on a continuous basis.

The major limitations to the education, training and awareness sector include limited dialogue on climate change initiatives and lack of a national situational analysis which should provide the basis for awareness programmes.

Financial limitations have been highlighted as key by the national consultants in accomplishing their tasks fully. The funds allocated to each section of reporting are not sufficient to ensure national coverage in terms of consultations and data collection. The level of funding also determines the quality and commitment of consultants hired. This has a bearing on the quality of the National Communication Report. Addressing these constraints will ensure that Zimbabwe has a solid foundation to move the climate change agenda forward.

Abbreviations and Acronyms

'A'-Level	Advanced Level
ABM	Agent Based Modelling
AIDS	Acquired Immune Deficiency Syndrome
AGRITEX	Agriculture, Technical and Extension Services
AWMS	Animal Waste Management System
AWOS	Automatic Weather Observing System
BCS	Best Case Scenario / the environmentally conscious scenario (B2a)
BCSDZ	Business Council for Sustainable Development Zimbabwe
BIOCLIM	Biological Climatic Model
BNR	Biological Nutrient Remover
BUH	Botswana Upper High
CA	Conservation Agriculture
CBD	Convention on Biological Diversity
CD	Compact Disk
CDM	Clean Development Mechanism
CDU	Curriculum Development Unit
CH_4	Methane
CIMMTY	International Centre for Improvement of Wheat and Maize
CO	Carbon Monoxide
Co_2	Carbon Dioxide
COMESA	Common Market for Eastern and Southern Africa
CPOL	Community Popular Opinion Leaders
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSO	Central Statistical Office
CV	Coefficient of Variation
DOC	Degraded Organic Content
DRR	Disaster Risk Reduction
DRSS	Department of Research and Specialist Services
ECD	Early Childhood Development
ECOCROP	Ecological Crop Requirements Model
EE	Environmental Education
EF	Emission Factor
EFDB	Emission Factor Data Base
EMA	Environmental Management Agency
EPA	Environmental Protection Agency
ESAP	Economic Structural Adjustment Programme
EU	European Union
FAO	Food and Agricultural Organisation
FC	Forestry Commission
GCM	Global Circulation Models
GCOS	Global Climate Observing Systems
GDP	Gross Domestic Product
GEF	Global Environment Facility

GHG	Greenhouse Gas
GIS	Geographic Information Systems
GNSS	Global Navigation Satellite System
GoZ	Government of Zimbabwe
GTS	Global Telecommunication System
GUAN	Global Upper Air Observations
GWP	Global Warming Potential
HadCM2	Hadley Centre Model version 2
HFC	Hydrofluorocarbon
HIV	Human Immunodeficiency Virus
HYCOS	Hydrological Cycle Observing System
IBM	Integrated Behaviour Model
IETC	International Environment Technology Centre
IKS	Indigenous Knowledge Systems
INC	Initial National Communication
IPCC	Inter-governmental Panel on Climate Change
ITCZ	Inter-tropical Convergence Zone
IWRM	Integrated Water Resources Management
LAPS	Local Area Prediction Systems
LPG	Liquefied Petroleum Gas
LULUCF	Land-Use, Land Use Change and Forestry
MDG	Millennium Development Goals
MENRM	Ministry of Environment and Natural Resources Management
MEA	Multilateral Environmental Agreements
MOEPD	Ministry of Energy and Power Development
MOHCW	Ministry of Health and Child Welfare
MSD	Meteorological Services Department
MSWDS	Municipal Solid Waste Disposal Site
N_2O	Nitrous Oxide
NCCC	National Climate Change Committee
NCCRS	National Climate Change Response Strategy
NCSA	National Capacity Self Assessment
NCSP	National Communication Support Programme
NEIS	National Energy Information Systems
NEP	National Environmental Policy and Strategies
NEWU	National Early Warning Unit
NGO	Non-governmental Organization
NHS	National Hydrological Services
NMVOC	Non-Methane Volatile Organic Compounds
NO_x	Nitrogen Oxides
NPP	Net Primary Productivity
NTT	National Task Team for Climate Change
OPEC	Organisation of the Petroleum Exporting Countries

PCGN	Permanent Committee on Geographical Names
PFC	Perfluorocarbon
PPP	Public-Private Partnership
RCZ	Research Council of Zimbabwe
SADC	Southern Africa Development Community
SAPP	Southern Africa Power Pool
SF_6	Sulphur Hexafluoride
SHP	Small Hydro Power
SIRDC	Scientific Industrial Research and Development Centre
SNC	Second National Communication
SO_2	Sulphur Dioxide
SWDS	Solid Waste Disposal Site
TB	Tuberculosis
TPF	Timber Producers Federation
TV	Television
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nation Framework Convention on Climate Change
UNITAR	United Nations Institute for Training and Research
WCS	Worst Case Scenario / the business as usual case (A2a)
US	United States
WHO	World Health Organisation
WHYCOS	World Hydrological Cycle Observing System
WMO	World Meteorological Organization
WRSI	Water Requirement Satisfaction Index
ZAPF	Zimbabwe Agricultural Policy Framework
ZBC	Zimbabwe Broadcasting Corporation
ZESA	Zimbabwe Electricity Supply Authority
ZFC	Zimbabwe Fertiliser Company
ZIMSEC	Zimbabwe Schools Examination Council
ZINWA	Zimbabwe National Water Authority

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CHAPTER 1

1. National Circumstances

1.1 Geographic profile

Zimbabwe is situated in the southern part of Africa between latitudes 15° 30" and 22° 30" south of the Equator and between longitudes 25° 00" and 33° 10" east of the Greenwich Meridian. The country is land locked and is bordered by Mozambique to the East, South Africa to the South, Botswana to the West and Zambia to the North and North-west. Zimbabwe has a total land area of approximately 390 757 square kilometres (km^2) and is divided into ten administrative provinces; Bulawayo, Harare, Manicaland, Mashonaland Central, Mashonaland East, Mashonaland West, Masvingo, Matabeleland North, Matabeleland South and Midlands as shown in Figure 1.1. Harare is the capital city and it has the major administrative and commercial functions.

Figure 1.1: Map of Zimbabwe
Source: The Permanent Committee on Geographical Names (PCGN) Zimbabwe. Map produced by DGIA, Ministry of Defence, UK 2002

The country's main topographical features, shown in Figure 1.2 include:

i. The central watershed, running from southwest to northeast and ranging from 1200m to 1500m above mean sea level. The watershed is 650 kilometres long and 80 kilometres wide.
ii. The highest elevation is along the eastern border with Mozambique where mountain peaks range from 2300m to 2500m
iii. The Zambezi and Limpopo River Valleys found in the north and south respectively have the lowest altitude of around 500m.

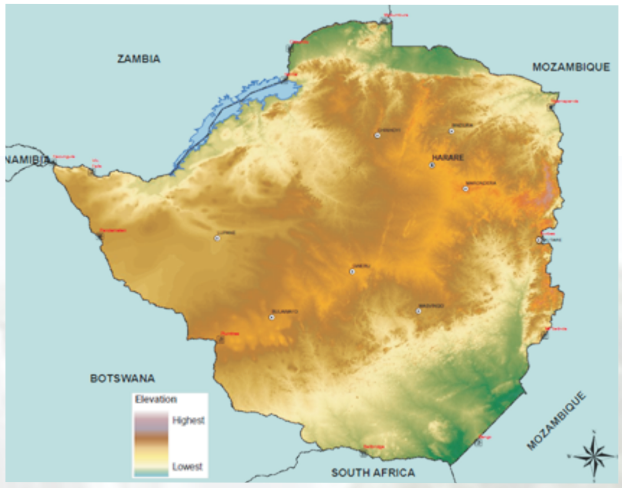


Figure 1.2: Zimbabwe's terrain

1.2 Climate

Zimbabwe does not experience the traditional spring, summer, autumn and winter seasons. Rather the seasons are as follows:

- Cool season – mid-May to August
- Hot season – September to mid-November
- The main rainy season– mid-November to mid March
- The post rainy season– mid-March to mid May

1.2.1 Characteristics of the Rainy Season

Rain does not fall everyday but tends to come in rainy spells which are interrupted by dry periods. Rainfall over Zimbabwe can be a result of orographic lifting, frontal systems, convergence and convection. Convection accounts for about 90% of the country's rain. In the beginning of the season (mid October to end December) cloud bands from the west of the country are the dominant source of rain whereas in the second part (January to March), the ITCZ (Inter-tropical Convergence Zone) is the main rain bearing system. The ITCZ is characterised by semi permanent low pressure systems over the Caprivi Strip and the Central Mozambique Channel.

Although it is migratory, the preferred position of the ITCZ axis is at about 12°S or 16°S, the latter being more favourable for a good rainy season.

1.2.2 Rainfall Distribution

Annual rainfall ranges from below 400mm in the south to over 1000mm in the eastern parts of the country with an average of about 657.5mm. Seasonal precipitation however varies from year to year. The mean annual rainfall distribution is as shown in Figure 1.3 (Meteorological Services Department).

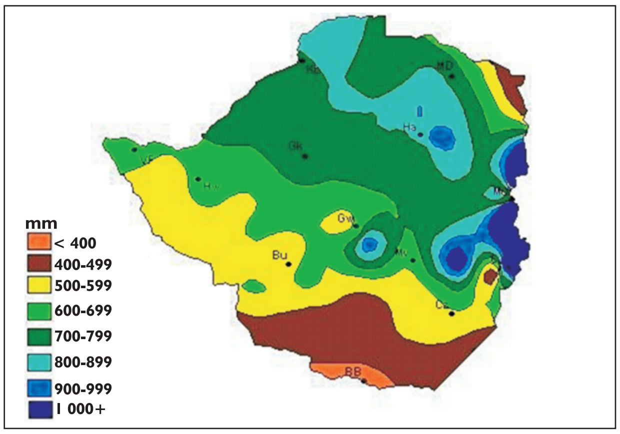


Figure 1.3: Mean Annual Rainfall

1.2.3 Tropical Cyclones

Tropical cyclones also play an important role to the Zimbabwe rainfall season. A number of these tropical cyclones enter the Mozambique Channel from the northeast between November and April reaching their peak in February. Depending on their proximity and relative position, tropical cyclones may induce an extended drought in the country (Torrance, 1982; Matarira, 1990) or give widespread and heavy rainfall within a very short space of time. Examples of tropical cyclones that affected Zimbabwe in recent times include Eline (2000) and Japhet (2003).

1.2.4 Botswana Upper High

Another important feature of the rainfall season is the middle level (500hPa) anticyclone which tends to establish its centre over Botswana and is hence referred to as the Botswana Upper High (BUH). This normally happens at the end of December and into early January. The resultant subsidence caused by this circulation regime prevents the formation of clouds and hence results in a prolonged dry spell especially in the south-western parts of the country bordering Botswana.

1.2.5 Temperature

The lowest minimum temperatures are recorded in June or July and the highest maximum temperatures in October, or if the rains are delayed, in November. The mean monthly temperature varies from 15°C in July to 24°C in November while the mean annual temperature varies from 18°C on the highveld to 23°C in the lowveld (Figure 1.4).

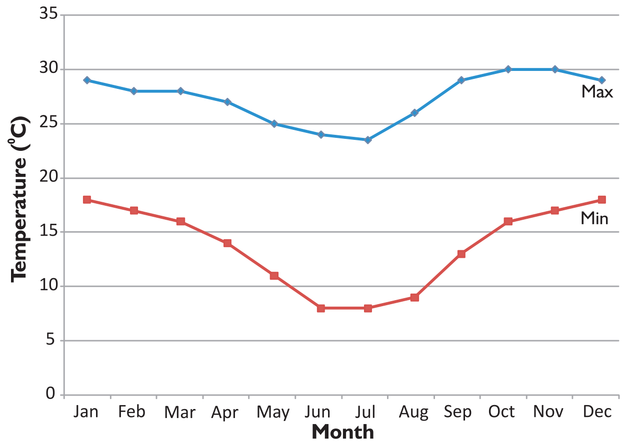


Figure 1.4: Average monthly minimum and maximum temperature

A combination of a dry south-westerly airflow, clear skies overnight and calm winds in the cool season sometimes results in ground frost. The ground frost occurs from mid May and reaches a peak around 20 June. The main peak however is reached from mid to end of July. Thereafter the incidence of frost decreases sharply throughout August with just some isolated cases in September.

1.3 Natural resources

The country has abundant natural resources that include beautiful scenery, arable land, forests, minerals, and surface and ground water. There are 12 national parks, one trans-frontier park (Trans Zambezi National Park), and other protected areas. The flora in the country is dry miombo woodland, with mopane woodland and other woodland types dominating while serpentine grasslands are found in the Great Dyke. Montane forest interspersed amongst high-altitude grasslands and heath is found in the Eastern Highlands (SABONET Report No. 14, 2002). Figure 1.5 shows that the eastern regions of the country have the highest plant diversity followed by the central watershed. The southern and western regions have the lowest plant diversity.

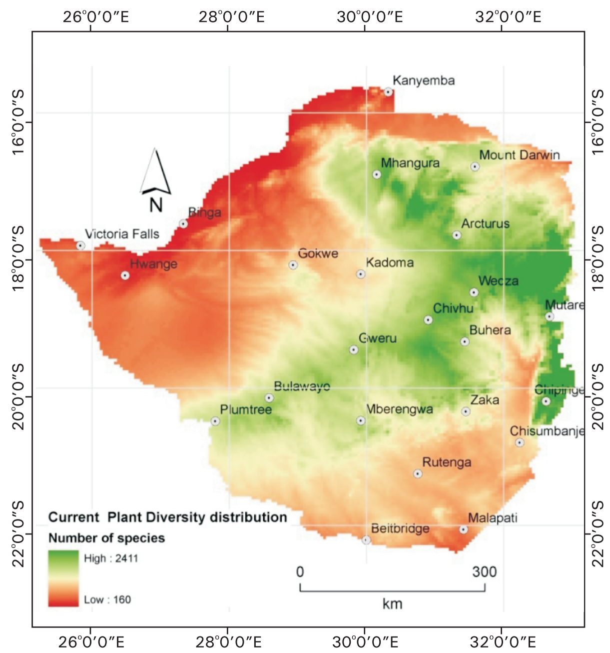


Figure 1.5: Spatial variations in tree species diversity in Zimbabwe

1.3.1 Water resources

Water resources in Zimbabwe are dependent on rainfall which is highly variable across most of the country with notable exceptions being the eastern Highlands, which receive high and fairly stable rainfall. Zimbabwe has an extensive network of over 10 000 small, medium and large dams . The main uses of the dams are irrigation, mining, industrial and hydropower. Construction of dams for irrigation water is a national priority due to a series of droughts ravaging Southern Africa and the desire to supplement agricultural output by winter cropping. The country relies on surface water resources for 90% of its requirements while groundwater supplies the remaining 10%. At present, agriculture uses 60% of all the water in dams but irrigation efficiencies range between 40% and 60% . In the urban areas, as much as 40% of water is lost during treatment and distribution (Chenje *et al* 1998). There are seven catchments in the country, namely Manyame, Mazowe, Gwayi, Runde, Sanyati, Save and Mzingwane, shown in Figure 1.6.

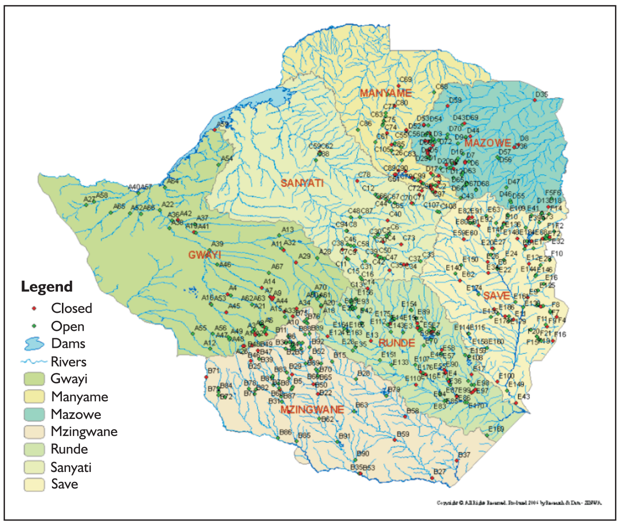


Figure 1.6: Catchments of Zimbabwe

The country is endowed with wetlands that include swamps, rivers, dambo areas and pans. A number of wetlands have been lost over the years due to draining for agricultural use, polluting waters that empty into wetlands, filling in through construction, among other factors.

Water use in Zimbabwe was governed by the Water Act of 1976 up to January 2000 when a new legislation was enacted. Under the 1976 Water Act, people were issued with water rights on a 'first come first served' basis. Water was treated as private property unless the right is taken over by the Minister for the good of the public. The new Water Act is meant to improve equity in access to water, improve the management of water resources, strengthen environmental protection and to improve its administration. Under the water permit system, there is no longer separation between surface water and ground water and the 'polluter pays' principle has been adopted to ensure the protection of water quality.

Water is classified as either for primary use or commercial use. The primary purposes of water use are reasonable use of water for the sustenance of life e.g. drinking, bathing, household cooking and watering small gardens. Commercial use of water requires a permit and is basically the use of water by an individual who derives a profit/benefit out of accessing the water. Water abstracted for primary use does not require a permit from the Zimbabwe

National Water Authority (ZINWA). Catchment Councils, composed of representatives of all categories of people in the catchment area including farmers were formed to ensure that the interests of all water users are represented. Catchment Councils were given the powers to:

- allocate water permits, with the Administrative Court (formerly the Water Court), being the Court of Appeal;
- supervise the exercise of permits to the use of water within the catchment area; and
- assist in the preparation of catchment plans in accordance with the Act.

1.3.2 Forestry

Zimbabwe's forestry resources cover approximately 66% of the total land area (257, 783km^2). Like many other sub-Saharan African countries, Zimbabwe's forest stocks generate a wide range of both timber and non-timber products and services. The products include fuelwood, fuelwood for charcoal making, sawn timber, pulpwood, building materials, wood for crafts, fodder, fruits, honey, mushrooms, edible insects, bark for rope, medicines, leaf litter, gum and resins. The services include watershed management, carbon fixation, microclimate stabilization, and the provision of windbreaks, shade, soil stability and wildlife habitat. Clearly given the relatively extensive woodland cover across the country, Zimbabwe has the potential to be a carbon sink. However, current pressures for more agricultural land and for wood for various purposes, including fuelwood reduces the carbon sink potential of the country.

Over a quarter of the woodland area is found in state lands, namely, national parks, wildlife reserves and forest reserves. Many people in the communal lands rely heavily on woodland resources for food, furniture and timber for construction.

Most of the country is covered by mopane/miombo woodland and savanna. About 21 million hectares of the land are under indigenous woodlands, 156 000 hectares under plantations and 12 000 hectares under natural forests. Non-commercial plantations cover 18 000 hectares of land. Commercial plantations, mainly eucalyptus and pines, occupy 120 000 hectares with the biggest area of 108 000 hectares in Manicaland. Commercial timber harvested from indigenous woodlands in communal lands is mainly teak and mukwa species. Sculptors are contributing to environmental damage of the indigenous forests by harvesting several species of hardwood to make wooden sculptures for sale especially in the Hwange and Victoria Falls areas of Matebeleland North. The Wattle species have been subjected to the most intense damage by fire. The eucalyptus is affected mostly by droughts. The distribution of various types of vegetation commonly found in Zimbabwe is shown in Figure 1.7.

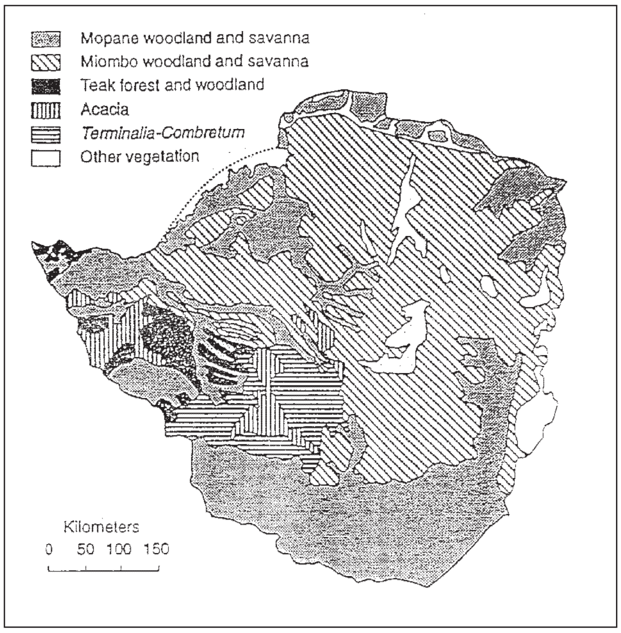


Figure 1.7: Common Vegetation Types in Zimbabwe
Source: *Department of Natural Resources (1961), After Rattray and Wild*

1.4 Population

In August 2002 Zimbabwe had an estimated total population of 11,6 million. The proportion of male and female population was 48 and 52 percent respectively. Sixty-five percent of the total population lived in rural areas while 35 percent lived in urban areas. The population density ranged from 9 persons per square kilometre in Matabeleland North to 2 174 persons per square kilometre in Harare. Harare's population constituted about 20 percent of the total population in the country. The average rate of natural increase expressed as the difference between the level of fertility and mortality for the whole country for the period September 2001 to August 2002 was at 1.3 percent.

The composition of population by age group and sex is shown in Figure 1.8. It can be observed that the proportion of the young population is greater than the old population.

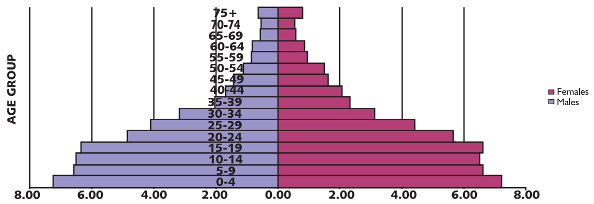


Figure 1.8: Population pyramid (percent, 2002 census)

The 1997 Inter-Censal Demographic Survey estimated the rural urban population distribution at 68 percent and 32 percent respectively, while the 2002 Population Census estimated 65 percent of the population to be living in the rural areas and 35 percent in the urban areas. The distribution depicts a gradual increase in urban population proportion.

Figure 1.9 shows that from 1994 to 1996 the country's population has been growing at a steady rate and then assumed a falling pattern up to 2002. This could be as a result of increased use of conventional family planning methods coupled with high mortality caused by HIV and AIDS, among other factors.

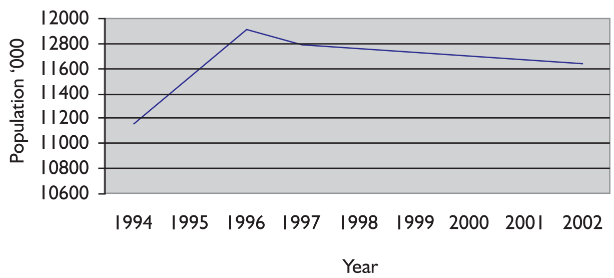


Figure 1.9: Zimbabwe Population Growth, 1994 to 2002

(Source: CSO, 2003 National Accounts Report)

1.4.1 Population Distribution

Zimbabwe is divided into ten provinces with varying population compositions and sizes. In all the provinces males are outnumbered by females. Harare province is almost all urban while Bulawayo is wholly urban. The rest of the provinces have a mix of rural and urban population distribution. Table 1.1 illustrates the population distribution by province as of 2002 population census.

Table 1.1: Population Distribution by Province by Sex, 2002

Province	Male	Female	Total
Bulawayo	323 550	353 100	676 650
Harare	947 386	948 748	1 896 134
Manicaland	747 242	821 688	1 568 930
Mashonaland Central	488 695	506 732	995 427
Mashonaland East	545 898	581 515	1 127 413
Mashonaland West	609 778	614 892	1 224 670
Masvingo	618 009	702 429	1 320 438
Matabeleland North	340 475	364 473	704 948
Matabeleland South	309 316	343 738	653 054
Midlands	703 831	760 162	1 463 993
Total	**5 634 180**	**5 997 477**	**11 631 657**

Source: CSO (2002), National Profile 2002 Population Census

1.5 Economic development

1.5.1 Industry

Figure 1:10 presents Zimbabwe's Gross Domestic Product (GDP) from 1994 to 2000, where the GDP at market prices increased by 881.6 in nominal terms. However, GDP at constant 1990 prices increased gradually from 1994 to 1998 then assumed a downward trend to year 2000. The decline is explained by poor performance of all sectors except agriculture, hunting and fishing; real estate and health. While nominal GDP per capita depicts an increasing trend throughout the period, real GDP per capita has been on a decline. From 1998 to 2000, the growth rates were at 0.8%, -3.3% and -7.1%, respectively. When comparing the periods before and after the introduction of the economic reform programmes against 1990 constant prices, it can be noted that per capita income fell from an average of Z$2 024 before the Economic Structural Adjustment Programme (ESAP) to an average of Z$1 930 during the economic reform programmes (CSO, 2000 Compendium of Statistics)

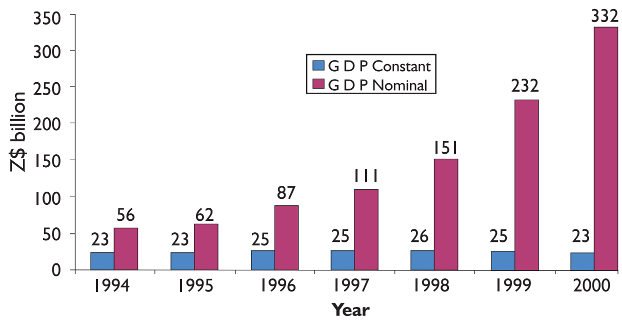


Figure 1.10: GDP trends from 1994 to 2000

1.5.2 Energy

Zimbabwe is experiencing constrained energy supplies, a factor that has adversely affected business and public transport operations throughout the country. The unreliable public transport in both the urban and rural areas has undermined productivity and contributed to a loss of market competitiveness and has inconvenienced the general public. In response, the Government has called upon the private sector to contribute by addressing the prevailing commuter transport challenges through the provision of staff buses and allowing firms and individuals with "free funds" to import their own fuel. However, the provision to freely import fuel has led to too many uncoordinated individual fuel importers.

Stability in the energy sector, encompassing liquid fuels, coal and electricity supplies is an indispensable pre-requisite for successful economic growth, as well as for household use. The country's vision is to ensure that by 2010, every province in the country will have a running large-scale bio-diesel plant, in the process promoting national self-sufficiency in the area of diesel supply, as well as guaranteeing viable markets for farmers growing oil seeds. Currently there are two biodiesel plants. As the Nation deepened its efforts towards foreign currency generation, as well as import-substitution programmes, government of Zimbabwe introduced state-of-the-art technology for the Bio-diesel Production Programme. This project requires feed-stock in the form of jatropha, cotton seed, sunflowers, among many other oil-seeds as inputs.

1.5.3 Mining

Mining is an important source of foreign currency to Zimbabwe although it is one of the greatest polluting activities to the environment. The major minerals reserve deposits in Zimbabwe comprise asbestos (As), gold (Au), copper (Cu), chrome (Ch), nickel (Ni) and iron (Fe). The distribution of mineral resources is shown in Figure 1.11.

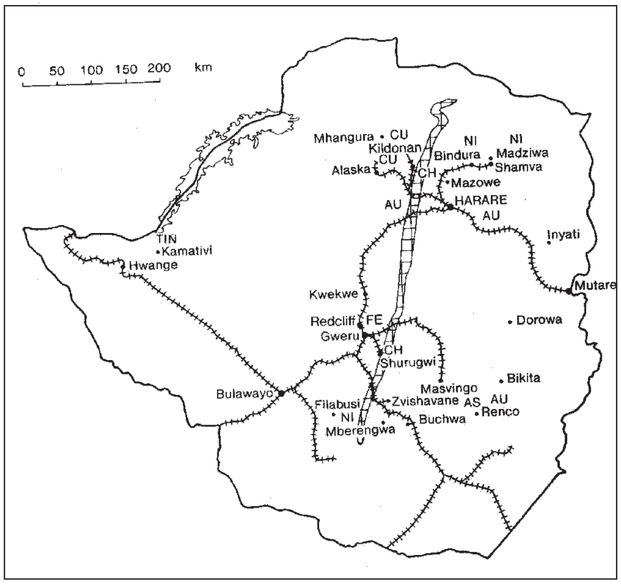


Figure 1.11: Zimbabwe Mineral Reserves by type.
Source: Michie, W. D. and E. S Nhandara (1999), Geography Today

The mineral volume decreased except for black granite and platinum. Mining activities can cause serious environmental problems as a result of the method used in extracting the ore i.e. underground or open cast. Open cast methods involve stripping of large pieces of arable land to remove the covering soil which disturbs the natural environment surrounding the mines. It removes vegetation and takes away land that could be used for agriculture. For example, in coal mining, the removal of the upper layer of land results in large quantities of spoil, i.e. heaps which are spontaneously combustible or present serious wind and water erosion problems. Coal mining sites in Zimbabwe are concentrated on the Zambezi Basin.

1.5.4 Agriculture

Zimbabwe has an agricultural based economy with the agriculture sector contributing about 15% each year to the GDP. The country is divided into five natural regions on the basis of soil type, rainfall, temperature and other climatic factors as shown in Figure 1.12. The first three regions are suitable for intensive crop and animal production while the other two are used for extensive livestock production and offer little scope for crop production. Rainfall ranges from 650mm to above 1 050mm per annum in regions 1 to 3 while in regions 4 and 5 it is below 650mm per annum.

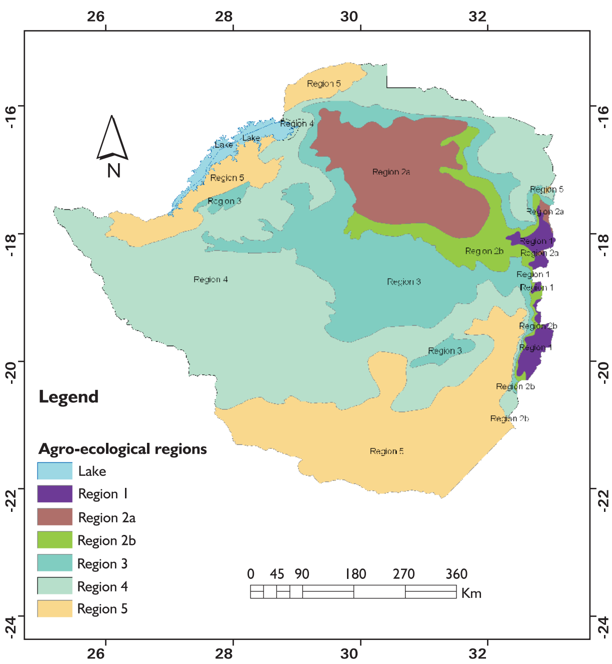


Figure 1.12: Zimbabwe Agro-ecological zones

Zimbabwe's agriculture is divided into four major sectors namely; Large Scale Commercial Farms, Small Scale Commercial Farms, Communal and Resettlement Schemes which comprise of the Old Resettlement Schemes, A1 and A2. The country produces a variety of crops in its different sectors and zones. These include grain crops such as maize, sorghum, mhunga (pearl millet), rapoko (finger millet), oilseeds (sunflower, groundnuts and soyabeans) and other industrial crops which include tobacco, cotton, edible dry beans and paprika. The country rears a variety of livestock that include cattle, sheep, pigs and goats. Table 1.2 presents hectarage and crop production (tonnes) for the years 1999 and 2000 for a few of these crops. The location of different types of agriculture across the country is heavily dependent on the agro-ecological zones. In terms of market value, the most important crops are tobacco, cotton and maize in that order but in terms of strategic importance maize comes first as it is the staple food.

Table 1.2: Hectarage and crop production (tonnes) for the years 1999 and 2000

Crop	Area (1999)	Area (2000)	Production (1999)	Production (2000)
Maize	1,477,990	1,373,117	1,606,588	1,619,651
Sorghum	143,912	116,248	57,535	46,307
Pearl Millet	146,849	122,717	25,161	19,359
Rapoko (Finger Millet)	36,595	29,673	16,735	11,634
Groundnuts	132,117	175,773	80,240	124,117
Edible Beans	14,483	15,088	9,489	7,443
Paprika	5,998	3,922	10,718	7,342

Adapted from CSO,2003 Agriculture Production Statistics

1.5.5 Livestock

Meat contributes to the nutritional status of the nation and to the national GDP. The country rears a variety of livestock in addition to its abundant wildlife species and poultry. Major domesticated animals are cattle, sheep, pigs and goats. Table 1.3 illustrates the growth patterns in numbers of livestock in the country.

Table 1.3: Numbers of Livestock Held ("000 head), 1994-2000

Year	Cattle	Sheep	Pigs	Goats
1994	5,140	436	232	4,471
1995	4,992	435	264	5,001
1996	5,078	379	268	4,823
1997	5,375	416	310	5,054
1998	5,566	386	324	4,990
1999	5,975	350	257	4,601
2000	6,013	340	270	4,248

Adapted from CSO, 2003 Agriculture Production Statistics

1.5.6 Transport

Zimbabwe has a fairly modern transport service, dominated by road transport, and contributes about 7% to GDP. Other predominant forms of transport are railway and air, while boats are used in the man-made dams of the country. The international routes radiate from Harare and Bulawayo (the second largest city) to neighbouring countries. In the year 2000 there was a total of approximately 18 514km of road designated as state roads in Zimbabwe, of which 9 498,9 km were gravel and earth. There has been a steady increase in the registered vehicle population in the country from 1980 to 2000, with the total number of vehicles rising by 8.7% over the period.

1.5.7 Tourism

Tourism in Zimbabwe is the seventh leading foreign exchange earner contributing about 16,3 % of the country's GDP (*Personal Communication, Reserve Bank of Zimbabwe*). Tourism in Zimbabwe is the seventh leading foreign exchange earner contributing about 16,3 % of the country's GDP. The country is richly endowed with a variety of tourist attractions. It has one of the Seven Wonders of the World and heritage site, the Victoria Falls. The scenic mystical beautiful eastern highlands is dominated by mountains, waterfalls and forests. The country accommodates a variety of national parks and trans-frontier parks with over 100 animal species and 400 bird species. Among the animal species are the big five, elephant; rhino; leopard; lion and buffalo. The country boasts of its tangible and intangible heritage. The tangible heritage consists of stone architectures such as the Great Zimbabwe monument and Rhodes Matopos monument while the intangible heritage is dominated by rich cultural diversity, inspiring musical sounds and mesmerising dances. Lake Kariba, one of the largest man-made lakes in the world, covering 5 000 km^2 with a stretch of 2 700 kilometres, has transformed into a major tourist attraction. The tourist attractions are heavily concentrated with magnificent luxurious hotels. In 1995, Zimbabwe had 158 touring and 290 hunting operators. There were 73 graded hotels, 75 ungraded hotels/lodging facilities and 90 camping caravan sites.

1.5.8 Trade

Total trade, sum of exports and imports, is a useful indicator of the level/volume of external trading activity. Zimbabwe's total trade has grown at the rate of 8 % from 1993 to 2000. Throughout the period under review, imports and exports rose by annual averages of 30.2% and 39.0%, respectively, and overall trade balance deficit grew from around ZW$1.6 billion in 1993 to ZW$16.5 billion in 1998. On Zimbabwe's trade direction, the table below depicts total imports and exports for the period 2000 to 2007. Fuel constitutes the major proportion of imports. Zimbabwe's total trade dropped slightly to $122 billion from 130bn in 2000, then rose to 201bn in 2002. From there, rose sharply to 616 481bn in 2006 and dropped by half to 302 594 billion in the following year.

Table 1.4: Total Trade in (ZW$) Billions

	2000	2001	2002	2003	2004	2005	2006	2007
Imports	57	61	97	1,081	11,959	46,433	461,915	283,741
Exports	72	61	104	587	4,235	31,139	154,566	18,853
Total Trade	**129**	**122**	**201**	**1,668**	**16,194**	**77,572**	**616,481**	**302,594**

1.6 Environmental protection

Concerns over the sustainable environmental management have increasingly become the subject of mainstream socio-economic policies at national, regional and international levels. Growing pressures on the environment and increasing environmental awareness have generated the need to account for the interactions between all sectors of the economy and the environment. Therefore, it is clearly recognized that environmental issues are an essential component of national development plans. Zimbabwe, through the Ministry of Environment and Tourism led the process of developing a National Environmental Policy and Strategies (NEP) in 2009. The policy compliments the Environmental

Management Act (Chapter 20:27), promulgated in March 2003, and other complimentary legislation pertaining to environmental protection, monitoring and sustainable management.

1.7 Education Development

Zimbabwe achieved the near universal primary education for all in the 1990s which laid a foundation towards the fulfilment of the Millennium Development Goal 2 (MDG 2). The goal seeks to achieve universal primary education by year 2015 irrespective of gender. The education policy adopted soon after independence in 1980 contributed to increased primary education with an increase in the number of schools by 9.6% from 1990 to 2000. Primary school net enrolment ratio improved from 81.9% in 1994 to 93% in 2002. There has also been a rapid increase in the number of secondary schools as well as school attendance since country's attainment of independence..There has also been a rapid increase in the number of secondary schools as well as school attendance. Tertiary education also improved significantly after 1990, with numerous vocational centres, polytechnics and training colleges being established. To date, twelve universities have been opened in addition to the University of Zimbabwe to absorb the increasing demand for tertiary education. This has greatly improved the country's educational profile.

1.8 Healthcare Development

The major health issues in Zimbabwe relate to child mortality, maternal health and the top five killer diseases. The top five killer diseases are HIV and AIDS epidemic, malaria, TB and diarrheal diseases. Maternal mortality figures were estimated by the 1999 Zimbabwe Demographic and Health Survey at 283 deaths per 100 000 live births during 1984 to 1994 and rose sharply to 695 per 100 000 live births in 1995 to 1999. The country targets to reduce under-five mortality from 102 per thousand over the period 1995 to 1999 to 34 per thousand by 2015, infant mortality from 65 per thousand during the same period to 22 per thousand by 2015. The sharp rise in child and maternal mortality rates are largely explained by the rapid spread of the HIV and AIDS epidemics. The country is experiencing one of the world's most severe HIV and AIDS epidemics, with 2.3 million people being affected and adult prevalence rate at 34 percent (UNAIDS, 2002). The survey also revealed that 25 percent of the households had no access to safe water and 42% had no access to sanitation, which further exposes children to the risks of water-borne diseases. Whilst malaria is one of the major public health problems in the country, Zimbabwe has measures in place to control malaria and the most common one is the spraying programme done under the Ministry of Health and Child Welfare. This programme normally commences at the start of the rain season and is aimed at reducing the spread of mosquitoes. The Roll Back Malaria Campaign, which is being spearheaded by the World Health Organisation (WHO), also tries to reduce deaths attributed to malaria by half in Zimbabwe.

1.9 Political and Decision Making Structure

Zimbabwe is a sovereign state with a democratically elected executive President who is both head of state and head of government. The Zimbabwe legal system is based on Roman-Dutch Law and the 1979 Lancaster House Constitution which now has undergone 18 amendments.

The legislature consists of the parliament that has two chambers which are the Upper House (Senate) and Lower House (House of Assembly). The Senate has a total of 66 members of which 50 members, 5 from each province are directly elected in single member constituency using the simple majority system. The president appoints 6 additional members and the remaining 10 seats are held by traditional chiefs who are chosen in separate elections. Constitution of Zimbabwe Amendment No. 18 of 2007 provides for the expansion of the Senate to 93 seats. Six senators would come from each province directly elected by voters registered in the 60 Senate constituencies; 10 Provincial Governors appointed by the President; the president and deputy president of Council of Chiefs; 16 chiefs, being two chiefs from each province other than metropolitan provinces, and five Senators appointed by the President.

The House of Assembly has 120 members, representing geographical constituencies, elected by the common-roll electorate, 10 tribal chiefs, 12 presidential appointees and eight presidentially appointed provincial governors. Like in many legislatures worldwide, the lower house wields more power than the upper house due to special restrictions placed on the powers of the upper house. The lower house designates the president, and may remove him through a vote of no confidence. The parliament may serve for a maximum of five years.

CHAPTER 2

National Inventory of Greenhouse Gases

2.1 Structure and process of greenhouse gas inventory

The GHG inventory team was composed of seven sector experts. The sector experts were responsible for collecting sectoral data and computing the greenhouse gas emissions and presenting the results in a sector report. The inventories team reported to the Climate Change Coordinator in the Ministry of Environment and Natural Resources Management. Training workshops were held at the beginning of the exercise to familiarize the team with the IPCC methodologies. Given the discontinuities in national statistical systems the team members spent significant time collecting data from secondary sources and verifying it. The year 2000 was the last year when sectoral data was collected through the national statistical systems. These systems are however now being resuscitated.

2.2 Methodology

2.2.1 Selection of conversion factors

In computing emissions in the energy sector all conversion factors were based on the typical figures used by the Ministry of Energy and Power Development. These figures were referred to regional default figures recommended by SADC and were also close to the IPCC default figures. Coal was however converted to energy on the basis of analysis made by the coal supplier.

2.2.2 Selection of emission factors

In the absence of national emission factors the greenhouse gas emissions were computed on the basis of IPCC default emission factors. In instances where individual industrial plant provided data the emission factors were based on the plant specific parameters provided. This is true for cement and ammonia production. In agriculture and land use change local parameters were used to compute emission factors. Livestock size and husbandry practices were used to compute the emission factors for methane. The methods are therefore a mix of tier 1 and tier 2.

2.2.3 Selection of approach for calculating greenhouse gas emissions

The approach to estimating greenhouse gases was to use manual worksheets. Some energy data was entered in the 1996 software. However, other sector experts preferred the worksheets hence the IPCC software was not fully utilized.

2.2.4 Reference approach (source: 1996 IPCC revised manual)

Given the absence of detailed data, the reference and sectoral approaches yielded very similar results. For instance for the energy sector figures were all extracted from the energy balance which naturally yields same estimates since default factors were used. There was no separate sectoral data collection apart from the energy balance.

2.2.5 Completeness of data

The major sources of emissions are energy use, industry, waste and agriculture. Within industry most of the emissions are from cement, ammonia and phosphoric acid production. Energy use constitutes more than 80% of the greenhouse gas emissions in Zimbabwe. Emission estimates were made for all these sectors subject to data availability and data quality. Industrial processes changed significantly between 1998 and 2004. Some processes have since stopped and some manufacturers have turned traders.

2.2.6 Analysis of data quality

Lack of an inventories data collection system limits peer review of data. It was therefore difficult to make an assessment of data quality as quality assurance is independent of the inventory system. Energy data is based on commercial information especially for electricity, coal and petroleum fuels. This data is of high quality. However, after 2000 the energy sector was deregulated and there was entry of numerous fuel importers into the market. Import data was therefore more difficult to compile. The revenue collection system is interested mostly in financial figures hence data in energy units was not easily available.

The Central Statistical Office collects production data from all sectors. This office was however underfunded between 2000 and 2010. Production figures for agriculture, industry and commerce was therefore limited. The system is however being revived and publication of statistics is now underway. During compilation of the inventories there was limited availability of official production figures.

2.3 Contribution of Zimbabwe to global warming

The summation of greenhouse gases emitted in Zimbabwe was calculated by sector based on the application of Global Warming Potentials (GWP) as follows: (CO_2=1: CH_4=21: N_2O=310; CO=3: NO_x=290: NMVOC=10000). Table 2.1 below shows the GHG emissions and estimated sinks. It can be observed that, Zimbabwe is an emitter of greenhouse gases. This finding includes the major managed forests and not the standing biomass in croplands and urban settlements. Emissions of non-CO_2 gases and their GWP play a critical role in this finding. Given the high uncertainty in nitrous oxide and NMVOC's, this finding can change between inventory years.

2.3.1 Major sources of GHG emissions

The major sources of greenhouse gas emissions are fuel combustion, agriculture, waste handling and industrial processes.

2.3.2 Total GHG emissions

The total greenhouse gas emissions are summarized in Table 2.1.

Table 2.1: GHG Emissions Summary for Zimbabwe for the year 2000

Country	Zimbabwe
Inventory Year	2000

National greenhouse gas inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol and greenhouse gas precursors								
Greenhouse gas source and sink categories	**CO_2 emissions (Gg)**	**CO_2 removals (Gg)**	**CH_4 (Gg)**	**N_2O (Gg)**	**NO_x (Gg)**	**CO (Gg)**	**NMVOCs (Gg)**	**SO_x (Gg)**
Total national emissions and removals	**25,805.7**	**88,034.6**	**335**	**60.22**	**148.64**	**798.86**	**82.23**	**1.38**
1. Energy	**23,832**	**0**	**47**	**4**	**148**	**770**	**76**	**0**
A. Fuel combustion (sectoral approach)	23,832		41	4	148	770	76	0
1. Energy Industries	7,488		0	0	24	2	0	0
2. Manufacturing industries and construction	13,012		0	0	11	5	0	0
3. Transport	1,071		0	0	19	121	0	0
4. Other sectors	2,255		41	4	94	642	76	0
Commercial and Institutional	362							
Residential	96		38	1	13	633	76	
Agriculture	1,797		3	3	81	9		
5. Other (please specify) Mining	6		0	0	0	0	0	0

Table 2.1: GHG Emissions Summary for Zimbabwe for the year 2000 *(continued)*

B. Fugitive emissions from fuels	0		6		0	0	0	0
1. Solid fuels			6		0	0	0	0
2. Oil and natural gas			0		0	0	0	0
2 Industrial Processes	**1,973.7**					**0.37**	**6.23**	**1.38**
A. Mineral products	13,69.2							0.3
B. Chemical industry	117							0.17
C. Metal production	487.5					0.37		0.91
D. Other production Food Production Beverages and Tobacco							6.23	
E. Production of halocarbons and sulphur hexafluoride								
F. Consumption of halocarbons and sulphur hexafluoride								
G. Other								
3 Solvents and other product use								
4 Agriculture			**219.9**	**56.22**	**0.64**	**28.49**		
A. Enteric fermentation			212.43					
B. Manure management			7.47	0.04				
C. Rice cultivation								
D. Agricultural soils				56.16				
E. Prescribed burning of savannahs								
F. Filed burning of agricultural residues				0.02	0.64	28.49		
G Other								
5 Land-use change and forestry		**88,034.6**						
A. Changes in forest and other woody biomass stocks		88,034.6						
B. Forest and grassland conversion								
C. Abandonment of managed lands								
D. CO2 emissions and removals from soils								
Other								
6 Waste				**68.1**				
A. Solid waste disposal on land			56.8					
B. Waste-water handling			11.3					
C. Waste incineration								
D. Other								
Memo items								
Aviation								
Marine								
CO2 emissions from biomass	**14,605**							

2.4 Dynamics of greenhouse gas emissions per sector

2.4.1 Key Category Analysis

Key categories are summarized below in Table 2.2. Key category analysis was done using only the direct greenhouse gases. Key categories were those emitting 1.49% and more in CO_2 equivalents using the Global Warming Potentials specified in the IPCC Second Assessment Report. The key categories were in the Energy, Industry, Agriculture and Waste sectors. CO_2 emissions from fuel combustion, methane emissions from fuel use in the household sector and nitrous oxide emissions from agricultural soils which included use of fertilizer were key categories.

Table 2.2: Key Source Categories

IPCC Source Category	Sector	Source Categories to be Assessed in Key Source Category Analysis	Applicable Greenhouse Gas	Emission Estimate (current year, non-LULUCF) (Gg CO2eq)	Level Assessment excl. LULUCF (%)	Cumulative level excl. LULUCF (%)
Sum				36,366.10		
1.A.2	Energy	CO_2 Emissions from Manufacturing Industries and Construction	CO_2	13,011.60	35.78%	35.78%
1.A.1	Energy	CO_2 Emissions from Stationary Combustion	CO_2	7488	20.59%	56.37%
4.A	Agriculture	CH_4 Em issions from Enteric Fermentation in Domestic Livestock	CH_4	4617.9	12.70%	69.07%
4.D	Agriculture	N_2O (Direct and Indirect) Emissions from Agricultural Soils	N_2O	3490.6	9.60%	78.67%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CO_2	CO_2	1,796.70	4.94%	83.61%
6.A	Waste	CH_4 Emissions from Solid Waste Disposal Sites	CH_4	1192.8	3.28%	86.89%
2.A	Industrial Processes	CO_2 Emissions from Limestone and Dolomite Use	CO_2	870.7	2.39%	89.28%
1.A.4	Energy	Other Sectors: Residential CH_4	CH_4	797.6	2.19%	91.48%
1.A.3	Energy	CO_2 Mobile Combustion: Road Vehicles	CO_2	785.1	2.16%	93.63%
2.A	Industrial Processes	CO_2 Emissions from Cement Production	CO_2	541.2	1.49%	95.12%
2.C	Industrial Processes	CO_2 Emissions from the Iron and Steel Industry	CO_2	443.2	1.22%	96.34%
1.A.4	Energy	Other Sectors: Commercial CO_2	CO_2	361.6	0.99%	97.34%
6.B	Waste	CH_4 Emissions from Wastewater Handling	CH_4	237.3	0.65%	97.99%
1.A.3	Energy	CO_2 Mobile Combustion: Aircraft	CO_2	160.8	0.44%	98.43%
1.A.4	Energy	Other Sectors: Residential N_2O	N_2O	157.2	0.43%	98.86%
1.B.1	Energy	CH_4 Fugitive Emissions from Coal Mining and Handling	CH_4	117.7	0.32%	99.19%
1.A.4	Energy	Other Sectors: Residential CO_2	CO_2	95.6	0.26%	99.45%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CH_4	CH_4	62.5	0.17%	99.62%
2.B	Industrial Processes	N_2O Emissions from Nitric Acid Production	N_2O	40.3	0.11%	99.73%
1.A.1	Energy	N_2O (Non-CO_2) Emissions from Stationary Combustion	N_2O	35	0.10%	99.83%
1.A.2	Energy	N_2O Emissions from Manufacturing Industries and Construction	N_2O	15.9	0.04%	99.87%
4.B	Agriculture	N_2O Emissions from Manure Management	N_2O	12.4	0.03%	99.91%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing N_2O	N_2O	7.3	0.02%	99.93%
1.A.3	Energy	CH_4 Mobile Combustion: Road Vehicles	CH_4	6.8	0.02%	99.94%
4.F	Agriculture	N_2O Emissions from Agricultural Residue Burning	N_2O	6.2	0.02%	99.96%
1.A.5	Energy	Other (Energy)-	CO_2	6	0.02%	99.98%
1.A.3	Energy	N_2O Mobile Combustion: Road Vehicles	N_2O	4.5	0.01%	99.99%

Table 2.2: Key Source Categories

IPCC Source Category	Sector	Source Categories to be Assessed in Key Source Category Analysis	Applicable Greenhouse Gas	Emission Estimate (current year, non-LULUCF) (Gg CO2eq)	Level Assessment excl. LULUCF (%)	Cumulative level excl. LULUCF (%)
1.A.1	Energy	CH_4 (Non -CO_2) Emissions from Stationary Combustion	CH_4	1.2	0.00%	99.99%
1.A.4	Energy	Other Sectors: Commercial CH_4	CH_4	1	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial N_2O	N_2O	0.9	0.00%	100.00%
1.A.2	Energy	CH_4 Emissions from Manufacturing Industries and Construction	CH_4	0.5	0.00%	100.00%

2.4.2 Energy

2.4.2.1 Description of sector

The main fuels used in Zimbabwe are coal (bituminous coal), liquid petroleum fuels (diesel, gasoline, kerosene, aviation gasoline, jet kerosene), liquified petroleum gas, biomass fuels,including firewood, charcoal, sugar bagasse, and other crop waste (Figure 2.1). Biomass fuels are mostly harvested on a non-commercial basis except for sugar bagasse which is produced as part of the sugar milling process. Ethanol is produced from fermentation of molasses as a by-product of the sugar refining process and is exported as an industrial raw material.

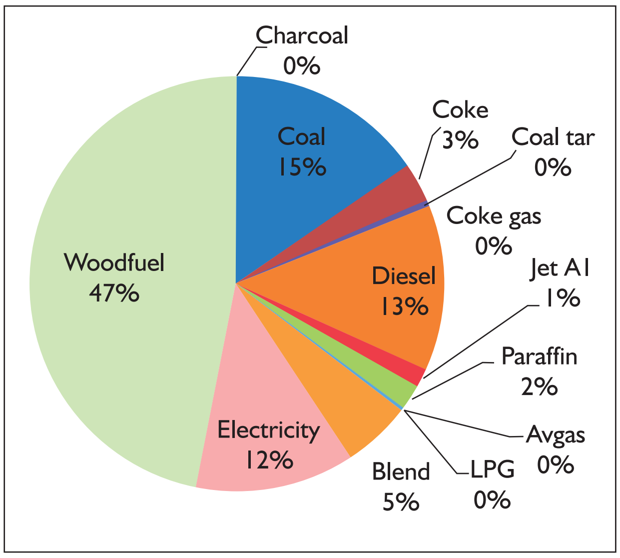


Figure 2.1: Energy Consumption by Fuel Type

All liquid petroleum fuels and liquid petroleum gas are imported. Coal is mined locally with some limited imports to bridge the gap during periods of limited supply. Local coal has a higher heat rate than imported coal and most industrial equipment is designed to use local coal.

In 2000 the residential sector used the most energy in terms of TJ (Figure 2.2). However the dominance of wood fuel use in the residential sector implies poor technology use and negative impact on the environment. Biomass fuel harvesting and land clearing for agriculture are the two major drivers of deforestation. However, change of policies in rural areas are achieving visible results in terms of tree regeneration.

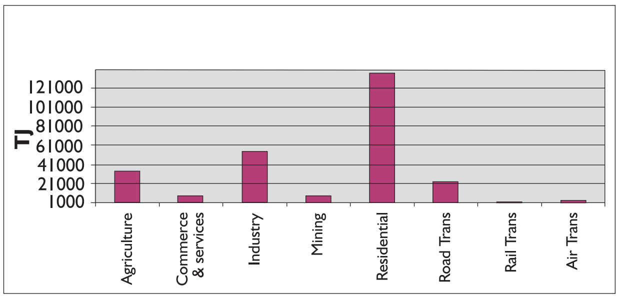


Figure 2.2: Energy Consumption by Sector (2000)

Coal is also used for steam raising and for firing furnaces in industry. Most industrial boilers are fire tube type boilers with chain grate fueling systems. Boiler capacities range from 1 tonne of steam per hour to about 20 tonnes of steam per hour. Steam pressure is about 10 bar in all cases. Multiple boiler installations are common. Figure 2.3 illustrates coal use by sector.

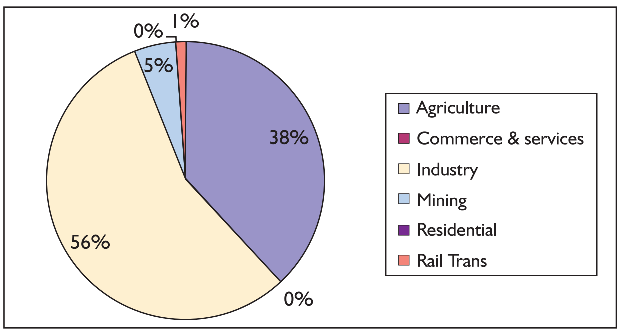


Figure 2.3: Coal use by sector (2000)

In addition, coal is used for smelting minerals and for firing bricks and other ceramics. Mining is a major user of coal but applications are similar to those in the manufacturing industry. In most cases mining is considered in combination with industry when assessing energy use. Coal is converted to coke for use in the steel and other ferrous metal industries. There is a coking plant at Hwange which also supplies coke oven gas to the power station. The steel plant at Kwekwe also has a coking plant to augment supplies from Hwange. In 2000 about 5 000 TJ of coke were produced in Zimbabwe. The other major user of coal is agriculture. In 2000 agriculture used 16 894 TJ of coal. Most of this was used for tobacco curing. There were also farms that used coal for drying crops like paprika and onion.

There is a minor usage of coal in rail traction. In 2000 about 485TJ of coal were used in traction. The main applications are steam locomotives for shunting mainly at Bulawayo sidings and for hauling tourist trains along the Bulawayo Victoria Falls railway line. Use of coal in the residential sector is very limited with most of it going into instutional households such as schools and hospitals. Some mining companies distribute coal to employees for own use.

Most of the electricity is used in industry and urban residential areas. There is limited access to electricity in rural areas hence the dominance of biomass fuels in rural households. Industry and mining account for the maximum demand whilst residential electricity users account for a significant part of the energy used. Figure 2.4 below shows the major consumers of electricity in the year.

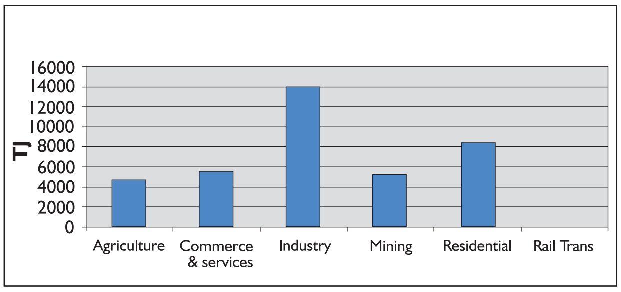


Figure 2.4: Electricity Consumption by Sector (2000).

Source: *Ministry of Energy and Power Development, Energy Balance.*

2.4.2.2 Petroleum Fuels Combustion

Petroleum fuels are distributed through a common system hence spliting between end uses is complex. The Ministry of Energy and Power Development had a database on energy which had a built in routine for estimating the use of petroleum fuels by sector. However, the routine did not split the fuel by enduse hence fuel used by industry would include use in transport and use for process heat. The same applied to other sectors. Gasoline is used entirely for road transport. This does not include aviation gasoline which is used for small aircraft. Kerosene is used for process heat especially in the food industry where a cleaner fuel than coal is required (Figure 2.5). Kerosene is also used for household lighting by low income groups. Jet kerosene is the most commonly used fuel for aircraft with local and international jet and turbo-propeller aircarft as well as helicopters being the major users. The availability of aviation fuel data and a customer aircraft inventory made it possible to estimate emissions by type of aircraft.

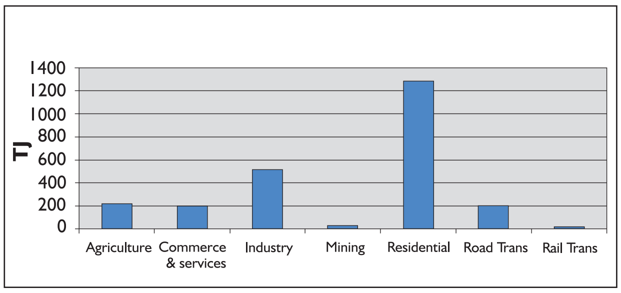


Figure 2.5: Kerosene use by sector (2000)

Liquid Petroleum Gas (LPG) is imported for use in the various sectors of the economy. LPG is used as an alternative cooking fuel in the household and commercial sectors, as a heating fuel in industry and agriculture. In 2000, 62TJ of LPG were used in Zimbabwe. Gasoline is blended with ethanol when ethanol is available. Around 2000, the international price for ethanol was high enough to warrant export of ethanol and importation of gasoline instead of blending. Diesel is mostly used in internal combustion engines. Small volumes of diesel are used for process heat or steam raising in industry types where a cleaner fuel than coal is required.

2.4.2.3 Description of category of sources

2.4.2.3.1 Methodology

The Ministry of Energy and Power Development operates a database on energy use. The data collected is used to compute the national energy balance. However, the last energy balance was produced in 2000. The database system crashed resulting in the loss of energy statistics and data was obtained from a hard copy of the energy balance for 2000. The Ministry is in the process of revitalizing the data collection system. Information of assumptions and models used to analyse energy use data in the production of the energy balance is not available. Since official consumption data is provided in TJ there was no need to identify conversion factors. Based on the reference approach total emissions from coal combustion were 547 712 Gg CO_2. This is based on the total energy sector coal consumption of 5 789 775 TJ and an emission factor of 94.6 Kg CO_2 per GJ.

2.4.2.4 Coal Combustion

About 50% of coal is used for electricity production. In 2000 the Hwange Power Station used 50 499 TJ while the old thermal plant used 8 670 TJ of coal. All power plants use pulverized coal in condensing turbines. The Hwange Power Station which is rated 920MW has a sent out capacity of 856MW which was constrained by limited maintenance and poor coal deliveries in 2000. The smaller thermal power plants are in Harare, Munyati and Bulawayo. These are a mixture of pulverized fuel fired and washed pea fired boilers. Their total reliable capacity is about 120MW but are not operational most of the time due to coal transport problems. In 1998 the plant load factor for Harare was 15.4%, Munyati 16.7% and Bulawayo 3.8%. Bulawayo power plant is closer to the coal mine but suffered a critical water shortage in 2000. Pollution control basically uses electrostatic precipitators for dust control at all thermal power plants.

Transformation efficiency is measured in terms of specific coal consumption expressed as Kg of coal per kWh of electricity produced . Table 2.3 shows trends in coal use efficiency per power plant from 1996 to 1998.

Table 2.3: Coal Use Efficiency by Power Plant (kg Coal/kWh)

Power Plant	1996	1997	1998
Hwange	0.505	0.5129	0.521
Munyati	0.652	0.6302	0.642
Harare	0.564	0.6722	0.615
Bulawayo	0.645	0.6476	0.642

Source: *ZESA Annual Reports*

2.4.2.5 Combustion of Petroleum Fuels

In the absence of data on fuel use by technology type, it was only possible to apply tier 1 methods for estimating emissions from petroleum fuels. The default emission factors from the IPCC database were used to compute the emissions. Data is available on vehicle population by type which gives an indication of the range of emission factor by technology type. However, data is not available on average vehicle kilometers per year. It was therefore not possible to make an allocation of fuel use by vehicle type. In aviation crude estimates on fuel consumption by aircraft type were made from the fuel purchase data combined with the asset variety by fuel customer.

Table 2.4: Changes in National Vehicle Population from 1995 to 2004

	Mixed	Almost All Diesel Powered				
Year	1	2*1	2*2	2*3	5	TOTAL
1995	384044	11815	23860	2258	9 362	433334
1996	422448	12997	26246	2884	10 290	476861
1997	464693	14297	28871	3172	1 1328	524358
1998	520989	1937	432589	4789	14510	594249
1999	534577	19975	33 523	4966	15309	610349
2000	544490	28418	34197	5079	15506	629690
2001	556280	29072	4797	5247	15641	613038
2002	570866	31301	47429	5726	15881	673205
2003	584714	32390	61330	5960	15926	702323
2004	597676	33665	62806	6118	15945	718214

Source: *Central Vehicle Registry*

1 up to 2300kg net mass
2*1 2300 to 4600 kg net mass
2*2 4601 to 9000 kg net mass
2*3 9001 kg net mass and above
5 Tractors and other farm equipment

In the absence of vehicle population make-up by technology emissions were estimated on the basis of IPCC default emission factors and total emissions were 2 789.8 Gg CO_2. This was based on petroleum fuel consumption figure for 2000 and default IPCC emission factors. Table 2.5 illustrates Carbon-dioxide emissions (Gg CO_2) from consumption of various fuel types.

Table 2.5: Carbon-dioxide emissions (Gg CO_2) from various fuel types

Fuel	Emissions Gg Co_2
Diesel	1475
Gasoline	942
Jet A1	191
Kerosene	177
AvGas	1.8
LPG	3
Total	**2789.8**

2.4.2.6 Fugitive Gas Emissions

Fugitive emissions are linked mostly to coal mining. There are no official measurements of methane content of coal even though methane levels in mines are monitored for safety reasons. Fugitive emissions of methane were therefore based on IPCC default emission factors. An average of the two extremes was used for this study. Coal mining involves both underground and surface mining. Coal mining data is not readily available hence the assumption was made that 50% of coal supplied was from underground mining and 50% from surface mining. The surface mine has been having problems with maintenance of the dragline hence production levels have declined compared to previous years.

Fugitive methane emissions were estimated at 27Gg based on default emission factors and a split of 50% between surface mine coal and underground mine coal.

2.4.2.7 Estimation of GHG emissions from energy for the year 2000

Greenhouse gas emissions from the energy sector are shown in Table 2.6 below.

Table 2.6: Greenhouse gas emissions from the energy sector

GHG Source	GHG Emissions in 2000 (Gg)
Transport	1434
Electricity	7494
Manufacturing and Construction	13027
Fugitive Emissions (Ch_4)	567
Other	2199
Total	**24721**

2.4.2.8 Evolution of emissions for the years 1990, 1994 and 2000

The emission trends in Figure 2.6 are showing a sharp increase after 1994 mostly due to emissions in the transport sector. The emissions are driven by the increase in number of vehicles. In the absence of country specific data for vehicle technology types it is not possible to make an improved judgement on the non-CO_2 emissions. However reduction in coal consumption is likely the driver for the reduction in methane emission trend.

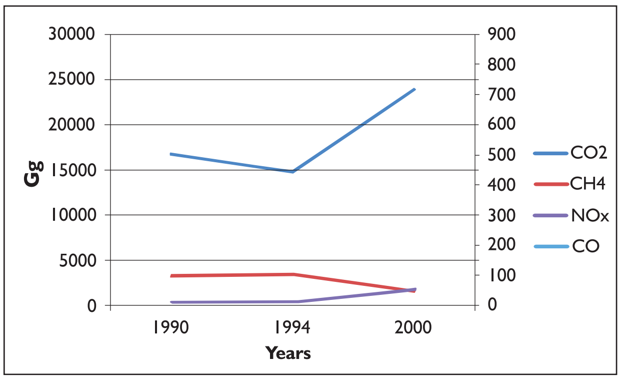


Figure 2.6: Greenhouse gas emission (Gg) trends for energy sector

2.4.3 Industrial Processes

2.4.3.1 Description of Sector

Emissions of greenhouse gases from industrial processes occur when raw materials are converted into semi-finished and finished products. In Zimbabwe, the industrial sector mainly comprises agro-based and mineral beneficiation operations. In estimating the quantities of all the emissions from this sector, the IPCC method was used in which the quantity of emissions is calculated as the product of activity data (production quantity) for each process and an emission factor (EF) per unit of production.

Most of the activity data were obtained from CSO, a government department which is the official custodian of all data in the country. The manufacturing industries are required by law to submit their production figures or the data for revenue obtained from their business to CSO. The statistical office then compiles the information from the same industrial sector and release aggregate data of the total production from all industries. Some data collected from individual industries and secondary sources were also used in areas where CSO could not provide the required information. Empirically derived emission factors in published references were used especially the IPCC Emission Factor Database (EFDB). Where the emission factors were missing in the IPCC EFDB other sources like the US Environmental Protection Agency (EPA) and EMEP/CORINAIR were adopted. Any uncertainties in the total emission figures for this sector could be a result of the use of EFs not representative of the particular production plants in the country as well as incorrect production figures supplied by various sources of data.

2.4.3.2 Description of Category of Sources

In this inventory, the following industrial production processes were considered; cement, ammonium nitrate, nitric acid, sulphuric acid, iron and steel, ferroalloys, alcoholic beverage and food.

Cement Production

The cement manufacturing process is one of the most important sources of carbon dioxide emissions both from the energy consumed and the chemical process itself. The carbon dioxide (CO_2) is emitted during the production of clinker, an intermediate product from which cement is produced. Sulphur dioxide (SO_2) is also emitted during the process.

For the inventory year under review only two cement producing plants were operating in the country. Both plants used similar processes to produce various grades of the Portland and Masonry cement. The activity data reported in this inventory was sourced from one of the producing companies. Information was made available in the form of annual clinker production figures as well as the estimated cement market share of the company in the country. The data was then used to estimate the annual national clinker production figures. Using the IPCC EF of 0.52 tonnes of CO_2 per tonne of clinker produced the total CO_2 emissions from this sub-sector was estimated to be 276.19 Gg. For the same year SO_2 emissions amounted to 0.16Gg. The same procedure was used to estimate CO_2 and SO_2 emissions for the other years that are reported in Figures 2.7 and 2.8, except for year 1994.

Cement production emission figures for CO_2 and SO_2 do not follow any particular trend as shown in Figures 2.7 and 2.8. There was a 38.4% decrease in CO_2 and SO_2 emissions from 1994 to 2000 and a 36.7% increase in CO_2 emissions from 2000 to year 2005. From 2005 to 2010, both the CO_2 and SO_2 emissions decreased by 11.5% and 13.6% respectively. The downward trend in the amount of emissions is not a reflection of equipment improvement but an indication of the increase or decrease in cement production during the harsh economic environment which Zimbabwe experienced.

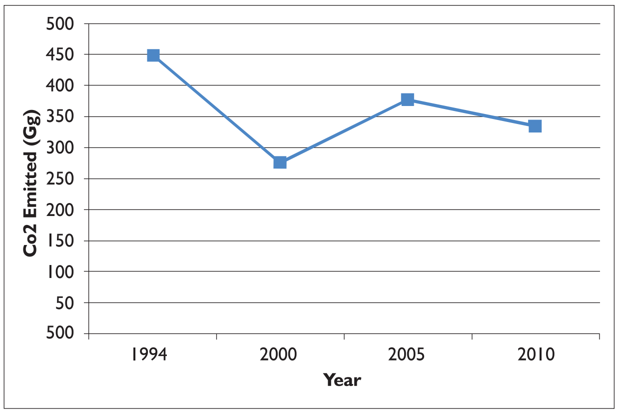


Figure 2.7: CO_2 emissions from cement manufacturing process for period 1994 to 2010

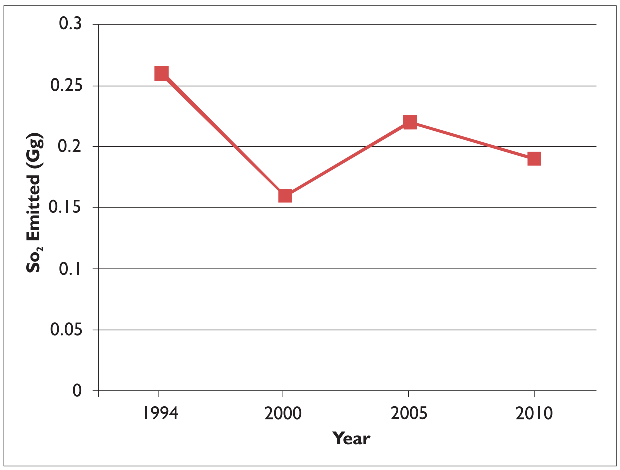


Figure 2.8: SO_2 Emissions from Cement Manufacturing Process for period 1994 to 2010

Nitric Acid Manufacture

Nitric acid is used in the manufacture of fertilizer and is produced in the catalytic conversion of ammonia. During the production process, nitrous oxide (N_2O) and nitrogen oxides (NOx) are emitted into the atmosphere. In Zimbabwe there is only one processing plant producing nitric acid. From primary data obtained from the nitric acid manufacturing company, the quantities of N_2O and NO_x emitted into the atmosphere during 2000 were 0.01Gg and 0.17Gg respectively. The IPCC EF of 0.8kg pollutant per tonne of nitric acid produced for N_20 and an EF of 12kg pollutant per tonne nitric acid produced for NO_x were used in the calculation.

Ammonium Nitrate (NH_4NO_3) and Sulphuric Acid (H_2SO_4) Manufacture

The agriculture sector is one of the most important in the country as it is a major foreign currency earner hence the importance of fertilizer production in the country. Ammonium nitrate is used as both a fertilizer in that form or used as a raw material in the manufacture of various compound fertilizers. Sulphuric acid is used in several industries for example as a raw material in the manufacture of fertilizer. Total emissions from the production of NH_4NO_3 could not be estimated because of lack of appropriate EFs. However, the total emissions of sulphur dioxide from the manufacture of sulphuric acid were 0.05Gg for year 2000.

Iron and Steel Manufacture

The production of iron and steel results in the release of process based CO_2, CO, SO_2, NMVOC and NO_x. Iron is first produced by the reduction of iron oxide with metallurgical coke in a blast furnace to produce pig iron. Pig iron (containing 4% C by weight) is used as a raw material in the manufacture of steel and iron products in several foundries in Zimbabwe. The production of pig iron results in the release of CO_2 and CH_4. The majority of CO_2 emissions from the production of iron and steel come from the use of coke in the production of pig iron. In year 2000 there was only one pig iron producer while steel production had other small producers.

In calculating the GHG emissions, pig iron production figures used were obtained from a secondary source. Using IPCC EFs the emissions were estimated to be 443.20 Gg of CO_2, 0.83 Gg of SO_2, 0.37Gg of CO, 0.03 Gg of NMVOC and 0.02 of NO_x for the year 2000. Using the same source of activity data, emissions for year 2004 were also calculated and results are shown in Table 2.7. There was a general decrease in emission levels from year 1994 to 2004. This was not due to technological advancement but rather decrease in production levels emanating from the economic down turn that the country experienced. For instance, the trend in CO_2 emissions from 1994 to 2004 is depicted in Figure 2.9.

Table 2.7: CO_2, SO_2, NMVOC, CO and NOx emissions from Iron & Steel Production

Year	Iron & Steel, Gg	CO_2, Gg	SO_2, Gg	NMVOC, Gg	CO, Gg	NO_x, Gg
1994	900000	1440	2.7	0.11	1.21	0.07
2000	277000	443.2	0.83	0.03	0.37	0.02
2004	150000	240	0.45	0.02	0.2	0.01

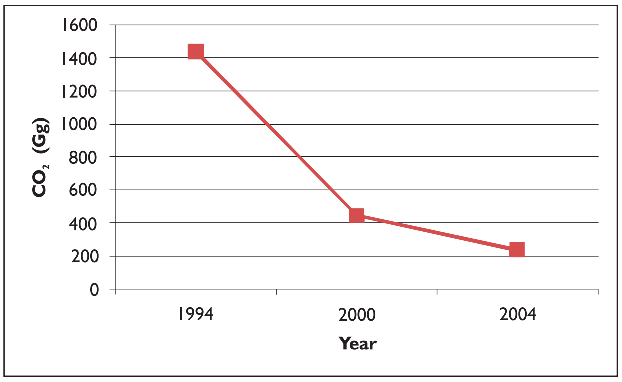


Figure 2.9: **CO_2 Emissions from Iron and Steel Production**

Ferroalloy Production

Ferroalloys are composites of iron and other elements like manganese, silicon and chromium. These alloys are used to alter the material properties of steels when they are incorporated into steel alloys. Carbon dioxide and methane are produced in the production of ferroalloys. Ferrochromium is the most produced ferroalloy in Zimbabwe and since 2001 only high carbon ferroalloys have been produced. Activity data for this subsector was obtained from a secondary source while the IPCC EFDB was used to source EFs. Calculated emissions of CO_2 in 2000 amounted to 317.69 Gg as shown in Table 2.8. The emissions from ferroalloys production were not estimated in the Initial National Communication thus there was no basis for comparison. However, when compared to year 2004 there was a 20% decrease in the emission of CO_2 from the year 2000 level, and again this was attributed to the decrease in production level.

Table 2.8: CO_2 emissions from Ferroalloy Production

Year	CO_2 (Gg)
1994	Not Estimated
2000	317.69
2004	251.00

Food and Drink Production

The production of food and drink contributes to the emission of the precursor greenhouse gas, NMVOC. For example in beer production, NMVOC emissions arise from the microbial fermentation process. For Zimbabwe, the processes that were considered subject to availability of activity data were sugar, bread/flour, meat and coffee production in the food sub-sector. In the alcoholic beverages sub-sector the processes considered were beer, brandy and spirit manufacture.

Activity data for both sub-sectors mentioned above were obtained from CSO, while IPCC EFs were adopted in calculating the emissions. Total NMVOC emissions for 2000 for alcoholic beverage production were 0.33 Gg while from food production a total of 5.9 Gg were produced.

2.4.4 Agriculture

Description of sector

According to the Central Statistics Office (2000), Zimbabwe's livestock production occurred in two major farming systems namely commercial and communal systems with a much smaller contribution from the resettlement farming system. The major livestock species produced were dairy and non-dairy cattle, sheep, goats, swine and poultry. Cattle constituted 80% of total livestock units, sheep and goats about 10% while swine and poultry contributed roughly 10% (FAO, 2005a). The pattern of emissions from different livestock species for 2000 was generally the same as for 1994 (Initial National Communication), although there was an overall increase of 17.6% in total annual methane emission from domestic livestock between 1994 and 2000.

As shown in Figure 2.10, about 88% of total annual emission from domestic livestock enteric fermentation in 2000 was from non-dairy cattle which, in Zimbabwe, are mainly kept under extensive and semi-extensive grazing systems. The equivalent percentage was 87.4% in 1994. Goats emission of methane was the second most important in 1994 and 2000, contributing 9.7% and 7.2% of total emission respectively. The implication would be that any national efforts to reduce total livestock emission should be targeted at non-dairy cattle and goats.

The two main Animal Waste Management Systems (AWMS) were solid storage and dry lot and, pasture range and paddock. Commercial swine and dairy production were characterized by the former

AWMS, wherein animals were kept on unpaved feedlots and the manure is allowed to dry until it is periodically removed. Upon removal the manure is mainly spread on fields. Consultations with the Pig Industry Board, a government parastatal for promoting commercial pig production through research and extension, indicated that over 95% of commercial pigs waste management was the solid storage and drylot management. Out of the Total Nitrogen Excretion (N_eX) of about 40 million kgN/yr, only about 3% of this excretion which came from the swine excretion in solid storage and dry lot management system resulted in the 0.04 Gg emission of N_20. The possible N_20 emission from the remaining 97% of the N_eX is not estimated because there is generally limited information available on N_2O emissions from animal waste during storage and treatment (Revised 1996 IPCC Guidelines).

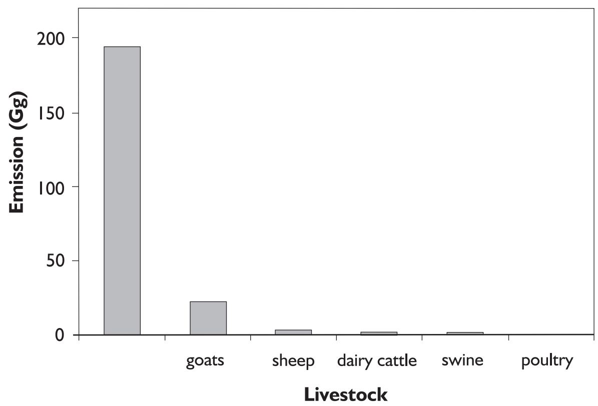


Figure 2.10: GHG emissions from domestic livestock enteric fermentations for the year 2000

No comparison to the 1994 estimates of Total Annual Emissions of N_2O could be made as this parameter was not estimated in the 1994 reporting.

Emissions from crop production

Burning of crop residues contribute to GHG emissions in Zimbabwe. The major crop residues burnt are tobacco, cotton and sugar cane. The first two have to be totally burnt in the field after crop harvest for the control of crop pests and diseases, while sugar cane foliage is burnt in the field to facilitate crop handling at harvesting and to destroy venomous snakes that may inhabit the sugar cane fields. The burning of other crop residues is difficult to estimate because the residues are either removed from the fields and stored as livestock feed, or they are grazed in situ. A remaining smaller fraction may be burned on the fields to prepare for cropping or, it may be ploughed under. As in 1994, the most significant emission of GHG from burning of crop residues in 2000 was 28.49 Gg of CO. This emission increased in the 6 year period by nearly 50%.

Direct emission of GHG from synthetic fertilizer applications on soils, animal waste use as manure and burning of crop residues was 2.16 Gg N_2O-N/yr, and was 54 times greater than N_2O emission from animal production emission (before the animal waste is used as manure). Of this emission, about 60% was from synthetic fertilizer application, compared to about 0.1% from animal waste used as manure. The practical implication of this is that, if any corrective measures were to be taken, perhaps a national consideration of efficient use of synthetic fertilizers would be appropriate. Total direct emissions of N_2O due to cultivation of histosols was 54 Gg.

Direct N_2O from animals grazing on pasture and range was 1.24 Gg, compared to the 0.04 Gg emission from animal waste management systems for housed animals previously discussed. These two emission estimates are still very small compared to the 54 Gg emissions from cultivation of histosols, implying that for this GHG emission, crop production emissions are more significant.

N_2O emission from agricultural soils due to atmospheric deposition of NH_3 and NO_X was only 0.19 Gg.Total nitrous oxide emission from leaching from soils was 57.26 Gg, which was of the same magnitude as direct emission from cultivation of histosols.

The nitrous oxide emissions sources and magnitudes are summarized in Figure 2.11.

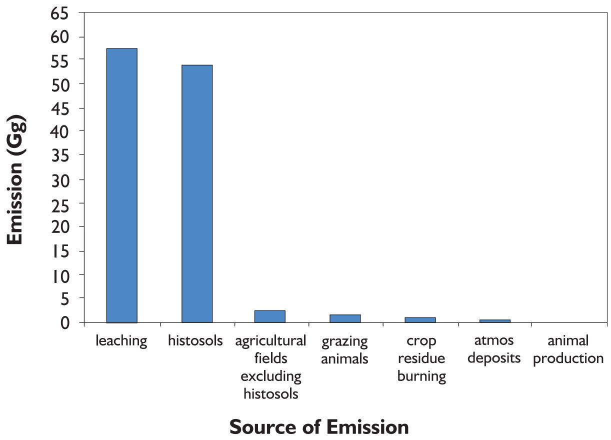


Figure 2.11: Nitrous oxide emissions in Zimbabwe in 2000

Description of category of sources

Methodology

Data used for GHG emission levels estimation was obtained from the livestock and crop production statistics from the Central Statistics Office and average population and production values for 1999, 2000 and 2001 were used to correct for the inter-annual fluctuation in the three years.

The major sources of greenhouse gas (GHG) emission were enteric fermentation from livestock, burning of crop residues and cultivation of histosols. Emissions from savanna burning are estimated under the energy sector.

Estimation of GHG emissions for the year 2000

The major sources of GHG emission for 2000 in Zimbabwe were enteric fermentation from livestock, burning of crop residues and cultivation of histosols. Of the 219.9 Gg emission of methane from enteric fermentation, 88% was from non-dairy cattle. Emission from goats was second in importance. N_2O from animal waste management was 0.04 Gg from swine. The major emission from burning crop residue was 28.49 Gg of CO. Total direct emissions of N_2O due to cultivation of histosols was 54 Gg. Total nitrous oxide emission from leaching from soils was 57.26 Gg, Future projections of GHG are made based on projected 20% increase, and are similar to projections made in the Initial National Communication.

Evolution of emissions for the years 1994, 2000 and 2010

Future greenhouse gas emissions from agriculture will be determined by the shift in agricultural practices. It is generally anticipated that future growth in human population will result in high demand for agricultural production. This will be characterized by more use of fertilizers and more intensive livestock production. However, in Zimbabwe, this may be dampened by increasing costs of production and limited access to high agricultural technology. Therefore, while there may be anticipated increases in agricultural production and hence greenhouse gas emission, the rate of increase in greenhouse gas emission may not be much higher than the 17.6% observed in the period 1994-2000 for total methane production from enteric fermentation. We hypothetically therefore use a growth rate of 20% in greenhouse gas emissions for the future up to 2010.

Projections (Table 2.9) are compared to the projections made in the Initial National Communication. There is a weak correlation between the two projections.

Table 2.9: Projections of future greenhouse gas emissions

Source of emission	Emissions in 1994 (Gg)	Emission in 2000 (Gg)	Projected Emission in 2010	2010 projection of the Initial National Communication
Enteric fermentation (CH_4)	179.82	219.9	263.9	305.05
Animal waste management (N_20)	-	0.04	0.048	-
Burning crop residues (CO)	19.81	28.49	38.19	33.61
Burning of crop residues (N_2O)	.03	0.02	0.024	0.05
Burning of crop residues (NO_x)	1.1	0.64	0.768	1.87
Cultivation of histosols (N_2O)	-	54	64.8	-

2.4.5 Waste

2.4.5.1 Description of sector

The disposal of waste in landfills is a common practice for managing waste in urban areas of Zimbabwe. In the year 2000, garbage was collected from city households once a week. The waste was disposed at designated areas around the urban centres. The nature and quantities of the waste is related to the population producing the waste, the GDP, waste handling practices and the type of landfills where the waste is deposited.

In 2000 sewage treatment in urban areas was the responsibility of the local authorities. Figure 2.12 illustrates the pathways for wastewater in urban areas. The possible points of generation of methane and some sludge on the pathway are in the septic tank, during onsite treatment, the sewer and at the wastewater treatment plants.

In the low-density suburbs, sewage waste is collected in septic tanks at household level. The septic tanks conditions are anaerobic and some methane is generated. Part of the liquid component of the waste is slowly released into the environment through soak-aways. When a septic tank is full, the waste, which is mainly sludge, is sucked by tankers and sent to sewage treatment works. At the time of the collection of waste from full septic tanks, most of the degradable organic carbon would have decomposed into methane and carbon dioxide.

At the sewage treatment works, all sewage waste is separated into liquid and sludge. The liquid is used either to irrigate nearby pastures or released into the water system for recycling. The sludge is either dried or fed into bio-digesters where applicable. Some of the sludge is also being distributed to nearby farmers for manure.

Though notable methane is generated at sewage treatment plants that have bio-digesters, most of the local authorities are not capturing the methane produced in sewage processing. In Harare, the captured methane from bio-digesters is mainly used as an onsite energy source. The rest of the methane is either flared, or emitted into the environment as methane. Equipment required to measure the actual quantities of methane generated is not in place in the various sewage waste treatment works.

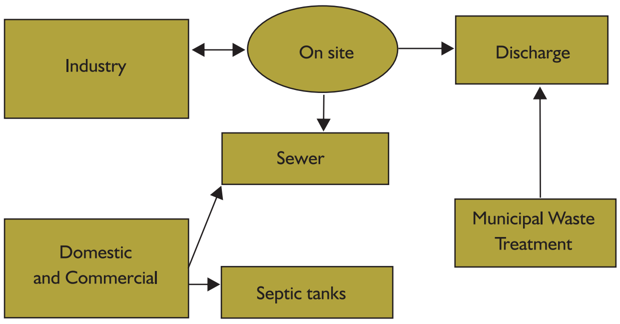


Figure 2.12: Pathways for wastewater in urban areas of Zimbabwe

2.4.5.2 Description of category of sources

Municipal Solid Waste Disposal Sites

Managed solid waste disposal sites (SWDS) are mainly found in urban centres while in growth points and other small settlements there are unmanaged SWDS, which are more similar to those in rural areas. The waste that is incinerated at designated incineration sites mainly originates from hospitals and includes surgery and general clinical waste.

Wastewater Treatment Sites

Most sewage treatment processing in small towns, growth points, mines and other institutions is aerobic and uses stabilisation ponds. These open ponds do not facilitate the formation and collection of methane. Methane is therefore not collected in many small towns and growth points. Although the infrastructure for bio-digesters is in place in some of the plants in major cities, they are currently non-functional.

2.4.5.3 Methodology

The GHG emissions considered in this study are those resulting from solid waste disposal and wastewater. These are the two sources that contribute significant proportions of GHG emissions in the waste sector. The default base methodology has been used for the GHG emission estimations in this report because the data available is inadequate. Rural population constitutes at least about 65% of the total population. In rural areas waste treatment includes mainly pit latrines and landfills. To some extent the waste is covered with water and soil respectively. This covering allows for anaerobic digestion, which also emits methane. Since the rural population is relatively scattered and as provided for in the IPCC guidelines GHG emissions from rural areas have not been considered in this compilation. The population growth rate used for projections in this report is based on statistics provided by the CSO.

Landfill methane

In this study solid waste disposal sites are either open dumps or managed landfills. Both types of sites can produce methane released from the organic matter contained in them. Open dumps according to this approach are shallow, open piles, generally only loosely compacted, and with no provision for control of pollutants generated, where scavenging by animals and humans can remove much of the biodegradable wastes (*Revised 1996 IPPC Guidelines*). Due to time and other resource limitations, data collected from Harare, Bulawayo, Gweru, Mutare, Bindura, Masvingo, Karoi, Victoria Falls, Chitungwiza, Chinhoyi, Marondera and Kariba was used to represent and deduce the waste generated in all urban centres in Zimbabwe.

The methodology used derives factors from the 1996 IPCC estimates and the waste composition figures for urban waste.The IPCC estimate for biodegradable composition of urban waste is replaced by the local figure of 0.78, which is based on the fraction of foodstuffs, and biodegradable material that constitutes 78% of the waste.

The following basic formula for estimating methane from solid waste in landfills was used, which is based on the default methodology provided for in the 1996 Revised IPCC Guidelines. Zimbabwe does not have a country specific methodology for estimating emissions from solid waste handling.

Methane emissions (Gg/yr) = $(MSW_T \times MSW_F \times MCF \times DOC \times DOC_F \times F \times 16/12 - R) \times (1\text{-}OX)$

where:

MSWT = Total MSW generated (Gg/yr) calculated based on the waste data for Harare, Bulawayo, Gweru, Mutare, Bindura, Masvingo, Karoi, Victoria Falls, Chitungwiza, Chinhoyi, Marondera and Kariba. The total waste was obtained by extrapolating on a per capita basis.

MSWF = Fraction of MSW disposed to solid waste disposal sites was also based on data obtained from the 12 above mentioned urban areas

MCF = Methane Correction Factor (fraction) used was 1, which is default value for managed dumpsites given in the IPCC 1996 Revised Guidelines

DOC = Degradable Organic Carbon (fraction) was calculated using equation 2 below

DOC_F = Fraction of DOC dissimilated

F = Fraction of CH_4 in landfill gas was considered to be 0.5 (default value)

R = Recovered CH_4 (Gg/yr) is the total methane recovered annually

OX = Oxidation Factor which is given by **F**- 0. However, 0 was used pending the availability of new data

The equation used to calculate DOC is

Per Cent DOC (by weight) = 0.4 (A) + 0.17 (B) + 0.15 (C) + 0.3 (D)

The values of A, B, C and D were based on the data from Harare which was readily available and relatively reliable. In addition, the significant urban population of Zimbabwe is found in Harare.

- A (per cent MSW that is paper and textiles) = 20%
- B (per cent MSW that is garden waste, park waste or other non-food
- organic putreascibles) = 30%
- C (per cent MSW that is food waste) = 10%
- D (per cent MSW that is wood or straw) = 18%
- The value of DOC (by weight) obtained is 20%

The emissions generated from solid waste in growth points were not determined since the waste management practises are mostly similar to those in rural areas.

Wastewater methane

To estimate the methane generated from municipal wastewater, data from the main wastewater treatment plants in Harare, which have functional bio-digesters, were used. The total methane from wastewater handling was calculated both from direct emission methane measurements at the waste treatment works in 2000 and the formula in the IPCC methodology.

Carbon dioxide emissions

As guided by the IPCC guidelines, carbon dioxide emissions from the decay or combustion of organic waste have not counted in the inventory since they are considered to be part of the natural carbon cycle. CO_2 emissions from organic wastes are balanced by re-growth of biomass, which uses up the carbon dioxide. Though the IPCC methodology considers carbon dioxide emissions that stem from the incineration of waste containing fossil fuels or solvents, the carbon dioxide emissions from such waste incineration are negligible representing less than 0.1% of the waste sector emissions and are thus were not estimated within this study.

Nitrous oxide

Though nitrous oxide is produced during the treatment of human sewage, nitrous oxide has not been included in the inventory and projections. The IPCC default methodology estimates the emission projections for nitrous oxide basing on an assumed per capita protein intake and the population projection. The data on per capita protein intake was not available.

GHG emissions from waste incineration

Although waste incineration can produce CO, NO_x and NMVOCs estimates of these emissions have not been done due to lack of applicable data. Sludge incineration that has been proven to produce the highest emission rates does not occur in Zimbabwe. The Revised 1996 IPCC Guidelines do not provide a new methodology for the emissions produced during combustion outside properly designed incinerators.

Estimation of GHG emissions for the year 2000

In the year 2000, the average per capita waste value of 0.48kg/cap/day derived from the four of the studied cities, Harare, Bulawayo, Gweru and Bindura was used to estimate methane emissions from the solid waste generated by the urban population. Table 2.10 presents a summary of the findings based on a worksheet in the IPCC Greenhouse Gas Inventory Workbook.

Table 2.10: Summary of findings

GREENHOUSE GAS SOURCE CATEGORIES	CH_4 in Gg/YEAR
Total Waste	
A. Solid Waste Disposal on Land	
1. Managed Waste Disposal on Land	56.8
B. Wastewater Handling	11.3
Total	**68.1**

Methane emissions from landfills

The total waste that was generated in the urban centres in the year 2000 is estimated to be 674 456 472 kg. The quantity of waste delivered to managed dumpsites is about 82% of total generated (553 054 307 kg). The total emissions of 56.8 Gg CH_4 from managed waste disposal on landfills includes waste from all urban areas whose population was estimated to be 3 859 384 in the year 2000 (33.18% of total population of 11 631 657).

Methane emissions from wastewater handling

Current wastewater handling practices mix wastewater from domestic, commercial and industrial sources. This wastewater is channelled to wastewater treatment plants at designated sites in the various urban centres. The Marlborough, Hatcliffe and Donnybrook all in Harare are aerobic. In Harare the three anaerobic treatment plants are Zengeza (which is non-functional), Crowborough and Firle. The volume of methane produced at Harare's Crowborough and Firle sewage works were determined through periodic measurements. In 2000 Crowborough sewage works received and processed a total of 35 464 176 m^3 of which 1% (354 642 m^3) of sludge was removed and produced 907 296 m^3 of methane. This gives an emission factor of 0.0256 m^3 methane / m^3 sewage.

In the Firle sewage works 5 1870 914 m^3 of raw effluent was processed in 2000. This raw effluent produced 518 710 m^3 of sludge. The quantity of methane generated is 1 158 550 m^3. This gives an emission factor 0.0223m^3 methane / m^3 sewage. The average emission factors for Crowborough and Firle is 0.0240m^3 methane / m^3 sewage and is used in estimation of national methane emissions.

In all the treatment plants in Zimbabwe sludge is estimated to constitute 1% of the total effluent produced. The sludge is disposed off as manure after bed drying. At both Crowborough and Firle some of the biogas was used to heat the biodigesters and the rest was flared. The estimates of methane emissions from measurements in Harare, Bulawayo, Mutare and Masvingo are given in Table 2.11.

Table 2.11: Methane emissions from wastewater handling in 2000

City	Methane generated m^3/year	Methane emitted into the atmosphere m^3/year
Harare	2 065 846	1 442 546
Bulawayo	999 072	999 072
Mutare	375 257	375 257
Masvingo	210 840	210 840
Total	**3 651 014**	**3 027 715**

The estimation of national methane emissions from measurements is 2.02 Gg whereas calculation using the IPCC methodology gives an emission value of 12.4 Gg. Considering that 1.1Gg of methane is used for boilers or flared at the Harare's Firle and Crowborough wastewater treatment works the net national estimated emissions from wastewater are 11.3 Gg in the year 2000.

Emissions from waste incineration

In Harare 10% of total waste generated 67 445 647 kg was burnt on site. In Gweru 60 tonnes of waste mainly hospital waste was incinerated in the year 2000. In Bulawayo the quantity of waste incinerated was 42 699 kg in the same year. About 4% of the amount incinerated on site in households and streets is plastic. The GHGs emitted by this incineration has not been accounted for in this report for lack of suitable methodology and the insignificance of the quantity of emissions from this source.

Sludge handling practices in Zimbabwe do not include any incineration; hence GHG emissions contributions from sludge incineration are negligible.

Evolution of emissions for the years 1990, 1994 and 2000

The baseline scenarios for methane emissions from waste in Zimbabwe indicated in Table 2.12 are based on results of some studies by Nziramasanga *et al* 1994.

Table 2.12: Methane emissions from waste from 1990 to 2010

Year	Population (millions)	Urban population (millions)	Landfill waste kt/year	Landfill methane kt/year	Sewage volume m^3/day	Sewage methane m_3/day
1990	9.4	3.1	521	131	242800	1639
1994	10.64	3.2	734	25.1	NE	NE
2010	15	6.5	1083	272	504854	3407

From the data in table above it can be deduced that the volume of sewage produced almost doubles every twenty years, which is similar to the trends in both population and volume of methane generated.

2.4.6 Land use, land-use change and forestry

Description of forest sector

Zimbabwe's forestry resources cover approximately 66% of the total land area (257, 783km^2). Like many other sub-Saharan Africa, Zimbabwe's forest stocks generate a wide range of both timber and non-timber products and services. The products include fuelwood, fuelwood for charcoal making, sawn timber, pulpwood, building materials, wood for crafts, fodder, fruits, honey, mushrooms, edible insects, bark for rope, medicines, leaf litter, gum and resins. The services include watershed management, carbon fixation, microclimate stabilization, and the provision of windbreaks, shade, soil stability and wildlife habitat. Forestry in Zimbabwe is divided into the indigenous forestry sector and the plantation forestry sector.

Indigenous Forestry Sector

The area of indigenous forests is comprised of natural forests, woodlands, bushlands and wooded grasslands comprising less than 27 million hectares. Zimbabwe's indigenous forests are divided into the following woodland types: Miombo woodlands, Teak woodlands, Mopane woodlands, Acacia woodlands and Terminalia/Combretum woodlands.

Miombo woodlands

These are the most extensive woodlands in Southern Africa and Zimbabwe occurring in most parts of the central watershed of Zimbabwe. Miombo woodlands have diverse uses ranging from watershed management, leaf litter, grazing and browsing, firewood, edible fruits and insects and timber. Furthermor,e most of these forests have been converted into intensive agricultural areas. These cover 9, 493,533 ha of Zimbabwe (Forestry Commission, 1992).

Teak woodlands

These are exclusive to the Kalahari sands and are predominantly found in the gazetted forests of western Zimbabwe and parts of Hwange National Parks. Teak forests have been managed for commercial timber exploitation, wildlife utilization, cattle grazing and water catchment management. These woodlands cover 1, 941, 741 ha (Forestry Commission, 1992).

Mopane woodlands

These are widespread in Zimbabwe and are often associated with low altitudes and hot areas with sodic or alluvial soils. The woodlands can be divided into: the dry early deciduous (in the north & west of Zimbabwe), the dry deciduous shrubs (in Save valley and upper Limpopo) and the dry early deciduous shrubs (on basalt soils in Southern Zimbabwe). Mopane woodlands are an important source of browse for both wild and domestic animals, timber for craftwork, very good firewood, small household items, fence posts, poles, mine props, railway sleepers and parquet flooring. Mopane woodlands cover a total of 7, 343, 044 ha or 18.8% of Zimbabwe.

Acacia woodlands

These occupy large tracts of land especially in drier areas. They are important in pastoral systems as the trees provide browse (leaves, flowers and pods) and grasses for grazing. They also provide gum Arabic which is important in confectionary and manufacturing of paints. Acacia woodlands cover a total of 3, 080, 801 ha or 7.9% of Zimbabwe.

Terminalia/Combretum woodlands

These woodlands are often found as tree-shrub combinations. They provide firewood, poles for construction and tool making. Combretum is an important component of this woodland type, but has been severely cut and most of the existing vegetation is secondary. A total of 4, 761, 107 ha of Zimbabwe is covered by Terminalia/Combretum woodlands (12.2%).

Threats to indigenous woodlands

It is important to note that the area of indigenous woodlands in Zimbabwe has shown a continuous decline in the past two decades (Kunjeku et al 1998). This is driven by deforestation, fuelwood consumption and other conversions. 70% of the country's total population live in communal areas and thus depend directly on forests for firewood, construction timber, food and fodder. Woodland degradation has been triggered by over-exploitation of open access common property, fires, disease and browsing by wildlife (especially elephants). Opening up of forestland for agriculture expansion tied to resettlement is the major driver of forest resources loss.

It would appear that between 1985 and 1992 the woodlands of Zimbabwe were being depleted at an average rate of 2.01% per annum. Overall biomass depletion has been taking place at an annual average of 47 million tonnes per annum (Kunjeku *et al* 1998). In the absence of better estimates we assume that the reductions and additions in forest resources for 1985 to 1992 as reported by Kunjeku et al 1998 extended to the period 1993 to 1999. Thus mean annual loss of growing stock due to deforestation, land clearance for agriculture, settlement and fuelwood consumption for the period 1993 to 1999 is estimated to have been 47 million tonnes per annum while additions remained at 44.34 million tonnes per annum.

Commercial Plantations in Zimbabwe

Zimbabwe has a well established plantation forest resource base covering 120 182 ha in 2000 (TPF, 2001). About 90% of the plantations are located in the eastern highlands, an area characterized by high altitudes (700-2 200 masl) and high rainfall (average of 1 000 mm/annum). Major plantation forest species include: *Pinus patula, P. elliottii, P. taeda, Eucalyptus grandis, E. camaldulensis* and *Acacia mearnsii*. Pines (softwoods) are mainly used for structural timber, pulp and paper while eucalyptus are used for poles, pulp and paper. Wattle is used for the production of tannin and high quality charcoal.

There has been a steady increase in areas planted with commercial forests between 1994/95 and 2000/01. The area under commercial plantations increased by 8.3% from 1994/5 to 2000/01 and declined by 0.9% between 1999/2000 and 2000/01 (Table 2.13). The increase has mainly been attributed to afforestation of existing land and purchases of new land by timber companies in 1997/8, while the decline was largely a result of losses due to resettlement.

Table 2.13: Land under Commercial Forest Plantations (ha)

Year	Pine	Eucalyptus	Wattle	Others	Total Area
1995	77 900	16 800	14 300	1 000	110 000
1996	79 000	17 400	14 000	300	110 700
1997	77 593	19 840	13 814	355	111 602
1998	80 087	23 812	13 627	578	118 104
1999	80 989	23 910	13 434	288	118 621
2000	79 082	29 036	11 789	275	120 182
2001	78 007	29 314	11 529	280	119 130

Source: *Timber Producers Federation 1995-2001*

2.4.6.1.1 Description of category of sources

Changes in forest stocks due to different activities

Changes due to economic activity refer to production activities such as harvesting, harvest damage and afforestation that affect (decrease/increase) the stock of forests. The volume of timber decrease due to harvesting is shown in Table 2.14.

Table 2.14: Decrease in Forest stocks due to harvesting (m^3).

Year	Pine	Eucalyptus	Wattle	Total
1999	923, 236.00	285, 958.00	59, 189.00	1, 241, 383.00
2000	971, 650.00	254, 009.00	34, 826.00	1, 260, 485.00
2001	845, 886.00	240, 623.00	46, 131.00	1, 132, 640.00

Source: *Timber Producers Federation, 2001.*

Other volume changes were due to forest fires and significant hectarages were lost to fire in the Eastern Highlands (Table 2.15).

Table 2.15: Decrease in Forest stocks due to fire (ha)

Year	Pine	Eucalyptus	Wattle	Total
1999	113	33	20	166
2000	97	36	15	148
2001	0	0	0	0

Source: *Timber Producers Federation, 2001.*

There were also changes due to natural disasters such as tropical cyclones. This is not an annual event but had devastating impacts in 1999/2000 (due to El Nino). A total of 4% of plantation area was devastated by the tropical cyclone. The worst affected were wattle plantations with an area of 13.7% destroyed (Table 2.16).

Table 2.16: Tropical cyclone damage by area in 2000 (ha).

Natural Disaster	Pine	Eucalyptus	Wattle	Total
Cyclone damage	2, 689	431	1, 746	4, 866

Source: *Timber Producers Federation, 2000.*

Table 2.17 shows that commercial timber stocks show a steady decline. It is clear that reductions in timber volume due to harvest, tropical cyclone, resettlement and fire exceeded additions in volume due to growth and afforestation/replanting, leading to net negative accumulation of stocks.

Table 2.17: Physical stock account for commercial forestry (million m^3).

Year/ Species	Opening stocks	Afforestation	Growth	Harvesting	Fire	Tropical Cyclone	Resettle-ment	Closing stock
1999								
Pine	19.877	0.001	0.009	0.923	0.027	0	0	18.937
Eucalyptus	3.983	0.001	0.011	0.259	0.006	0	0	3.730
Wattle	0.115	0.000	0.001	0.059	0.000	0	0	0.056
Poplar	0.008	0.000	0.001	0.004	0.000	0	0	0.004
Total	**23.983**	**0.002**	**0.021**	**1.245**	**0.033**	**0**	**0**	**22.728**
2000								
Pine	18.937	0.001	0.009	0.972	0.025	0.684	0	17.267
Eucalyptus	3.730	0.001	0.011	0.254	0.007	0.085	0	3.396
Wattle	0.056	0.000	0.001	0.035	0.000	0.012	0	0.010
Poplar	0.004	0.000	0.000	0.000	0.000	0.000	0	0.004
Total	**22.728**	**0.002**	**0.021**	**1.260**	**0.032**	**0.780**	**0**	**20.678**
2001								
Pine	17.267	0.261	0.014	0.846	0	0	0.039	16.657
Eucalyptus	3.396	0.363	0.015	0.241	0	0	0.599	2.935
Wattle	0.010	0.014	0.000	0.046	0	0	0	-0.021
Poplar	0.004	0.000	0.008	0.072	0	0	0	-0.059
Total	**20.678**	**0.639**	**0.037**	**1.204**	**0**	**0**	**0.638**	**19.512**

Source: *Mabugu and Chitiga 2002*

Methodology

CO_2 emissions from forests and other types of vegetative matter can be zero if there is a balance between depletion and regeneration. Standing forests act as carbon reservoirs and growing forests act as carbon sinks. On the other hand, cleared vegetation might be burnt on or off-site, or usable logs might be carried off and the remains allowed to rot over time. In the absence of a balance, a net flux of GHG into the atmosphere will occur if more biomass is burnt than what grows. Estimation of emissions from this category of sources is divided into forest and grassland conversion and changes in forest and other woody biomass stocks. Emissions from abandonment of managed lands were not estimated due to insufficient and unreliable data. Table 2.18 shows the land-use patterns in Zimbabwe according to woody cover classes.

Table 2.18: Land-use patterns in Zimbabwe according to woody cover classes by land tenure

Land-use	Total Area (ha)	Proportion of total Area (%)	Proportion arable land (%)
Non-agricultural			
National Parks	5,045,490	12.90	-
Forest Land	1,335,157	3.41	-
State Land	205,255	0.52	-
Urban	99,077	0.25	-
Sub-total	**6,684,979**	**17.08**	-
Agricultural			
Communal Land	15,445,686	39.50	49.4
Resettlement Area	3,958,276	10.12	8.0
Small Scale Commercial Farming Area	1,122,781	2.87	4.3
Large Scale Commercial Farming Area	11,893,668	30.41	38.3
Sub-total	**32,420,411**	**82.9**	**100**
Grand Total	**39,105,390**	**100.00**	**100**

Hectarage was calculated from equal area projection; ***Source:*** *ForMat Volume No.1 March, 1998.*

CO_2 uptake due to managed forests.

In Zimbabwe, the changes that occur in forests are the largest in woody biomass stocks. These changes largely determine the country's GHG sinking capacity. For example natural undisturbed forests are carbon reservoirs but commercial plantations, re-growing natural forests and other growing woody biomass constitute a significant carbon sink.

Commercial plantations in Zimbabwe are mostly confined to the Eastern Highlands and are comprised of pine (79 082ha), eucalyptus (29 036ha), wattle (11 789ha), and other species (275ha) (table 2.13). According to Kwesha and Dreiser, (1998) indigenous forests comprised of: natural moist forests (11 732ha), woodlands (20 804 046ha), bushland (4 974 200ha) and wooded grasslands (1 204 445ha). When compared to the last study done in 1994, this constitute a change in the woody biomass stocks by the following margins: commercial plantations (-1 240 437ha) and woodlands (+1 211 334ha). Growth rates vary from 0.2 t dm/ha for some commercial plantation species to 24.51 t dm/ha for eucalyptus. Woodlands, bushland and natural moist forests grow at 1.9, 1.5 and 2.7 t dm/ha respectively.

State forests and forests under national parks and other protected areas can be considered to be carbon reservoirs. Commercial forests represent mostly exotic tree plantations as mentioned above are considered to be sinks. Woodlands comprise of varied densities of interlocking deciduous trees with or without much grass cover when compared to wooded grasslands. Bushlands are thickets of bushes varying in density with much more grass cover while natural moist forests consists of tall evergreen trees associated with high altitudes and high rainfall areas like the Eastern Highlands. All these biomass stocks are assumed to be reasonably reliable to allow estimations to be done on an area basis. Where trees are dispersed, the IPCC guidelines recommend that the number of trees be taken into account rather than the area covered by the trees.

Total carbon in annual growth of logged and exotic plantations was estimated at 24 760 Kt C (worksheet 5-1 sheet 1 of 3). During the year 2000 Zimbabwe's forestry sector harvested an estimated biomass amounting to 1500 Kt dm and this is depicted as total biomass consumption from stock (worksheet 5-1 sheet 2 of 3). These figures were used to estimate annual carbon release which was estimated at 750 Kt C for year 2000 (worksheet 5-1 sheet 3 of 3). Net annual carbon uptake for Zimbabwe stood at 24 009 Kt C.

This baseline information is derived from Forestry Commission estimates of national woody cover.

Using the IPPC carbon content of dry matter of 0.5, total carbon increment is estimated for each of the eight woody biomass classes and converted into carbon dioxide sinking (removal). For the year 2000, wood biomass is estimated to have removed (sunk) 88, 035 Gg of CO_2.

Estimation of GHG emissions for the year 2000

Deforestation in the broader sense of the word, including reductions in tree density and vegetation cover has been widespread in Zimbabwe. According to Whitlow (1980) many areas have experienced more than 3% decrease in woodland canopy cover per annum during the 1980s. From that time to date there has been no reliable data on this and thus it is not clear whether this trend is continuing over the whole country, and if so, at what rate. Each year about 13 million hectares of the world's forests are lost due to deforestation, but the rate of net forest loss is slowing down, owing to new planting and natural expansion of existing forests (FAO FRA, 2005).

The ten countries with the largest net forest loss per year between 2000 and 2005 (Brazil, Indonesia, Sudan, Myanmar, Zambia, United Republic of Tanzania, Nigeria, Democratic Republic of the Congo, Zimbabwe, Venezuela (Bolivarian Republic of)) had a combined net forest loss of 8.2 million hectares per year. Africa also continued to have a large net forest loss, but the rate of loss appears to be slowing, from 4.4 million hectares per year in the 1990s to 4.0 million hectares annually in 2000-2005 (FAO FRA, 2005).

In the year 2000, the Zimbabwe Commercial Plantations lost a total of 4 866 ha (Table 2.16) to tropical cylone damage and could not be off-set by new afforestation since only 1 904 ha were planted (TPF 2000). Table 2.15 shows that a further 148 ha of plantation forest was lost to fire (TPF 2001).

The amount of biomass burned during the clearance of land for cultivation is not known as there is no data. According to FAO, FRA, 2005, biomass stocks in forest and other wooded land were estimated (Table 2.19). Biomass from other wooded land, were only estimated for 1990 and not for 2000 and 2005 as areas of other wooded land could not be separated from other land in the figures. Carbon stocks in forest and other wooded land was also estimated by FAO in FRA (2005) (Table 2.20).

Evolution of emissions for the years 1990, 1995 and 2000

Table 2.19: Biomass stock in forest and other wooded land

Biomass (million metric tones oven-dry weight)						
FRA 2005 categories	Forest			Other wooded land		
	1990	2000	2005	1990	2000	2005
Above ground biomass	1,063	917	843	125	-	-
Below ground biomass	286	246	226	60	-	-
Total living biomass	**1,349**	**1,163**	**1,069**	**185**	**-**	**-**
Dead wood	189	163	150	26	-	-
Total	**1,538**	**1,326**	**1,219**	**211**	**-**	**-**

Data source: *FAO, Global Forest Resources Assessment 2005.*

Table 2.20: Carbon stock in forest and other wooded land.

Carbon (million metric tonnes)						
FRA 2005 categories	**Forest**			**Other wooded land**		
	1990	**2000**	**2005**	**1990**	**2000**	2005
Carbon in above ground biomass	532	458	422	62	-	-
Carbon in below ground biomass	143	123	113	30	-	-
Carbon in living biomass	**675**	**581**	**535**	**92**	**-**	**-**
Carbon in dead wood	94	81	75	13	-	-
Carbon in litter	-	-	-	-		
Carbon in dead wood and litter	94	81	75	13		
Soil carbon	-	-	-	-		
Total	**769**	**662**	**610**	**106**	**-**	**-**

Data source: *FAO, Global Forest Resources Assessment 2005*.

The following formulae were used to come up with tables.

a. **Column F:** Volumes were obtained from TPF Plantation Statistics 1999/2000.
b. **Column G:** Both conversion and expansion ratios are needed thus the default conversion ratio (0.5 t dm/m^3) and the expansion ration for logged forests (1.90) were combined by using a ratio (0.95) which is the product of the two. N.B Expansion ratio was applied to account for non-commercial biomass (limbs, small trees etc) harvested with commercial roundwood.
c. **Column I:** FAOSTAT figure for production of woodfuels (1000m^3 under bark) was multiplied by the default bark factor (1.15) to get volume over bark. This figure was then multiplied by biomass conversion and expansion factor (0.6) obtained from Table 5.4[4] of the FRA 2010 guidelines for country reporting.
d. **Column K:** Total of H, I and J columns.
e. **Column L:** For commercial data, the data on the TPF Plantations Statistics 1999/2000 was multiplied by the default conversion ratio (0.5 t dm/m^3).

For wood-fuels, the IPCC wood-fuel production figure was multiplied by the bark factor to get volume over bark. The resultant figure was then multiplied by the default global fraction (0.47) as given by FRA 2010 guidelines for country report.

2.4.7 Quality Control and Quality Assurance

The inventories were estimated on the basis of official statistics from the Central Statistical Office. Information was also collected from the line ministries and the agencies responsible for the various sectors. The energy sector data was mostly extracted from the national energy balance as produced by the Ministry of Energy and Power Development. During years following 2000 data collection systems were adversely affected by due to limited funding, downsizing and poor performance of most entities.

Workshops conducted during the compilation of the greenhouse gas inventory were used to present the available data for review and comment by sector experts. The Central Statistical Office was also represented at these workshops. The draft report was circulated for comment by sector experts and those who were not part of the GHG inventory team. In the absence of an organised GHG inventory database it is difficult to assess the effectiveness of data review given the high staff turnover and the fragmentation of some of the data collection systems. It is hoped that data collection systems will be revitalised by the next submission.

CHAPTER 3

3. VULNERABILITY AND ADAPTATION ASSESSMENT

3.1 Background

Climate change will have profound effects on key sectors of the Zimbabwean economy. The objective of this study was to assess and predict the effects of a changing climate on different sectors of Zimbabwe's economy. To this end, we used regional climate change scenarios developed using the Global Circulation Model (GCM) simulation. The potential effects of a changed climate within 70 years and possible adaptation strategies were identified for different sectors namely forestry, biodiversity, rangelands, water resources, human health, agriculture and human settlements.

In this study interpolated current climate data at high spatial resolution, i.e. 4.5 km was used to represent the current climate. In addition, downscaled global circulation model (GCM) future climate data readily made available at http://www.worldclim.org/ were used to show climate scenarios up to 2080. The Commonwealth Scientific and Industrial Organisation (CSIRO) CSIROMK3 model projections were adopted, since the data are readily available in downscaled mode at http://www.worldclim.org/. The temperature and precipitation predictions of the CSIROMK3 model are similar to those from other models such as Hadley Centre Models (HaCM2). The CSIRO models used in this study have been developed and adapted to the climatic conditions prevailing in the southern hemisphere. Two scenarios were considered in this report; the business as usual case (A2a) hereafter referred to as the Worst Case Scenario (WCS), and the environmentally conscious scenario (B2a) hereafter referred to as the Best Case Scenario (BCS). The specific objectives of this study were to:

- determine the levels of vulnerability in Zimbabwe of different sectors and geographic regions under the current climate and future climate change scenarios;
- assess and develop a framework for appropriate adaptation measures for different sectors and affected geographic regions of Zimbabwe; and
- synthesize the vulnerability and adaptation results for the purpose of conducting technical assistance needs assessment for Zimbabwe.

3.2 Climate scenarios

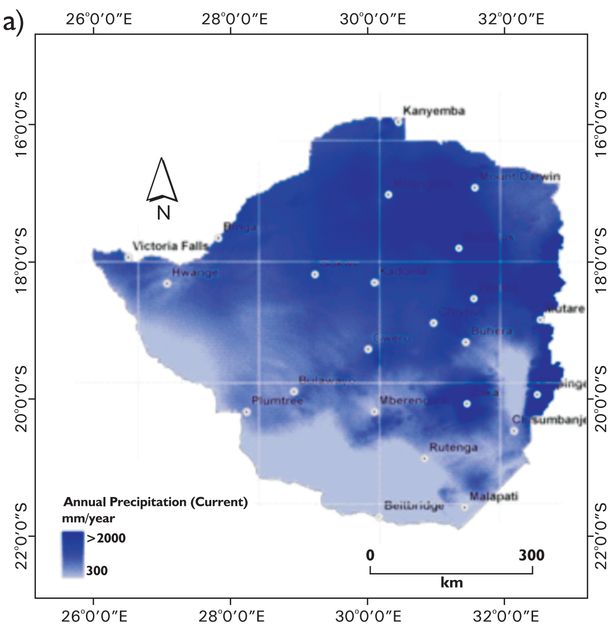
Zimbabwe lies in a region with limited and unreliable rainfall patterns. The country is therefore greatly concerned with the effects of climate change on its economy because in both rural and urban areas, economic activities are strongly linked to agriculture and highly dependent on natural resources. The total annual rainfall ranges from 300 mm in the southwest to over 1 000 mm in the northeast and east.

Fig 3.1 illustrates the current rainfall distribution based on meteorological station data as well as future anomalies derived from the difference between the current and the projected rainfall from CSIROMK3 best case (middle) and worst case (right) rainfall scenarios in Zimbabwe. Model projections reveal that the present southwest-northeast-east rainfall gradient will become steeper under both the BCS and WCS (Fig. 3.1). In the BCS, the annual rainfall range is expected to remain stable between 300 mm to above 2 000 mm but under the WCS, annual rainfall range is expected to increase from 200 mm in the southwest to over 2 000 mm in the north-eastern and eastern parts of the country.

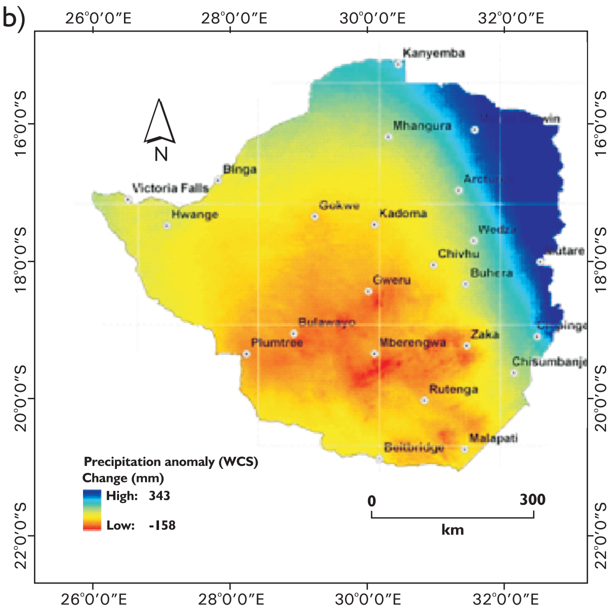
With regards to temperature, Zimbabwe experiences the lowest minimum temperatures in

June or July while the highest maximum temperatures are experienced in October. The relatively high elevation of most parts of Zimbabwe, moderates temperature. Most parts of the country, therefore, experience temperatures that are generally lower than might be expected for their latitudes. The mean annual temperature varies from 18°C in the highveld to 23°C in the lowveld. The highveld experiences some frost in June or July in most years but temperatures rise to around 30°C in October. In the lowveld region, temperatures rarely fall below 2°C in winter but can rise to over 40°C in summer. Mean monthly temperature projections for both the worst and best case scenarios based on the CSIROMK3 model indicate a general warming of around 2°C by 2080.

a)



b)



c)

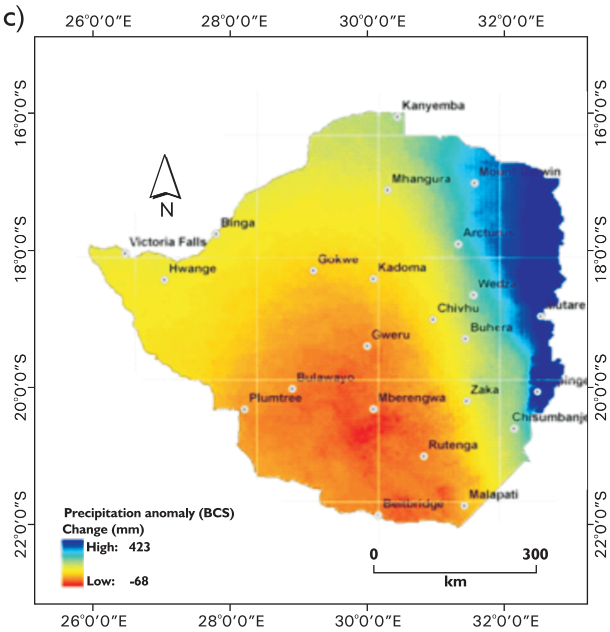


Figure 3.1: Current geographical distribution of annual precipitation in Zimbabwe (a) and the projected precipitation anomalies over Zimbabwe based on the difference between CSIROMK3 projections for the year 2080 and the current precipitation for the worst case scenario (b) and the best case scenario (c)

3.3 Agriculture sector

3.3.1 Vulnerability

Zimbabwe's agriculture is mainly rain-fed. This is true for both communal and commercial agriculture. Consequently, any rainfall changes will have a direct impact on agricultural performance. Figures 3.2, 3.3 and 3.4 show the sensitivity of maize, sorghum and cotton in both the communal and commercial farming sectors of Zimbabwe, respectively. Data on the relationships between rainfall and crop yields indicate that in communal lands, rainfall variability significantly correlates with maize yield ($r = 0\,49$, $P < 0.001$, $n = 30$), sorghum yield ($r = 0.61$, $P < 0.01$, $n = 30$), and cotton yield ($r = 0.79$, $P < 0.01$, $n = 20$). These results demonstrate the vulnerability of communal agriculture to climate variability and change. Data from commercial farms show that only maize yield is significantly correlated with total annual rainfall ($r = 0.71$, $P < 0.01$, $n = 30$) and therefore sensitive to rainfall. Typically, the rises and falls in rainfall correspond with increases and decreases in maize yield, respectively. In contrast to communal agriculture, no significant correlation between rainfall and sorghum yield ($r = 0.24$, $P > 0.1$, $n = 30$), as well as between rainfall and cotton yield ($r = 0.21$, $P > 0.1$, $n = 20$) were found in the commercial farming sector. This is expected because most commercial farms are historically located in rainfall areas with relatively low variability and hence they suit drought-resistant crops such as sorghum and cotton. These findings indicate the reduced vulnerability of small grains such as sorghum and shrub crops, in particular cotton, in the commercial farming areas of Zimbabwe.

Based on the current climate data, a mechanistic model, ECOCROP (Hijmans, *et. al.,* 2004) was used to model the spatio-temporal suitability of maize, sorghum, and cotton throughout Zimbabwe. The suitability assessments were based on climate variables, i.e. rainfall and temperature including their derivatives namely minimum average rainfall, optimal rainfall, optimal maximum rainfall , maximum rainfall, kill temperature, minimum average temperature, maximum average temperature and maximum average temperature at which plants cease to grow during the growing season. While it is clear that climate variables are not the only determinants of crop suitability, it is climate that is changing while other factors like fertility; soil type etc. are assumed to be constant, at least in the short term. Thus suitability, as used in this context refers to the ability of the current and projected climate to support optimal crop growth.

Results show that the area suitable for maize and cotton significantly correlate with national yields for these crops. However, there was no significant relationship between the area modelled as suitable for sorghum and sorghum yield. This suggests that overall sorghum is less sensitive to climate variability. Although sorghum is less sensitive to rainfall variability than maize and cotton, in communal lands, the planted area for sorghum has been decreasing. In contrast, on commercial farms, the area planted under sorghum has been increasing, a pattern perhaps attributed to contract farming for beer brewing.

Temporal trends in yield and area put under cultivation for maize, sorghum and cotton in communal lands and on commercial farms from the 1970s/1980s to 2000 shed insight on the levels of vulnerability of Zimbabwe's agricultural sector. It was found that, in communal lands, area planted under maize has been increasing while the area under sorghum and cotton has been declining. The fact that the area planted under cotton and sorghum in the communal lands has been declining since the early 1980s whereas that under maize has been increasing suggests that communal farmers devote more time to maize production, yet results indicate that it is more vulnerable to rainfall variability than sorghum and cotton. Given the sensitivity of maize to climate change, communal farmers may be better off shifting from maize to sorghum and cotton since sorghum is a small grain with lower risk of crop failure and cotton is a cash crop that could serve as a safety net when sold to buy food during times of drought. Both are less vulnerable to climate change than maize.

In the commercial farming sector, however, an opposite trend was observed where the area planted under maize has been declining while the areas planted under cotton and sorghum have been increasing in the period spanning the early 1980s to 2000. Although the decline in the area under maize on commercial farms may increase food insecurity in the country, high yields from sorghum can offset low maize yields while income from cotton may provide the cash needed to buy food during droughts.

Another important aspect of the results of this study is that in the future, the proportion of Zimbabwe that is considered 'excellent' for cotton and sorghum will both increase from the current 20% to 50 % under the WCS (Figs. 3.6 and 3.7). Under the BCS, the proportion that is deemed 'excellent' for cotton and sorghum will more than double. In contrast, area regarded 'excellent' for maize will decrease from the current 75% to 70 % and 55% under the BCS and the WCS respectively (Fig. 3.5). The projected changes in crop suitability show that in the south-western parts of the country, sorghum and maize will become increasingly vulnerable to climate change while cotton will become less vulnerable (Figs. 3.5-3.7). By contrast, in the north, central and eastern parts of the country, maize, sorghum and cotton will become less vulnerable. Altogether, these changes suggest that to mitigate the effects of climate change, communal farmers should opt for small grains and cash crops such as cotton in place of maize. Overall, the south-western parts of the country are projected to become less suitable for all the three crops. The cumulative effect of climate change may result in balancing food crop and commercial (e.g. cotton) crop production. In fact commercial crop production could be used to generate income that may be used for food imports where necessary.

3.3.2 Adaptation

Most communal farmers in Zimbabwe depend on rain-fed agriculture. Therefore, optimizing rain-fed crop production has potential to improve the adaptive capacity of these farmers. Rainfall projections presented here point toward a drying trend, thus adaptation strategies in the agricultural sector should focus on strategies to conserve moisture. Adoption of new agricultural management strategies that include use of improved short-season seed varieties especially for maize, and use of drought resistant small grains points, is a key strategy for coping with climate change. Commercial crops such as cotton may also buffer farmers against climate change as cotton fetches a higher price than maize at the market and is less vulnerable to climate change because cotton is deep-rooted and can draw water from deeper soil layers.

Having developed the geographical maps for the vulnerability analysis, it enabled Zimbabwe to determine which crops can best be grown where, as such preserving the food security. Also, Zimbabwe through the Ministry of Agriculture (MoA), is actively promoting conservation agriculture as a key adaptation measure to a changing climate. While the benefits of conservation agriculture are not yet fully understood relative to conventional agriculture, in the meantime increasing irrigation agriculture is crucial for ensuring the viability of agriculture especially in the south and south-western parts of the country where rainfall is projected to decrease by the greatest magnitude. Thus, adaptation strategies that lead to efficient use of available moisture, as well as, the provision of supplementary moisture through irrigation are important for Zimbabwe in the face of a changing climate. In this regard, the development and adoption of efficient water use and irrigation technologies is critical.

There are several programmes that Zimbabwe has so far embarked on to enhance its adaptive capacity to climate change. For example, Zimbabwe is promoting irrigation development and has invested a lot in dam construction throughout the country. In drier regions of the country, the use of simple rainwater-harvesting technologies is being promoted. But so far the transfer of these technologies is beset with problems that include lack of funds to train and pay skilled personnel who transfer the knowledge to farmers. Finally, to complement the efforts already under way, seed companies and research organizations should expedite work on developing more drought-tolerant and higher yielding crop varieties.

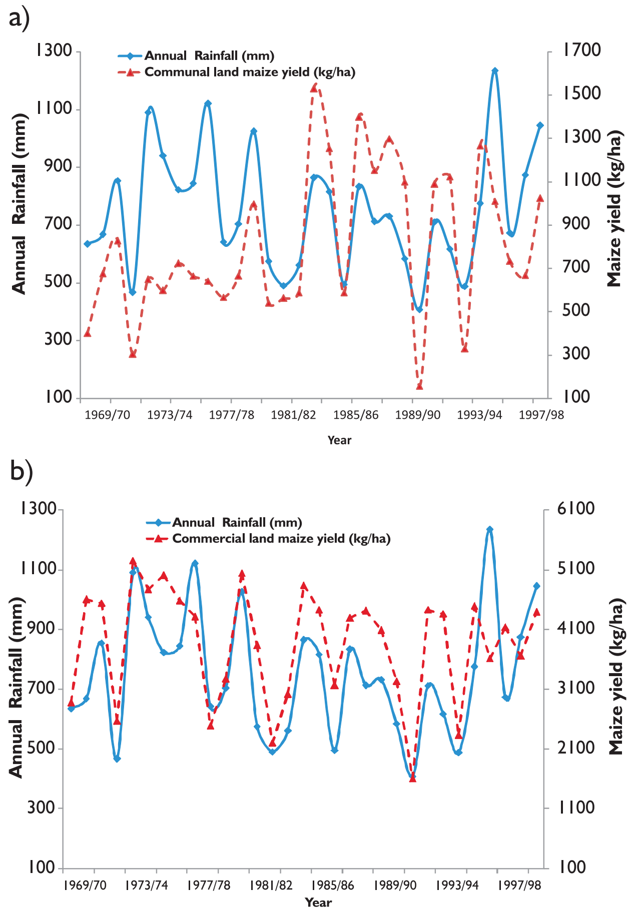
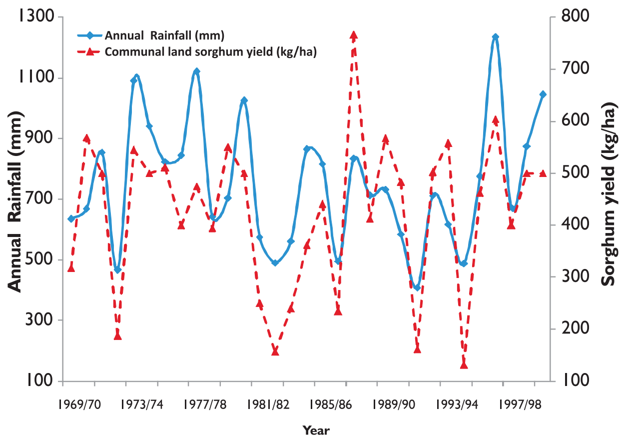


Figure 3.2: The sensitivity of maize yield in communal lands (a) and on commercial farms (b) to changes in annual rainfall in Zimbabwe.

a)



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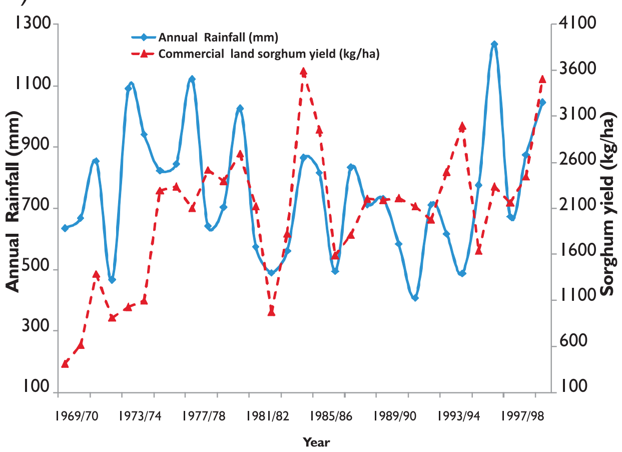
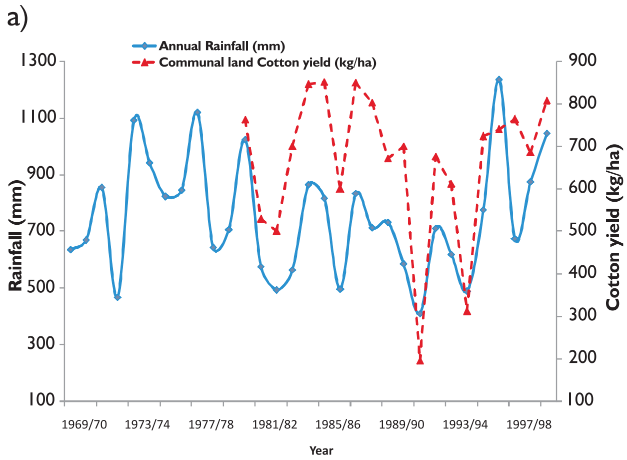


Figure 3.3: Significant relationships between sorghum yield in the communal and annual rainfall (a) and non-significant correlation between sorghum yield and annual rainfall in the commercial farms (b).

a)



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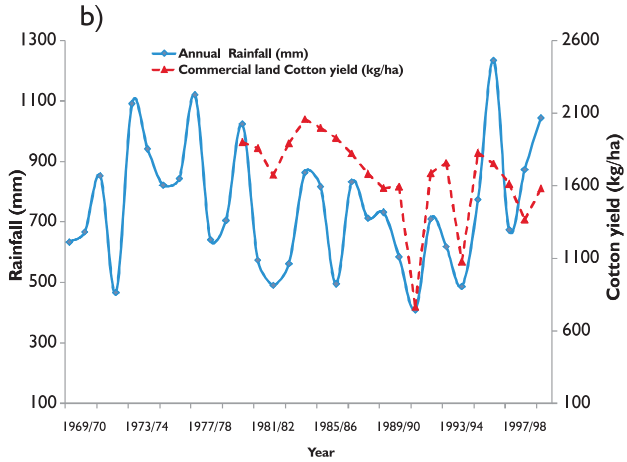
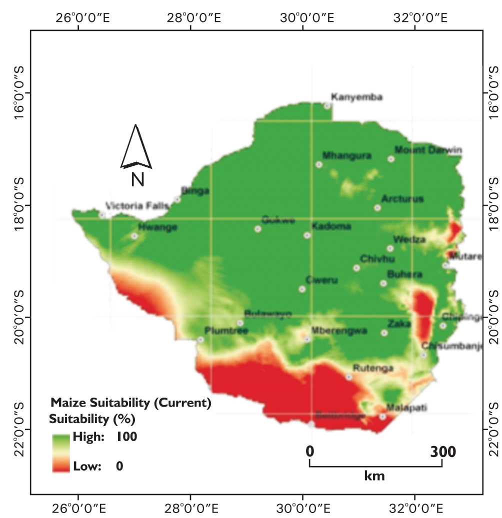


Figure 3.4: Relationships between cotton yield in the communal and annual rainfall (a) and non-significant correlation between cotton yield and annual rainfall in the commercial farming sector (b).

a)



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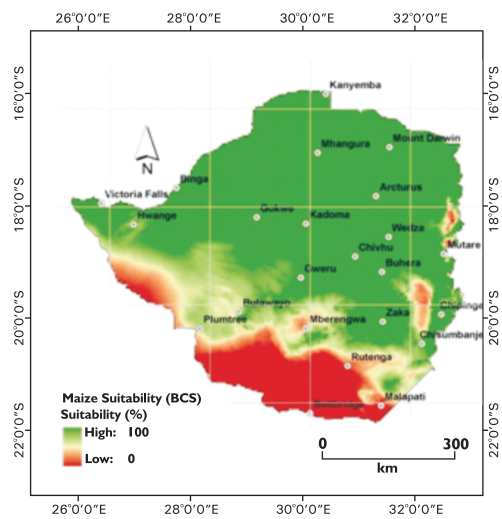


N

c)

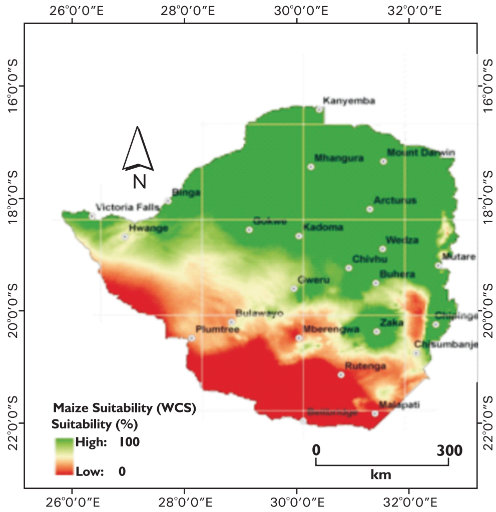
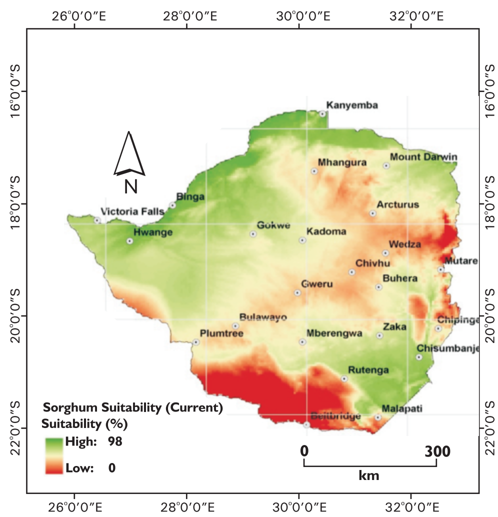
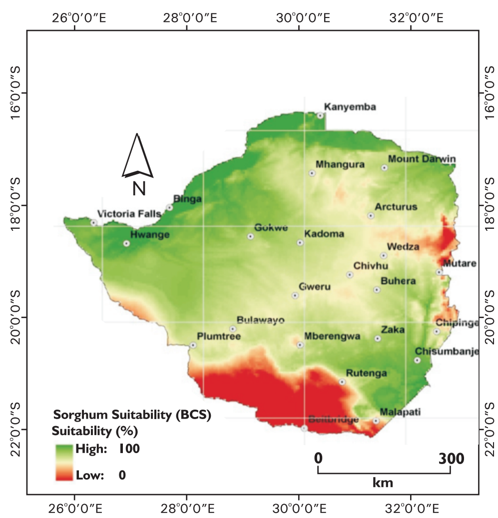


Figure 3.5: Geographic distribution of maize suitability for the current climate (a) and the projected climates in 2080 for best case scenario (b) and worst case scenario (c) in Zimbabwe

a)



b)



c)

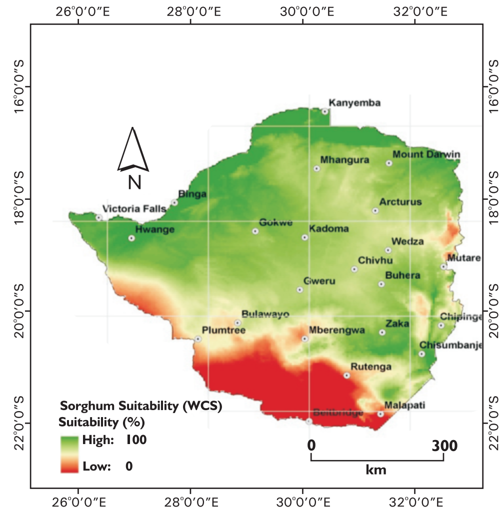
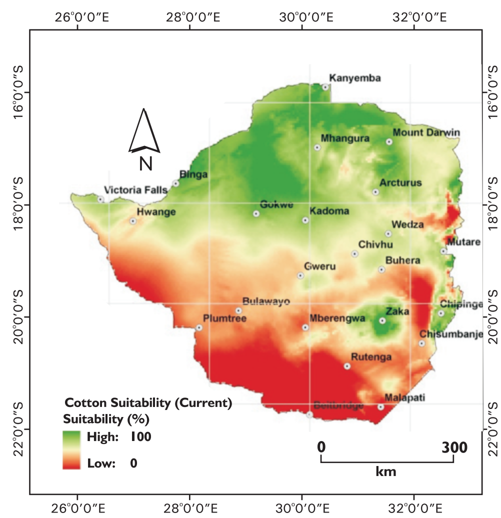
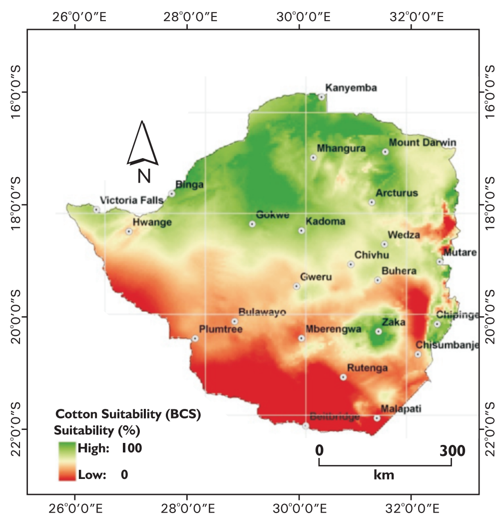


Figure 3.6: Geographic distribution of sorghum suitability for the current climate (a) and the projected climates in 2080 for best case scenario (b) and worst case scenario (c) in Zimbabwe.

a)



b)



c)

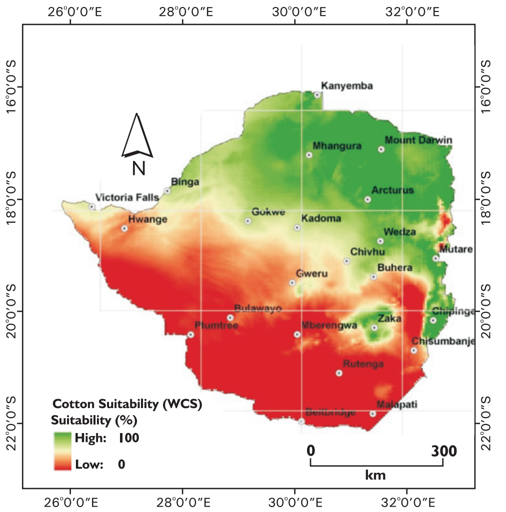


Figure 3.7: Geographic distribution of cotton suitability for the current climate (a) and the projected climates in 2080 for best case scenario (b) and worst case scenario (c) in Zimbabwe.

3.4 Biodiversity sector

3.4.1 Vulnerability

Zimbabwe's flora is rich. An estimated 4500 vascular plant species occur in Zimbabwe, of which 214 are endemic plants while a further 504 species are included in the IUCN red data list . Two components of biodiversity namely, plant diversity and net primary productivity (NPP), were used to assess the vulnerability of biodiversity to climate change. A total of 54 000 herbarium records from locations distributed throughout the country were used to calculate plant diversity throughout the country. Regression analysis was used to test for significant relationships between plant diversity, rainfall and temperature. Results show that plant diversity increases as the precipitation of the warmest quarter increases (Fig. 3.8 left). However, when precipitation of the warmest quarter exceeds 450 mm, further increases in precipitation appear to have no significant positive effect on plant diversity. These results imply that in drier regions of the country such as southern and western parts, plant diversity is sensitive to rainfall but in wetter regions (e.g., the Eastern Highlands) plant diversity is less sensitive to rainfall variability. This is consistent with the current understanding of the effect of rainfall on vegetation in savannah ecosystems (Sankaran *et al.*, 2004, Sankaran *et al.*, 2008).

Plant diversity is also sensitive to temperature changes. Fig 3.8 (right) shows that plant diversity decreases as the maximum temperature of the warmest month (October) increases. Together, these findings suggest that the expected rise in temperature accompanied by a decrease in rainfall amounts may have a negative effect on plant diversity and ecosystem function in Zimbabwe.

The geographic distribution of plant diversity is not even in Zimbabwe. Figure 3.9 shows that under the current climate, the eastern regions of the country have the highest plant diversity followed by the central watershed. The southern and western regions have the lowest plant diversity. Figure 3.9 (right) indicates that by year 2080 under the worst case climate scenario, plant diversity is projected to decline throughout the country and areas that currently harbour high diversity will shrink. However, under the best case scenario, the projected decrease in plant diversity by 2080 is expected to be less pronounced compared to the worst case scenario.

A total of 25 major vegetation complexes occur in Zimbabwe. Under the worst case climate scenario, the pressure on plant diversity in each vegetation complex will be significantly higher than under the worst case scenario. Regardless of whether the climate change scenario considered is the best or the worst, the expected minimum pressure on plant diversity is 42%.

Under the worst case climate scenario, the pressure on plant diversity will be highest in the western regions and lowest in the eastern regions but moderate for the central parts of the country. The pressure pattern for the best case climate scenario is similar except that pressure on plant diversity is expected to be lower.

The relationship between Net Primary Productivity (NPP) and the current climate was analysed using regression analysis. The results show that about 69% of the variation in NPP can be explained by precipitation of the warmest quarter. Figure 3.10 (a) shows that NPP increases as the precipitation of the warmest quarter increases. This indicates that in Zimbabwe NPP is limited by the low availability of rainfall during the warmest quarter. Net Primary Productivity is also sensitive to temperature, in particular the maximum temperature of the warmest month. Figure 3.10 (c) illustrates that NPP increases with increasing temperature of the warmest month but above 30°C, further increases in temperature result in significant decreases in NPP. Put together, these results suggest that the projected decreases in precipitation coupled with increases in temperature, will cause a corresponding decrease in NPP in most parts of the country.

Currently in Zimbabwe, there is an apparent east-west gradient of decreasing NPP (Fig. 3.11) with the western regions of the country being the least productive while the eastern regions are the most productive. Under the best case scenario, NPP is predicted to increase in the central and eastern parts of the country (compare Fig 3.11 a) and Fig 3.11 b)). This pattern may be explained by the fact that in these regions, temperature is expected to increase yet rainfall will not change much. Already, the central and eastern parts of Zimbabwe receive relatively high amounts of rainfall (above 700 mm of annual rainfall per annum). Consequently, the projected increase in temperature in these areas will likely be accompanied by resultant significant increases in NPP as initial increases in temperature correlate positively with increases in NPP (see the rising curve in Fig 3.10). In contrast, under the worst case scenario, temperature is projected to increase and rainfall decrease. It is predicted that these changes will result in significant decreases in NPP in most parts of Zimbabwe by 2080 (see Fig. 3.11) and the western and southern regions of the country will be worst affected by climate change.

3.4.2 Adaptation

From the vulnerability assessment, it is clear that climate change will likely have differential impacts on Zimbabwe's plant biodiversity with the most vulnerability projected to occur in the southern and western parts of the country. The eastern highlands and the central parts of the country appear to have the greatest adaptive capacity to climate change as the vegetation in these regions is less sensitive to climate variability because of high rainfall (i.e., mean annual precipitation > 750 mm). Given that the impacts of climate change are inevitable, biodiversity management strategies that aim at maintenance and restoration of biodiversity are likely to reduce the adverse impacts of climate change. In that regard, adaptation strategies in the biodiversity sector include reduction of non-climatic stresses such as human disturbances, in particular, overexploitation of biodiversity as well as minimising uncontrolled fires as these tend to lower the ability of ecosystems to provide goods and services to society and compromise the resilience of ecosystems to climate change. Despite Zimbabwe having a number of protected areas aimed at conserving biodiversity, most of its biodiversity is located outside of protected areas. Thus, there is need to strengthen protected area networks as well as increasing off-reserve conservation efforts in order to enhance the effectiveness of protected areas.

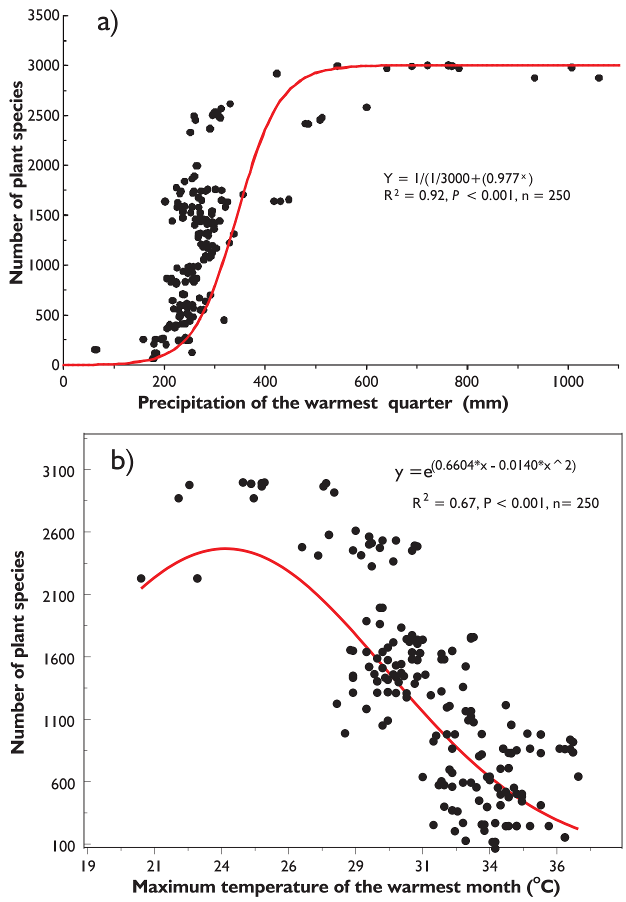


Figure 3.8: Relationship between (a) plant diversity and precipitation of the warmest quarter in Zimbabwe and (b) between plant species diversity and maximum temperature of the warmest month and in Zimbabwe.

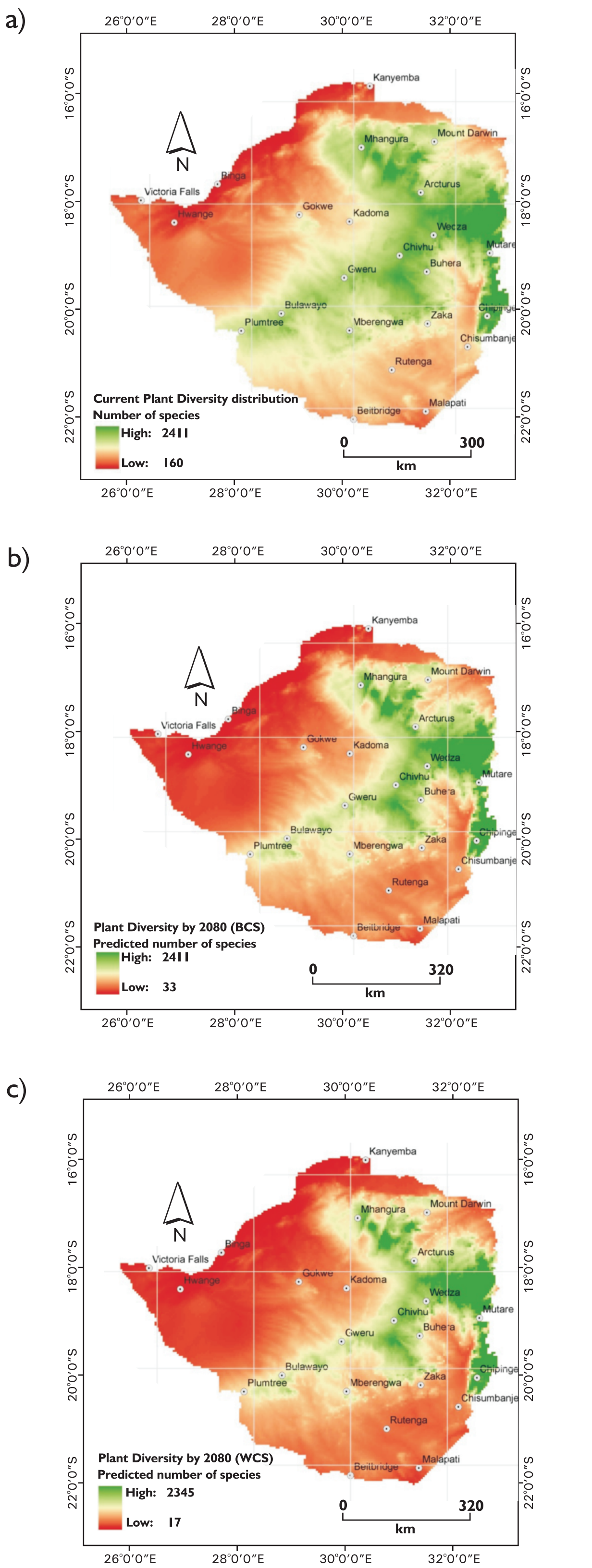


Figure 3.9: The geographical distribution of plant diversity under the current climate (a), predicted distribution in the year 2080 under the worst case (b) and best case climate scenarios (c).

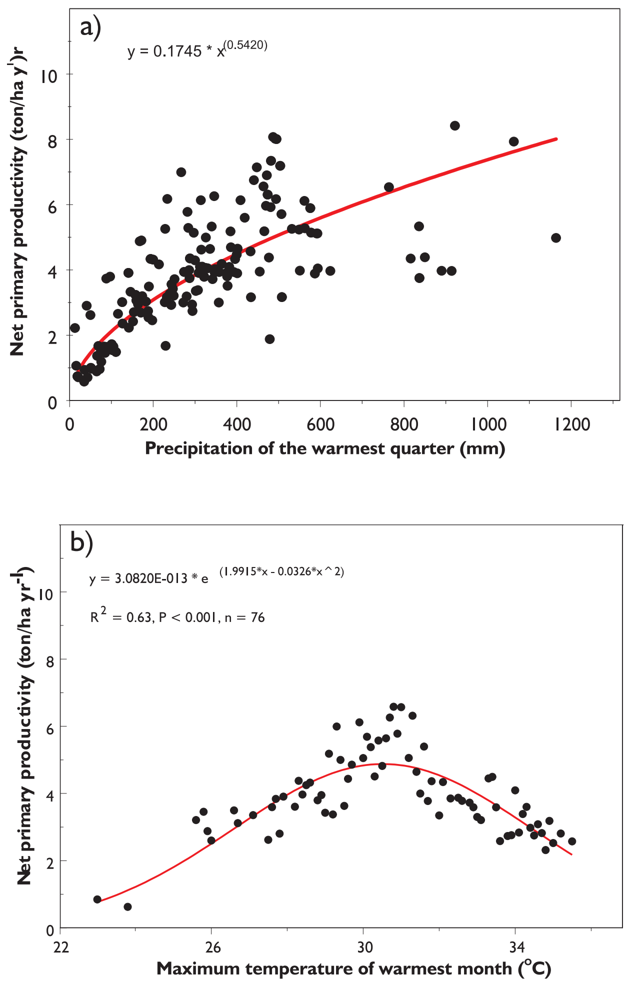
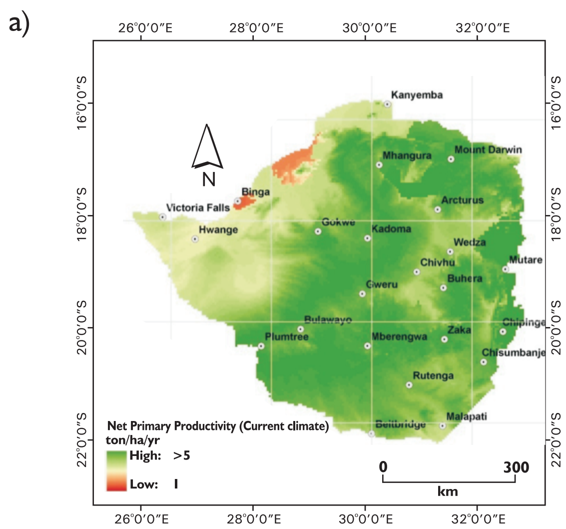


Figure 3.10: Relationship between (a) primary productivity and precipitation of the warmest quarter in Zimbabwe and (b) between primary productivity and temperature of the warmest month in Zimbabwe.



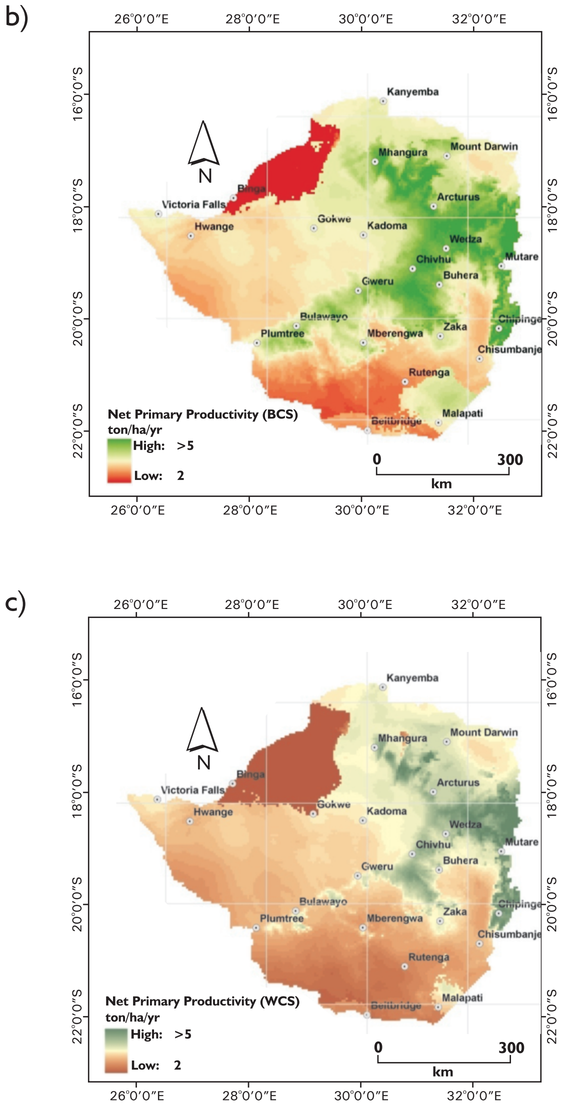


Figure 3.11: Net primary productivity under current (a), best case scenario (b) and worst case scenario (c).

3.5 Rangelands

3.5.1 Vulnerability

Zimbabwe's rangelands consist of uncultivated lands which are mainly used for both wildlife and domestic livestock grazing and browsing. Net primary productivity (NPP), which is the amount of organic matter fixed per unit time in a specific place, is the single most important indicator of rangeland health . High NPP corresponds with high availability of forage for both livestock and wildlife and vice versa. Analysis of NPP variations in space and over time in Zimbabwe shows that NPP is related significantly to rainfall especially the precipitation of the warmest quarter of the year (Fig. 3.10 a), as well as the maximum temperature of October (Fig. 3.10 c). This provides direct evidence that NPP is sensitive to climate and therefore is vulnerable to changes in climate. Vulnerability of NPP to changes in climate translates to vulnerability of the wildlife and livestock industry.

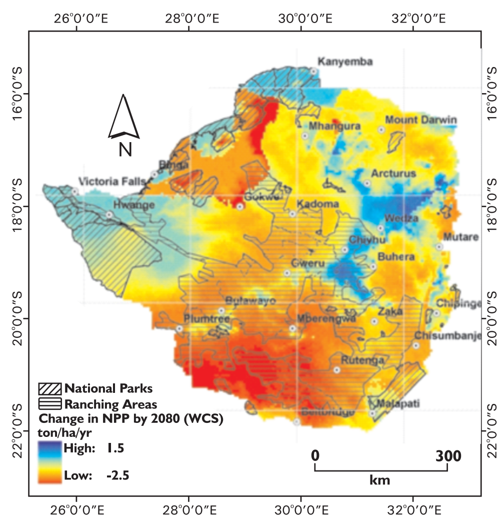
The climate change scenarios yielded by the CSIROMK3 model show that NPP in Zimbabwe will decrease from the current average maximum of over 8 tonnes per hectare per year to just over 5 tonnes per hectare per year by 2080 (Fig. 3.12). This translates to decreased rangeland carrying capacity for both livestock and wildlife. Changes in the geographic distribution of NPP (NPP anomalies) indicate that the southwest and north-western parts of Zimbabwe will experience more reductions in NPP than in other parts of the country (Fig. 3.12). These results indicate that the projected changes in climate will increase the vulnerability of rangelands especially in the south-western parts of Zimbabwe. However, in the northeast parts of Zimbabwe, indications are that rangelands will experience less pressure. An analysis of the extent of vulnerability in different vegetation complexes of Zimbabwe in both the BCS and WCS indicate that the highest reduction in NPP will be experienced among vegetation complexes in the eastern parts of the country such as the *Pitosporum-Ilex-Rappanea* complex while the least impact will be on *Baikiaea* vegetation complex.

3.5.2 Adaptation

The projected reduction in NPP will likely reduce the carrying capacity of rangelands i.e. fewer animals will be sustained within rangelands. NPP provides an estimate of how much biomass and therefore forage is available in a rangeland. Therefore, if NPP (a proxy of forage amount) falls below the minimum threshold that is required to feed livestock and wildlife as a result of climate change, then reducing dependency on ranching for the livestock sector is a practical adaptation strategy. Adaptation might also include the use of supplementary feeds for the livestock industry. In other words, there is need for agricultural production policies and practices to recognise reduced NPP in rangelands.

It is important to note that climate change may also affect the spatial extent of livestock disease outbreaks, such as anthrax. Thus, it is important that ranching practices in ranching regions should improve disease surveillance mechanisms that would be useful in controlling such diseases. It is also important that land use planning practices be instituted especially the ones that take into consideration the needs of changing climate so as to come up with competitive land use practices.

a)



b)

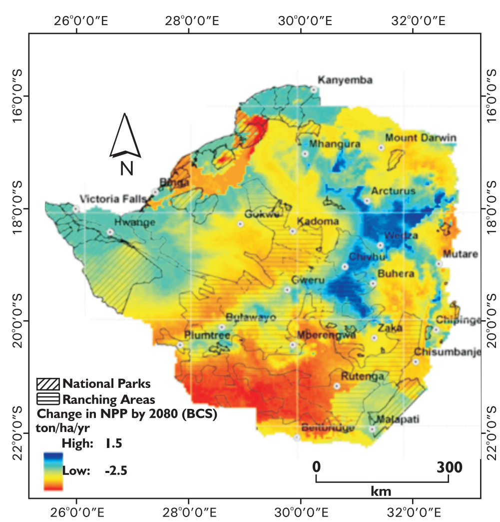


Figure 3.12: Projected variations of NPP anomalies in Zimbabwe for the year 2080 under the best case scenario (a) and worst case climate scenarios (b).

NPP anomalies in Zimbabwe for the year 2080 under the best case scenario (a) and worst case climate scenarios (b).

3.6 Water Resources

3.6.1 Vulnerability

Water resources in Zimbabwe are dependent on rainfall which is highly variable across most of the country with notable exceptions being the eastern Highlands, which receive high and fairly stable rainfall. Since runoff, which contributes over 90% to the country's water supply from dams and rivers, is sensitive to rainfall variability, Zimbabwe's water resources are vulnerable to climate change. Most of Zimbabwe's surface water comes from rivers which record a mean annual runoff of approximately 20.1 billion m^3 per annum (Thornton, 1980). In Zimbabwe, runoff indicates a strong positive relationship ($r=0.78$, $P < 0.01$) with rainfall implying that with increasing rainfall there is a corresponding increase in runoff. Rainfall is highly variable in space and time and such variations are major determinants of runoff and therefore water availability per year.

The runoff coefficient of variation (CV), a useful statistic for comparing the degree of variation from one run off series to another, indicates that currently runoff has a high variability in the western parts of the country but variability is low in the eastern parts (Fig 3.14). The catchments that have the highest CV include Lower Umzingwane, Shashe, and Gwayi while, Budzi, Odzi, Pungwe, Kairezi and Mazowe have relatively low runoff variability. The runoff variability follows the rainfall gradient in which catchments that receive relatively high amounts of rainfall have lower CV than those that receive low rainfall. This suggests that water resources in low rainfall areas are susceptible to changes in rainfall inputs which are the major drivers of the surface component of the hydrological system.

To assess the potential effect of climate change on surface water resources in Zimbabwe, a logistic regression function based on the rainfall- runoff relationship using data for the period 1956 to 2006 was used. Results show that rainfall significantly explains 84% of the variations in runoff (Fig. 3.13). Results of correlation analysis show that there is significant positive relationship between observed and modeled runoff (r = 0.51). Further, a t- test confirmed that there was no significant difference (t = 0.2062, df = 64, p-value = 0.8373) between the observed and modeled runoff. Thus the model used to predict runoff under future rainfall scenarios amounts based on the CSIRO A2A and B2A models, is fairly robust.

The predicted runoff under both the worst case scenario (WCS) and best case scenario (BCS) indicate that runoff will decrease significantly in the Umzingwane, Shashe, Nata, and Save catchments (Fig. 3.15). Catchments with high runoff coefficient of variability will likely experience high runoff anomalies. Currently, most catchments in Zimbabwe have low runoff conversion rates. This implies that most of the runoff is not exploited. Runoff conversion ratio is the proportion of the runoff that is captured and stored in water impoundments relative to the total runoff generated in a catchment.

In this study, the current water available per capita was calculated by dividing the total amount of water in water impoundments such as dams and lakes by the current total population as reported in the census report of 2000. Future water demand was derived from dividing the predicted runoff by the projected population for the year 2080. Under the best case scenario, water available per capita will decrease from 2.5 megalitres to approximately 1.8 megalitres by 2080. The projected decreases under the worst case scenario are even higher.

3.6.2 Adaptation

Most of Zimbabwe's surface water comes from and is replenished by runoff, which varies in space and over time. At present, water utilisation is approximately 22 % of the mean annual runoff. With climate change projections indicating a drying trend characterised by high rainfall variability, the adoption of measures that increase water utilisation in water impoundments as well as increase the network of water storage facilities across the country is critical. This is especially important as most catchments have low runoff conversion ratios that lead to most runoff being lost. Improving water use efficiency in the agricultural sector may help alleviate water scarcity problems projected to occur under different climate change scenarios. At present, agriculture uses 60% of all the water in dams but irrigation efficiencies range between 40% and 60% (Chenje *et al* 1998). In the urban areas, as much as 40% of water is lost during treatment and distribution (Chenje *et al* 1998). Therefore, increasing water use efficiency in the irrigation sector and reducing water losses in urban centres are essential strategies for dealing with projected declines in surface water resources in a changing climate in Zimbabwe.

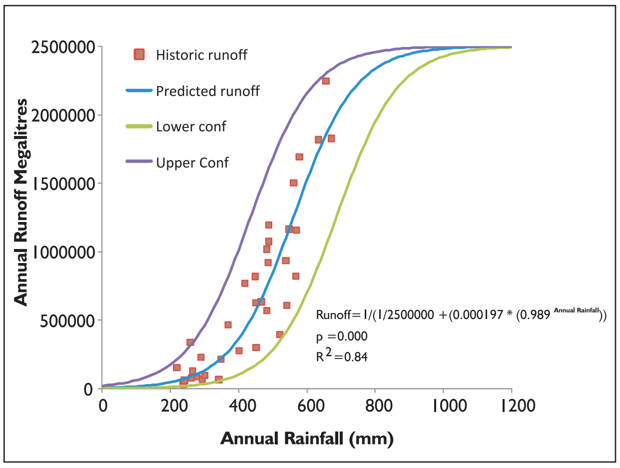


Figure 3.13: The logistic regression function derived from the 50 year runoff-rainfall relationship used for runoff prediction in Zimbabwe. The lower and upper 95% confidence interval limits are shown

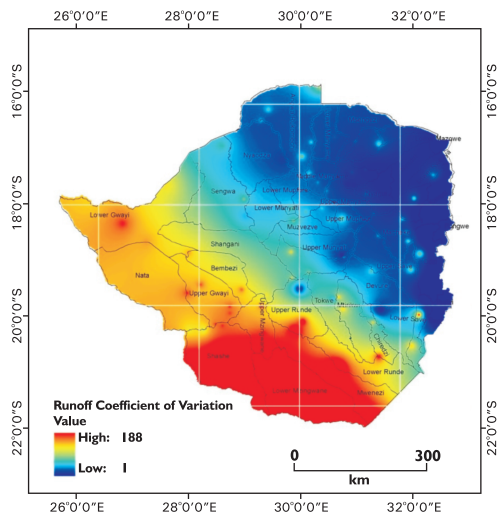


Figure 3.14: Geographical variations in runoff response to changes in rainfall throughout Zimbabwe.

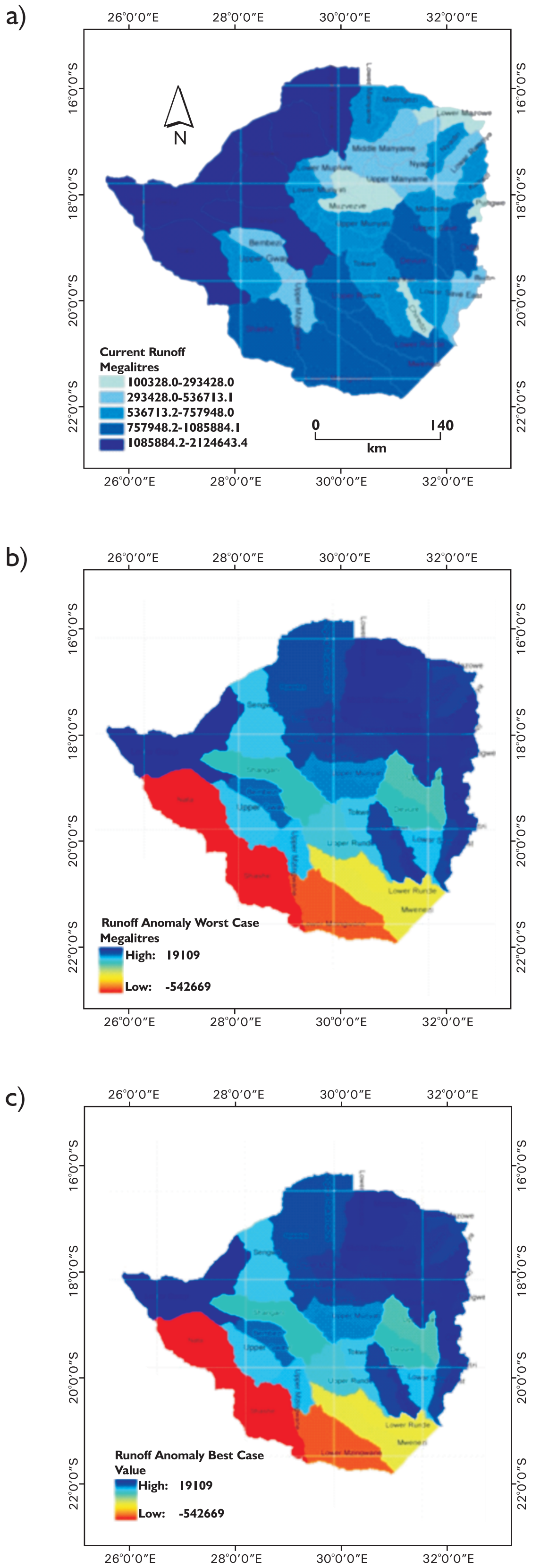


Figure 3.15: Current runoff (a) and the projected rainfall anomalies in sub-catchments across Zimbabwe for the worst case (b) and best case (c) climate scenarios for the year 2080 in Zimbabwe.

3.7 Health sector

3.7.1 Vulnerability

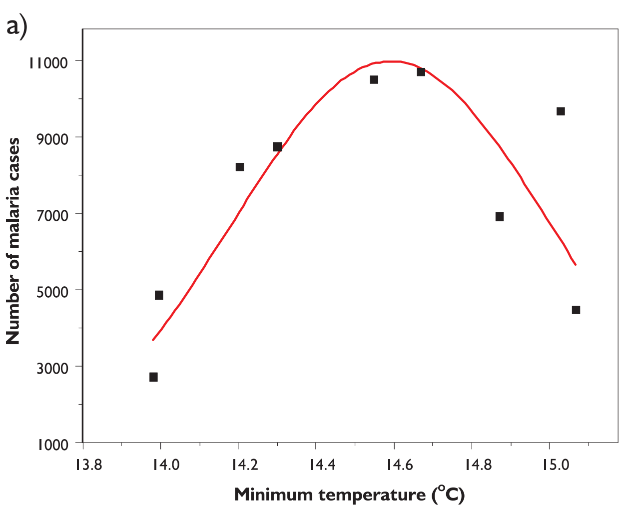
Malaria is an indicator disease that was used to assess the potential impact of climate change on the health sector as its distribution and seasonal transmission correlate significantly with temperature and rainfall in Zimbabwe. Understanding the changes in malaria occurrence in a changing climate is important in Zimbabwe since, 75% of the country is prone to malaria. Data for the period from 1990 to 2000, indicate that there is a significant curvilinear relationship ($r^2 = 0.74$, $P < 0.01$, $n = 9$) between malaria incidences and mean annual minimum temperature in Zimbabwe but the relationship between malaria incidences and mean annual maximum temperature is negative and linear ($r^2 = 0.38$, $P < 0.01$, $n = 9$) (Fig 3.16.). Also, malaria occurrence is positively correlated with rainfall in Zimbabwe ($r^2 = 0.38$, $P < 0.01$, $n = 9$).

The malaria hazard for Zimbabwe based on the bioclimatic (BIOCLIM) GIS models for the years 1992, 1996, and 2000, reveal a strong link between recorded malaria incidences and temperature, as well as rainfall. These years were selected because they represent an extreme drought, a normal rainfall year and a typically wet year, respectively. Hence, they capture the gradient of malaria hazard in the country. Figure 3.17 shows that malaria incidences were lower in a drought year (1992) and an exceptionally wet year (2000) but high in an average year (1996). This indicates that excessive rainfall coupled with high temperatures may negatively affect the breeding pattern of the *Anopheles gambiae* mosquito. The projected malaria hazard for Zimbabwe for the year 2080 under both the best case and worst case climate scenarios shows that the high malaria hazard will be concentrated in the low lying parts of the country including the Zambezi valley, and the South-east lowveld (Fig 3.18). The susceptibility to malaria is not expected to change much in other areas such as the Highveld where temperatures are moderate.

3.7.2 Adaptation

Zimbabwe has measures in place to control malaria and the most common one is the spraying programme done under the Ministry of Health and Child Welfare. This programme normally commences at the start of the rain season and is aimed at reducing the spread of mosquitoes. The Roll Back Malaria Campaign, which is being spearheaded by the World Health Organisation (WHO) also tries to reduce deaths attributed to malaria by half in Zimbabwe. Under this programme, WHO provides technical and financial resources needed to combat malaria. Access to health centres is critical in the fight against malaria. But while most districts in the country have a fairly dense network of health centres, the districts with a high malaria hazard e.g., Chiredzi, have a poor network yet the malaria hazard is projected to increase in these districts.

To address this mismatch between high malaria hazard and the number of health centres present in a district, it is recommended that in districts with high malaria hazard, the number of health centres should be increased. As a general rule, the location of additional health centres should be selected such that no major human settlement is more than 20 km from the nearest health centre. This will greatly improve access to health services and increase the communities' adaptive capacity to malaria in a changing climate. Selection of candidate sites that meet this criterion can easily be done using a geographical information system expert system. Overall, increasing access to health centres and drugs will increase the country's adaptive capacity to projected increases in environmental diseases like malaria.



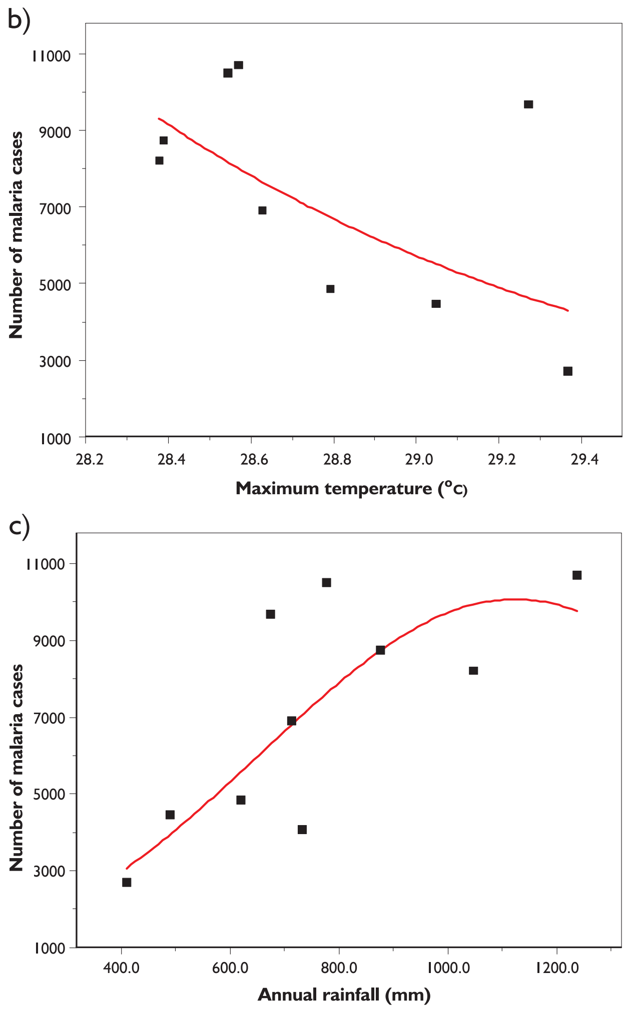
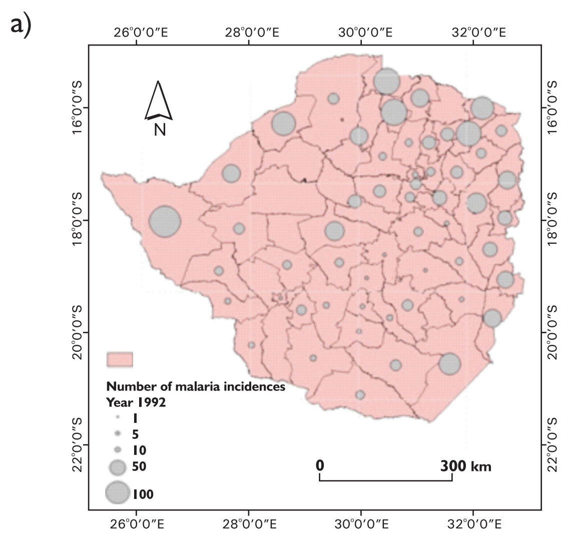


Figure 3.16: Relationships between recorded malaria cases and mean annual minimum temperature (a), mean annual maximum temperature (b) and mean annual rainfall (c) in Zimbabwe.



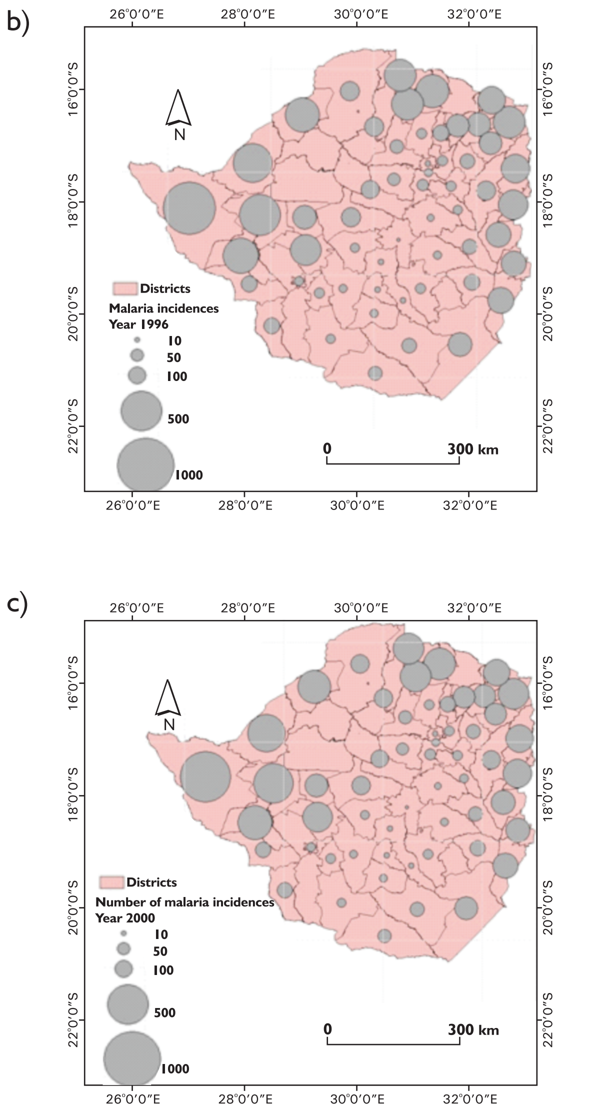
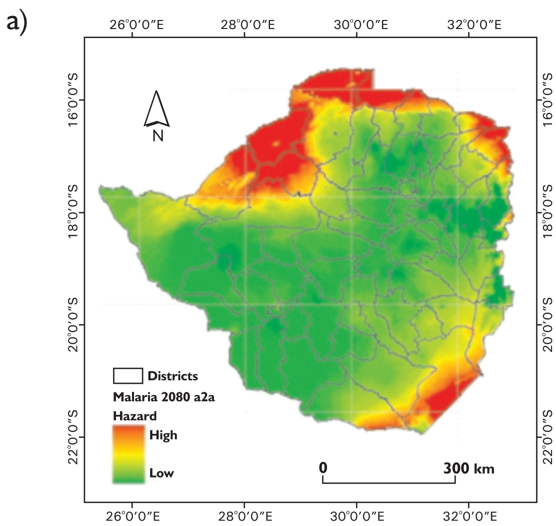


Figure 3.17: Geographical variations in malaria incidences during a drought year (1992, a), normal year (1996, b) and a year with above average rainfall year (2000, c).



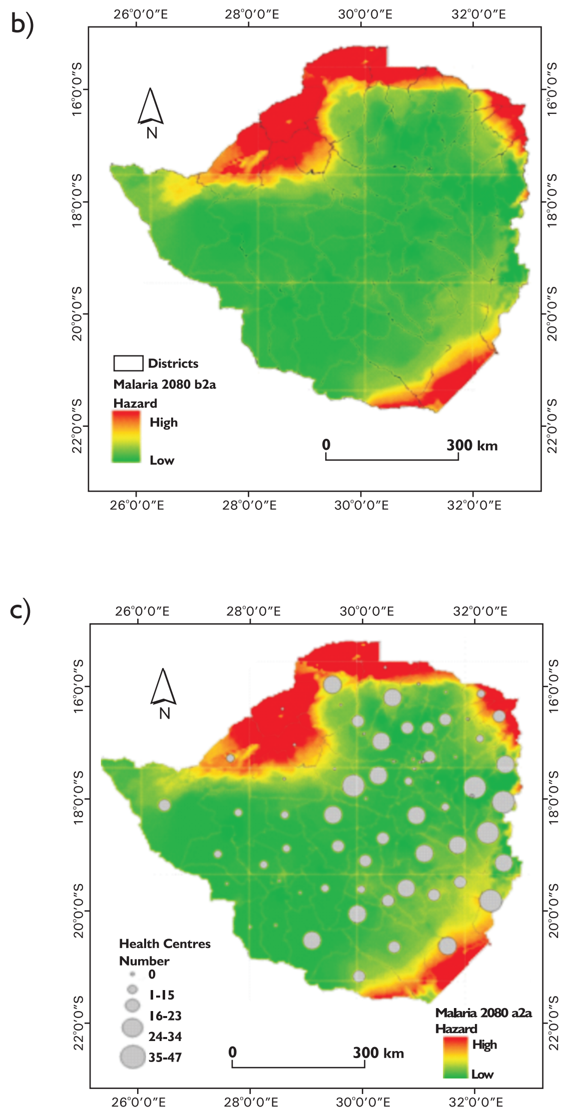


Figure 3.18: Projected malaria hazard in Zimbabwe in the year 2080 under the worst case (a) and best case (b) climate scenarios and the mismatch between projected malaria hazard in the year 2080 and number of health centres in the country (c)

3.8 Agro-ecological Regions Sector

3.8.1 Vulnerability

An agro-ecological classification of Zimbabwe was performed by Vincent and Thomas (1960). It was mainly based on the long-term average rainfall and temperature as modified by soil type. This classification divided the country into five natural regions based on their ability to support agricultural activities. In this classification agro-ecological region

1 is the most productive while agro-ecological region 5 is the least productive. The agricultural sector is dependent on rainfall such that any changes in rainfall affect agricultural productivity in different regions. Correlation analysis between agricultural production and rainfall indicate that there is a significant positive correlation between the two.

Results from the analysis of coefficient of variability show that rainfall is highly variable in space and time (see agriculture sector section). In general, areas in agro-ecological regions 1 and 2 have relatively low rainfall variability compared with agro-ecological region 3 to 5. In addition, higher rainfall areas experience lower variability. Thus, agricultural yields tend to follow this pattern (see agriculture sector section). If this trend persists then the change in rainfall variability could be significant throughout the country.

Based on the typical crops grown in each agro-ecological region, crop suitability was modelled under different climate scenarios using the ecological crop requirements model (ECOCROP) in a GIS environment. Tea is the key indicator crop of Region 1 and therefore, its suitability was modelled under different climate scenarios. Figure 3.19 illustrates tea suitability based on the current, best case and worst case scenarios. The projections show a significant increase in the proportion of suitable areas for tea production is expected under both the worst case and best case climate scenarios. Thus tea appears to be less vulnerable to climate change (Fig 3.19).

Wheat was used as the indicator crop for agro-ecological region 2. In this region, the proportion of the area that is excellent for wheat production is projected to significantly decrease under the best case and worst case scenarios (Fig 3.20). However, under both scenarios the area that is very suitable and marginally suitable will slightly increase. At the same time, a marginal increase in the area that is marginally suitable for wheat point towards some slight sensitivity of wheat to climate change. Nevertheless, decrease in suitability may be counterbalanced by the fact that the bulk of the agro-ecological region 2 is projected to be suitable for wheat production.

Soya bean was modelled as the key indicator crop for agro-ecological region 3. Projections of soya bean suitability show a slight decrease in area that is excellent under the best case scenario whereas significant declines are expected under the worst case scenario (Fig 3.21). These decreases are likely to be compensated by expected increases in areas that are suitable and very suitable for soya bean. The slight increase in areas that are marginally suitable for soya bean reflects the possible sensitivity of soya bean to changes in climate.

Region 4 is a relatively dry region with frequent dry spells. Typical crops grown in this agro-ecological region are drought-resistant crops such as millet. Areas that are modelled as suitable to excellent for millet production will increase under the best case scenario while a slight decrease is expected under the worst case scenario (Fig 3.22). Nonetheless, there are slight increases in the suitable to very suitable areas under worst case scenario. Thus millet appears to be less sensitive to climate change in agro-ecological region 4. Region five is unsuitable for rain-fed agriculture and can only profitably sustain livestock ranching.

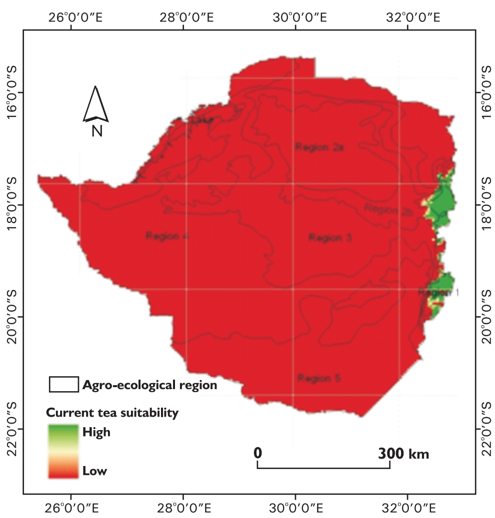
An analysis of crop suitability versus inter-seasonal climate variability reveals that the suitability of crops that characterise each region is projected to contract and expand in tandem with changes in annual rainfall. For instance during the 1992 drought, the whole agro-ecological region 1 was not suitable for tea but in a year with average rainfall (e.g., 1996) tea was mostly confined to region 1 (its prescribed region). However, in years with above average rainfall, the area that is suitable for tea production expands to include other regions within the Eastern Highlands.

Under drought conditions, wheat is mainly confined to agro-ecological region 1. In years with average rainfall, the areas suitable for wheat production tend to expand throughout the country but contract in the eastern highlands because of excessive rainfall. Overall, soya bean is sensitive to drought. It thrives during years with average to above average rainfall. Millet is particularly suited to the relatively dry conditions prevailing in the lowveld areas.

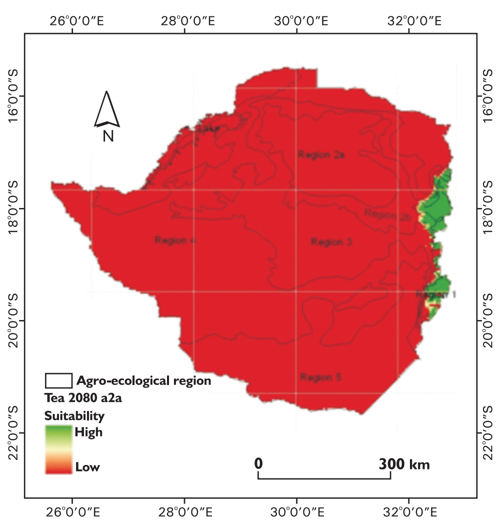
3.8.2 Adaptation

The projected increases in rainfall variability points towards the need for increased harvesting of water resources. In addition, in areas that already have water impoundments there is need for increased and efficient use of water resources contained therein. To cushion farmers against rainfall variability and frequent intra-seasonal dry spells, there is need for development and adoption of drought tolerant crop varieties.

a)



b)



c)

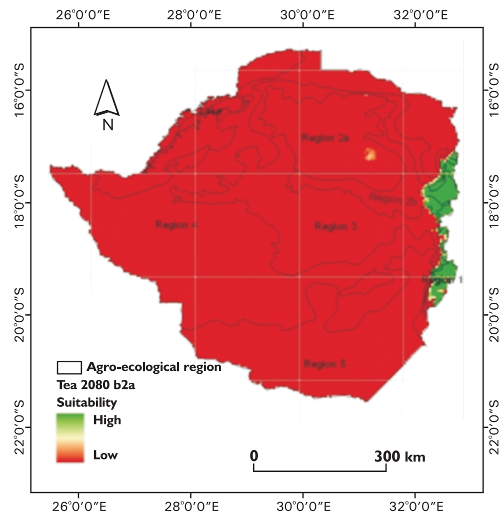
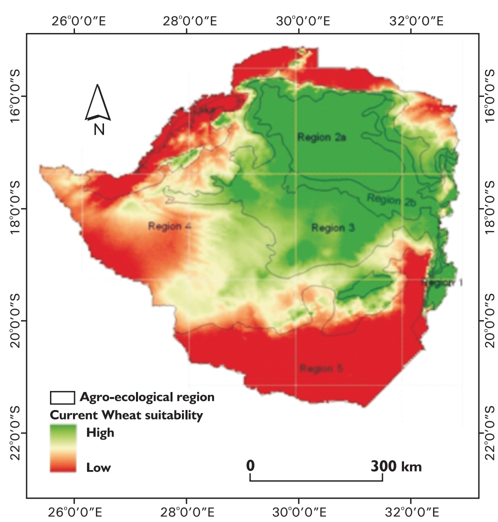


Figure 3.19: Geographic distribution of tea suitability for the current (a) and projected changes in the distribution of tea suitability for worst case scenario (b) and best case scenario (c) in the year 2080.

a)



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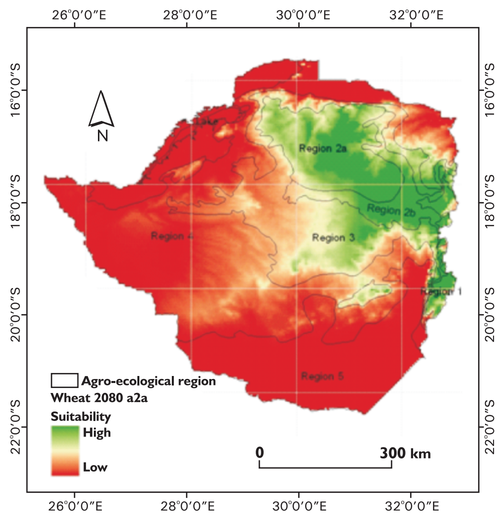
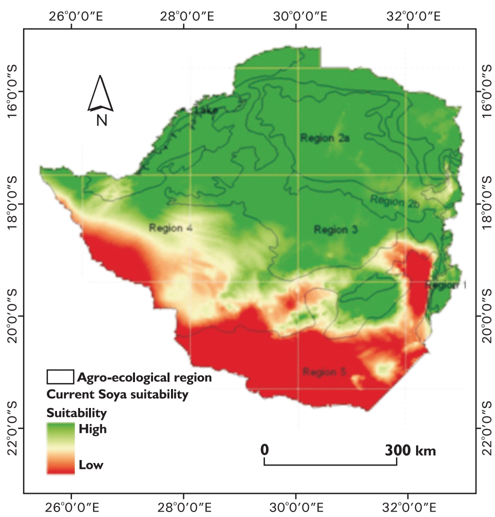


Figure 3.20: **Geographic distribution of wheat suitability for the current (a) and projected changes in the distribution of tea suitability for worst case scenario (b) in the year 2080.**

a)



b)

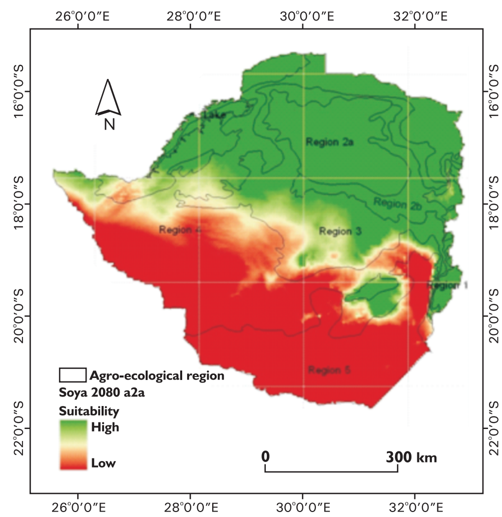
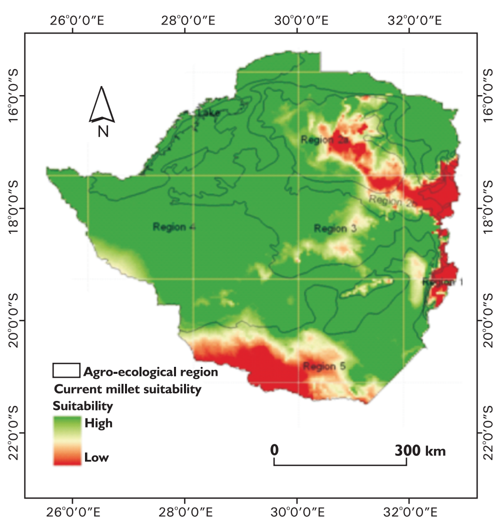
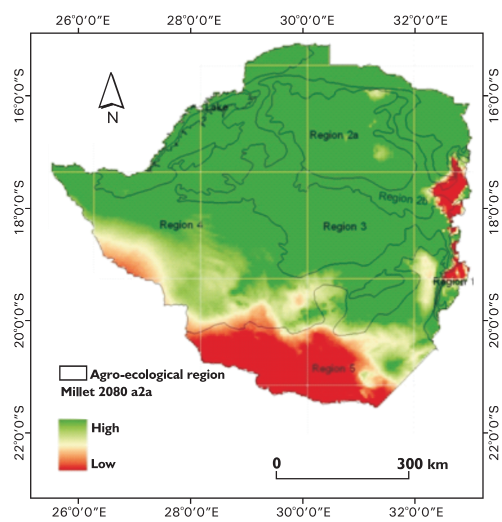


Figure 3.21: **Geographic distribution of soya suitability for the current (a) and projected changes in the distribution of soya suitability for worst case scenario (b) in the year 2080.**

a)



b)



c)

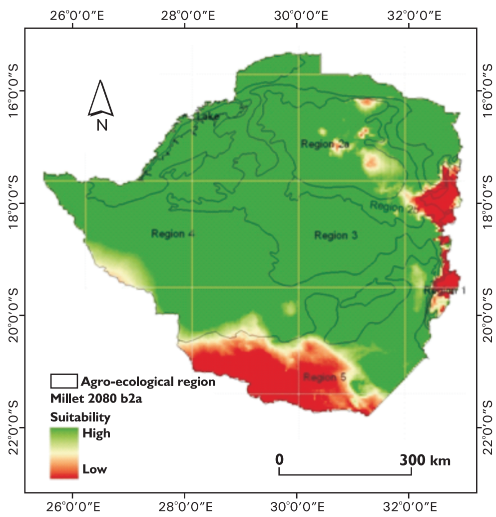


Figure 3.22: Geographic distribution of millet suitability for the current (a) and projected changes in the distribution of millet suitability for worst case scenario (b) and best case scenario (c) in the year 2080.

3.9 Human settlements and Tourism sectors

3.9.1 Vulnerability

As a country that is highly reliable on agriculture, Zimbabwe is highly vulnerable to climate change. Analysis shows that variability in rainfall translates to high variability in agricultural yields. The density and prosperity of human settlements is normally a function of land productivity assuming the absence of other economic interventions. Thus, reduced agricultural productivity in most areas of Zimbabwe may translate into increased migration of populations to areas where climate change has the least effect.

The projected decrease in runoff and rainfall trends from the northeast to the southeast shows that most of the towns in Zimbabwe located on the central watershed may run the risk of water shortages. The capital city, Harare already has a population of 3 million and is growing at a fast rate. Thus, any reduction in available water will lead to increased water scarcity. Also, the second largest city, Bulawayo, is currently facing periodic water shortages because of high variability in rainfall in the western regions of Zimbabwe. The projected climate change scenarios indicate reduced flows in the catchments around Bulawayo. In regions such as the Muzarabani area in the north and the Limpopo basin in the south, highly variable rainfall may lead to increased risk of drought and flooding. Thus, a changed climate will have negative impacts on human settlements.

Healthy environments are important for prosperous human settlements. Indications are that the districts in the Zambezi and Limpopo valleys are likely to experience increased malaria risk. Thus, settlements in these regions are likely to be at high risk of increased malaria incidents.

Climate change poses a threat to biodiversity. In this study, it was shown that with decreasing rainfall and rising temperatures, significant declines in biodiversity are expected to occur in most parts of the country especially the western regions where most of the park estates are located. Also, there is a high chance that the current destruction of habitats through agricultural expansion, is likely to interact with climate change to accelerate the rate of loss of biodiversity. The projected declines in biodiversity will change ecosystem processes and may lower the resilience of ecosystems to other global environmental changes . This has profound consequences for services Zimbabwe derives from ecosystems. For instance, biodiversity is a key to the success of the tourism sector as most tourists visit the country to view the variety of game species and unique landscapes it offers.

3.9.2 Adaptation

Optimizing rainfed crop production has potential to improve the adaptive capacity of rural settlements. The development and adoption of rainwater harvesting technologies and irrigation via the construction of dams throughout the country particularly targeted at drier areas of the country such as the western, southern and the north-eastern parts is critical. The development of drought tolerant crop varieties which constitute an important adaptation strategy is essential.

The design of climate proofed settlements is an important imperative. For example, in flood prone areas, settlement designs have to follow low flood risk areas. The development of flood and drought early warning systems is also important. Water recycling in urban centres is an important adaptation strategy. Cities such as Windhoek in Namibia are already practicing water recycling as they lie in an arid region. The use of solar energy becomes important as there may be reduced flows into the big hydropower schemes.

Reducing the current pressures on biodiversity is an essential adaptation strategy which is important for ensuring that ecosystems are buffered against climate change if they are to continue to provide goods and services to society. Biodiversity loss will mostly affect tourism as the sector is heavily dependent on wildlife. Thus, adaptation strategies for tourism may include protecting biodiversity both in and outside the park estates.

4. MEASURES TO MITIGATE CLIMATE CHANGE IN ZIMBABWE

4.1 Perspectives on participation of the Republic of Zimbabwe in the global agreements on reduction of GHG emissions and adaptation to climate change

Zimbabwe is committed to the reduction of greenhouse gases whilst promoting development. The energy sector has a high demand for fossil fuels especially for transport and industry. There are also renewable energy sources that if developed can help in minimizing the emissions of greenhouse gases. However, issues of capital, skills and technology are key barriers in this respect. Climate change mitigation is viewed as a global responsibility but can yield significant positive results for development in Zimbabwe if synergies with energy supply and protection of natural resources are maximized.

4.2 Greenhouse gas drivers by sector

The main source of greenhouse gases is the energy sector. Energy demand growth is therefore the key driver for greenhouse gas emissions. Figure 4.1 shows fossil energy use profile from 1987 to 2000. Zimbabwe has seen a decline in local energy supply since 1998. There have been no wood fuel surveys to help estimate current demand. The National Energy Balance has not been updated recently. This report will therefore focus on available energy data mainly from commercial fuels and electricity.

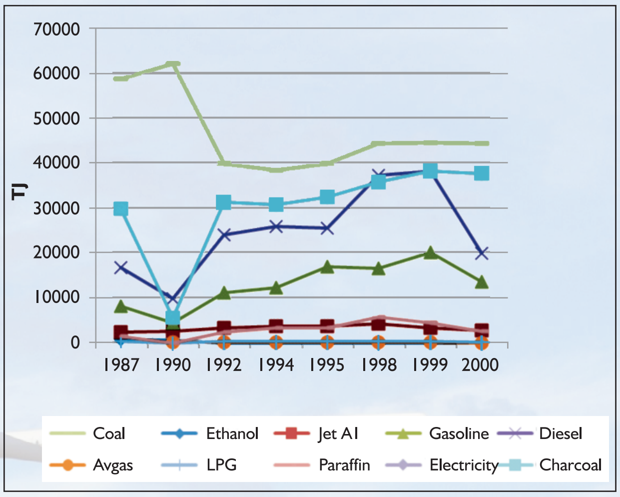


Figure 4.1: Fossil energy use profile (TJ)

Electricity imports increased to about 45% of total supply. The current regional shortages have resulted in increased electricity load shedding. Electricity production from thermal power plants has declined significantly with Hwange Power Plant operating below 50% capacity and the small thermal power plants were shut down most of the time. Hwange Power Plant is constrained by inadequate maintenance and coal supply and the small thermal plants are constrained by coal delivery constraints. Electricity demand growth is being driven by population growth. Changes in electricity demand over the years are illustrated in Figure 4.2. Industry is the major user of electricity but industrial demand growth is constrained by the prevailing economic environment.

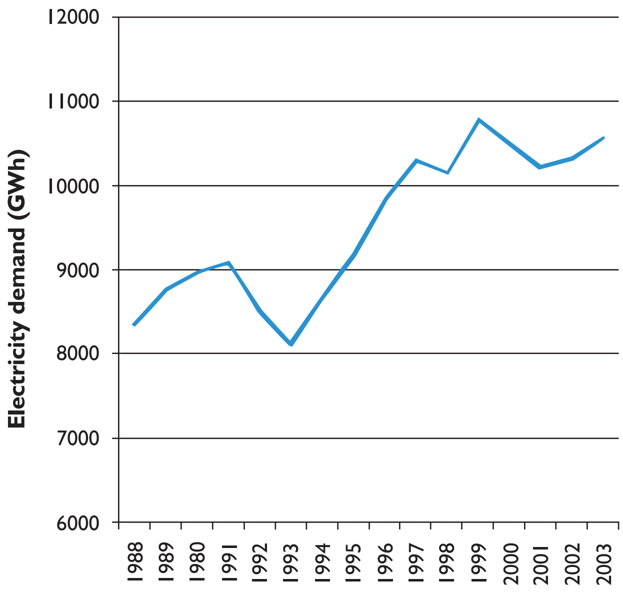


Figure 4.2: Electricity demand growth

Local coal production declined in the last ten years as shown in Figure 4.3. Industry has relied more on imported coal from neighbouring countries. Most boiler equipment is designed on the basis of local coal specifications. Lower quality of imported coal has seen most industrial boilers operating at below optimum efficiencies. Recently, there has been new investment into local coal production which has seen some growth in local coal supply.

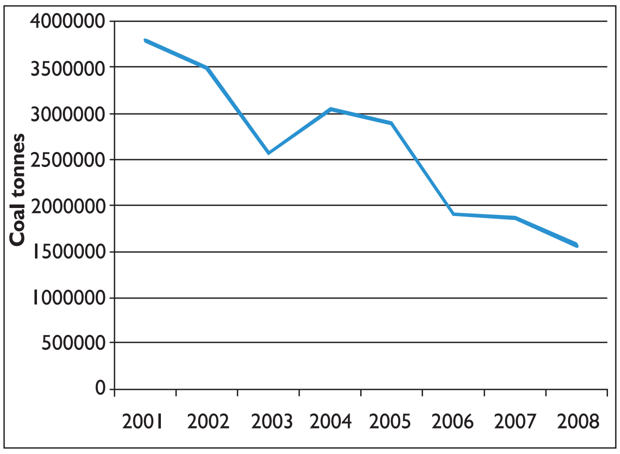


Figure 4.3: Coal Production in Tonnes

Zimbabwe relies heavily on personal vehicles for transport. Public transport is dominated by small mini-buses which service urban and rural routes. There are some larger buses plying the rural and intercity routes but these cannot service the market fully. Most minibuses are poorly maintained and fuel use efficiency is below optimum levels. There was a decline in supply of imported fuel between 2000 and 2008. The petroleum fuels sector was deregulated to allow entry of private companies in the fuel business. Currently, the market is relying on private fuel importers with the state owned oil company serving the bulk market as well as fuel imports.

Road transport has a high population of motor vehicles including used cars imported from developed countries (Figure 4.4). This is likely to continue as long as new vehicle alternatives continue to be beyond the reach of the majority. Apart from vehicle vintage there is inadequate maintenance of roads and road infrastructure which results in poor traffic flows. Operational costs for road transport especially passenger transport are high thus making it difficult to adequately maintain the vehicles. More efficient service providers keep to the trunk roads with paved surfaces hence the countryside routes are serviced by small companies with limited resources. Urban commuter transport is also not a viable option hence it's dominated by the small operators using poorly maintained vehicles.

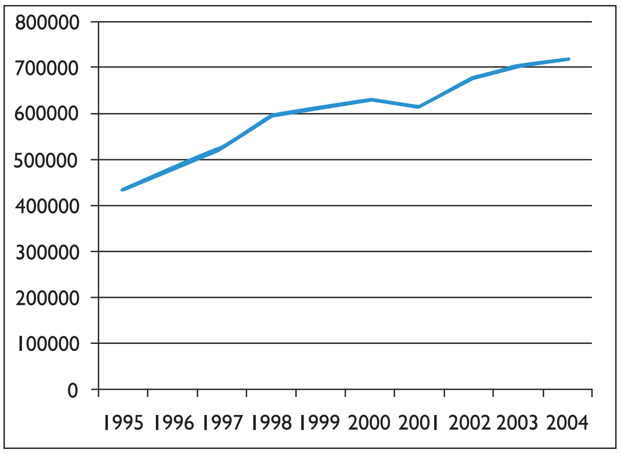


Figure 4.4 Road Vehicle Population Growth

In the waste sector emissions from landfill waste and waste water are driven by urban population. Greenhouse gas emission projections for waste are estimated in the inventories report. The graphical illustrations are presented in Figure 4.5 below.

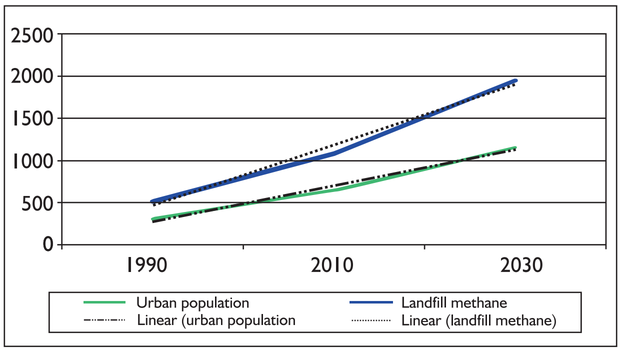


Figure 4.5: Urban population and landfill methane generation trends

Current landfills are overfilled and management practices are just being improved after years of neglect. There is no methane recovery system in place and apart from some spontaneous combustion, methane is released directly into the atmosphere. Emissions from waste water are influenced by population and method used for waste water treatment. Harare, Gweru, Mutare, Bulawayo and Masvingo use anaerobic digesters whilst the small towns and cities use aeration ponds. In the case of aeration ponds, methane emissions are reduced significantly. The emission's projections that are presented in this report are based on estimates of urban population growth (Figure 4.6).

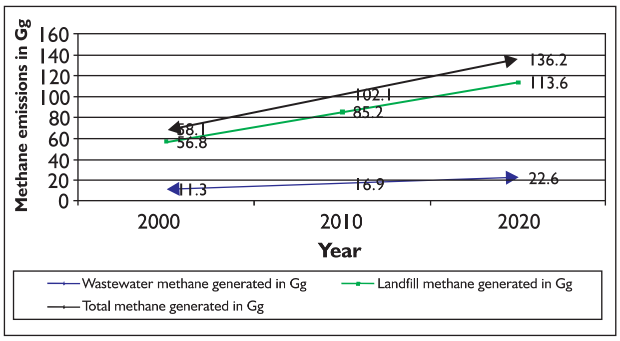


Figure 4.6: Projected Wastewater methane generation and emissions.

Other sectors contribute to greenhouse gas emissions but no mitigation options are envisaged at this stage. These sectors include industry and agriculture. A number of mitigation actions and programmes were identified in the INC. These programmes focus on activities that were presented in the Initial National Communication which to date are yet to receive the required support. The current assessment is limited by resources to carry out a survey especially of the industrial sector. Given the current economic environment any data collected may also not reflect the future trends in economic development. There is general shortage of skills and inadequate data collection systems. Even the identified programmes could not be analysed in detail due to limited financial resources.

4.3 Sectoral GHG Mitigation Programs

4.3.1 Industrial Energy Management

4.3.1.1 Program Objectives

Energy management is the integration of energy within business management principles and activities so as to achieve a lower energy intensity of production. Energy management incorporates principles of energy switching, energy efficiency improvement and demand side management.

The objective of energy management is to improve matching energy supply and demand and to reduce the investment burden for the energy sector. Other benefits of energy management programmes are:

- Reduction of production cost
- Reduction of the environmental impact of energy use
- Improvement of reliability of energy supply especially electricity
- Reduction of resource use – coal, petroleum fuels and firewood.

The SADC Industrial Energy Management Program which ran from 1988 to 2002 focused on building capacity of engineers to implement energy management programmes. The program also identified the potential for industrial energy management as a way of reducing the investment stress on the energy sector. An estimated 30% of industrial energy could be saved through efficiency improvement and demand side management. Some industrial sub-sectors were found to use twice as much energy as comparable sectors globally. Industrial boilers were found to be operating often below 50% efficiency levels despite being designed for 74% to 80%.

4.3.1.2 Target Technologies and their Benefits

Energy management is not technology specific. It is a management process that optimizes the use of technology. However, there are some technologies that are recognized for their higher energy efficiency which are included as components of energy management systems. These technologies include;

- Compact fluorescent lighting and other high efficiency lighting systems
- Variable speed drives
- Power factor correction equipment
- Improved boiler efficiency
- Steam system insulation
- High efficiency electric motors
- Passive space cooling
- Utilization of natural lighting.

4.3.1.3 Barriers to Energy Management

Barriers to energy efficiency improvement, energy management and adoption of renewable energy options have all been studied extensively over the years. In 1998 the Government of Zimbabwe got assistance from the Global Environment Facility to develop a project to address barriers to industrial energy efficiency improvement. The project did not materialize due to lack of co-financing but output from the study provided a strong basis for future interventions. The following is a summary of the barriers as analysed in the GEF PDF-B study of 1998-2000.

Weakness in information support for energy efficiency awareness.

- Some of the main barriers to climate change mitigation include: Lack of a government policy on energy efficiency along with a layout of instruments that can be used to encourage improvement of energy efficiency in industry.
- Absence of an up to date database on energy efficiency technologies and their effectiveness as well as mechanisms to support access to these technologies. In addition, information on expert services is not available to support energy services.
- Lack of information on the benefits of energy efficiency to company objectives and how these benefits are calculated and translated into company programmes and the financing options that are available to support integration of energy efficiency into company programmes.

Weakness in Institutional Capacity for Support Mechanisms

Energy efficiency improvement is achieved by integrating specific management principles into the day to day operation of an entity. There is need to provide awareness and skills in the support institutions such as government ministries, utilities, industry bodies and financiers that would be necessary for industry activities to integrate energy efficiency improvement in all activities. To this end the following key prerequisites have been identified:

- policies need to be analysed for their impacts on energy efficiency improvement.
- relevant sectors need to employ staff with expertise in industrial processes and energy efficiency improvement.
- Ministry of Energy and Power Development needs to provide technical support and analytical skills for the inclusion of energy efficiency improvement in all other sector policies.
- energy pricing needs to incorporate environmental and social costs. In addition to pricing, the cost of production needs to be adopted as the primary indicator for efficiency improvement. This is essential to raise awareness on the true cost of energy and how energy efficiency should be valued in an environment of high energy subsidies.
- energy subsidies need to be targeted and be structured to reduce abuse. Energy subsidies come in various forms. In Zimbabwe electricity prices are often suppressed by policy especially in the residential and agricultural sectors. The new energy policy seeks to reduce import duties for renewable energy and energy efficient equipment. However, there is a need for setting up management systems to ensure appropriate use of such technologies in order to improve the energy supply balance. Distortions that are caused by selective application of subsidies need to be avoided. An example is the reduction of

duties and taxes for investment made for equipment imported under the solar PV GEF pilot project.

4.3.1.4 Inadequate Technical Fall Back for Companies Wishing to Implement Energy Efficiency Improvement

Energy services require a range of technical support services to enable collection and analysis of data as well as design and assessment of technology solutions. It is through demonstrated examples that the energy efficiency market can grow especially in the small scale enterprises where there are limited engineering skills. The following were observed:

- Those interested in energy services have limited access to technology information and specialized technology design and assessment skills. There is also limited background information and support services for available technology solutions and global technology development trends.
- Equipment suppliers have sales outlets with limited technical capacity to recommend specialized technology solutions especially with regards to energy efficiency improvement. Technology solutions such as compressed air systems, boilers and refrigeration systems tend to be recommended on the basis of service demand without energy performance criteria.
- There is no supplier technical support for confirmation of retrofits especially where energy efficiency improvement would be achieved on the basis of altered operating set-point/environment for equipment.

4.3.1.5 The Market for Energy Services is Underdeveloped

A market is defined by the existence of need of service, technology solutions, finance and technical capacity to sustain services. In the case of energy management in Zimbabwe the market is limited in all aspects of the development of a sustained demand. The following were identified as the major weaknesses

- decision makers lack in awareness on markets for energy services.
- service providers are unable to deliver the appropriate marketing services to unlock the market for energy services.
- financiers are not appreciative of the energy efficiency business and therefore fail to deliver suitable financial products.
- consulting services and equipment suppliers are not coordinated to deliver the appropriate energy services and technical solutions. There is a tendency for equipment suppliers to provide incomplete consulting services as a way of justifying specific solutions.

4.3.1.6 Proposed Program for Barrier Removal

The proposed program is to initiate energy efficiency improvement systems that can be sustained through a market. Previously there have been activities to build various components of the energy services market but not enough integration has taken place to achieve an active market. The following proposed activities may assist in initiating energy efficiency improvement systems:

- establish an energy information system within the Ministry of Energy and Power Development to allow for analysis of energy use patterns as well as the impacts of various measures to influence energy use efficiency.
- establish a database of energy efficiency improvement opportunities in Zimbabwe with sufficient detail for energy users to analyse their own opportunities. The database would serve as a template for assessment of energy efficient technologies and their potential for investment.
- establish a network of energy services experts that includes linkage with international partners to enable access to technology and technology information.
- develop standards for provision of energy services especially audits and development of proposals for investment. These will enable beneficiaries to assess services by consultants and to appreciate the benefits of energy services.
- initiate a program to facilitate development of facility energy management programmes with funding to enable target entities to access low cost financing for the purpose.

Potential Industrial Energy Efficiency Improvement Activities

There are various opportunities for energy efficiency improvement in industry. Surveys carried out on behalf of the Business Council for Sustainable Development and the Ministry of Energy and Power Development show that energy leakages in Zimbabwe could account for more than 30% of the energy used. Potential for reducing energy consumption especially in the industrial sector is estimated to be at least 20%. Some of the opportunities for efficiency improvement are as follows:

- Optimisation of air pressure for compressed air systems. Some compressed air systems are operating at higher than recommended air pressure. This increases energy use as the air compressors face higher resistance than otherwise required. The major reason for this is the existence of numerous air leaks in most systems. Repair of leaks and reduction of pressure would improve energy efficiency in the compressed air systems. Often the survey teams also deduced that the number of compressors in operation could be reduced.
- Repair of insulation for steam pipes and condensate return lines. There is a prevalence of deteriorated insulation on industrial steam lines. Some steam systems also lack optimal condensate collection and return hence heat is lost unnecessarily.
- Poor motor sizing results in either overloading or under-loading. Motors operating at below full load tend to absorb excess reactive power leading to poor power factor. Maintenance teams were observed to replace motors with the nearest larger size when the appropriate replacement motor is not available. In some cases over-sizing was taken as a measure to reduce chances of burn out when a specific motor is giving over temperature problems. The survey teams observed that use of rewound motors tended to increase failure rates as well as poor maintenance of motor loads such as fans and pumps. In some small scale enterprises poor protection schemes led to motor failure in the case of power system instability which in turn led to use of rewound motors which would repeatedly fail. Regular motor checks could be used to prevent these problems.
- Improve boiler efficiency through flue gas heat recovery and reduction of energy loss through frequent blow downs. Combustion efficiency can also be improved by optimizing fuel/air ratios and excess air.
- Increased use of natural lighting through installation of translucent roofing sheets offers an opportunity in a large number of facilities. In addition outdoor security lighting which is left burning during day time can be put on intelligent controls with motion and daylight sensors.
- Underground lighting in mines can be converted to more efficient lamps than incandescent ones with a marked increase in lamp life and a decrease in energy use and maintenance cost.

4.3.1.7 Renewable energy programme

The country has considerable experience in renewable energy technologies through promotions led by the Ministry of Energy and Power Development as well as a number of NGOs over the past years. The parent ministry has a fully fledged department of Energy Conservation and Renewable Energy which is responsible for promoting and facilitating sustainable development in the energy sector through efficient use of energy resources and increased use of new and renewable sources. The department has implemented a number of technology based projects as clean and renewable alternatives to conventional energy sources. These include solar energy technology; small hydropower, wind technology, biogas technology, improved woodstove technology and biofuels. The following section details how these technologies have been implemented in Zimbabwe.

Solar Energy technology

Zimbabwe lies in a high solar radiation belt with annual radiation averaging around 20 MJ per square meter per day. Winter average radiation is 16 MJ/m^2, while the highest radiation, received in October for most centres except those in the extreme south (Beit Bridge and Buffalo Range for which highest radiation is received in December – January), is 22 MJ/m^2. For some centres (Beit Bridge, and Buffalo range) the average maximum radiation can reach as high as 24 MJ/m^2 (Energy Resource Assessment Study).

Applications of solar technology in Zimbabwe have been through donor supported programmes which have focused on solar photovoltaic (production of electricity) for water pumping, refrigeration, lighting in households and institutions, powering of radios and TVs as well as solar thermal (heat production) for cooking, water heating and crop drying. Over 100 000 solar systems have been installed countrywide, both at commercial and subsidized cost.

Small Hydropower (SHP)

The technology involves generating electricity of up to 30MW, from dams and from run of perennial rivers. A potential of over 120MW for SHP exists in both irrigation dams and perennial rivers especially in the Eastern Highlands for both grid-connected and off grid systems. Current government policy is that all water bodies should be exploited and all new dams should have provision for power generation. A number of units have been installed in Zimbabwe which range from 30KW-1.1MW. Less than 10% of this potential has been utilized and the technology offers opportunity for GHG mitigation programme.

Wind technology

Wind speeds over Zimbabwe are generally low, averaging 3.0 m/s. The windiest months are September and October (3.8 m/s) and the lowest mean speeds (2.6 m/s) are recorded in May and June from measurements done at 10 m above the ground. In Zimbabwe, wind energy has been extensively applied to water pumping (wind mills). However a few wind turbines have been installed in Zimbabwe. One station at Temaruru Rusape was installed to generate a total of 6KW.

Biogas technology

Biogas is a methane-rich combustible gas produced from decomposing biomass (anaerobic digestion) and is used for cooking and lighting. The nitrogen-rich effluent released from the digester after biogas production is used as fertilizer. Biogas technology is encouraged for small holder farming areas, commercial farms, boarding schools and similar rural institutions. Three main types of digesters have been promoted in Zimbabwe and these are the Indian, Chinese and Camartec and these range from 6 to 50 cubic meters. Over 350 biogas digesters have been constructed to provide biogas for direct cooking and lighting but only a few units are still working.

In addition to biogas generated from animal waste, Zimbabwe also has several municipal sewage plants that produce biogas from the anaerobic waste digesters. These plants are in Harare, Mutare, Bulawayo, Masvingo and Gweru but only Harare collects the gas but most of it is flared into open air. Potential exist for biogas production from municipal sewage waste, dairy farms, piggery waste and from cow dung at rural household level.

The improved woodstove technology

The technology involves the use of an wood efficient stoves made out of bricks and is aimed at conserving existing wood fuel resources by improving end-use efficiency. This wood technology complements afforestation efforts as well as giving time for natural regeneration of trees. It uses only a third of the amount of firewood used on an open fire. More than 15 000 stove units have been constructed in Zimbabwe but a few are still in use.

Biofuels

Biofuels are fuels from plants and animals (oils and fats) and offers an opportunity for climate change mitigation and improved energy security at local and national levels. Biofuels are green fuels and therefore carbon neutral as they sequestrate carbon dioxide during plant growth. The Government decided to embark on a national biofuels programme in 2005 to partially substitute imported fossil fuels with locally produced biofuels. The initial target was to substitute at least 10% of daily consumption of fossil liquid fuels with biofuels. The programme is being pursued through a two pronged approach that involves the growing of the *Jatropha curcas* plant and processing of the seed into biodiesel. The second approach is aimed at expanding sugarcane growing and resuscitating the blending of ethanol with petrol.

The ethanol target will soon be met as the two major players in the sector have capacity to produce the required quantities. For biodiesel there is need to effectively promote the growing of *Jatropha curcas*. A 35 million litre capacity plant already exists and requires feedstock. Ethanol production is also coupled with cogeneration from bagasse and offers an opportunity for clean electricity production.

Barriers for renewable energy uptake in Zimbabwe

Most of the technologies highlighted above have been promoted through a number of government or donor funded projects since the late 80s but technologies have not been adopted/ commercialized due to a number of barriers. The major barriers are:

Lack of clear policies/ legal framework/ strategies

The National Energy Policy was produced in 2010. Pursuant to this policy, strategies and action plans are being developed and the policy is yet to be launched and operationalised. This indicates that the guiding framework for the sector is still weak. Thus there is need to define specific policies for renewable energy and its sub sectors. Such an approach creates an enabling investment in the renewable energy sector thereby enhancing uptake of clean energy options resulting in emission reduction.

Limited finances due to high capital costs

Worldwide, renewable energy technologies tend to be expensive to set up compared to conventional technologies. There is need for deliberate policies aimed at reducing costs such as favourable feed-in tariffs, subsidies and tax redemptions to make these affordable. There is also need to consider a number of international protocols as funding sources such as the Clean Development Mechanism (CDM) and GEF. However, there is limited local capacity to tap into these funding sources.

Socio-cultural behaviour

In Zimbabwe, like any other developing country, there is a general tendency by communities to resist change or adopt better energy options and habits. For example, the resistance to adopt and use biogas as a cooking fuel against firewood or electricity or use of wood saving stoves versus opens fire. However this can be attributed to myths and lack of awareness on the part of the beneficiaries.

Lack of information dissemination and consumer awareness

The major challenge that is facing renewables in Zimbabwe is lack of awareness of the available options and how to use energy more efficiently. A number of demonstration projects were done but the approach seems to have failed. Thus there is a need to come up with an effective method coupled with functional demonstrations. Awareness programmes may also increase uptake of energy efficient options.

Inadequate skilled workforce and training

There is limited technical expertise in the renewable energy sector to promote the available technologies. This may be attributed to the country's tertiary education curriculum which does not have specific energy programmes at undergraduate level. The country relies on in-house training and short international training courses on renewable energy.

Lack of stakeholder/community participation in energy choices and renewable energy projects

In the past, energy planning has been done by decision makers with minimum or no consumer consultation. This led to project failure as beneficiaries did not appreciate the technologies. At the same time, the option provided would not address beneficiary's energy needs. There is need to involve communities and relevant stakeholders in energy planning.

Lack of ownership and vandalism

Most renewable energy projects initiated were either abandoned or vandalized due to lack of community ownership. This could have been due to the fact that there was minimum or no meaningful contribution made by the communities to project planning. Hence no sense of ownership and the need to protect project assets. Solar water pumping and biogas technologies are some of the projects that have been vandalised and failed. Communities should understand and appreciate the technologies before projects can be introduced. At the same time the technologies should address people's needs so that communities appreciate their importance.

Limited institutional capacity and after sales follow up and monitoring

The Ministry of Energy and Power Development being the main driver on energy issues should be visible throughout the country to give guidance and raise awareness to all. However the ministry is still centralized in Harare and has one provincial office in Bulawayo. This has resulted in limited community outreach capacity for awareness, training, monitoring and evaluation of renewable energy technologies. However, NGOs have been helpful in promoting renewables.

Recommended Programme for Implementation

The barriers identified above can be addressed by the programme for renewable energy uptake in Zimbabwe. The proposed programme will be executed in three phases. **Phase 1** will comprise of creating an enabling environment for investment in the renewable energy sector and enhance understanding the importance of renewable energy. **Phase 2** will involve piloting the technologies. **Phase 3** will involve up scaling of successful technologies throughout the country.

4.3.2 Zimbabwe waste sector mitigation programme

Greenhouse gases from the urban waste sector in Zimbabwe mainly come from anaerobic wastewater treatment facilities and Municipal Solid Waste Disposal Sites (MSWDS) in urban areas. These emissions result from the anaerobic decomposition of the Degradable Organic Content (DOC) of the waste or sludge. The conversion of the DOC into compost through an aerobic process reduces the amount of DOC disposed off into the MSWDS. The resultant organic manure can be used in agriculture, domestic lawns and gardens or recreational facilities such as golf courses.

4.3.2.1 Program Objective

The program aims to promote the use of composting technologies in urban areas in Zimbabwe.

Waste Prevention, Recycling and Composting Options in Zimbabwe

Waste Prevention

Generating no waste at all is the most preferred waste prevention avenue. This can be achieved by reducing waste at source. In addition, less material resources will be used per product at the manufacturing level (EPA 2008). Preventing waste generation saves money in waste transportation, disposal, recycling, conserves valuable landfill space; and reduces energy and resource use. This can be achieved through the following;

- educating citizens about source reduction,
- emphasizing change in purchasing practices and product reuse;
- implementing a backyard composting program;
- establishing or encouraging the establishment of salvage and reuse operations;
- implementing volume-based refuse collection fees; and
- regulating packaging or other materials sold and/ or used.

Recycling and Reuse

Waste reuse operations generally cost very little for collection and little for processing. Operations that salvage materials before they enter the refuse collection and disposal system will not only save on collection and processing costs, but also raise revenue in some cases. Private repair and reuse operations can net considerable profit as well as provide jobs for the local community. Communities can actively promote private salvage/reuse operations through written listings and other types of publicity. Reusing materials in-house at the residential or commercial level prevents these discards from entering the municipal waste stream.

Composting

Composting is viewed as nature's way of recycling organic material. It is the biological process of breaking up of organic waste such as food waste, manure, leaves, grass trimmings or any bio-degradable material into useful humus-like substance by various micro-organisms including bacteria, fungi and actinomycetes in the presence of oxygen. Composting systems can be opened or closed. In open systems the organic matter will be placed in open piles or rows while closed systems involve the placement of the waste into containers or reactors. The open system is rarely used in low-income countries due to its technical complexity.

Type of materials that can be composted and their sources

As high as 70 percent of the Municipal Solid Waste (MSW) is organic material (IPCC 2000). Reduction of organic waste disposed off into the MSWDS can be easily achieved through composting of the organic material at different stages of the waste generating or handling processes using various technologies. The option of composting can significantly reduce waste stream volume and will offer economic advantages for many urban areas in Zimbabwe. The US Environmental Protection Agency (US-EPA) reported that some communities in the United States have achieved as high as 60% recycling and composting levels (EPA 2008). Any material or waste that is organic or contains organic material can be composted. Typical materials that can be composted include; food waste, kitchen waste, manure, leaves, grass and yard trimmings.

Sustainability of the composting program

Legislation need to promote composting in order for the strategy to be sustainable. There is need to conduct extensive advertising and awareness campaigns. Financial incentives or instruments may also go a long way in promoting composting.

Barriers to the composting program

The barriers to implementation of these technologies can be broadly classified into economic or financial, technological, institutional, legal and cultural.

Table 4.1: Barrier Analysis for Composting Waste

CATEGORY	EXAMPLES	PROPOSED SOLUTION
FINANCIAL	Initial capital outlay: waste containers, vehicles, buildings	Mobilisation of financial resources, Public-Private Partnerships (PPP)
	Operating and maintenance costs: leasing and maintenance, utilities, labour, administrative expenses, licenses, supplies, insurance, residue disposal, marketing fees, contract fees, and publicity programmes·	Mobilisation of financial resources, sale of organic manure

Table 4.1: Barrier Analysis for Composting Waste *(continued)*

CATEGORY	EXAMPLES	PROPOSED SOLUTION
TECHNOLOGICAL	Inadequate or non-existing standards for finished composts	Training, development of standards
	Inadequate design data for composting facilities	Training and technology transfer
	Lack of experienced designers, vendors, and technical staff available to many municipalities	Training, research at academic and research institutions
INSTITUTIONAL	Lack of coordinated waste handling approaches	Advocacy by Non-Governmental Organisations such as Environment Africa, BCSDZ, Practical Action
	No ready markets	Partnerships with Private Companies like ZFC Limited, Windmill or the Zimbabwe Organic Producers and Promoters Association (ZOPPA)
LEGAL	Potential problems with corporate, vendors and individuals	Engagement of local authorities and government agencies as enforcing agents
		Coming up with mandatory waste reduction targets
CULTURAL/ SOCIAL	Socio-cultural behaviour	Training and Advocacy
	Lack of information dissemination and consumer awareness	
	Lack of appreciation due to failure to account for all cost and benefits	
	Lack of ownership Vandalism	Engagement of law enforcement agents and local authorities

Recommended Programme for Implementation to Reduce GHG's

- Identify goals of the composting project. Goals must be determined based on the community's short- and long term solid waste management needs. The project may have multiple goals, for example achieving mandated waste reduction goals.

- Identify the scope of the project—backyard, yard trimmings, source-separated, mixed MSW, or a combination. Most composting projects, whether municipally or privately operated may require some governmental support or approval. Larger expenditures may be needed, depending on the composting technique selected. Private programmes require siting and perhaps other permits.

- Get political support for changing the community's waste management approach. The legislation, national and local government institutions should support the compositing initiatives.

- Identify potential compost uses and markets. A valuable use or market needs to be found for the resultant organic manure. In general, the uses for compost include agricultural applications, nurseries and greenhouses, surface mine reclamation, forestry applications, as a topsoil, landscaping, soil remediation, roadside landscaping management, and as final cover in landfill operations.

- Initiate public information programmes. Establishing an effective two-way communication process between project developers and the public is crucial, and public involvement in the project must begin during the planning stages. New waste management practices require substantial public education efforts because they usually require some changes in the public's waste management behaviour.

- Inventory of materials available for composting. The planning process should include an accurate assessment of the quantities of materials available for processing and their composition and sources. The data compiled by the Environmental Management Agency (EMA) in the National Waste Management Strategy is a one of the reliable sources. Such data can help determine the size and type of equipment the planned facility will need and also the facility's space requirements.

- Visit successful compost programmes. As part of the education and training programme, the programme coordinators may also visit some local, regional or international sites with successful composting programmes for benchmarking purposes.

Evaluate alternative composting and associated collection techniques. The following factors need to be considered in coming up with the best technology and strategy to conduct the compositing project:

- Preferences of the community
- Collection and processing costs
- Residual waste disposal costs
- Markets for the compost produced
- Markets for recyclables
- Existing collection, processing and disposal systems.

- **Potential Sources of Funding**
  - Financial Institutions and Banks
  - Government budget allocation
  - Development Agencies
  - Micro-Financing Schemes

- **Support Mechanisms**
  - Reduced or no import duty on waste recycling or compositing equipment
  - Fiscal incentives such as subsidies etc
  - Tax rebates
  - Green certificates.

- **Emission Reduction Estimation**
  - Percentage DOC in waste disposed of at the MSWDS
  - Annual organic fertiliser production.

4.3.3 Proposed climate change mitigation projects in agriculture

Agriculture occupies a central role in Zimbabwe contributing between 14 and 18 per cent of GDP, over 40 per cent of national exports, 60 per cent of raw materials to agro-industries, and provides livelihood to over 70 per cent of the population as well as employment for some one-third of those in the formal labour force. Since independence in 1980 Zimbabwe had maintained a positive growth of about 2% per annum. However, since 2000 value of production has been on a downward trend (Min. of Agriculture. 2006).

An attempt is made to introduce conservation agriculture in order to maximize labour and fuel/energy use and conserve moisture. Conservation farming reduces the use of compound fertilizers in favour of organic farm made manure. This technique has proved its worth. What is left is working on farmers' attitude.

It is significant to note that the area under maize production, the country's main staple food, has remained more or less constant over the decade, at about 1.2 million hectares. Thus, the reduction in annual production has come from declining yields. Between 1995 and 2000, the three-year moving average maize yield ranged between 1 and 1.2 tonnes per hectare. However, from 2000 onwards there has been a persistent decline in the three-year moving average toward 0.5 tonnes per hectare. This decline in maize yields can be attributed to declining soil fertility, lower use of inputs such as fertilizer, recurring droughts, and a non-conducive macro- and sectoral policy environment for increasing agricultural production, especially for food crops.

4.3.3.1 Conservation Agriculture Options

The CA options used in any circumstance need to ensure the three principles are observed. These can be broadly classified into 3 categories based on farm power sources as follows:

- Manual Systems
- Mechanized animal traction systems
- Mechanized tractor drawn / fossil fuelled systems

Equipment available ranges from that adapted to manual systems to the most sophisticated systems used in advanced commercial farms. The possible options that can be adopted to achieve this essentially depend on;

- Available farm power sources
- Crops to be grown by the farmer
- Socio-economic status of the farmer
- Availability of equipment selected
- Economic viability
- Technical suitability of the techniques chosen

With advent of adverse climatic conditions over the past few decades, farmers have devised their own coping strategies. Typical farm-level adaptation measures include adjustments in:

- Crop management practices
  - Diversification – mixed/inter cropping
  - Timely planting
- Improved water and soil management
  - Water harvesting and supplementary irrigation
  - Planting in the stubble, crop rotations,
  - Agro-forestry and organic fertilizers
- Improving climate forecasts and agricultural information, early warning systems and growing of drought tolerant varieties are some of the strategies being adopted for coping with climate change.

Conservation agriculture is not without its challenges, the most notable being that of weed control. In the smallholder farming sector, there is widespread dependence on mechanical weed control. This is mainly done by hand hoeing, supported to some extent in maize production by animal drawn cultivators. Weeding where no ploughing was done represents one of toughest operation especially in fertile soil in high rainfall areas. As a way of alleviating this challenge it becomes necessary to embark on chemical weed control; involving the use of herbicides.

4.3.3.1.1 Chemical Weed control

Weeds are a major deterrent to CA. Previous studies in Zimbabwe showed the weed control benefits of ripping combined with chemical weed control. CIMMYT, working with Weed Research team on various herbicides including glyphosate concluded that weeds can be suppressed giving rise to a competitive yield per hectare. Some projects have successfully applied herbicides in CA programmes in Zimbabwe e.g. Union Project. However, training on correct use is important.

4.3.3.1.2 Major Gaps / Limitations in available equipment

Most locally available equipment is not effective for CA. This is mainly due to lack of capability to handle crop residues or trash. This may result in poor precision planting. There is also a lack of manure applicators as manure is the soil fertility backbone in CA.

Where some equipment is available, the cost tends to be prohibitive. The high cost is attributable to manufacturing per order by the local industry. Farmers would generally consider the following before investing in new equipment. These are; labour constraints, weed control problems, draft power availability, the need to increase cultivated area, profitability from cash crops and the need to achieve timeliness.

Other important factors include, cost/ affordability (credit schemes, policy incentives), availability (supply and distribution systems), traditional practices (matching of equipment to traditional practice), awareness (role of development and extension programmes) and the durability, effectiveness, spares back up (maintenance) and versatility. Mechanization offers a new window for diverse farmer circumstances. However, the unavailability of equipment remains a challenge that needs to be addressed.

4.3.3.1.3 Barriers to CA implementation

The following have been identified as major barriers to CA implementation:

Appropriateness of technology

- Limited compatibility with existing equipment
- Mismatch: Equipment design versus service facilities
- Research and Development initiatives limited by cost considerations

Product support

- Inadequate rural service centres
- Lack of expertise in available service centres
- Limited distribution networks

Advocacy

- Government policy and CA aspirations divergence
- Stakeholder coordination, the missing link
- Unregulated supply of equipment

Opportunities/Interventions

- All inclusive CA business model to enhance adoption
- Policy convergence a CA prerequisite initiative
- Avail resources for farmers to be organized
- Appropriate technology
  - Modular designs versus existing equipment
  - User friendly and gender sensitive designs
  - Import substitution initiatives
  - Modular designs facilitating ease of operations
- Product awareness
  - Training
  - Field days
  - Radio programmes.

4.3.3.1.4 Recommendations for implementation

- Provide targeted extension capacity development to support CA scaling up in short to medium term.
- Formalize AGRITEX /NGO partnerships at district level to support scaling up of CA
- CA has broad based support from government, donors and NGOs and would be a good base for developing a district level innovations and lesson learning platform.
- Consolidate the mainstreaming of CA in policies and programmes of government,

donors and NGO's to realize the long term benefits of CA through enhanced government leadership role in CA forums.

- Support resource allocation to research to ensure that appropriate CA systems evolve to enhance the productivity of the smallholder farmer.
- Explore innovative frameworks for utilizing the available experienced human resource base in Zimbabwe (e.g. retired professionals and commercial farmers/managers) in scaling up CA
- CA promoters to adopt a menu approach that offers flexibility and choice to farmers. Focus on building capabilities of farmers to make informed choices.
- Position CA scaling up efforts within the current donor funding frameworks and thematic issues: food security, climate change, sustainable livelihoods (poverty reduction) and aid effectiveness.

4.3.3.1.5 Up-scaling

The following are conditions needed for up-scaling CA:

- Develop- input and out markets
- Institutional frameworks- to support innovation at all levels
- Strategic- partnerships, adaptive research in community based extension services,
- Capacity building of all service providers
- Behavioural change
- AGRITEX should have the capacity to promote and mainstream CA.

4.3.3.2 Horticulture Sector

Fruits and horticulture was one of the fastest growing subsectors in Zimbabwe agriculture during the 1990s. From a total of 20,000 tonnes of produce exported in 1992 the industry grew to over 80,000 tonnes exported by 2001. However, However, since then total exports of vegetables, fruits and flowers have declined rapidly to total about 50,000 in 2007(Figure 4.5). This was due to change in land ownership leading to loss of markets. In the strictly controlled EU fresh produce markets producing entities have to pass stringent compliance standards to be allowed access. New farm owners would need to go through the certification processes before they can be allowed to access the EU markets. Apart from the commercially produced fruits referred to above, Zimbabwe has the potential to increase the production of some locally adapted fruits. These include; mangoes, avocado peers, peaches and guavas.

These fruit trees grow well in most parts of the country with limited management, though they can also be agronomically managed through use of fertilizer, both organic and inorganic, irrigation, pest control practices and proper spacing in an orchard environment.

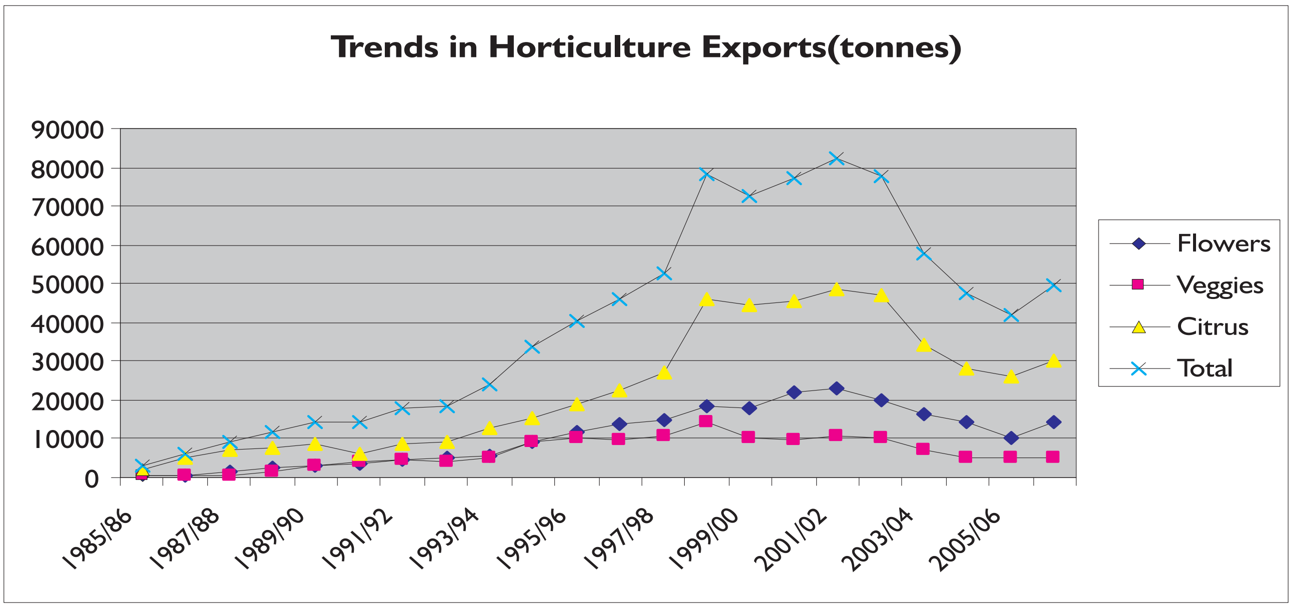


Figure 4.7: **Horticulture Export Trends (Source: Horticulture Promotions Council).**

4.3.3.2.1 Barriers to fruit production

The growth in production of these fruits has been hampered by difficulty in marketing the fruits during harvesting time. In other words, local markets cannot absorb or consume all the produce at maturity resulting in rotting which presents hygienic and health challenges. There is potential to increase fruit production if the farmers can realise some consistent income from sale of the fruits. The table below shows the yield potential for some of the fruit.

Table 4.2: Summary of Fruit Production Data

Fruit	Avocado Agro-ecological Regions	Harvesting	Spacing	Yield
Mango	2, 3, 4, 5	December to mid-April	8 x 8m	5–25t/ha
Peach	1,2,3,4	-	7 x 7m	20t/ha
Avocado	All	-	12 x 12m	4–11t/ha

Source: Farm management Handbook; 2010

The trees are generally large and perennial in nature, presenting a viable carbon sink.

4.3.3.2.2. Recommended programme for implementation

Despite the fact that fruits are a source of nutrition, not all households do have fruit trees. Fruits can be consumed in various forms chiefly as fresh, dried and canned. Drying and canning increase the shelf life of the fruit, making sure it can be consumed off-season. Processing also increases marketing options, as preserved fruits can even be exported. However, despite the ease of production, many households have not considered fruit farming as a viable enterprise. The reasons are varied, lack of motivation being the main one.

The project therefore seeks to promote fruit farming, starting with naturally growing trees listed above; these are; mangoes, peaches, avocados and guavas. These have been chosen because they are widespread in nature. The tree sizes present significant carbon sinks.

It is proposed that the project stimulate fruit production by investing in fruit processing equipment and techniques. Processing will broaden the market base for fruits, creating a win –win situation for the farmers, the public and the environment.

It is envisaged that different processing plants will be established starting with high fruit growing areas. Priority will also be given to remote areas where access to fresh produce market is restricted.

A marketing specialist will support the services of Agriculture Extension Officers to improve uptake of the produce. The issues of product quality, health and safety are critical.

A survey will be conducted to determine the areas to benefit initially as well as consumer preference analysis for proposed new products to be developed. The project should last three years so that the farmers receive training in production, processing and marketing. The environmental benefits of promoting the growing of fruit trees would be carbon sequestration while farmers will benefit from the sale of the fruits. Extensive production may yield meaningful carbon credits that can qualify for carbon trading.

4.3.3.3 Reducing carbon emissions from wildfires through stakeholder dialogue and preparedness in Mtao forest reserve in Zimbabwe

On average, forests account for 6 per cent of Gross Domestic Product (GDP) in Africa, which is the highest in the world (NEPAD 2003). According to the official national accounts figures for Zimbabwe, forests contribute significantly to the economy, accounting for 3% of the GDP (with the bulk coming from the forestry plantation industry in the eastern part of the country) and employing 8% of the total workforce in the manufacturing sector. These figures are likely to underestimate the true contribution of forests to national income, wealth and welfare in the country largely because several of the high value tangible and intangible benefits/losses of forest resources are not accounted for in these measures (Mabugu and Chitiga, 2002).

Zimbabwe is highly vulnerable to natural and other disasters that have adverse effects on communities, the national economy and the country's development objectives. Despite the importance of forests and woodlands in the economy there has been a general increase in the incidences of uncontrolled fires in Zimbabwe since the year 2000. These fires have been particularly devastating in the newly resettled areas, gazetted forest areas, national parks and commercial timber plantations, resulting in loss of human life and property as well as destroying vegetation and small animals indiscriminately. In 2009 alone it was estimated that close to 950 905.22 ha was destroyed by fire (Environmental Management Agency Fire Assessment Report, 2009. This figure indicates that fire incidences increased by more than 133% which is more than double the hectarage lost to fires in 2001. Matebeleland South province lost an estimated 21% of the forested area with Gwanda district having the highest damage. Harare Metropolitan had the least affected area losing 1% of the forested area to fire during the same period.

4.3.3.3.1 The problem

The majority of wildfires in developing countries of the tropics and subtropics including Zimbabwe are caused by human activities usually associated with land-use practices and changes. One of the underlying reasons for the high incidences of fire has been land clearance for agriculture following the land reform programme. In addition, divergent views among communities regarding government policy on resettlement on state forests and timber plantations have also contributed to increase in forest fires. In many rural areas, there has been a breakdown in traditional community institutions. This has contributed to poor management of forest resources in the face of no alternative regulatory system. The loss and degradation of natural forest cover in Zimbabwe has increased dramatically over the past two decades and the country now has one of the highest annual deforestation rates in Africa at 1.7% in the period 2000 to 2005 (http://rainforests.mongabay.com/20zimbabwe.htm). Natural causes such as lightning strikes also have a potential to ignite fires in the forest. When forest fires are not properly managed, they may result in death and injury to the people who cannot escape the fire and loss of property (Svotwa *et al*, 2007).

The Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) confirmed earlier findings that emissions avoidance and carbon sequestration by changes in the use and management of forests can make a meaningful contribution to reducing atmospheric CO_2. Developing countries have no specific emission-reduction targets under current climate-change deliberations. Nevertheless, there are many opportunities for mitigating atmospheric carbon in sustainable land management.

4.3.3.3.2 Land-based opportunities to mitigate carbon emissions

Many land-based opportunities to increase carbon stocks or avoid carbon emissions exist. For forests, carbon stocks can be increased and carbon emissions avoided by:

- protecting secondary and other degraded forests to allow them to regenerate naturally;
- restoring native forests through assisted and natural regeneration;
- maintaining existing forest-carbon stocks and sink processes by avoiding deforestation;
- establishing plantations on non-forested lands;
- managing forests sustainably to provide biomass energy; and
- managing forests to reduce fire incidences (reducing carbon emissions).

In response to the fire outbreaks that have become frequent, the government of Zimbabwe through the Ministry of Environment and Natural Resources Management (MENRM) has developed a national fire protection strategy in 2005. The key implementing agencies are the Forestry Commission (FC), National Parks and Wildlife Management Authority and EMA.

4.3.3.3.3 Project Justification

In addressing the problems of fires, Zimbabwe has heavily relied on law enforcement and suppression rather than adopting a holistic community-based approach to fire management. The implementation of the fire protection strategy by the FC has been slow largely due to a number of factors. These include budgetary constraints, lack of capacity at national, provincial, district and local levels, weak enforcement of fire suppression through legislative approaches, lack of involvement of traditional leaders and communities in forest management and fire preparedness. Furthermore, there is absence of an enabling environment that allows interaction at grass roots level as required in a participatory process. The FC is also under resourced and as such is unable to effectively enforce and apply the provisions of the Forest Act in order to address fire threats.

To avoid widespread fire disasters in the forestry sector in the country, there is need to foster stakeholder dialogue in order to ensure better understanding of forest fires and their consequences. There is also need to build capacity and awareness amongst the all stakeholders in the country to enable better management and monitoring of fires even at the grassroots level. Thus the project aims to implement an integrated approach or community based fire management approach mostly focusing on gazetted forests and commercial exotic timber forests. Capacity building for stakeholders will take the form of workshops, print and electronic media campaigns, road shows as well as facilitating dialogue between communities that are living in and adjacent to forests and plantations so that they are capacitated to protect forests against wild fires.

4.3.3.3.4 Project area

The project will be implemented in Chirumanzu district at Mtao forest reserve. The forest reserve is surrounded by commercial, resettled and communal farming areas. Mtao forest is 8 170 ha in extent. It was established to increase area under exotic commercial timber plantations especially the hardwoods for pole production. These forests are also of great commercial importance and produce a range of timber-based products for the domestic and export markets.

4.3.3.3.5 Activities and Expected outputs.

The activities and expected outputs are as indicated below.

Output 1: Increased public awareness on fire hazards, protection and management in Mtao forest reserve.

Activities

1.1 Hold 6 fire management consultative meetings (two per farming group). These meetings will be held initially to introduce the project to farming communities and have their buy in at the beginning of fire season. The last meeting to evaluate the project will be held at end of fire season.

1.2 Produce and distribute technical and publicity materials.

1.3 Publicize fire danger ratings through billboards, print and electronic media.

Output 2: Increased capacity of key stakeholders in forest fire management

Activities

2.1 Training of key district and law enforcement agents from the selected district.

2.2 Facilitate the development of fire management and protection plans at the local level.

2.3 Training of village fire brigades in communities surrounding Mtao forest reserve.

2.4 Develop and adapt draft fire management training manuals for both district and community level.

2.5 Facilitate the provision of fire detection and fire equipment.

Output 3: **Effective fire Information System in the selected project area**

Activities

3.1 Acquire satellite data on fire incidences in target area.

3.2 Develop local level fire detection, suppression and post suppression information system.

3.3 Hold monthly fire meetings to monitor fire events during the fire season.

3.4 Hold two community-level evaluation meetings.

3.5 Hold award ceremonies at the end of the fire season to award communities with best results in fire management.

Output 4: Forest resources in Mtao forest reserve assessed and monitored

Activities

4.1 Mtao forest resources assessed using recommended inventory methods.

4.2 Acquire satellite data to enable forest resource assessments.

4.3 Calculate carbon stocks in plant biomass (both above and below ground).

4.3.4 Mitigation Options from the 1st National Communication

The Initial National Communication was produced following significant work on development of methodologies for greenhouse gas inventories and greenhouse gas abatement costing. There are also several capacity building projects that were carried out prior to the production of the initial National Communication. Worth noting are the UNEP led abatement costing studies, the US country Studies, the UNDP Capacity Building Project and the UNITAR led project on capacity building and establishment of National Committees on Climate Change. There was a great interest in energy efficiency and renewable energy soon after independence and all this work fed into the Initial National Communication process. The following is a summary of the options for greenhouse gas mitigation identified in the initial communication.

Most of these options remain valid till today. Some of them have been implemented to a limited extent. These include prepayment meters and zero tillage. The coke oven gas plant has since gone into disrepair thus confirming the need for incremental financial support. Years preceding 2000 saw a decrease in capital investment in industry. Autonomous efficiency improvement fell and industrial output continues to be below capacity till today. Barriers to implementation of most of these options remain the same.

Table 4.3: Summary of Options from Initial National Communication

Sector/Option	Primary Energy saved (PJ)	
	2010	2030
Industry		
Efficient boilers	45.9	136.1
General savings	0	10.2
Efficient motors	1.1	4.3
Efficient furnaces	10.2	10.2
Nh3 from coal as opposed to electrolysis	6.8	6.8
Agriculture		
Efficient Motors	0.1	0.5
Zero tillage	0.3	0.3
Efficient tobacco barns	2.1	4.4
Solar PV power	0.003	0.003
Services		
Efficient motors	0.2	1.0
Residential		
Prepayment meters	0.1	0.1
Geyser timers	0.9	1.4
Biogas digesters	0.6	0.8
Solar geyser	1.3	1.9
Power generation		
Hydro power	0.0	28.4
Power factor correction	1.8	6.5
Central PV power	0.0	3.6
Solid fuels (Fuel transformation)		
Coke oven gas in power generation	0.6	0.6
Direct CO2 (LULUCF)		
Afforestation	0.6	0.6
Total	**72.6**	**217.7**

4.3.5 Conclusion

There are significant opportunities to reduce greenhouse gas emissions in Zimbabwe. The opportunities have small immediate reductions when compared to global targets but hold great potential when viewed from the perspective of avoidance of future emissions. The opportunities also offer options for poverty reduction and improved industrial efficiency. This report give an indication of how some of the programmes can be implemented but it is necessary that for each opportunity a study is done to confirm potential and to draw up a work plan.

CHAPTER 5

5. RESEARCH, SYSTEMATIC OBSERVATIONS AND TECHNOLOGY

5.1 Introduction

The United Nations Framework Convention on Climate Change (UNFCCC) recognises the importance of reducing scientific uncertainty and increasing the understanding of the causes, effects, magnitude and timing of climate change and therefore calls on Parties to promote and cooperate in all efforts being made to achieve a better understanding of anthropogenic climate change. Zimbabwe recognises the importance of climate change research and systematic observations.

Monitoring programmes and research projects which are closely related to issues of climate change are on course and are being implemented by government departments, research institutions, civil society and in some instances private agencies. Systematic observations described in this chapter are being done mostly in the field of meteorology and hydrology. However, monitoring is being done in fields such as agriculture and energy but to a limited extent.

5.2 Systematic Observations in Zimbabwe and Participation in International Observation Networks

5.2.1 Meteorology

In order to understand the changing climate, Zimbabwe is taking part in the Global Climate Observing Systems (GCOS) activities in monitoring climate by maintaining a systematic observation network. Meteorological observations are done by the Meteorological Services Department (MSD) in Zimbabwe. The main tasks delegated to this department are meteorological and agro-meteorological observations and weather forecasting. The service provides meteorological information to Zimbabwean institutions, enterprises and organisations, takes part in the national, regional and international programmes, prepares and publishes short, medium and long term forecasts. The observation network covers the entire country. Zimbabwe is a member of World Meteorological Organisation (WMO).

Meteorological and atmospheric observations in Zimbabwe cover the following aspects of GCOS:

1. Global Surface observations
2. Global Upper Air Observations (GUAN).

The MSD observation network comprises 64 stations operating at basic synoptic network at WMO level of which 46 of the stations are manned by meteorological personnel while the rest operate as part time being manned by trained staff from supporting institutions, mostly agricultural research stations. Of the 64 surface stations 14 stations have been equipped to provide upper air data. Dissemination of data, products and services to regional and international data centres for WMO is done through the Global Telecommunication System (GTS). Fourteen of the stations participate in GCOS activities providing surface and upper air data. The MSD heavily relies on Global Circulation Models (GCM) for weather prediction and forecast verification.

5.2.2 Hydrology

The semi-arid nature of Zimbabwe's climate requires that the network of water resources be closely monitored. The availability of accurate and timely data is quite important for water resources planning and management. In Zimbabwe, data on runoff has been collected as far back as 1925 and nearly 500 gauging stations collect. Figure 1.6 shows the distribution of the gauging stations across the country (refer to National Circumstances chapter in this report).The Zimbabwe National Water Authority (ZINWA) is responsible for hydrological data collection. Apart from river flows from gauging stations, ZINWA also collects data on dam levels, evaporation rates at most dams, abstractions and water use, sediment loads, borehole levels and discharge rates.

The World Meteorological Organization (WMO) and the World Bank formulated the World Hydrological Cycle Observing System (WHYCOS) in 1993 whose main objective was to strengthen the technical and institutional capacities of National Hydrological Services (NHS) so that they could meet end-user requirements for water related information. In order to strengthen the capacity of NHS's capability to provide regional and basin wide information, focus was made on regional and national initiatives that resulted in development of regional HYCOS such as the one for Southern Africa Development Community (SADC). Under SADC HYCOS, 50 data collection points have been installed which form a network for hydrological data exchange.

5.2.3 Agriculture

The National Early Warning Unit (NEWU) with the support of Ministry of Agriculture, MSD and UN agencies such as Food and Agriculture Organisation (FAO) maintains a database that stores and processes mostly climatic data. The Agromet database stores climatic data collected from 32 stations which form part of the surface observation network for the MSD. The database is managed by the MSD.

The data collected is used in the development of a fortnightly crop and livestock bulleting which is disseminated to all provinces of Zimbabwe. The bulletin provides an overview of the status of crops, livestock and yield projections based on forecasts in each of the provinces. National crop and livestock assessments are done three times in a season, and yield estimates are obtained through a model, GeoWRSI which uses the water requirement satisfaction index (WRSI) to predict yield for the season. Verification of model output is done when actual field data is collected at the end of the season.

5.2.4 Health

The Disease Control Unit within the Ministry of Health and Child Welfare (MOHCW) oversees the monitoring, surveillance and evaluation of infectious diseases. Surveillance and monitoring is done through health facilities such as clinics and hospitals around the country. MOHCW cooperates with other international bodies such as World Health Organisation (WHO) in disease monitoring and surveillance. The Disease Control Unit plans and implements response mechanisms for identification and control of health epidemics at national, provincial down to the lowest level. MOHCW has a comprehensive database of all the diseases in Zimbabwe.

5.2.5 Energy

The Ministry of Energy and Power Development (MOEPD) monitors the production and consumption of energy in the country through its departments and subunits. The Zimbabwe Electricity Supply Authority (ZESA) monitors the production and use of electricity, accounting even for the losses incurred during distribution. The Forestry Commission monitors fuel wood consumption through use of satellite images. Fossil fuel consumption is monitored through use of statistics at ports of entry into the country. No comprehensive biomass energy use survey has been conducted in the country.

5.3 Status of research in the Republic of Zimbabwe

A lot of climate related research has been carried out through institutions of higher learning both at undergraduate and postgraduate level. However, few of these research outputs have been compiled into a meaningful database. The Ministry of Science and Technology through the Research Council of Zimbabwe (RCZ) is now in the process of collecting such research which will be made available electronically through their website. The Scientific, Industrial Research and Development Centre (SIRDC) also carries out research related to technological needs for mitigation and adaptation to climate change such as energy saving light bulbs and stoves that efficiently burn firewood. While research has been carried out on climate related issues, challenges remain on having finer details due to sparse observation networks and gaps in available data.

5.3.1 Meteorology

The MSD hosts a lot of data, with some stations having data for more than a century. However use of these data by research institutions remains limited. The MSD has been operating on a 'cost recovery' basis for almost a decade now. The system is meant to meet part of the costs of maintaining the observation network and delivery of service. However, the charges levied for data access remain high for researchers carrying out climate related research. As such use of meteorological data and products remains limited. Results of research carried at individual level have not been readily available for verification and use in adaptation and mitigation programmes. Gaps in datasets available due to constant breakdown in equipment often results in research being carried out using a coarse resolution.

Most of the equipment from the MSD is from old generation and now very costly to maintain. From 1999, financial constraints slowed progress in maintenance of old equipment let alone acquisition of new equipment. The shortage of consumables like fibre tipped pens, tracing ink, special lubricating oil, heat sensitive paper and lack of spare parts to repair faulty equipment seriously affected operations of the MSD. Meteorological instruments have not been calibrated regularly hence compromising on the quality of observations. Some of the equipment is too old, and no longer have easily available backup spares or support from developers. Most rainfall stations have not been reporting due to broken down equipment and/or lack of training in recording rainfall data. The spatial distribution of the stations is quite poor especially over the southeast, southwest, northwest and north-eastern parts of the country. In these areas, climate related research is limited and thus there is reliance on satellite derived data.

Efforts are under way to use Geographic Information Systems (GIS) and Remote Sensing to develop site specific models for rainfall forecasting through research. Capacity to develop numerical weather prediction models is very low. The project muted to develop a Local Area Prediction System (LAPS) has not taken off because of data problems and lack of technical capacity.

5.3.2 Hydrology

Institutions of higher learning such as universities have been involved in research in the water sector. WaterNet, a Unit within Faculty of Engineering at the University of Zimbabwe has done some research, however there has not been coordinated efforts to disseminate the results of this research to a wider audience. Detailed research on the impact of and vulnerability to climate change and variability is needed. Other areas of research could include water quality and usage patterns as well as the impacts of climate change on ground water. Most research done so far has been focussing on impacts of climate change on water resources but lacks continuity due to limited funding.

Systematic support to local innovations using traditional and scientific means is of utmost importance, more so in view of climate change. Local innovations are derived from life experiences and would easily be accepted and used as adaptation strategies by the local communities. Currently there is very limited funding towards this kind of research.

While local innovations are a good idea, testing of ideas is often difficult to implement as smooth operation of equipment is punctuated with down time of several days. On the other hand piece meal adoption of technologies has caused incompatibilities in formats resulting in loss of data meant for research. Telecommunication systems within the water sector are old, using MS DOS and as result fails to match new acquired information systems. While gauging stations are many, nearly 50% of them are down due to lack of service, spare parts, expertise and support for the equipment. Research requiring hydrological data in these areas is often done using interpolated data.

5.3.3 Agriculture

Various climate related research projects have been undertaken in agricultural department of various institutions of higher learning and research institutes. Much research has been conducted on Conservation

Agriculture (CA) and several projects have been done by the Crop Production Branch in the department of Agriculture, Technical and Extension Services (Agritex) with support from FAO. The Department of Irrigation, Development within the Ministry of Agriculture, together with the University of Zimbabwe are involved in testing and adapting the imported irrigation technologies before releasing them onto the Zimbabwe market.

For some time now, research has focused on modelling the response of crops and ecosystems to changes in temperature and rainfall due to climate change. Current research has resulted in development of climate related options as adaptation strategies for smaller holder farmers who are the major contributors to maize production in Zimbabwe. The International Centre for Improvement of Wheat and Maize (CIMMTY) through its project 'Maize for Africa' is now focusing on early maturing and drought resistant maize varieties. Other research efforts are focusing on integration of indigenous knowledge systems (IKS) into climate change prediction, such as use of IKS in seasonal forecasting. The thrust is towards helping farmers increase their adaptive capacity through development of adaptation strategies that are tied to the environment in which they live.

Current gaps which require research are in the creation of an integrated information system of agriculture which has the capabilities of collecting, processing and providing information to the Ministry of Agriculture, other agricultural institutions and organisations, in line with current developments. Other challenges faced within the agriculture sector include a database containing only yield data. Some of the data has remained in hardy copy due to lack of expertise in synchronizing and merging datasets in different formats. The monitoring of soil fertility which used to be done by the Department of Research and Specialist Services (DRSS) is not being done due to obsolete equipment, lack of human resource capacity and chemicals.

5.3.4 Health

Most of researches on health have concentrated on malaria. However there is need to consider the impacts of future climate change on other health related problems and the vulnerabilities. Future research could also focus on vulnerabilities associated with HIV/AIDS and their relationship to climate change. There is need to take the approach of Agent Based Modelling (ABM) so as to monitor and map transmission of the diseases.

Other projects could focus on the creation of a malaria information system that allows monitoring the spread of malaria by capturing the data and converting it into a workable format. There is also need for maps showing the spatial epidemiology of the diseases. Current research in Zimbabwe has shown that schistosomiasis (bilharzia) is now resistant to generic drugs as used in the past. A patient now has to repeat treatment within 3 – 6 weeks to clear the bacteria in the body. The mutation of bacteria causing schistosomiasis needs further research so as to establish if these changes are in any way related to climate change.

5.3.5 Energy

The Energy Requirements Assessment project investigated Zimbabwe's potential for renewable energy sources and other energy efficient mechanisms. The project focused on all forms of energy available and the viability and limitations in their use. Whilst wind energy is a clean and renewable form of energy, wind speeds are below the optima required. The costs of setting up solar energy equipment are prohibitive even for household use. The biodiesel project has just been started and there is still need to identify possible sources of methanol and sodium hydroxide as well as the capital equipment for commercial production of the biodiesel from *Jatropha curcas.* ZERO, a regional NGO through its project on wind energy is working on establishment of wind powered projects in Temaruru, a small shopping centre in Manicaland province.

A prototype GIS energy database has been designed and should be adopted by Ministry of Energy and Power Development (MOEPD) for monitoring energy activities. However, there is need for financial investment to allow continuous update of the database. This database will form the nucleus of the energy database for the ministry.

5.4 Enhancement of observation networks

In order to allow Zimbabwe to actively participate and provide real time monitoring and up to date datasets there is need to harness all observation networks. Uptake of new technologies should be increased through proper training on support and maintenance of equipment. It is envisaged that if the following recommendations are adopted the country will be able to keep in tandem with new developments:

- Replacement of old equipment in line with new technologies that currently have continuous support.
- Build capacity of instrument technicians to maintain equipment.
- Maintenance of the operation of historically uninterrupted stations and observing systems.
- Establishment of a data management system that facilitates access, use and interpretation of data and products as a basis for monitoring the climate system and research.
- Resuscitation of the rainfall station network and training of new volunteer observers at research institutions.
- Prioritising installation of additional observation stations focussing on data-poor regions and poorly observed parameters especially in regions that are more sensitive to climate change for key measurements that have inadequate temporal resolution.
- Active response to the GCOS implementation plan.
- Advocating for a holistic approach in climate change research.
- Encouraging research institutions to mobilise funds for climate change research.
- It is important to have equipment for pollution, ozone and greenhouse gases measurement.
- Holistic approach in adoption of technologies that cut across sectors such as meteorology and hydrology as a way of reducing costs.
- Using GIS as a spatial decision support tool for sustainable, scalable and expandable monitoring systems.
- Adapting technologies to Zimbabwean environment before use so as to improve their lifespan.
- Develop agricultural technologies that increase climate change resilience in rainfed agriculture.
- There is need for systematic support for home grown innovations and solutions.
- Replacement of outdated information management systems, that use DOS to overcome interoperability challenges.

Technology transfer in key sectors of the economy

Agriculture is the backbone of the Zimbabwean economy. As such meteorological information such weather forecasts, is of utmost importance. Rainfall patterns have a direct bearing on agricultural production, water resources management and health sector. Climate change adaptation strategies are being developed. However sound technologies are required for the country to cope with climate extremes and shocks. This section focuses on the barriers to adapting new technologies and the strides the country is taking in line with current technological developments.

5.4.1 Meteorology

Given the importance of systematic observation of climate parameters and the need to implement the GCOS plan there is need for adoption of up market technologies by the MSD. These include:

- AWOS (The Automated Weather Observing System): this will reduce the number of personnel required.
- RADAR: important in every day monitoring of weather events, especially during the summer season.
- Soil thermometers, for monitoring soil moisture, a special component in yield forecasting.
- Robust database management system that is user friendly.
- Acquisition of AWOS and new RADAR has been affected by financial constraints.

5.4.2 Hydrology

Technologies that are best suited for adoption by water sector include the following:

- Micro-catchment systems: In such a system runoff is captured and directed to an adjacent agricultural area using for example tree crops. The runoff then flows over short distances with the root zone becoming the storage reservoir. Small projects are ongoing as test beds by institutions of higher learning.
- On-farm micro-catchment systems whereby all water control structures are constructed inside the farm boundaries. Structures include contour ridges, semi-circular and trapezoidal bunds, small pits, eyebrow terraces, runoff strips, contour bench terraces and small farm water harvesting reservoirs for supplementary irrigation. Through support of nongovernmental organisations water harvesting reservoirs have been installed in few places for local communities to gain knowledge and test the techniques. However uptake by individual households remains low.
- The use of Biological Nutrient Removers (BNRs) in effluent polishing. Currently BNRs are used as end pipe technologies yet the effluent quality remains very poor due to overload on the systems. It is possible to recover phosphates for fertilisers using these technologies; as such Zimbabwe has to seriously invest in waste water handling technologies. The prices for acquiring the technology have remained too high.
- Availability of water for both domestic and industrial use remains critical. The use of water demand management techniques such as low volume flushing systems, pressure reduction, public awareness and behavioural change can be combined to achieve water conservation given the changing climate and pressure on water resources.
- Utilisation of dambos. For years dambos have remained a major source of rural livelihoods in the dry areas of Zimbabwe as well as during dry periods. When utilised in conjunction with water management technologies such as bunds, they yield high volumes of food crops. Communities have turned to the use of dambos but the challenge is mismanagement that has resulted in erosion. Thus there is need for capacity building in the water resources management and use of appropriate technologies.
- The use of drip irrigation systems in the production of horticultural crops has been piloted in the drier areas of Zimbabwe such as Chivi. However, breakdown of the equipment and limited financial resources has affected the expansion of the program to other districts.

5.4.3 Agriculture

Agriculture needs to adapt to climate change and this now calls for a shift from business as usual to use of techniques that are climate smart whilst giving the farmer the best yields. Policies that create an enabling environment will help Zimbabwe meet its UNFCCC obligations, at the same time helping agriculture to adapt to climate change. Therefore the adoption of transferrable technologies that suit Zimbabwe's situation, effective policies and programmes will stimulate Zimbabwe agriculture's potential to adapt to climate change. Such technologies include the following:

- Gene technology. There is need for new crop cultivars which are short season and drought tolerant as already initiated by CIMMTY. This program will allow farmers to plant later than normal planting period but still harvest.
- Soil fertility management and best tillage techniques that improve soil water storage, optimising water use resulting in higher yields.
- Water harvesting techniques that promote conservation of rainfall. Conservation Agriculture (CA) has been implemented and farmers are slowly taking up the concept and benefits have been realised. In other places CA has been shunned due to its labour intensive nature. There is need to look at the various methods that will allow farmers to choose the best option for

themselves without really forcing them to adopt certain CA technologies.

- Improved and cost effective irrigation systems.
- Improved digestibility of animal feed through mechanical and chemical processes. Animal productivity will be increased while methane production is reduced.
- Alternative energy supply systems such as solar, biogas and biodiesel for use in irrigation and drying crops. The use of solar energy remains low due to prohibitive installation costs. Solar energy is mostly being used in homes. Biogas has not been popularised and biodigesters installation has been done in a few places mostly for household use. As with other technologies the cost of a single biodigester for home use is around US$500 which is too high for local communities. The prohibitive costs have reduced the uptake of biogas technology.

5.4.4 Energy

Energy remains one of the core drivers of the economy while contributing the most to GHG emission in the country. In order to meet requirements of the users whilst adhering to the convention, the following technologies are suggested for adoption:

- High efficient light bulbs for domestic use. These have already been adopted but the uptake is still low due to prohibitive costs and limited education and awareness on the technology option.
- Solar water heaters should be encouraged. Production costs of solar energy remain relatively high resulting in low uptake of this energy option.
- Promotion of low carbon fuel such ethanol-gasoline blending and coal bed methane. Construction of a plant for blended fuel is ongoing in the southeast of the country.
- Use of renewable energy sources such as wind farms for electricity generation, solar cookers, biogas digesters, solar crop dryers, bagasse and many other such technologies where appropriate. These have to be adopted as small projects given the huge costs involved if they have to be undertaken at the national level.
- Mini-hydropower electricity generation to boost already available electricity. The huge investment into such projects remains a challenge for the country and all such projects remain on the cards due to limited funding. There is need for government to encourage industry and other players to get involved in Clean Development Mechanisms in order to improve electricity provision.

5.4.5 Industry/Waste Sector

Industry and waste sector contribute significantly to GHG emissions. Technologies that can be adopted in these sectors are suggested below:

- Landfill gas recovery-(reduces CH_4 emissions),
- Post-consumer recycling (avoids waste generation) ,
- Composting of selected waste fractions (avoids GHG generation),
- Thermal processes including incineration and industrial co-combustion of sugarcane bagasse and timber waste products
- Anaerobic digestion adoption in municipalities
- Using thermal processes to efficiently exploit energy content of waste instead of using biogas
- Efficient use of materials to reduce waste generation
- Efficient design of wastewater treatment plants to reduce GHG emissions.

Feasibility studies on all these options have been done and sites have been identified for carrying out such projects. However, the huge capital investment required has seen the municipalities not being able to adopt technologies.

5.5 Cooperation development and capacity building

Climate change is a global environmental issue that requires cooperation in the implementation of national, regional and international programmes geared towards combating the negative effects of climate change. There is need for capacity building in terms of development of forecasting and climate models. In order to tap and increase uptake of new technologies there is need for training in different disciplines including climate related research, development of sustainable spatial decision support systems, and linkages among research institutions, nationally, regionally and internationally. Exchange programmes should be encouraged to allow transfer of best practices and adoption of best methodologies.

As an example, there is need for a holistic approach in solving hydrological and meteorological problems. The functions and operations of observation network are governed by WMO. Technologies are available for real time monitoring. Cooperation between the hydrological and meteorological institutions would reduce national budgetary requirements. A good network of AWOS and radar systems would save both institutions, making it possible to jointly provide early warning information for disaster risk reduction in the wake of extreme events related to climate change.

There is also need for the development of a climate change portal which allow for data integration and access in distributed environments. Such a portal would allow sharing of research, national communications, climate related news, adaptation strategies developed and initiatives which address climate change.

5.6 Database Management System for National Communication Data

National climate database is very important. Datasets available are housed within different institutions. One such institution is the Meteorological Services Department. The MSD quality controls and archives data collected from synoptic and volunteer stations across the country, as well as disseminating data, data products and services to regional and international data centre for WMO through the Global Telecommunication System (GTS). The MSD maintains Zimbabwe's national climate data archive containing official weather records some dating as far back as 1901. Although some of the climate data is in paper form, most of it is now available in digital database files. Archived datasets include hourly observations of temperature, humidity, wind speed and direction, atmospheric pressure, cloud types, amounts, and heights, and occurrence of rain, thunderstorms as stipulated in the WMO guidelines. The MSD was using CLICOM database management program which has since been replaced with CLIMSOFT, a new database management system.

The MSD operates on a cost recovery basis and use of the data for research remains limited due to the high costs involved. There is need for investment into a national communication database management system that allows access, use and integration with other cooperating partners. Research institutions can derive maximum benefits from using the data for national research projects.

5.6.1 Integrating Climate Change Activities

Proposals have been made for the development of a national portal that integrates all climate change activities. The steps being taken are as outlined below:

a. Identification of all sectors taking part in climate change activities and list of activities
b. Listing of datasets available
c. Completed and ongoing climate change related research and institutions involved
d. Identification of gaps.
e. Listing of national climate change activities and link them to national communications.

With the above information available, it is envisaged that a portal will be developed where users can access information on National Climate change response strategy, National Communications, datasets used in national communications reports, national activities and initiatives to mitigate and adapt to climate change. Also available on this portal will be information on national adaptation strategies and UNFCCC protocols and national obligations. A database management system in the portal will allow access to data in distributed environment that will allow access to data hosted by different institutions.

5.7 Conclusions: Research and Systematic Observations and Technology Transfer

A number of monitoring and research programmes that are related to issues of climate change are ongoing. Various government, research institutions and private sector are actively involved in projects aimed at minimising vulnerability of Zimbabwe to climate change and increasing the adaptive capacity of communities.

Monitoring is being done mostly in sectors such as meteorology, hydrology and agriculture among others. The Meteorological service is concentrating on improving weather forecasts and accuracy. The Department of Agriculture, Technical and Extension Services has launched conservation agriculture which is meant to help improve household food security. A project "Maize for Africa" by CIMMTY is concentrating on coming up with new crop cultivars that are early maturing and drought tolerant. The Department of Irrigation together with the University of Zimbabwe are involved in testing and adapting the imported irrigation technologies before releasing them onto the Zimbabwe market. Several other projects are ongoing in the energy sector with some test beds for wind power and biodiesel. The Disease Control Unit is currently investigating the relationship between mutation of the bacteria causing schistosomiasis to climate change.

Active involvement of Zimbabwe in adapting to climate change requires use of recent and up-market technologies. Monitoring programmes are often punctuated by breakdowns therefore loss of data. In order to be able to use the technologies there is need for capacity building to run the equipment, to develop models and to use available models to come up with future scenarios. Therefore there is need for regional and international cooperation to allow strengthening of technical capacity of institutions. Uptake of new technologies remains limited due to limited funding and lack of expertise, non-availability on local markets and prohibitive costs from a consumer's perspective.

Data exchange and management remains limited to a few organisations. However, for smooth running of climate change programmes, there is need for a portal that allows data exchange and integration in distributed environments. Such a portal will aid sharing research results and dissemination. This will strengthen cooperation and promote partnerships among institutions working on climate change issues.

CHAPTER 6

6. EDUCATION, TRAINING AND PUBLIC AWARENESS

This chapter deals with issues on education, training and public awareness for climate change. It is divided into three sections, namely: the status of climate change courses within the educational system, public participation in knowledge exchange and awareness raising and the proposed climate change communication strategy. These issues were arrived at from consultations at a series of workshops held with various stakeholders. The stakeholders included parliamentarians, teacher training college heads, directors in the education system, school heads, teachers, natural resources officers, among many others.

6.1 Status of climate change courses within the educational system

In order to give the proper context to the status of climate change courses within the education system, it is important to give some background of the curriculum currently operational in Zimbabwe. The primary and secondary school curricula were reviewed. The tertiary institutions do not have curriculum set at the national level. The information provided about the curriculum in the subsequent sections was obtained from the Curriculum Development Unit (CDU) in the Ministry of Education, Sports, Arts and Culture.

6.2 The Zimbabwean curriculum system

The curriculum refers to the aggregate of all that is imparted on the learner through the total experiences of the school system. This is done in a deliberate design to achieve educational goals. The experiences the learner goes through come mainly from three sources:

- The formal curriculum that is planned by the school and approved by the Ministry of Education
- The co-curricular activities such as sports, clubs, games, cultural activities and educational tours
- The hidden curriculum that is the communication by the school of a whole set of exemplary behaviour patterns.

The Zimbabwean school curriculum has four levels:

1. Early childhood development (ECD) which is a two-year programme catering for children aged 3-5 years including learners with special needs.
2. The primary school curriculum which is a 7 year programme for children aged between 6-13 years. The curriculum covers various subject areas such as languages, environment, geography, science, music, and arts.
3. The secondary school curriculum offers a broad range of subjects for all learners. It has two components in terms of its structure. It has compulsory subjects such as English, History, Mathematics, Shona/Ndebele and Science. It also has optional subjects such as Geography and Civic Education.
4. The 'A'-Level curriculum which covers a period of 2 years and comprise a combination of any three subjects. These subjects are grouped into the Arts/Humanities, Science/Mathematics, Business/Commerce and Vocational subjects.

6.2.1 Climate change status in the Zimbabwe school curriculum system

The Ministry of Education, Sports, Arts and Culture has responded to both local and international initiatives to integrate climate change into the school curriculum. This follows the recommendations of the Presidential Commission of Inquiry into Education and Training. This commission recommended that Environmental Education (EE) should be integrated into the school curriculum. This is in support of one of Zimbabwe's national goals which states that:

'To make sustainable development a national priority, to take a proactive role in environmental issues and to respond to environmental challenges facing Zimbabwe at the personal, local, national, regional and global levels through education and communication'.

Pursuant of this goal, the Curriculum Development Unit (CDU) in the Ministry of Education, Sports, Arts and Culture has developed skeletal materials on climate change which are being incorporated into the school curriculum. It is expected that when fully developed, the materials in the curriculum can be used from the ECD level up to 'A'-Level. Currently the subjects that have a direct bearing on climate change in the school curriculum include:

- At primary level: Social Studies, Environmental Studies and Agriculture
- At secondary level: Geography is the main carrier subject. However, other subjects like Agriculture, Science and Civic Education also carry components of climate change
- Civic education which has been introduced into the secondary school system is the main carrier subject for Disaster Risk Reduction (DRR). To this end, a teacher's resource book on DRR has been produced for use in schools.

There is a general view that the content of the curriculum used in both primary and secondary schools does not adequately address the issue of climate change. This is mainly because climate change is a small component of the curriculum in such subjects as Geography, Environmental Science and Civic Education. It is being taught as part and parcel of natural resources management or as EE. It is also taught as part of environmental hazards related to agriculture. Here progress has been made in the production of modules which cover the following topics related to climate change:

- Water management
- Soil management
- Wildlife management
- Integrated pest management
- Biodiversity, and
- Agro-forestry

While some aspects of climate change have been integrated into the school curriculum, there is need to enhance the teaching and learning of climate change at all levels of the school system. This enhancement will include the following aspects:

- The establishment of climate change parameters or issues in Zimbabwe in relation to the education system
- Conducting curriculum audits in terms of the content and process of climate change
- Convening of national workshops to fully integrate climate change into the school curriculum
- Conducting in-service training workshops for educators on the integrated climate change curriculum, and
- Monitoring and evaluation of the teaching and learning of climate change.

The in-service training of the educators should have the following as its objectives:

- Identification of the training needs of teachers. Teachers to be offered the in-service training should come from the carrier subjects of climate change such as Agriculture, Geography, Environmental Science, and Civic Education.
- Identification and training of a core team of trainers. These will conduct the in-service training at provincial and district level until saturation levels are reached or a critical mass of teachers with climate change skills is produced.

6.2.2 Tertiary level courses

The tertiary education sector is made up of teacher training colleges, agricultural training colleges, polytechnic colleges and universities. Universities are mainly state owned though there are a few run by private entities such as churches.

Currently, the teacher training and agricultural colleges cover climate change issues as part and parcel of the carrier subjects which are then taught at primary and secondary schools. As a result, the same weaknesses pointed out under the school curriculum also apply to them i.e. the course content is not broad enough and will need enhancement. This is the reason for proposing in-service training for those teachers already produced by these colleges so that their foundation on climate change issues can be strengthened.

The colleges will need to revisit the content of the carrier subjects such as Geography, Environmental Science, Physics and Civil Education to produce syllabi that includes or integrates climate change into the curriculum. This process should be followed by the production of relevant materials for use in the training colleges. The main processes to be involved in the production of materials will include:

- Conducting a needs assessment
- Preparation of draft materials based on the findings of the needs assessment
- Reviewing the content of the draft materials for quality and consistency especially in the definition of terms and the understanding of concepts related to climate change
- Pre-testing the materials for suitability in terms of use for training on climate change
- Editing the draft manuals after a thorough evaluation of the content has been done
- Printing and distributing these materials to the teacher and agricultural training colleges for use on new graduands for their training programmes
- There will also be a need to produce a teacher's guide to these materials for use in the classroom.

6.2.3 The university sector

Every university has its own policy on what subjects to offer. In other words there is no standard or defined curriculum as in the case of primary and secondary school sectors. Not all subjects used as carrier subjects at primary and secondary levels are reflected in the university system within the country. The older universities, such as the University of Zimbabwe and the National University of Science and Technology offer these subjects. Thus, an evaluation of the status of courses on climate change offered at these institutions is imperative.

At the University of Zimbabwe, courses on climate change are offered in the departments of Geography and Environmental Science, Physics and Agriculture. Climate change is streamlined into other courses in the disciplines of Crop, Animal, Soil sciences and Agricultural Economics and does not stand alone. Indeed, climate change is not offered as a standalone course in any of the faculties of the University of Zimbabwe.

The situation is also similar at other universities. For example, at the Great Zimbabwe National University, climate change courses are offered through the Department of Geography and Environmental Studies. Here, climate change is streamlined into courses that deal with climatology and meteorology. The same situation is also true for Bindura University of Science Education, Midlands State University and Chinhoyi University of Technology.

The situation above arises from the fact that most of the state universities copied the University of Zimbabwe model when they were being set up. There is therefore a need to conduct a situational analysis of the courses offered by all universities in the country where carrier subjects such as Geography, Environmental Science, Agriculture, Engineering, are currently being taught. The objective will be to investigate the content of such courses in terms of how they cover the climate change issue. The analysis should be able to establish the exact courses where climate change is being taught such as climatology, meteorology, water resources management, crop science, agricultural engineering and so on. This analysis will provide a basis for standardizing the teaching of courses throughout the country's universities much in the same way as suggested under the section on teacher and agricultural training colleges.

6.2.4 Public participation in knowledge exchange and awareness-raising

The Climate Change Office in the Ministry of Environment and Natural Resources Management has held more than fifteen climate change workshops since 2006. These workshops were meant to exchange information and raise awareness on climate change. The results of these workshops have clearly shown low awareness on climate change across various stakeholders e.g. policy makers, communities and several sectors in the economy. The low levels of awareness have been reported to be between 18-42% (NCSA, 2008).

Given these low levels of awareness, this report evaluates different strategies of raising awareness and exchange of information across various stakeholders and sectors of the economy. The findings reported here were from workshops which involved stakeholders from education, energy, water, agriculture and other sectors of the economy. Most of the participants in these workshops recommended targeted outreach programmes on awareness and information exchange on climate change adaptation and mitigation across various stakeholders and grassroots communities. For the strategies to be effective it was suggested that the following stakeholders should be targeted:

- Legislators (members of parliament - both lower and upper houses)
- Cabinet (the President, Deputy Presidents, Prime Minister, Deputy Prime Ministers and Ministers)
- Heads of government departments (Permanent Secretaries, Principal Directors and Directors)
- Schools (both primary and secondary)
- Tertiary colleges and universities
- Other important sectors such as Agriculture, Health, Transport, Tourism, Energy, Water and, Urban settlements, and Communities at grassroots.

The major components of a programme for raising awareness for various stakeholders are:

- What is climate change
- causes of climate change
- impacts of climate change
- options available for climate change adaptation and mitigation.

For high level policy makers the need to put a legal, institutional and policy framework on climate change issues should be emphasized in most of the messages. Harmonization of sectoral policies and their implication on climate change issues should also be emphasized. So far one workshop has been held for all permanent secretaries in all government.

At grassroots level the main target for awareness creation are communities and farmers. Community leaders, women, children, disabled people and all vulnerable groups should be included. The approaches to be used to create awareness and exchange information must be participatory in nature. Communities should define by themselves what they understand by climate change and their ways of adapting to it. For several decades communities have lived with climate disasters and risks. Over time they have also developed coping mechanisms and strategies to deal with this climate risk. Hence there is a wealth of indigenous knowledge systems (IKS) on how to cope with climate variability and change. This knowledge must be captured and documented from various parts of the country according to agro-ecological zones. The knowledge will allow better communication with farmers on climate change issues. When indigenous knowledge systems is combined with scientific knowledge, robust, sustainable and appropriate adaptation technologies will be developed to mitigate climate change. Various research institutions and universities are conducting research on IKS and climate change in the country.

In order to increase awareness and exchange of information across various stakeholders the following strategies are suggested:

- Empower officers in various sectors with awareness materials
- Develop awareness materials such as posters, pamphlets, videos, compact discs (CDs) in both English and vernacular languages
- Promote drama, poetry and essay writing competitions
- Use media such as newspapers, radio, and television
- Involve the use of the Junior Parliament
- Dedicate a national day for climate change commemoration.

The strategy used to create awareness among various stakeholders should not be uniform. The literacy levels, socio-economic conditions and costs are primary factors to be considered in selecting a strategy. However, there are some strategies that can be used across various stakeholders.

In rural areas, where there is limited availability of electricity, the use of radio, TV and videos is of limited application. In such circumstances, it is recommended that drama, posters and village workshops should be used. Field days organized by various officers in the health, agriculture, water, and other sectors should complement the above mentioned strategies. The strong network of field officers who are widely spread in communities must be used to create awareness and exchange of information. However, to make this strategy effective, these officers must be supported with a lot of awareness materials written both in English and vernacular languages.

It is also recommended that climate change should be commemorated annually like in the case of the world biodiversity day, world food day and world health day. Using the same principle, the country must dedicate a day for climate change. On such a day, awareness will be created at village, district, provincial and national levels. A climate change theme should be agreed upon and celebrated each year.

For schools, pupils are encouraged to enter essay competition writing on climate change. Such approaches have been adopted by a local non-governmental organization in Zimbabwe: Environment Africa. In Zimbabwe there is a Junior Parliament which consists of school going children. This forum can provide a good platform to create awareness to youth and their constituencies.

For senior policy makers, the use of radio, television, videos, newspapers and workshops would be ideal strategies to create awareness. Already, one workshop has been organized for parliamentarians as well as another one for permanent secretaries. More workshops need to be organized upon availability of funding and government budget allocation.

In order to enhance the exchange of information and awareness creation there is need to establish multi-stakeholder forums. These forums at village, district, province and national levels will take place at regular intervals. Through these forums exchange of materials, dissemination of awareness materials and advocacy activities will be coordinated. These forums will also allow monitoring and evaluation of these activities. It is also recommended that budgetary allocations must be increased in the third communication in order to upscale awareness raising activities and information exchange throughout the country.

6.3 Proposed Climate Change Communication Strategy

Qualitative data obtained from a number of consultative workshops and stakeholder in depth interviews led to the development of the Zimbabwe Climate Change Education, Awareness and Training Communication Strategy. This qualitative data gathering process targeted teachers, heads of schools (both primary and secondary), education officers (both primary and secondary), curriculum development unit officials, Zimbabwe Examination Council officials and principals of teachers' training colleges. The strategy has eleven thrusts as summarized below.

1. **The Participatory Approach**
   The approach is meant to promote feelings of programme ownership or citizenship as opposed to possible non-cooperation resulting from perceived imposition of the programme. People are given the opportunity to give their understanding of causes of climate change, impacts and solutions appropriate in their areas.

2. **Production and dissemination of information, education and communication materials**
   This involves production of flyers, posters, pamphlets, t-shirts, caps, hats and banners with climate change messages in all local languages. These messages will also be on various household items. The messages should be simple, locally relevant, and easy to understand. This is targeting improved understanding of climate change issues through use of one's first language. It also leads to increased acceptability of the programme.

3. **Use of media**
   This involves the use of radio, television, videos, newspapers, magazines, chat shows to spread climate change information. An example of a very popular talk show which is a Zimbabwean equivalence of the Oprah Winfred show is known as *The Mai Chisamba Show*. Media people will also be trained and educated on climate change issues to make sure their reporting is informed and accurate.

4. Debates

Debate on climate change will be encouraged at all educational levels as well as within the communities both rural and urban. Schools will be encouraged to form climate change debating, poetry and drama clubs. These clubs will compete at ward, district, provincial and national levels on locally developed themes on climate change.

5. Use of Social Gatherings

Climate change messages are to be factored in at various gatherings including but not limited to funerals, weddings, church meetings and traditional ceremonies.

6. Catch them young

Promoting creation of environmentally aware future generations by creating climate change aware young persons through programmes implemented by the junior members of the lower house of parliament and senate in their respective constituencies.

7. Commemoration Day

This involves setting up and commemorating the Zimbabwe Climate Change Day. This will involve marches with banners, t-shirts, hats, caps, bandanas and umbrellas with various messages on climate change. Some the key messages can be as follows:

- Climate change is here to stay
- Ignore climate change and you perish
- Be prepared for climate change
- Climate change-everyone's concern
- Climate change can be managed
- Climate change is a reality
- Climate change is real, Act now.

These messages will also be used as topics for school essay writing, poetry and drama competitions.

8 Exposure

This component of the strategy focuses on exposing school children and students to a variety of climate change impacts through field trips and educational tours. These trips are important because climate change impacts vary with places in terms of their nature and severity.

9. Behaviour change

Raising knowledge levels, does not automatically translate to behaviour change, but leads to the development of beliefs in people. These beliefs serve to guide the decision to perform or not to perform related behaviours. The resultant behavioural beliefs determine people's attitudes toward personally performing the behaviour (Fishbein & Ajzen, 2010). The strategy considers adoption and application of selected behaviour change models to ensure increase in behaviour change towards climate change adaptive behaviours. Application of these models translates these raised knowledge levels into positive attitudes subsequently leading to positive intentions and finally exhibiting of climate change adaptive behaviours.

The strategy considers the Community Popular Opinion Leader Approach (CPOL), where those local popular people whose opinions are usually readily followed by fellow community members are targeted as leading persons in the dissemination of climate change information as well as advocating for climate change adaptive behaviours. People form beliefs that important individuals or groups in their lives would approve or disapprove of their performing the behaviour as well as beliefs that these reference themselves perform or do not perform the behaviour in question (Fishbein & Ajzen, 1975).

The social learning model is another behaviour change approach proposed. This involves models in the forms of local and national celebrities disseminating climate change information and exhibiting climate change adaptive behaviours as a way of facilitating socio-cognitive learning with vicarious reinforcements of these behaviours in communities (Bandura, 1986).

Integrated Behaviour Model (IBM) which includes three main constructs as determinants of behaviour intention: attitude toward performing the behaviour, social norm associated with the behaviour and personal agency, including self-efficacy and perceived control with regards to the behaviour (Kasprzyk & Montano, 2008).

10. Training

The strategic approach is to strengthen existing structures and networks through training of trainers. The targeted trainees being:

- In-service training of teachers in primary and secondary schools
- Training of local natural resources officers in the communities
- Local NGO officers working with the communities
- Local community leaders (chiefs, headmen, councillors and village heads)
- Community popular opinion leaders.

11. Information and Networking

The thrust of this strategy focuses on specific strategic activities that include creation and strengthening of existing networks. It is specific on the respective implementers as succinctly summarised in Table 6.1 below. The strategy will encourage sharing of information and networking at both local and international level.

Table 6.1: Strategic activities for local information and networking

No	ACTION ITEMS	RESPONSIBILITY
1	Teach Climate Change in all schools and at grassroots levels	Ministries of education as well as those responsible for agricultural colleges and the training of natural resource officers
2.	Provide resource materials for teaching and spreading the Climate Change messages and increasing awareness	CDU and other stakeholders
3.	Revise current curricula of relevant subjects to include Climate Change in schools and other training institutions	Ministries of education as well as those responsible for agricultural colleges and the training of natural resource officers
4.	Engage local communities through the local leadership and utilize their indigenous knowledge systems (IKS)	Ministry of Environment and Natural Resources, relevant Parastatals, natural resources officers, Climate Change office, National Ozone Office, Ministry of Science and Technology
5.	Develop training materials for Climate Change	CDU in association with ZIMSEC, Climate Change Office, National Ozone Office Universities, NGOs
6.	Training of trainers on Climate Change	Ministries of education as well as those responsible for agricultural colleges and the training of natural resources officers, Universities, NGOs

Table 6.1: Strategic activities for local information and networking *(continued)*

7.	TV and Radio talk show programmes on Climate Change on a weekly basis	MENRM, ZBC, Universities, NGOs and other stakeholders
8.	Situation analysis of current levels of awareness in order to develop relevant materials for specific target groups	MENRM, CDU, ZIMSEC, Universities, NGOs
9.	Produce materials in all local languages and distribute to education district offices	Both ministries of education, CDU, ZIMSEC. Also language departments in tertiary institutions
10.	Tie Climate Change to the current review of 'O' Level syllabi and extend it downwards to primary level	CDU, ZIMSEC
11.	Sought Funding for the mainstreaming of Climate Change in curricula : develop a budget for the process as well as advocating for a line item in the national budget	MENRM, both Ministries of Education, Ministry of Finance
12.	Mainstream climate change education, awareness and training into the National Climate Change Strategy	MENRM, Climate Change Office

The strategy also emphasises the establishment of multi-stakeholder forums at ward, district, provincial and national levels through which the various components of the strategy will be operationalized. Lastly, a comprehensive monitoring and evaluation programme for climate change education, awareness and training will be put into place.

International information and networking strategies

Besides the local level information and networking efforts, climate change education, awareness and training strategies will be undertaken at the international level. This will be done through the launch of a newsletter. Initially the newsletter will be a bi-annual publication but it is envisaged that it will be eventually published on a quarterly basis. The newsletter, whose title is proposed to be '*The Climate Change Communicator*' will feature the following:

- Research highlights and major breakthroughs in the area of climate change
- News from the field i.e. farmers' experiences on coping and dealing with climate change
- Training opportunities in terms of scholarships, internships and bursaries in the field of climate change and related disciplines
- Funding opportunities for training and attending workshops, seminars, conferences, especially for post-graduate students interested in the field of climate change
- Up-coming events in the climate change arena such as conferences, workshops, seminars, etc.

In collaboration with the Ministry of Environment and Natural Resources Management and through the Climate Change Office, links will be established with regional and international organizations in order to promote climate change education, awareness and training activities. Targeted regional bodies will include SADC, COMESA, the South African Society for Atmospheric Science, ECOWAS among others. Civil society organizations will include the PanAfrican Climate Justice Alliance, Civil Society Network on Climate Change, ForumCC, Kenya Climate Change Working Group among many others. International bodies will include the AU, OPEC, the Arab League, UN bodies and various continental bodies dealing with climate change issues.

It is proposed that funds be mobilised for awareness, education and training activities. These funds will also cover the costs of printing and dissemination of '*The Climate Change Communicator*' to various stakeholders. The proposed targets for the newsletter are:

- The Zimbabwe Academic of Sciences
- The Research Council of Zimbabwe
- Schools and tertiary institutions
- Environmental Non-Governmental Organizations
- Civil society organizations such as the Zimbabwe Council of Churches
- Trade Union networks
- Mobile cellular networks
- Financial institutions
- Industry and commerce among many other networks.

Conclusion

Qualitative data obtained from a number of consultative workshops and stakeholder in depth interviews led to the development of the Zimbabwe Climate Change Education, Awareness and Training Communication Strategy. This qualitative data gathering process targeted teachers, heads of schools (both primary and secondary), education officers (both primary and secondary), curriculum development unit officials, Zimbabwe Examination Council officials and principals of teachers' training colleges.

Among issues covered was the exploration of courses within the educational system which cover climate change concerns. It was established that climate change was taught at primary, secondary and tertiary education levels but not as a stand-alone subject. Carrier subjects such as Geography, Science and Social Studies are used to teach climate change but the curriculum lacked depth. The teachers are ill equipped to teach the subjects and need in-service training. At the same time, there is a dire need to develop relevant climate change teaching materials for distribution to schools and tertiary colleges.

Awareness of climate change issues by the public and policy makers was found to be low. There is therefore a need to develop a strategy to raise awareness of climate change issues targeting specific stakeholders. The stakeholders to be targeted include policy makers, heads of government departments, schools, universities and communities at grassroots levels. The suggested awareness strategies to be used include use of both electronic and print media as well as school competitions, commemorations and workshops at the grassroots levels.

A proposed climate change communication strategy is presented with eleven strategic thrusts to address some of the issues identified by the awareness level gaps. The thrust on information and networking is specific in terms of the proposed activities and implementers. The strategy also emphasizes the establishment of multi-stakeholder forums at ward, district, provincial and national levels through which the various components of the strategy will be operationalized. A comprehensive monitoring and evaluation programme for education, awareness and training will be put in place. The strategy also identifies and gives responsibilities to key stakeholders who will move the process forward until climate change becomes a reality for everyone.

More importantly, it is recognized that we live in a global village. To this end, regional and international bodies will also be engaged in the discourse on climate change for education, awareness and training. The main tool for engagement is a proposed newsletter to be titled '*The Climate Change Communicator*'. This will report on the various efforts being made towards dealing with climate change issues.

CHAPTER 7

7. POLICY, CONSTRAINTS AND GAPS

7.1 Analysis of Climate Change related policies

7.1.1 Introduction

The Ministry of Environment and Natural Resources Management (MENRM) is responsible for environmental policy formulation and overseeing environmental management and conservation in Zimbabwe. Zimbabwe is yet to produce a national Climate Change Policy. Meanwhile Multi-lateral Environmental Agreements (MEAs) have been adopted as policy instruments to guide national efforts towards addressing climate change issues e.g. United Nations Framework Convention on Climate Change (UNFCCC, 1992), Montreal Protocol (1988), Convention on Biological Diversity (CBD,1992) and United Nations Convention to Combat Desertification (UNCCD, 1994). These MEAs are used as principal guides on environmental decisions in order to achieve rational environmental outcomes.

Environmental Management Agency (EMA) is responsible for formulation of environmental quality standards, facilitation of the preparation of national and sub-national environmental management plans, regulation, monitoring, and reviewing environmental management practices in the country. Several policies have been crafted to guide the protection of the environment. Climate change is a crosscutting issue and is being addressed independently by various sector policies. This chapter gives an analysis of climate-change related policies, programmes and measures that policy makers and practitioners should address within different sectors of Zimbabwe. Current Climate Change-related policies within various sectors that indirectly address and guide climate change decisions include:

- National Environmental Policy
- National Drought Management Policy
- Water Resources Policy and Strategy
- Agriculture Policy
- Land Reform Policy
- Wildlife-based Land Reform Policy
- Forest-based Land Reform Policy
- Energy Policy
- Transport policy
- National Disaster Management Policy
- Gender Policy, and
- Population policy.

Across sectors, there is a general need for a more integrated approach in policy formulation and implementation. The inadequacy of up-to date information on policies makes it difficult to effectively plan, manage and monitor climate change progression in Zimbabwe. This report is a result of extensive consultation through workshops with key sectors, literature review, complemented by interviews with selected key stakeholders in various sectors such as health, water and energy.

7.1.2 Environmental policy

Climate Change issues have now been included in the National Environmental Policy of Zimbabwe (2009). This has encouraged wide consultation and activities relevant to the UNFCCC. The National Environmental Policy is supported by several Acts and Instruments. Climate change is, however, not addressed as a stand-alone issue in the National Environmental Policy but is implied in activities that result in GHG emissions. Climate change issues are also addressed in environmental education and awareness modules in various school curricula.

Supporting Acts to the National Environmental Policy include:

- Environmental Management Act (Chapter 20:27)
- Forest Act (Chapter 19:05 as amended in 1999)
- Communal Lands Forest Produce Act (Chapter 20 of 1987)

- Control of Hardwood Export SI 112
- Parks and wildlife Act (Chapter 20:14).

Despite the lack of a stand-alone climate change policy, the government developed various environmental policies that address climate change issues. These policies emphasise on maintaining environmental integrity rather than climate change *per. se*. Within these policies, mitigation and adaptation measures to climate change can at best be inferred. These policies include; Environmental Impact Assessment Policy of 1997, National Environmental Education Policy and Strategies of 2003, National Fire strategy and Implementation Plan of 2006.

7.1.3 Energy Policy

The National Energy Policy (2009) plays a critical role as it provides the impetus for production and supply of energy. Energy impacts on all sectors of society and the economy and energy activities relate to both the supply and demand. Energy is crucial to economic and social development and to alleviation of poverty. Zimbabwe has abundant renewable energy sources which include solar, wind, hydro and biomass. The most widespread renewable energy source in Zimbabwe is biomass. Biomass energy encompasses energy from fuel wood, forestry and agricultural wastes (including bagasse); ethanol from sugar cane; biogas and biodiesel.

Climate Change is comprehensively addressed within the renewable energy component of the Energy Policy. It was formulated to address climate change mitigation. The policy priority is to improve the management of the biomass resources at the local level. Mini-grid solar systems have been installed in different parts of the country to complement the rural electrification programme. Solar thermal technologies have not been widely adopted in Zimbabwe although solar water heaters are installed in some households.

Barriers in the sector include lack of aggressive promotion in households and commercial market; uncoordinated research; poor back up service especially in remote rural areas; limited local experience and expertise with some technologies; resistance to new technologies by end users; high up-front costs for the promotion and adoption of the technologies; lack of awareness on available options; inadequate funding for the sub sector; and lack of expertise to adopt and adapt foreign technologies.

Policy interventions include increased usage and promotion of renewable energy as an environmentally friendly form of energy; diversification of supply options and increased access to modern energy in rural areas.

7.1.4 Agriculture Policy

The Zimbabwe Agricultural Policy Framework (ZAPF) was developed by the Ministry of Agriculture. The document gives a 25 year horizon (1995-2020) in agricultural development and policy proposals. The policy document has been guiding the ministry in implementing its various initiatives. Policy development has been piecemeal to address immediate climate change challenges.

In 2000, Ministry of Agriculture reviewed its agricultural policy, with the development of a national drought mitigation strategy and a livestock sector revival strategy. These strategies provide a basis for the development of future policies and strategies. The agriculture sector faces numerous challenges that undermine sustainable agricultural production and productivity. Key challenges are tenure insecurity, declining state institutional capacity, declining agricultural production support, limited agricultural policy incentives, declining production and information gaps.

7.1.5 Water Policy

Policy issues within the water sector are addressed in the Water Act, the Zimbabwe National Water Authority (ZINWA) Act and the Water Resources Strategy. The Zimbabwe National Water Authority is the implementing agent. Policy instruments address the following; Integrated Water Resources Management (IWRM); protection of catchments; water abstraction; dam construction and maintenance of hydrological observation stations. The government still faces a big challenge in its desire to satisfy water and irrigation demands.

7.2 Possible interventions

- Incorporate climate change in the SADC protocol on shared water course systems
- Incorporate climate change in the water policy
- Incorporate climate change in the River System Outline Plans
- Establish a closer working relationship between the ministry of water and research institutions
- Re-visit operation rules of the dams such as timing of release of water
- Promote efficient utilisation of water resources (water demand management)
- Capacity development in climate change issues in the water sector
- Construction of new hydrological stations
- Rehabilitation of the existing hydro stations
- Carry out siltation surveys.

7.2.1 Health Policy

The Health and Child Welfare Act is the principal legislation that guides human health interventions in Zimbabwe. There is also a National Health Strategic Plan which incorporates various programmes that include:

- Nutrition programmes
- Communicable and Non communicable diseases
- Water and sanitation
- Malaria Control
- HIV/AIDS programmes.

However, the strategic plan does not directly acknowledge the impacts of climate change. Thus there is need to mainstream climate change the subject within the strategic plan.

7.2.2 Science and Technology Policy

The Science and Technology Policy aims to promote national and technological self reliance by ensuring:

- rapid and sustainable industrialization
- adequate shelter and food production
- a good health delivery system
- environmentally sound development programmes
- availability and provision of sufficient energy resources
- employment creation.

Environmentally sound development technologies through the Global Navigation Satellite System (GNSS) have been brought into the country by institutions like SIRDC to monitor the rate of depletion of water in the country's inland lakes and dams. The evidence from climate change studies should influence the technology, products from research and development and the ultimate policies. On the other hand, research and development should continuously evolve with policy in order to keep in line with climate change.

7.2.3 Education Policy

Although there is Universal Access to Education policy in Zimbabwe, there has been a slow response to the incorporation of climate change in school curricula from primary to tertiary levels. There is need to revise syllabi for all education levels. There is dearth of knowledge on climate change among policy and decision makers. There is therefore need to raise climate change awareness at individual, institutional and systemic levels.

7.3 Policy interventions

It is recommended that at policy level, a National Climate Change Response Strategy be developed. The formulation of the strategy should be spearheaded by MENRM through a consultative process. In the strategy formulation process, the following aspects should be considered:-

- A clear policy formulation process should be documented and articulated and capacity building for government officials on the policy formulation, implementation and evaluation and monitoring
- The policy should have mitigation, adaptation, awareness, education and training in all the sectors of the economy
- Review and update of policy gaps
- Policy research and development
- Development of regulations and legislation
- Mainstream climate change issues in sector policies

- Incorporation of climate change in curriculum by education sector
- Coordination of policy implementation activities among ministries, departments, research institutions and other stakeholders
- Develop a funding framework (fiscus, partnerships with development partners)
- Monitoring and evaluation of the policy implementation on a time based model.

7.4 Constraints and gaps, and related financial, technical and capacity needs

7.4.1 Introduction

Zimbabwe produced the Initial National Communication in March 1998, Technology Transfer Needs Assessment in Zimbabwe and National Self Capacity Assessment for climate change, biodiversity and land degradation in Zimbabwe between 2005 and 2008. These documents highlighted a number of challenges, most of which are yet to be addressed. This chapter highlights constraints and gaps and related financial, technical and capacity needs for implementing measures under the Climate Change Convention and for improving climate change reporting on a continuous basis. The chapter also highlights ways of addressing these challenges so that the country will be able to effectively execute the requirements of the convention. The methodology of chapter preparation was through an aggregation of information from previous studies and reports, as well as contribution by consultants who prepared the Second National Communication. Participants from various thematic areas and some key stakeholders also contributed to the contents of this section of the report at various workshops. The gaps, constraints and needs highlighted below are related to reporting and implementation of climate change initiatives in Zimbabwe.

7.4.2 General gaps, constraints and needs

7.4.2.1 Lack of awareness and limited climate change knowledge

According to the Zimbabwe NCSA (2008), only 18% of survey respondents ranked their level of awareness on climate change to be high while 42% ranked theirs to be very low. The statistics show that the level of awareness is still low in Zimbabwe. This limited awareness affects climate change reporting and implementation of related initiatives. These effects include lack of appreciation resulting in failure by stakeholders to provide appropriate information making it difficult to implement climate change initiatives.

Increasing awareness among key stakeholders, decision-makers from various institutions and the general public about the value of GHG inventory process, assessment and other climate change related activities would in increasing appreciation of the importance of climate change related information. This, will in turn, facilitate the exchange of information and data between the various institutions and stakeholders thereby contributing to the sustainability of all climate change related processes and initiatives.

To raise the level of awareness in Zimbabwe the following are proposed:

- Preparation of appropriate awareness material for all different levels of stakeholders. These levels range from primary school children, academics, politicians, as well as rural communities
- Education, Training and Public Awareness to enhance understanding of the subject and increase knowledge base that will be essential for the practical implementation of climate change initiatives
- Hold targeted awareness workshops. For example for policy makers/ legislators, industry, line ministries, local leaders and local governments and any other relevant stakeholders. This will enable stakeholders to incorporate climate change concerns at various levels.
- Establish a national climate change forum to share and discuss climate change issues.

7.4.2.2 Information and data gaps

Data gaps have become a major issue for inventory preparation in many countries and many of them are still faced with these challenges. All climate change reports, decisions and projects are based on available data and information. The quality of the reports is determined by the accuracy of data and information used. For Zimbabwe, there is a general consensus that there is inadequate data for enabling climate change related decisions and preparing climate change reports with regards to mitigation and adaptation. This was highlighted as the major challenge faced by Second National Communication consultants during preparation of this report.

In some instances, data was unavailable at all, inadequate or outdated. In addition, some institutions were reluctant to release the data to the consultants while others charged exorbitant rates for accessing the data. Inadequate data can be attributed mainly to limited capacity (technical and financial) by key institutions mandated to record or collect data. Loss of information from previous initiatives is also a challenge that needs to be addressed. This could be attributed to poor documentation, lack of proper databases or management systems for archiving data.

Proposed solutions to address data and information gaps include:

- supporting and commissioning climate change related studies to generate e.g. community and sector specific vulnerability assessments
- establishing mechanisms to continuously record required data and developing a well managed climate change database.
- creating a web based information sharing platform to allow easy access to climate change data and information.

7.4.2.3 Technical capacity limitations

GHG inventory and other climate change studies and initiatives in the country are constrained by lack of technical capacity and expertise. For Zimbabwe technical capacity limitations include; limited number of experienced consultants, limited human resources with requisite climate change expertise in the Climate Change Office, limited capacity for line organization to provide sector input (Energy, Agriculture, Water etc) and limited technical expertise to implement technology based climate change projects.

In order to address these technical capacity constraints the following are proposed;

- Training personnel of line organizations such as Ministries of Energy, Agriculture, Industry and other relevant organizations such as Central Statistical Office (CSO) and Environmental Management Agency (EMA) to record information necessary for climate change reporting and project implementation
- Expand the Climate Change Office to ensure that there are enough personnel to deal with climate change issues and give climate change guidance to all stakeholders at any given time
- Train more consultants on climate change reporting and formulation of climate change proposals.

7.4.2.4 Methodological constraints

Limited understanding of applying complex UNFCCC methodologies used in emission estimation amongst other climate change related studies is a challenge being faced by the country in trying to meet the convention's reporting requirements. In some cases local available information is not compatible with the complex formulas involved. In trying to benefit from funding opportunities such as GEF and mechanisms such as CDM most countries are finding it difficult to benefit due to the complexity of the methodologies that are involved in proposal formulations. Training of experts on specific methodologies e.g. GHG emission reduction methodologies may enable the country to adequately report to UNFCCC.

7.4.2.5 Research and systematic observations capacity limitations

Climate change decisions are usually based on facts and figures through real time or recorded data. There is therefore need to provide a sound and scientific basis for national climate change decisions based on accurate and high quality data. As such high quality systematic observations of the global environmental system are essential for understanding and evaluating the earth's system. In Zimbabwe, systematic observations are mainly meteorological, hydrological and to some extent, agricultural. Some of the systems are ageing and in some cases non-functional thus compromising on data quality and availability. There is also a general lack of interest and limited support for climate change research. There is now a serious shortage and limited coverage for systematic observations due to shortage of equipment.

Proposed solutions:

- Enhance observations through investment into recent technologies as well as Data Management Systems. These will make it possible to generate a comprehensive set of variables needed for many climate related research
- Use of automated stations.

7.4.2.6 Technological constraints

Many climate change adaptation and mitigation initiatives are technology based. For example renewable energy solutions are all new technologies which were not common in the past. These technologies are imported from the developed world where they are being developed. This poses a challenge on availability and suitability. These technologies need to be adapted to local conditions and local community needs so that they are appropriate. This has been a challenge for developing countries as there is also a lack of technical expertise to adapt these technologies, hence their failure. The other technology related constraint is the high cost of these technologies. The technologies can work for communities but their prize is far beyond the reach of ordinary citizens in developing countries. For example an electric geyser in Zimbabwe costs an average of US$500 while a solar water heater costs around US$1800.

Proposed solutions to technological constraints

- There is need for technical capacity training for local technological institutions on technology adaptation and development. Partnerships can be forged between local institutions and international technology developers so as to produce appropriate technologies. Local production will certainly reduce costs.
- There is also need for deliberate policies and financial incentives to ensure that the use of these technologies is favourable. Such incentives include duty free rebates as well as tax concessions.

7.4.2.7 Financial constraints

Finances have been highlighted as key to successful reporting and implementation of the UNFCCC's obligations. Finances are required for awareness raising and information dissemination, capacity building and training for individuals and institutions, establishment of data bases, data collection and validating and equipment acquisition especially for research and systematic observations.

Proposed mitigation and adaptation initiatives require funding for successful implementation e.g. renewable energy technologies. Further assessments would also require funding as this will provide accurate information to enable informed climate change related decisions and interventions. There might be need for lobbying central government to allocate funds to directly support climate change initiative. Adequate funds to undertake climate change related initiatives such as data generation and public awareness should be made available. Where these funds are provided there is need to ensure accessibility and timely disbursements to ensure that activities are executed in time. Each thematic area covered in this communication needs to provide details of their funding requirements.

7.4.3 Sector specific constraints for urgent interventions

During the second national communication reporting process a number of constraints or challenges were identified in different sectors in relation to preparation of reports and implementation of climate change initiatives. Below are details of critical sector specific challenges and their proposed solutions.

7.4.3.1 GHG inventories

Critical constraints in preparation of the GHG inventories for National Communications are the limited expertise, data availability and the absence of a functional National Energy Information System. This has made preparation of reports and analysis of GHG emissions difficult due to lack of primary data on emission sources from the energy sector.

7.4.3.1.1 Solution

Capacity building for GHG inventory compilers is urgently required. Resuscitation of the whole energy information system within the Ministry of Energy and Power Development. This includes procurement of computer hardware and software and training of personnel to manage the system. The system is meant to contain all energy related data and will be made accessible for climate change related business.

7.4.3.2 Vulnerability and Adaptation

The major constrain in reporting vulnerability and adaptation is limited access to and non availability of data for comprehensive analysis of vulnerabilities. Specific limitations were on assessing community level adaptive capacities, long term forest plot data and dam levels as well as water abstraction data. On implementing adaptation initiatives, financial limitation has been cited as the major challenge.

Proposed solutions

- Conduct relevant evidence based vulnerability and adaptation assessments for various key sectors such: Agriculture, Water and Forestry.
- Consolidation of Agricultural coping strategies developed in the country and building on successful strategies at national level is recommended.

7.4.3.3 Mitigation

Greatest potential to climate change mitigation in Zimbabwe lies within the energy and waste sectors. Mitigation projects are mostly technology based and limited access to technology for Renewable energy and energy efficiency systems has been identified as a constraint hampering mitigation efforts.

Proposed solution

To overcome this major limitation it is proposed that the country establish a national facility to access new technologies. This facility will promote technology supply, adoption, development, and funding as well as backup services.

7.4.3.4 Research and systematic Observation

The two major challenges in Zimbabwe in this area relate to limited data access for research and coverage for systematic observation systems to generate real time data on a continuous basis.

Proposed solution

- Establishing a national data or information portal/ management system of related climate change information that can be accessible to researchers and project implementers
- Installation of modern automated weather stations.

7.4.3.5 Education, training and awareness

The two major limitations to the sector include limited dialogue on climate change initiatives and lack of a national situational analysis of the levels of awareness to provide a basis for raising awareness.

Proposed solutions

- Establish national climate change forums where organizations and individuals can discuss climate initiatives at national and local levels
- Conduct a national situational analysis on awareness in order to prepare the relevant awareness material.

7.5 Financial Needs

7.5.1 National Communication financial Constraints

With regards to reporting, financial limitation has been highlighted as key by the national consultants. The funds allocated to each section of reporting were not sufficient to ensure national coverage in terms of consultations and data collection. The level of funding determines the quality and commitment of consultants. The workload was not commensurate with the financial benefit compared to other consultancy work in other disciplines. This has a bearing on the quality of the report to a great extent. For project implementation, access to funding mechanisms such as CDM and GEF remains a challenge for Zimbabwe. Capacity to develop climate change related proposals for funding is very low.

Proposed Solutions

- There is need to increase consultancy fees for national reporting to attract high quality consultants
- Conduct training on GEF proposal writing and on accessing UNFCCC funds such as Adaptation fund and other available climate change funds.

7.5.2 Project Management Team

With regards to reporting, the management team highlighted,

- Inadequacy of computer and communication facilities to effectively execute the reporting process
- Untimely disbursement of funds from UNEP is affecting reporting timelines and contracting
- With regards to implementation of climate change initiatives, the current institutional arrangement of the climate change sector, in Zimbabwe, is limiting the execution of initiatives. For example the climate change office in Zimbabwe is manned by two individuals who are expected to manage national communications, mitigation, adaptation, negotiations and any other initiatives such as awareness and CDM. This presents a challenge for the office that has limited personnel without a vehicle and poor internet connectivity while the office is also not well funded.

Proposed solutions

- There is need to set up appropriate consultants teams for each reporting section and build their capacity before they are engaged, to give proper guidance on the work that is required.
- There is need to expand the climate change office staffing and ensure that the office is well funded.
- There is also need to provide basic office and communication facilities including vehicles and internet facilities.

In conclusion, by addressing the identified policy, constraints and gaps will ensure that Zimbabwe has a solid foundation to move the climate change agenda forward.

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LIST OF CHEMICAL SYMBOLS, UNITS AND CURRENCY

CHEMICAL SYMBOLS

CO_2	Carbon Dioxide
CH_4	Methane
NO_x	Nitrogen Oxides
CO	Carbon Monoxide
H_2O	Water Vapour
N_2O	Nitrous Oxide
O_3	Ozone
NMVOCs	Non-methane Volatile Organic Compounds
CFCs	Chlorofluorocarbons

UNITS

kg	Kilogrammes
km	Kilometres
mm	millimetre
ha	Hectares
t	Tonnes
dm	Dry matter
KW	Kilowatts
MW	Megawatts
m^3	Cubic metres
Gg	Gigagrams
PJ	PetaJoule

CURRENCY Z$ **Zimbabwe Dollar**

ANNEX 1

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