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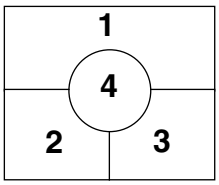
Cover shows: Lake Malawi in the background and back insert, and

**1.** Mt. Mulanje
**2.** Nyala antelopes
**3.** Savanna bushfires
**4.** Agricultural produce



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REPUBLIC OF MALAWI

# PREFACE

The Republic of Malawi signed the United Nations Framework Convention on Climate Change (UNFCCC) in June 1992 at Rio de Janeiro, Brazil, during the United Nations Conference on Environment and Development (UNCED). This demonstrated Malawi's solidarity with the International Community against the global threat of Climate Change. Furthermore, Malawi ratified the UNFCCC on 21st April 1994 and became a Party to the Convention showing the Country's total commitment to addressing the climate change issues nationally and globally through co-operation.

The ultimate objective of the UNFCCC is *"…stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system …."*

Malawi has not been spared from the adverse impacts of weather and climate as evidenced by recent floods and drought. These extreme climatic events cause loss of life, damage property and infrastructure, affect food security and hinder efforts in poverty eradication.

It is pleasing to note that the UNFCCC recognises that socio-economic development and poverty eradication are overriding priorities of developing countries.

Malawi wishes to acknowledge the external financial and technical assistance received for the preparation of this Initial National Communication, which outlines the country's actions undertaken and envisaged plans to the Conference of Parties (COP) of the UNFCCC.

Malawi is submitting this Initial National Communication in fulfilment of her commitment as a Party to the UNFCCC.

**Dr. Bakili Muluzi**
**PRESIDENT**

REPUBLIC OF MALAWI

# FOREWORD

The loss of life and extensive damage to socio-economic structures caused by recent extreme climatic events in Malawi, such as droughts and floods resulting from the El-Nino/ Southern Oscillations (ESNO) phenomenon, provide strong evidence for the global importance of climate change.

Malawi, a landlocked and Least Developed Country, heavily dependent on agriculture, is very vulnerable to the adverse impacts of climate change because it is affected seasonally by natural disasters. Moreover, the country has limited capacity to undertake either adaptive or mitigative measures, hence climate change has exacerbated the poverty of the people of Malawi. Fortunately, the UNFCCC recognises that *"...economic and social development and poverty eradication are first and overriding priorities of developing countries..."*.

The UNFCCC entered into force globally on 21st March 1994, while Malawi ratified it in April 1994 and became a Party on 21st July 1994. The Initial National Communication of Malawi is our commitment to the UNFCCC and also our contribution to global efforts to address the climate change problem. This is in line with the National Sustainable Development Agenda of poverty reduction as outlined in the Malawi Poverty Reduction Strategy Paper (MPRSP). The preparation of the Initial National Communication has assisted in building capacity in climate change issues and producing a database for formulating and implementing sustainable policies and programmes for development. The communication has covered the mandatory Inventory of Greenhouse Gases (GHG), Vulnerability and Adaptation (V&A) and Mitigation Analysis, although the latter is not mandatory on Malawi as a Least Developed Country (LDC).

I trust that Initial Communication has elaborated Malawi's needs in the field of climate change to ably mobilise the financial and technical support so as to ensure sustainable development of the country. I wish to express my profound gratitude, and that of the people and the Government of Malawi, to all those who have contributed in various ways, in the production of this Initial National Communication of Malawi, more especially to the Global Environmental Facility (GEF), the United Nations Development Programme (UNDP), the United States Country Study Programme (USCSP), and not least, the National Communications Support Programme (NCSP) for financial and technical support.

I am pleased, to present, on behalf of the people of Malawi, the Initial National Communication of the Republic of Malawi, to the UNFCCC Secretariat for onward transmission to the Conference of the Parties.

**Uladi B. Mussa**
**MINISTER OF NATURAL RESOURCES AND ENVIRONMENTAL AFFAIRS**

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The Environmental Affairs Department in the Ministry of Natural Resource and Environmental Affairs wishes to acknowledge the assistance received from institutions and individuals in preparing and finalising the Initial National Communication of Malawi, namely:

- UNDP/ GEF for providing financial support;
- The UNFCCC Secretariat for providing information and guidelines, and arranging for useful and relevant workshops;
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- The National Climate Change Project Steering Committee, Chairman and Members for their contributions;
- The National Council on the Environment (NCE) and Technical Committee for the Environment (TCE) for their useful comments on the draft document;

Thanks to all national institutions, government departments, private sector and the University of Malawi for the provision of expertise and data inputs which contributed significantly to the finalisation of the document.

Finally, the Environmental Affairs Department would like to acknowledge the untiring efforts of the Editorial Committee, the Project Manager, the National Expert and EAD secretarial staff for drafting and finalising the Initial National Communication of Malawi.

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# ACRONYMS AND ABBREVIATIONS

| | | |
|---|---|---|
| ADD | : | Agricultural Development Division |
| AGDP | : | Agricultural Gross Domestic Products |
| AIDS | : | Acquired Immune Deficiency Syndrome |
| ALDSP | : | Agriculture and Livestock Development Strategy Plan |
| APRU | : | Agricultural Policy Research Unit |
| ARET | : | Agricultural Research and Extension Trust |
| ASAP | : | Agricultural Sector Assistance Programme |
| AWS | : | Automatic Weather Station |
| AvGas | : | Aviation Gas |
| BNF | : | Biological Nitrogen Fixation |
| BOC | : | British Oxygen Company |
| BOD | : | Biochemical Oxygen Demand |
| $C_{12}H_{22}O_{11}$ | : | Mollasses |
| $C_6H_{12}O_6$ | : | Glucose |
| CAB | : | Congo Air Boundary |
| $CaCO_3$ | : | Calcium carbonate, (limestone) |
| CaO | : | Calcium oxide, (lime) |
| CFC | : | Chlorofluorocarbons |
| CCCMI – TR | : | Canadian Climate Centre for Modelling and Analysis 1– Transient |
| $CH_3CH_2OH$ | : | Ethanol |
| $CH_4$ | : | Methane |
| CO | : | Carbon monoxide |
| $CO_2$ | : | Carbon dioxide |
| COMAP | : | Comprehensive Mitigation Analysis Process |
| COMESA | : | Common Market for Eastern Southern Africa |
| COP | : | Conference of Parties |
| CPL | : | Coal Products Limited |
| CSIRO-TR | : | Commonwealth Scientific and Industrial Research Organisation, Transient ( Australia, 1999) |
| CSR | : | Centre for Social Research |
| DAHI | : | Department of Animal Health and Industry |
| DANIDA | : | Danish International Development Agency |
| DARTS | : | Department of Agricultural Research and Technical Services |
| DEAP | : | District Environmental Action Plan |
| DM | : | Dry matter |
| DOC | : | Degradable Organic Carbon |
| DoE | : | Department of Energy |
| DoM | : | Department of Mines |
| DSM | : | Demand Side Management |
| EAD | : | Environmental Affairs Department |
| ECHAM 4 | : | European Centre/Hamburg Model 4 Transient ( Germany1996) |
| EIA | : | Environmental Impact Assessment |

| | | |
|---|---|---|
| ENSO | : | El Nino/Southern Oscillation |
| ESCOM | : | Electricity Supply Corporation of Malawi |
| FAO | : | Food and Agricultural Organization |
| FEWS | : | Farming and Early Warning System |
| FINNESE | : | Financing Energy Services for Small Scale Energy Users |
| FRIM | : | Forestry Research Institute of Malawi |
| GAP | : | Guide to Agricultural Production |
| GAW | : | Global Atmospheric Watch |
| GCOS | : | Global Climate Observing System |
| GCOS-N | : | Global Climate Observing System, Network |
| GDP | : | Gross Domestic Product |
| Gg | : | Gigagrams |
| GHG | : | Greenhouse Gases |
| GIS | : | Geographical Information System |
| GSN | : | Global Surface Network |
| GTS | : | Global Telecommunication System |
| GTZ | : | Germany Agency for Technical Development |
| GUAN | : | Global Upper Air Network |
| GWH | : | Giga Watt Hour |
| GWP | : | Global Warming Potential |
| $H_2O$ | : | Water |
| Ha | : | Hectare |
| Had CM2 | : | Hadley Centre Unified Model 2 Transient Ensemble Mod(1996) UK |
| HEP | : | Hydroelectric Power |
| HFC | : | Hydroflourocarbons |
| HH | : | Household |
| HIV | : | Human immuno-deficiency Virus |
| HSI | : | Habitat Suitability Index |
| IBSNAT | : | International Bench Mark Sites Network for Agro technology |
| IPCC | : | International Panel on Climate Change |
| ITCZ | : | Inter tropical Convergence Zone |
| JICA | : | Japanese International Co-operation Agency |
| LDC | : | Least Developed Country |
| LEAP | : | Long Range Energy Alternative Planning |
| LPG | : | Liquefied Petroleum Gas |
| LUCF | : | Land Use Change and Forestry |
| MACRO | : | Malawi Aids Counselling and Resource Organisation |
| MAGICC | : | Model for the Assessment of Greenhouse Gas Induced Climate Change |
| MASAF | : | Malawi Social Action Fund |
| MD/MET | : | Meteorological Department |
| METEOSAT | : | Meteorological Observing Satellite |
| MIRTDC | : | Malawi Industrial Research and Technology Development Centre |
| MMCT | : | Mulanje Mountain Conservation Trust |

| | | |
|---|---|---|
| MNLDMP | : | Malawi National Livestock Development Master Plan |
| MoAI | : | Ministry of Agriculture and Irrigation |
| MoNREA | : | Ministry of Natural Resources and Environmental Affairs |
| MSW | : | Municipal Solid Waste |
| MW | : | Mega Watt |
| $N_2$ | : | Nitrogen |
| $N_2O$ | : | Nitrous Oxide |
| NAREC | : | Natural Resources and Environment Centre |
| NCCC | : | National Council on Climate Change |
| NCE | : | National Committee on the Environment |
| NCSP | : | National Communications Support Programme |
| NEAP | : | National Environmental Action Plan |
| NHBGM | : | National Herbarium and Botanical Gardens of Malawi |
| NMVOC | : | Non-Methane Volatile Organic Compounds |
| $NO_x$ | : | Oxides of Nitrogen |
| NRA | : | National Roads Authority |
| NRCM | : | National Research Council of Malawi |
| NSO | : | National Statistical Office |
| NSREP | : | National Sustainable Renewable Energy Programme |
| $O_2$ | : | Oxygen |
| $O_3$ | : | Ozone |
| OECD | : | Organisation for Economic Cooperation and Development |
| OILCOM | : | Oil Company of Malawi |
| PCC | : | Petroleum Control Commission |
| PFC | : | Perflourinated Compounds |
| PROBEC | : | Programme on Biomass Energy Conservation |
| PRSP | : | Poverty Reduction Strategy Paper |
| R & D | : | Research and Development |
| RETS | : | Renewable Energy Technologies |
| RTH | : | Regional Telecommunication Hub |
| S&T | : | Science and Technology |
| SADC | : | Southern African Development Community |
| SCENGEN | : | Scenario Generator |
| SDNP | : | Sustainable Development Network Programme |
| SE'ly | : | South Easterly |
| SL | : | Sustainable Livelihood |
| SPGRC | : | SADC Plant Genetic Resources Centre) |
| t | : | Tonne (metric) |
| TCE | : | Technical Committee on the Environment |
| TRF | : | Tea Research Foundation |
| TRIM | : | Tobacco Research Institute of Malawi |
| UN | : | United Nations |
| UNDP | : | United Nations Development Programme |
| UNEP | : | United Nations Environment Programme |
| UNFCCC | : | United Nations Framework Convention on Climate Change |

| | | |
|---|---|---|
| CRSP | : | Collaborative Research Support Project |
| USAID | : | United State Agency for International Development |
| USCSP | : | United States Country Support Programme |
| V&A | : | Vulnerability and Adaptation |
| Watbal | : | Water Balance Model |
| WB | : | World Bank |
| WMO | : | World Meteorological Organisation |
| WWM | : | Waste Water Management |
| PV | : | Photo voltaic |

# EXECUTIVE SUMMARY

## Introduction

This is the Initial National Communication of Malawi prepared in fulfilment of her commitments under the United Nations Framework Convention on Climate Change (UNFCCC). Malawi signed the UNFCCC in Rio de Janeiro, Brazil in June 1992 during the United Nations Conference on Environment and Development (UNCED). The UNFCCC was subsequently ratified on 21st April 1994 making Malawi a Party to the Convention. The ultimate objective of the Convention is to achieve *" … stabilization of greenhouse gas concentrations, in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."*

As a party to the Convention Malawi is obliged under the Article 4.1 (a) to "Develop, periodically update, publish and make available to the Conference of the Parties in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol using comparable methodologies agreed upon by the Conference of the Parties." Malawi, like all other parties to the UNFCCC, acknowledges the potential risks and threats posed by climate change, in relation to already existing environmental and climatic problems. The UNFCCC in Article 4.7 recognises that "The extent to which developing country Parties will effectively implement their commitments under the Convention…and will take fully into account that economic and social development and poverty eradication are first and overriding priorities of the developing country Parties…".

The preparation of the Initial National Communication is the first step in the actual implementation of the UNFCCC. As a Least Developed Country (LDC), Malawi lacks the financial and technical resources to implement the UNFCCC. The United States Country Studies Program (USCSP) provided the first financial support in 1994 for a project entitled "Malawi Climate Change Study" which covered Greenhouse Gas (GHG) Inventory based on year 1990 and Vulnerability and Adaptation (V&A) Assessments.

The Global Environmental Facility (GEF) through the United Nations Development Programme (UNDP) further assisted Malawi to implement a project MLW/96/G31 entitled " Enable Malawi to prepare its Initial National Communication in Response to its Commitment to the UNFCCC." The development objective of the project was to build capacity and facilitate the process of taking climate related issues into account in Malawi, thus increasing the capacity of the country to deal with climate change and its adverse effects.

The project planned to undertake the following studies:
1. Inventory of greenhouse gases following the guidelines adopted by the Conference of the Parties (CoP);
2. An assessment of potential impacts of climate change in Malawi;
3. An analysis of potential measures to adapt to climate change and to abate the increase in greenhouse gas emissions in Malawi.
4. Preparation of a national action plan to address climate change and its adverse impacts; and
5. Preparation of the Initial National Communication of Malawi for submission to the CoP.

The Environmental Affairs Department (EAD), in conjunction with the Meteorological Department and other key institutions, coordinated the activities of the project. National teams were formed to undertake various studies in the Inventory of Greenhouse Gas Emissions, Vulnerability and Adaptation (V&A) Assessment, and Mitigation/Abatement Analysis and also in the compilation of the Initial National Communication.

The Initial National Communication comprises eight chapters as follows:

1. National Circumstances;
2. Greenhouse Gas (GHG) Inventory;
3. Vulnerability and Adaptation (V&A) Assessment;
4. Climate Change Mitigation Abatement Analysis;
5. Research and Systematic Observation;
6. Education, Training and Public Awareness;
7. Sustainable Development and Climate Change; and
8. Proposed Climate Change Projects.

## UNFCCC Implementation

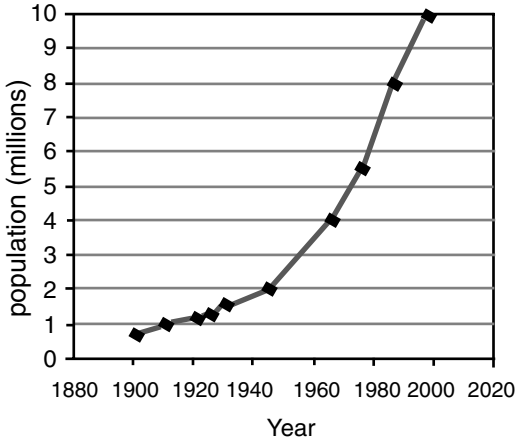
In spite of low national capacities, Malawi has undertaken measures to implement the UNFCCC. In 1994 Malawi finalised the National Environment Action Plan (NEAP), which outlines measures and priorities to promote sustainable use of the environment. Furthermore the following strategic measures are now in place:

1. A legal framework (Environment Management Act, 1996) for environmental management;
2. An Environmental Policy (1996);
3. Environmental Impact Assessment (EIAs) guidelines and procedures for development activities/projects; and
4. Mainstreaming of environmental education and conservation in institutions.

## National Circumstances

### *Location and Population*

Malawi lies between 09°25' and 17°08' latitude South and 32°40' and 34°55' longitude East and covers 11.8 million hectares, of which 9.4 million hectares is land, while the rest is composed of water bodies dominated by Lake Malawi. Of the total land area 31% is suitable for rain-fed agriculture, 32% is marginal and 37% is unsuitable for agriculture. The population of Malawi was estimated at 9.9 million in 1998 with a growth rate of about 2%. About 85% of the population is based in rural areas. Women form 51% of the population. The overall life expectancy in the country is low and was estimated at 40 years ( based on 1998 census).




**Total Population 1901-1998 Censuses**

**Source: National Statistical Office (2000): 1998 Malawi Population and Housing Census**

### *Economy*

The economy is based on agriculture which contributes 35-40% of the country's Gross Domestic Product (GDP) and involves more than 80% of the total labour force. Furthermore, agriculture accounts for 90% of the total export earnings and 60-70% of the inputs to the manufacturing sector and also dominates the commercial and distribution sectors. The economy is thus heavily overburdened and vulnerable not only from its dependence on rain-fed agriculture but also from the fact that Malawi is landlocked with high transportation costs. Hence the country had a per capita income of only US$ 125 in 1994. The external debt as percentage of GDP in 1994 was 265.1% and decreased to 106.9% in 1996 but increased to 129.4% (Reserve Bank of Malawi, 1999 as cited by UNDP, 2001b).

### *Climate*

The annual rainfall ranges from 600-2000 mm and its spatial and temporal distribution is greatly influenced by the heterogeneous topography and Lake Malawi. Residual tropical cyclones that occasionally reach Malawi from the Indian Ocean cause heavy rainfall and damaging floods especially in the southern parts of the country.

The temperature regime is tropical continental and is greatly modified also in its spatial and temporal distribution by the highlands and Lake Malawi. The country's latitudinal position exposes it to the influence of extra-tropical systems that move eastwards around the Southern African coast. Hence in winter (May-August) cool/cold moist air influx from the southern latitudes reaches the country and periodically cause ground and air frost.

### *Natural Disasters*

Natural disasters occur more especially in the rainy season (October-April). Such disasters include drought, floods, landslides, pests and disease outbreaks. Tornado type wind systems occur frequently and cause structural damages to buildings. The country experiences earth tremors/earth quakes; the severest tremor attained 6.7 on the Richter Scale in March 1989,and caused loss of life and extensive structural damage to buildings and other infrastructure. The natural disasters hinder socio-economic developmental efforts because agriculture, which is mainly subsistence, is adversely affected. The country has a low capacity to either adapt or mitigate the impacts of these extreme climatic events.

### *Natural Resources*

Malawi is endowed with diverse of natural resources that support its development aspirations and initiatives. The resources include water, forests, fisheries, wildlife, air, land and human resources. These resources are presently undergoing stresses due to increased human and animal populations, globalisation, and environmental degradation and climate change.

### *Energy*

The indigenous forests are the major source of biomass energy, which accounts for 95% of the energy requirements. The balance of the energy mix includes fossil fuels and hydroelectricity that contribute 4% and 3% respectively.

Other renewable energy sources are solar, biogas, wind, and micro/mini hydropower all of which are relatively under utilised.

### *Transport*

The principal transport modes in Malawi are road, rail, air and water. These modes are all vulnerable to adverse weather and climate variations. The road transport mode is the most commonly used for domestic and regional freight as well as passenger services. However, there is only 2600 km of bituminised roads (17%) out of 15300 km of road infrastructure available in the country. Transportation costs for imports and exports of goods are very high because Malawi is landlocked.

### *Health*

The health services in Malawi experience a number of constraints such as high patient to doctor ratio, inadequate infrastructures, prevalence of serious communicable diseases and lack of resources to purchase the necessary medicines. Malaria and HIV/AIDS are affecting the most productive age group thereby negatively impacting the economic productivity of the nation. Projects and programmes are being implemented to address and minimise adverse effects of the constraints.

### *Gender*

Women form 51% of the population and are actively involved in the productive sector of the economy. However their contributions have not fully been recognised. Gender mainstreaming is being promoted to empower women and other vulnerable groups in economic, social and cultural sectors.

### *Poverty*

Poverty is widespread and growing with 65% of the population living in poverty. The government is developing, through a consultative and participatory process, the Poverty Reduction Strategy Paper (PRSP). The PRSP will be the roadmap for all government development activities and the guiding framework for Government's developing partners. Government is also improving its ability to assess and monitor poverty through various sectors.

### *Greenhouse Gas (GHG) Inventory*

Two national GHG inventories, based on the years 1990 and 1994 were undertaken to meet Malawi's obligations under Article 4.1(a) of the United Nations Framework Convention on Climate Change (UNFCCC). The US Country Studies Program supported the first GHG inventory, which was based on the year 1990.

The study covered the Energy, Industrial Processes, Agriculture, Land Use Change and Forestry and Waste Management Sectors. The Global Environment Facility (GEF) provided funding for the current GHG inventory based on 1994.

### *GHG Inventory Results*

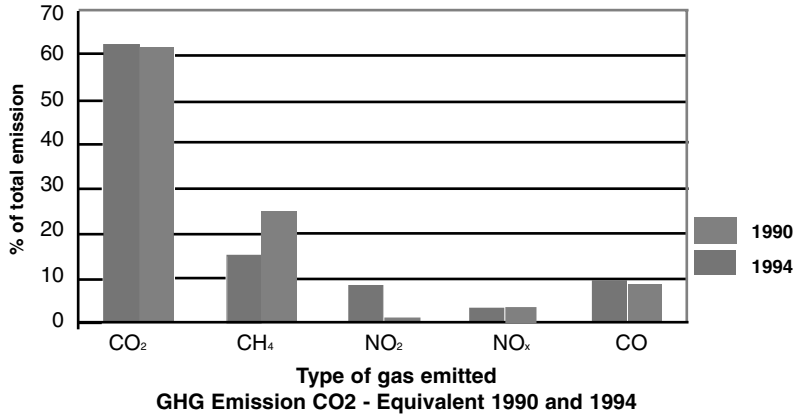
Based on both 1994 and 1990 GHG inventories, Malawi is a net emitter of CO2. The greatest contribution of emissions arises from the Land Use Change and Forestry (LUCF) sector, followed by the Energy sector. The tables below show the summary of sectoral emissions for 1990 and 1994. The observed increase in sink capacity may be attributed to improved methodology and activity data for the 1994 inventory compared to 1990.

## Summary Report of National Greenhouse Gas Inventory for 1994 (Gg)

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ Emissions | $CO_2$ Removals | $CH_4$ | $N_2O$ | $NO_x$ | CO |
|---|---|---|---|---|---|---|
| **Total National Emissions and Removals** | **19247.28** | **-1016.00** | **187.90** | **7.77** | **26.31** | **951.80** |
| 1. Energy - | | | | | | |
| - Reference Approach | **660.88** | **0.00** | **135.09** | **0.71** | **24.03** | **879.58** |
| 2. Industrial Processes | **58.38** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| 3. Agriculture | **0.00** | **0.00** | **48.50** | **7.05** | **2.24** | **72.20** |
| 4. Land Use Change and Forestry | **18528.02** | **-1016** | **0.02** | **0.018** | **0.04** | **0.020** |
| 5. Waste Management | **0.00** | **0.00** | **4.29** | **0.00** | **0.00** | **0.00** |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ Emissions | $CO_2$ Removals | $CH_4$ | $N_2O$ | $NO_x$ | CO |
|---|---|---|---|---|---|---|
| **Total National Emissions and Removals** | **21869.54** | **-1320.81** | **336.26** | **1.09** | **28.92** | **934.23** |
| 1. Energy - | | | | | | |
| - Reference Approach | **619.13** | **0.00** | **276.23** | **0.72** | **27.12** | **895.95** |
| 2. Industrial Processes | **50.12** | **0.00** | **4.02** | **0.00** | **0.00** | **0.00** |
| 3. Agriculture | **0.00** | **0.00** | **50.83** | **0.36** | **1.58** | **30.78** |
| 4. Land Use Change and Forestry | **21200.30** | **-1320.81** | **0.86** | **0.010** | **0.21** | **7.50** |
| 5. Waste Management | **0.00** | **0.00** | **4.33** | **0.00** | **0.00** | **0.00** |

The figure below shows the percentage total gas emissions expressed as $CO_2$ equivalent. $CO_2$ accounts for 60% of the total emissions in both years.




**GHG Emission CO2 - Equivalent 1990 and 1994**

### *GHG Inventory Constraints*

The International Panel on Climate Change (IPCC) 1996 Revised Guidelines provided useful guidance materials for the preparation of the sectoral GHG inventories. However, the lack of relevant data affected the final output. Malawi needs to undertake some measures to improve future GHG inventories such as:

1. Improve the quality and quantity of activity data from the various sources in the country;
2. Improve the collection of annual production and consumption data such as firewood, charcoal and agricultural residues;
3. Produce national energy balance sheets relevant to GHG-inventory;
4. Develop management information systems suitable for GHG inventory bottom-up approach for vehicles; and
5. Develop local emission factors for national and regional use.

## Vulnerability and Adaptation (V&A) Assessment

Global circulation models (GCMs) were used to project temperature and rainfall for the years 2020, 2075 and 2100. The socio-economic sectors addressed were Water, Agriculture, Forestry, Fisheries and Wildlife. The main constraints in V&A assessments were lack of quality of activity data, and methodological limitations in the use and the operation of the GCMs and specific sector models. Future studies,should include the Human Health, Energy, and Transport sectors should be undertaken as well as training to strengthen local human capacity.

### *Climate Change Scenarios*

The development of climate change scenarios for Malawi faced constraints of low capacity and lack of operational skills to deal with the relevant Global Circulation Models (GCMs). The projected temperatures show an increase of 1-3$^{0}$C. Rainfall showed mixed patterns; some areas will become wetter while others will get drier.

### *Water Resources*

Malawi's water resources comprise surface and ground waters. The surface water resources consist of a network of river systems such as Shire, Ruo, Bua, Rukuru, and Songwe and lakes such as Malawi, Chilwa, Chiuta and Malombe. The lakes and river systems cover up to 20% of the total surface area. Lake Malawi, the third largest in Africa, stocks large quantities of surface water resource. However, all lakes, including Lake Malawi, were omitted from the assessment because of lack of activity data and methodologies but will be included in future studies.

The ground water resources are from two major aquifers, namely extensive but relatively low yielding Precambrian weathered basement complex aquifer and a high yielding quaternary alluvial deposits along the Lake Malawi shore plains and also the Lower Shire Valley. In the study, only three representative basins were selected namely Rukuru, Bua and Linthipe.

The General Climate Models were utilised to develop scenarios of future climate change in the years 2020, 2075 and 2100. River-discharges were simulated by a Water Balance Model using the generated outputs from climate scenarios of temperature and precipitation for the years 2020, 2075 and 2100. The main findings and limitations of the study are as follows:

1. Temperatures in the basins are projected to increase by 1-3$^{0}$C and rainfall may increase by 5 to 22% or decrease by 1 to 16% depending on model and location.

2. Runoff in each basin is projected to decline more especially in the Linthipe Basin.
3. The amount of water available in each river basin is higher than the amount demanded for irrigation and domestic consumption.

The study had a number of constraints due to lack of data that resulted in inability to assess water demand for the industrial sector and poor projections of human population in the basins.

***Fisheries***

The surface water bodies of lakes Malawi, Malombe, Chiuta and Chilwa and major river systems were included in this assessment to study the vulnerability of fish to climate change. In addition, the effect of climate change on the aquaculture system has been assessed. Lake Malawi has an estimated 700-1000 fish species ranking it as the richest community of freshwater species in the world. Lake Malawi is also a world centre of heritage for fresh water fish biodiversity and has the largest number of endemic species.

Fish production has decreased with time in Malawi as a result of water level variations in natural water bodies, lake water temperatures, surface wind and rainfall. Aquaculture is very vulnerable to drought and even floods. The vulnerability of fish to projected climate change has been studied and the following results were obtained:

1. fish resources will be vulnerable to future extreme climatic events especially drought through low water levels and threat of drying up of dams and shallow lakes;
2. projected increase in surface water temperatures may not adversely affect fish production by 2020, 2075 and 2100;
3. rainfall over Lake Malawi is projected to decrease by the year 2100 thereby threatening fish production;
4. wind speed is projected to increase over Lake Malawi but may not adversely affect fish production; and
5. the waterweeds, water hyacinth and azolla, together with sediment and nutrient, loadings are projected to increase thereby adversely affecting fish production.

***Forestry***

The assessment to evaluate how climate change will affect forest ecosystems was undertaken in a Dzalanyama Forest Reserve that represents most of the common forest species in Malawi. The study looked at sensitivity of forests and possible adaptation policy options.

The GCMs, Holdridge and Gap Models were used in the assessment, which showed the following:

1. There will be species composition change in favour of tree species better adapted to drier environments by the year 2020.
2. Dzalanyama Forest Reserve may witness a decline in wood productivity of as much as 37% per hectare between 2020 and 2100; and
3. Under the extreme climate change scenario, wood production will drastically decline in Dzalanyama forest reserve.

### *Wildlife*

The assessment focussed on the ungulates of two physiographically different national parks, Nyika and Lengwe situated in cool and wet northern highlands and the dry and hot in the Shire River Valley in the south, respectively. The assessment has shown that:

1. Temperatures are projected to increase in both parks by 1-30C by 2100, thus reducing the Habitat Suitability to low levels;
2. Rainfall projection is mixed, but a declining trend is apparent by 2100;
3. The Habitat Suitability Indices (HSI) show a decline in both parks by 2100;
4. The cooler and wetter Nyika National Park could benefit from projected warmer temperatures by 2100 while Lengwe National Park may experience severe conditions; and
5. The nyala and zebra will be the most vulnerable to projected climate change in both parks.

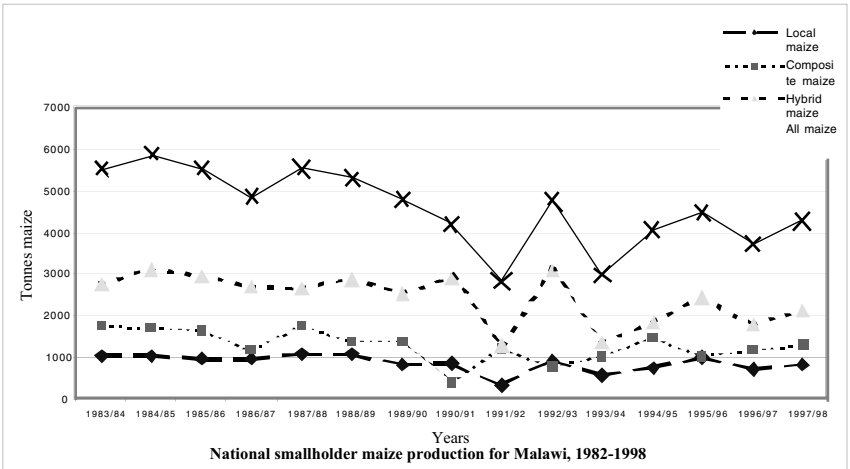
### *Agriculture*

Agriculture, the mainstay of Malawi's economy and survival, is presently heavily dependent on weather/climate especially natural rainfall. The vulnerability of agriculture especially maize yields and quality of livestock to projected climate change was assessed at three representative sites namely: Chitedze, Chitala and Bvumbwe. Maize is the main staple food of Malawi and is grown by smallholder farmers under rain-fed conditions.

The GCMs and CERES-Maize models were utilized to generate future climate change scenarios and the determination of growth and yield of maize at the three locations. The results show that:

1. At Chitedze in the fertile mid-altitude Lilongwe plain, projected yields are lower than under normal conditions;
2. At Bvumbwe in the southern Shire Highlands, projected maize yields are higher than under baseline conditions due to increased expected temperatures by 2100; and
3. At Chitala in the hotter and drier lakeshore environment, the projected maize yields are lower than under baseline conditions due to projected increased temperatures and declining rainfall.

Thus maize yields may be very vulnerable to the projected climate change especially a decrease in rainfall. Malawi has been experiencing declining maize yields (See following figure).




**National smallholder maize production for Malawi, 1982-1998**

Overall adaptation options were identified but prioritisation and costing were not undertaken due to time constraints and lack of capacity. Other crops and livestock were not considered in this study but will be included in the next assessment.

## Mitigation / Abatement Analysis

Malawi is a Least Developed Country (LDC), hence reducing emissions of Greenhouse Gases is not an obligation under the UNFCCC. However, the reduction of emission of GHG's and the enhancement of sinks provide opportunities and challenges for the socio-economic development of the country. Thus Malawi undertook mitigation analysis in Energy, Agriculture and Forestry. The opportunities could be the exploring and acquisition of new climate friendly technologies that could enhance the national development. Malawi has established a National Sustainable and Renewable Energy Programme (NSREP) to increase access to and efficient use of renewable energy for the rural, peri-urban and urban populations. In the study the Comprehensive Mitigation Analysis Process (COMAP) and the GACMO models were utilised.

### *Energy*

Malawi's energy resources include biomass, coal, hydropower, solar and wind. The energy system is dominated by biomass, which is the major energy source for the domestic and industrial development. Petrol and diesel are mostly used in the transport sector while coal is mainly used in industries. These energy sources emit greenhouse gases when combusted.

### *Assessment of Mitigation Options*

Mitigation options were categorised into technology-based and market-based mitigation options. The technology-based mitigation options are outlined in the following table:

**Technology-based Mitigation Options**

| Technology | Baseline Case | Alternative Option |
|---|---|---|
| 1. Wood fuel stoves | ● 3-stone<br>● Metal (charcoal stove) | ● Improved mud stove<br>● Ceramic stove |
| 2. Biogas | ● Paraffin for lighting<br>● Firewood for cooking | ● Use biowastes to produce biogas for lighting and cooking |
| 3. Lighting | ● Paraffin<br>● Incandescent lamps | ● Electricity (rural electrification)<br>● Compact fluorescent lamps |
| 4. Renewable energy (solar) | ● Firewood for cooking and water heating<br>● Paraffin for lighiting<br>● Conventional electricity for lighting and powering of electricity equipment | ● Solar cookers<br>● Solar water heaters<br>● Solar PV |

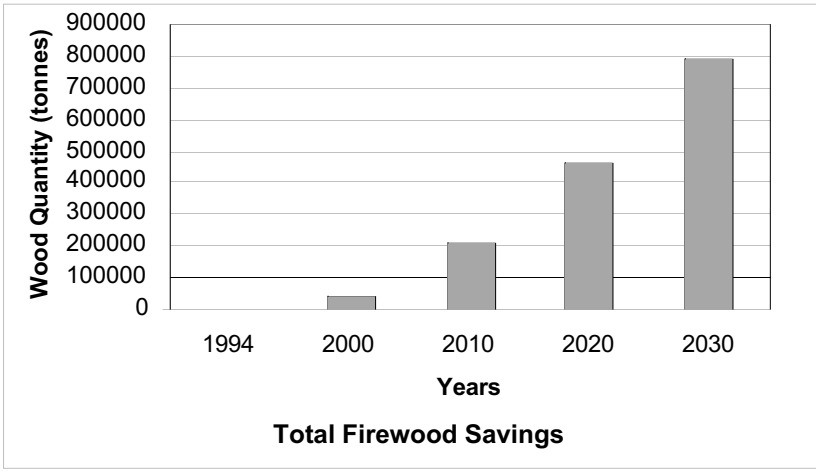
Detailed analyses were conducted on biomass-based mitigation options as they offer the greatest potential for GHG emission reduction. These are:

1. Improved firewood mud stove for cooking and heating water;
2. Improved ceramic stove for cooking and heating water; and
3. Biogas technology for cooking, heating water and lighting.

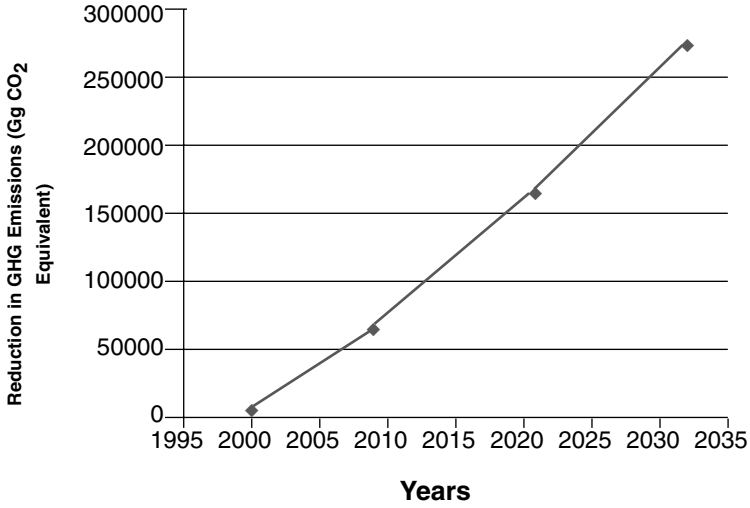
The market-based mitigation options considered include energy pricing, fiscal incentives, regulation, and demand side management (DSM).

### *Impact of Technology-based Mitigation Options*

Use of the biomass-based mitigation options would result in substantial annual wood savings, which are showing an increasing trend with time. Aggregate annual savings are projected to increase from around 41,000 tonnes in 2000 to about 800,000 tonnes in 2030. The impact of these options is shown in following figure:.




The following figure shows the potential annual emission reductions in CO2 equivalent arising from the biomass based mitigation measures. The annual emission reductions in global warming show an upward trend. It is estimated that by 2030, the annual reductions in CO2 equivalent will be about 279,308 Gg.




Apart from the biomass-based mitigation options analysed above, there is potential for further GHG reduction through:

1. Use of briquettes instead of firewood;
2. Rural electrification through grid extension, mini/micro hydropower and solar heaters and cookers which would reduce use of biomass energy;
3. Increased use of public transport and catalytic converters which would reduce GHG emissions from liquid fuels; and
4. Wind water pumping instead of diesel and petrol engines.

Detailed analyses of these options could not be conducted because of limited availability of data.

***Impact of Market-Based Mitigation Options***

The market-based mitigation options are likely to create an enabling environment for the proliferation of technologies that would significantly reduce GHG emissions.

Removal of duty and surtax on the renewable energy technologies (RETs) and certification of RETs installers and inspection of installation would result in the wider use and acceptance of RETs, which are cleaner technologies. The delivery mode should ensure that the RET supplier offers backup support and services to the users. Public media should also be used to promote the awareness of the RETs.

**Land Use Change and Forestry**

The GHG inventories of 1990 and 1994 showed that the Land Use Change and Forestry component emitted the highest amount of carbon dioxide (CO2) resulting in net emissions for the country.

In 1990 timber supply exceeded demand. The COMAP model projections up to 2030 predict that, supply will continue to exceed demand. However, the overall biomass situation in Malawi is worrisome because biomass demand exceeded sustainable biomass supply in early 1990s.

Land Use Change and Forestry biomass mitigation analysis shows that the biomass pool increased compared to the baseline scenario. In Malawi there is need to increase the amount of carbon sequestration by instituting mitigation measures such as natural regeneration, forest protection and agro-forestry.

**Agriculture**

GHG emissions from the agriculture sector are small compared to those from land use change and forestry sector and the energy sector. The COMAP model could not be utilized to develop mitigation scenarios for the agriculture sector because only annual crops were used.

**Research and Systematic Observation**

Malawi has research infrastructure that needs to be strengthened especially in capacity and capability on climate change issues. The need to effectively handle and operate socio-economic scenario models, and Vulnerability and Adaptation Models and also Mitigation Analysis Models underscore the importance of the research in the country. The development of climate change scenarios is very vital indeed for meaningful V&A assessment and Mitigation/ Abatement analysis.

Systematic observations in the country more especially those needed for climate change studies are inadequate and scanty from spatial and temporal considerations. Infrastructures to make systematic observations in many sectors such as meteorology and hydrology need rehabilitation. Data collection on the important Lake Malawi and other water bodies need to be developed or improved to take into account climate change issues. There is need to install a GCOS – Surface station on Mulanje Mountain at 3000 metres to complement other African GCOS- Surface networks whose systematic observation will also meet national needs.

**Education, Training and Public Awareness**

## Education, Training and Public Awareness

Significant efforts have been made in education, training and public awareness on environmental issues. The formal educational institutions are now incorporating environmental education as witnessed by the introduction of undergraduate and graduate environmental degree courses. However, climate change is not adequately covered.

Public discussions, debates and seminars on climate change have been undertaken and covered by the mass media. However, there is also need to raise public awareness on climate change issues to the rural people with appropriate educational information kits. Climate change should be included in the educational curricula for primary, secondary and tertiary levels. It is also necessary to strengthen the capacity and capability of various local institutions to include climate change in planning and development initiatives in the country. Community Based Natural Resource Management should also incorporate climate change issues.

## Sustainable Development and Climate Change

Sustainable development does not only imply increased income levels but also necessitates the provision of social services, empowerment of communities, inter-generation equity and sustenance of natural resources. In Malawi, poverty has led to high dependency on natural resources resulting in their over-exploitation such biomass energy leading to high deforestation and GHG emissions.

In its development agenda, Malawi has produced Vision 2020 and Malawi Poverty Reduction Strategy Paper which provide framework for national development goals, policies and strategies inorder to alleviate poverty.

## List of Priority Action Areas

(a) Strengthen Institutional Framework in areas such as:
- Mechanisms for environmental management and legal frameworks to include climate change.
- Policy framework development especially adaptation on climate change with relevant stakeholders.

(b) Strengthen activity data collection and monitoring systems more especially to support systematic observations for Global Climate observing System (GCOS).

(c) Strengthen the capacity in Climate Scenario generation vital for V&A assessments and Socio-economic Scenarios and other model use for the improvement of mitigation/abatement analysis.

(d) Develop relevant research into flood control and adaptation technologies appropriate to flood prone areas such as the lower Shire river valley.

(e) Increase public awareness and education in climate change issues.

(f) Prepare the National Action Plan (NAP) for Climate Change.

# CHAPTER 1: NATIONAL CIRCUMSTANCES

## 1.1 Introduction

Malawi is a land-locked and densely populated country in Sub-Saharan Africa, lying in the southern end of the Great East African Rift Valley. It lies between latitudes 09°25'S and 17°08'S and longitudes 32°40'E and 35°55'E. The total area is 118,484 km2 of which 20% is covered by water mainly Lake Malawi. The country is bordered by Mozambique to the east, south and west; Tanzania lies to the north; and Zambia to the north-west.

## 1.2 Major Physical Features

Topography is heterogeneous, dominated by the rift valley in which lies Lake Malawi at 475 metres above mean sea-level. The lake covers three quarters of the entire length of the country from north to south. Its deepest point is 77 metres below mean sea level in the northern sector. There are two inhabited islands in the lake. The altitude varies from 40 metres in the rift valley (Nsanje) to 3000 metres on Mulanje Mountain, the third highest in Africa. The plateaux region of the country lies at 1000-2000 metres above mean sea level (Figure 1.1).

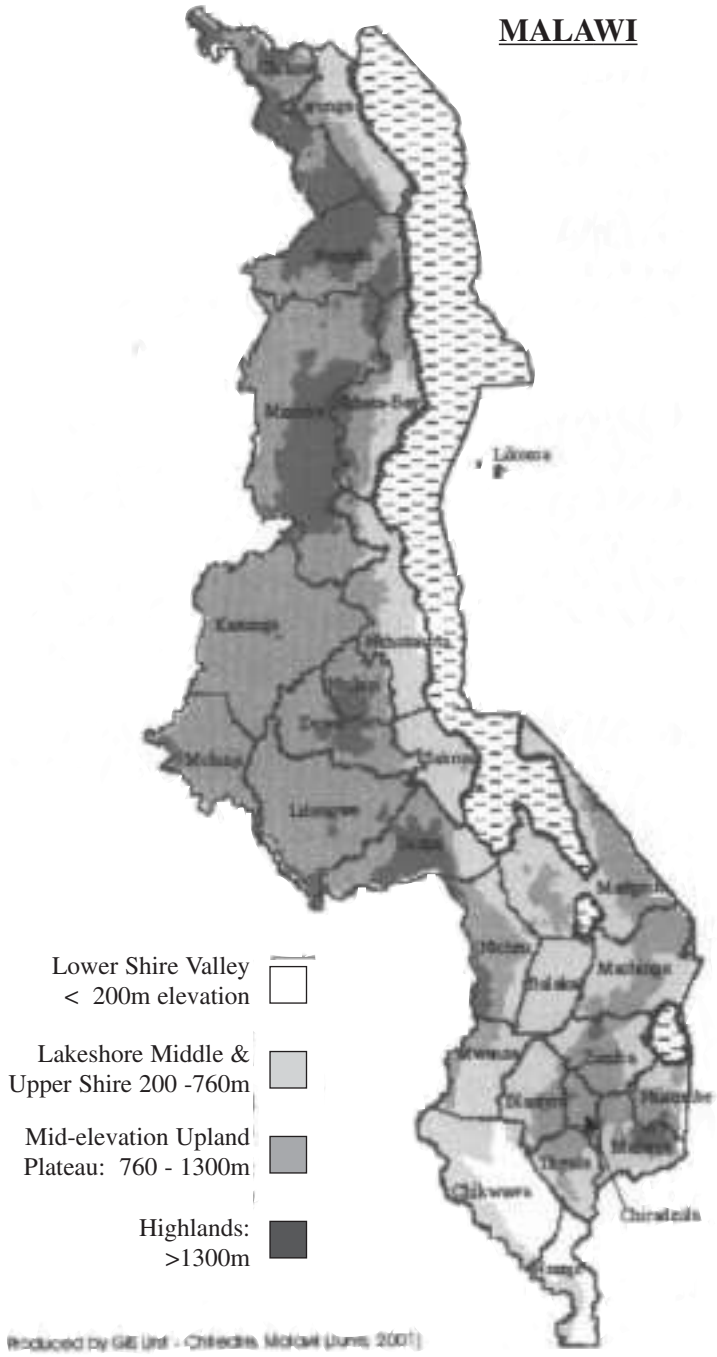



**Figure 1.1: Major Relief Units of Malawi**

## 1.3 Government and Administration

Malawi was formerly known as Nyasaland. Dr. David Livingstone, a missionary from Scotland, first visited the country in 1859 and publicised the country to the international community. It became a British protectorate in May 1891. The country was not spared from the slave trade scourge. The Federation of Rhodesia and Nyasaland (now Zimbabwe, Zambia, and Malawi) existed from 1953 to 1963. Malawi achieved its independence on 6th July 1964 and Republican status on 6th July 1966. In 1994, political government changed from one party state to multiparty democracy and a new constitution was adopted. The constitution guarantees freedom of speech, religion and assembly. Administratively, the country has three regions with twenty-seven districts spread across the regions.

Malawi has three arms of Government namely the Executive, the Legislature and the Judiciary. The Head of Government is the President, elected into office by majority popular vote, with a maximum of two consecutive five-year terms. The National Assembly is made up of parliamentarians from all various parties, elected from constituencies distributed throughout the country. The Civil Administration is committed to the principles of good governance and transparency. The country has a hybrid legal system that includes criminal and civial law based on English Legal System.

To promote the Country' politial, economic and cultural aspirations, Malawi has joined a number of sub-regional and international organisations including the Southern African Development Community (SADC), the Common MArket for Eastern and Southern African (COMESA), the Commonwealth and the United Nations (UN). In addition Malawi ia s signatory to many international conventions, treaties and agreements aimed at prioritising sound environmental management for sustainable development.

The private sector is encouraged to take a leading role in the economic development of Malawi and the constitution protects private investment.

## 1.4 Natural Resources

### 1.4.1 Forest Resources

Forest resources occupy 2.6 million hectares, of which 97% is indigenous forest and 3% plantation. Most of the forests are in the upland and hilly areas and along the rift valley scarps. These forests are variable, ranging from complex montane to the lowland ones. The natural forest in Malawi is broadly defined as being dominated by miombo woodland, represented by the genera, Brachystegia, Isobernia, Combretum, Julbernardia and Acacia.

### 1.4.2 Mountain Ecosystem

Malawi has several inportant mountain ecosystems including Nyika and Viphya Plateaus, Dedza Mountain, Kirk Range, Zomba Plateaus, and the famous Mulanje Mountain endowed with a wealth of biodiversity. However, only Mulanje Mountain is presently of global and regional significance. Mount Mulanje at 3000 metres above mean sea level is third highest in Africa. It has six different plant communities including Afro-montane forests, near the mountain summit, which caters for a large number of endemic flora and fauna species many of which are endangered or threatened by extinction

Mulanje Mountain is one of the 200 global eco-regions in the world for conservation of biodiversity and designated as an Afro-montane Regional Centre of Endemism. The massif also serves as the source of headwaters of nine rivers and represents an important source of

timber and other products such as the commercially valuable Mulanje Cedar. Mulanje mountain biodiversity has threats from unsustainable use of resources due to high population, agricultural encroachment, damaging bush fires, and invasion of alien species.

Mountain Mulanje is surrounded by tea plantations. There is need for an effective systematic observation station to meet the Global Climate Observing Systems (GCOS) requirements at the summit of the mountain. Mulanje is prone to landslides due to heavy rainfall. There is a Mulanje Mountain Conservation Trust (MMCT) which started in 1994 to preserve the unique biodiversity and ecosystems of Mulanje Mountain.

### 1.4.3 Wetlands

Malawi has some important wetlands which are sources of natural methane. These include wetlands of Lakes Malawi, Chiuta and Chilwa and also Shire River. The Lake Chilwa Wetland contains over 3500 to 4000 plant species, and 1000 species of animals and micro-organisms. Malawi designated the Lake Chilwa Wetland as its wetland of "international significance" under the Ramsar Convention because of its physical, biological, ecological and socio-economic attributes.

**Figure 1.2: Wetlands along Shire River.**
**Source:** EAD Outreach, Lilongwe

The wetland has substantial water fowl population and fisheries but is often affected by droughts which sometimes cause Lake Chilwa to completely dry up. Climate Change impacts on Lake Chilwa wetland and other wetlands could result in serious adverse effects.

### 1.4.4 Energy Resources

The energy resources include biomass, which accounts for 93% of the energy, where as hydro-power generated mainly along Shire River contributes to about 2% of the energy consumed. The indigenous forests are the major source of bio-energy. Other renewable energy sources are biogas, solar and wind which are relatively under - utilised.

### 1.4.5 Water Resources

The water resources are stocked in the country's Lakes Malawi, Malombe, Chiuta and Chilwa, rivers and aquifers that cover 20% of the territorial area. The surface and underground water resources depend on rainfall. Most of the rivers display seasonal flow patterns and dry up during the dry season. The mean annual rainfall over Lake Malawi is estimated at 1549 mm. The total surface inflow is approximately 920 m3/s of which 400 m3/s is from Malawi, 486 m3/s is from Tanzania and 41 m3/s is from Mozambique. The water bodies in Malawi support important wetlands especially those along the shores of Lake Malawi and Lake Chilwa and the Shire River valley, which are habitats for various flora and fauna.

### 1.4.6 Land Resources

Land suitability for rain-fed agriculture in Malawi is affected by topography, slope, rainfall, temperature (spatial and temporal distribution), soil type and depth. Only 31% of the country's total land area is suitable for rain-fed agriculture. This has resulted in the use of unsuitable and marginal lands, due to population pressures, hence causing environmental and

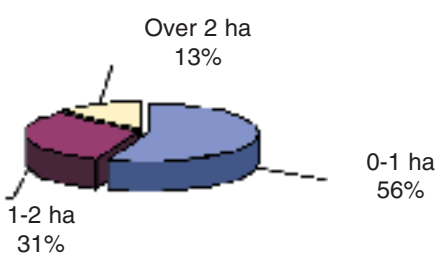



**Figure 1.3 (a): Land Holding Size by Householding**

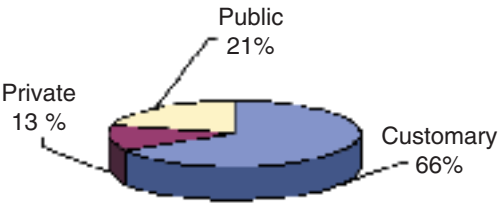



**Figure 1.3 (a): Land Tenure System Percentage Distribution**

land degradation. Landholding is such that 56% of Malawian households have 0 to 1 hectare of land, most of which is under customary tenure (Figures 1.3a and 1.3b).

### 1.4.7 Wildlife Resources

Malawi is rich in wildlife resources that play a major role in the socio-economic well being of communities and the nation as a whole. The majority of these resources are found in protected areas, which constitute 22% of total land area.

Wildlife resources are under threat of over-exploitation due to combined influence of land pressure, rapid population increase and general poverty. Other climatic factors such as droughts and high temperatures pose additional threats.

### 1.4.8 Fisheries

There are between 700 and 1000 fish species in Malawian water bodies. The fisheries industry contributes 4% of GDP and over 60% of animal protein intake. In addition, this diversity of fish species are of global significance since most of them are endemic to Malawi. Fish resources are also threatened by over-exploitation, water pollution and drought.

## 1.5 Climate

The climate is tropical continental but significantly moderated by the effects of Lake Malawi,

high altitudes, and proximity to the influence of westerly frontal systems which move eastwards around the South African coast.

There are two seasons:

i. rainy season (October - April)
ii. dry season (May - October)

However, as explained later, the dry season is subdivided into two parts namely cool and wet (May - August) and hot and dry (September - OCtober). The mean annual rainfall ranges from 500 mm in the dry and hot valley areas 3000 mm over highlands. annual mean temperature ranges form $12^{0}$C to $32^{0}$C.

### 1.5.1 Major Weather Systems

***The Monsoon***

The winter Asian monsoon affects and contributes to rainfall received in Malawi, during the November to February period when moist North Easterly flow prevails across the Indian Ocean.

***The Inter-tropical Convergence Zone***

The Inter-tropical Convergence Zone (ITCZ) is the main rain bearing mechanism, prevailing during November to February when the country receives widespread rainfall. However, its appearance and movement from the northern hemisphere into Malawi is not as predictable as its retreat into northern hemisphere during the start and cessation of the rainy season respectively.

***The Congo Air Boundary (CAB)***

The CAB is a north-westly moist air mass that brings extensive, reliable and moderate to heavy rainfall over Malawi ( November-February) after its passage over the Congo forests. Its movement is in a North West –South East direction influenced by pressure differences between the Atlantic Ocean, inland low systems and Indian Ocean.

***Tropical Cyclones***

Tropical depressions/cyclones that develop in the Mozambique Channel or enter it from the south-west Indian Ocean affect the rainfall over Malawi. Depending on relative positions, Malawi either gets extensive rainfall or dry weather especially in southern part of the country. Occasionally, tropical cyclone/depression moves westwards inland from the channel and reaches Malawi. As a result, widespread and torrential rainfall is received over many areas resulting in floods that cause socio-economic damages.

### 1.5.2 Rainfall Distribution

**Summer Rainfall (October to April)**

The El Nino/Southern Oscillation (ENSO) phenomenon is now significantly recognized as a major factor in determining the behaviour of summer precipitation in Malawi. ENSO seems to affect ITCZ and CAB, the main rain bearing mechanisms. As in 1991/92 during El Nino occurrence, the country gets mainly deficient rainfall resulting in drought situations with adverse socio-economic consequences. La Nina occurrence brings in more rainfall that also results in floods, which cause severe damages with adverse socio-economic results.

**Winter Rainfall (May to August)**

Winter rainfall is generally less significant except for areas on windward sides of highlands where substantial rainfall is received. This supports winter crops especially in southern and northern highlands such as wheat and rice.

**Mean Annual Rainfall Distribution**

Lake Malawi influences rainfall distribution in the central and northern lakeshore areas resulting in maximum rainfall areas centred over the lake overshadowing the topographic effects. However, in the southern areas topography greatly influences rainfall distribution with maximum areas over highlands. Malawi experienced very high 24-hr rainfall events such as the 569 mm (22.4 inches) at Nkhota-Kota in 1957 and 508 mm (20 inches) at Zomba in 1946. For shorter duration the highest is 180.6mm in one and half hours on 11th January 1957 at Nkhata-Bay. Mean annual rainfall distribution in Malawi is shown in Figure 1.4.

**1.6**


**Figure 1.4: Mean Annual Rainfall Distribution.**

**Temperature Distribution**
Maximum temperatures are relatively high though moderated by topography and Lake Malawi. Centres of maximum temperatures are along the rift valley with maximum of 350C (Figure 1.5). The peak values are attained end October or early November just before the onset of the rainy season. The second peak is achieved in March/April as the sun moves north. Seasonal and monthly variations are not as pronounced as the daily variations. The minimum temperatures are attained in June/July, when ground frost does occur.

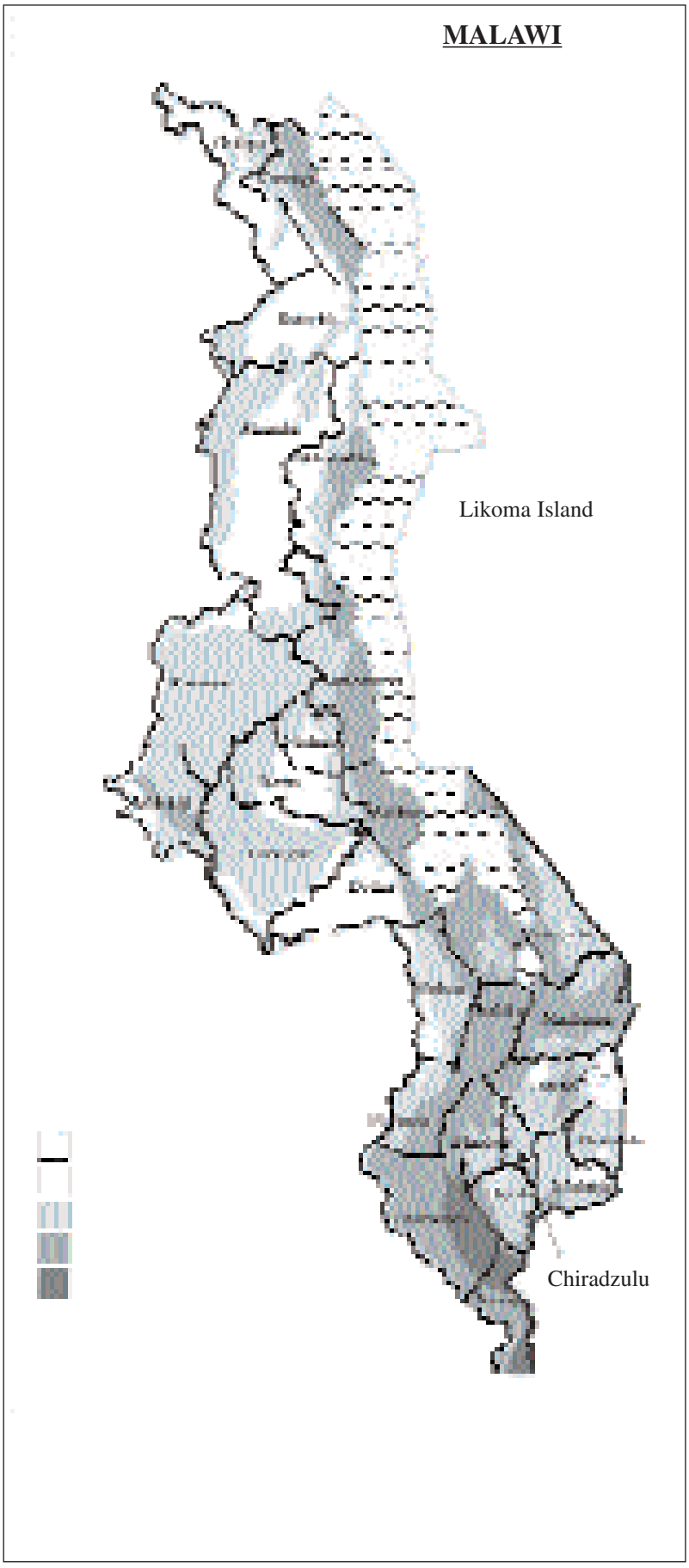



Figure 1.5: Mean Annual Temperature Distribution

## Population

Malawi's population has been increasing rapidly over the last 40 years. The projected population for 1994 based on the 1987 census was 10 million, growing at about 3.2% per annum. The population dependency ratio is high with more than 44% of the population aged 14 years or younger (Figure 1.6). There has been a decline in migration to other countries. The majority of Malawians live in rural areas (85%).

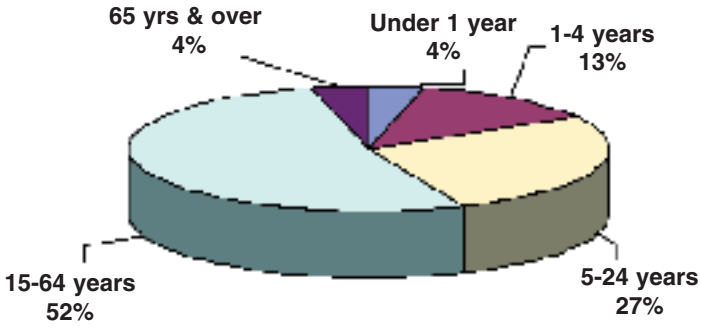



**Figure 1.6: Population Distribution by Age Groups**

Malawi has established a Population and Human Resource Development Unit, Family Planning Programme and a draft National Population Policy to address the issue of population and its impact on social economic development.

## 1.7 Economy

Malawi is classified as a Least Developed Country (LDC), with 65% of its population defined as poor of which 29% is below the poverty line. The GDP per capita for 1994 was 135 USD.

**Table1.1: Socio-Economic Indicators for Malawi (1994)**

| Sector | Value |
|---|---|
| Population (estimate) | **10,000,000** |
| Area (square kilometres) | **119,140** |
| Gross Domestic Product (million MK) | **9142.7** |
| Gross Domestic Product per capita (MK) | **943.8** |
| Share of Industry in GDP % | **18.1** |
| Share of Agriculture in GDP % | **31.3** |
| Land Area for Agriculture (million hectares) | **1.8** |
| Land Area Under Forestry (million hectares) | **2.6** |
| Urban Population as % of total | **15** |
| Population in Poverty %<br>Absolute Poverty % | **65**<br>**29** |
| Livestock Population Dairy Cattle<br>Non-dairy cattle<br>Goat<br>Poultry | **7600**<br>**741300**<br>**856300**<br>**11250000** |
| Life Expectancy (years) | **40** |
| Literacy (%) | **56** |
| External Debt as % of GDP | **265.1** |

US$ = MK 8.73

Malawi has an agricultural based economy. The agricultural sector is the largest employer (80%), foreign exchange earner (90%), and contributes 35-40% of GDP (Table 1.2). Tobacco is the highest foreign exchange earner. Agriculture also contributes 60-70% of inputs into the manufacturing sector. In 1994, Malawi registered a negative growth of real Gross Domestic Product (GDP) of 12.4 % unlike 1993, which recorded a positive growth of 10.8%. This was partly attributed to the fact that the agricultural sector performance registered a decline of 29.7%. The climatic conditions for 1993/1994 were unfavourable for growing crops, with most parts in the Central and Northern Regions experiencing dry conditions during critical crop growing periods, while in 1998/99 good performance was achieved due to favourable weather conditions and other inputs. The GDP in million MK at 1994 factor cost, was 10,404.4, 12,256.9 and 13,186.9 in 1995, 1997 and 1999, respectively. Between 1992 and 1998, the external debt increased from 120.4% to 155.5% of GDP.

| | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000* |
|---|---|---|---|---|---|---|---|
| Agriculture | 2319.4 | 3237.7 | 4063.5 | 4068.9 | 4494.9 | 4494.2 | 5168.3 |
| Small scale | 1624.2 | 2331.6 | 3070.2 | 2964.9 | 3524.9 | 3984.9 | 4139.2 |
| Large scale | 695.2 | 906.0 | 993.3 | 1104.9 | 969.3 | 955.3 | 1029.2 |
| Mining & Quarrying | 43.2 | 47.1 | 205.7 | 157.4 | 164.0 | 169.6 | 175.5 |
| Manufacturing | 1597.0 | 1685.2 | 1675.1 | 1691.3 | 1700.4 | 1690.1 | 1704.6 |
| Electricity & Water | 149.0 | 151.9 | 151.7 | 160.5 | 172.2 | 171.5 | 176.0 |
| Construction | 202.3 | 198.0 | 231.4 | 254.2 | 261.6 | 309.2 | 375.6 |
| Distribution | 2536.6 | 2576.2 | 2574.8 | 3017.8 | 2948.6 | 2927.2 | 3106.0 |
| Transport & Communication | 465.3 | 550.0 | 505.0 | 553.2 | 558.1 | 581.8 | 626.8 |
| Professional Services | 626.7 | 690.7 | 834.4 | 1127.7 | 1034.3 | 1046.7 | 1155.1 |
| Ownership of dwellings | 162.0 | 165.2 | 168.8 | 172.4 | 176.1 | 179.1 | 183.7 |
| Private, Social & Community | 211.2 | 215.3 | 236.5 | 260.1 | 262.0 | 263.9 | 265.9 |
| Procedures of Government Services | 1113.8 | 1197.7 | 1167.6 | 1200.1 | 1220.9 | 1243.6 | 1260.2 |
| Unallocable Finance Charges** | -283.8 | -310.6 | -314.8 | -406.8 | -336.1 | -336.1 | -314.0 |
| GDP at Factor Cost | **9142.7** | **10404.4** | **11499.7** | **12256.9** | **12656.4** | **13186.9** | **13855.8** |
| Annual average Exchange rates (MK/US$) | **8.7367** | **15.2823** | **15.2771** | **16.4449** | **31.0727** | **44.0880** | **47.4219** |

*** preliminary estimates**

** Accounting procedure to reflect balances between demand and supply.

Source: National Economic Council, National Statistical Office, Reserve Bank of Malawi and Treasury

Malawi's economy is fragile and dependent on climatic conditions. Climate change will impose additional constraints in agricultural production and hence affect the economic growth of the country.

The industrial sector's contribution to GDP in Malawi, though small compared to that of agricultural sector, makes a consistent positive contribution to the economy. However, the manufacturing sector experiences constraints such as foreign exchange availability, high cost of imports and exports and stiff competition from imported goods because Malawi is landlocked.

The economic significance of the mining sector is increasing because Malawi is promoting investment in this sector as a means of diversifying the economy from agriculture.

## 1.8 Energy Production, Transformation and Consumption

The Department of Energy in the Ministry of Natural Resources and Environmental Affairs co-ordinates energy issues in the country. The overall strategy of the Department is to ensure the development of a robust and efficient private sector driven energy sector that supports national socio-economic policies and sustainable management of energy resources.

The energy mix in Malawi consists of biomass-based fuels, hydroelectricity, petroleum products and coal. Over 93% of the population depend on wood fuel while 4% have access to grid electricity. Fossil-based fuels meet the balance. Other renewable energy forms such as hydropower, solar, wind and biogas are under-developed except for large scale hydro-electric power (HEP) generation on Shire River. The National Sustainable and Renewable Energy Program (NSREP) aims at enhancing the access to and efficient use of renewable energy sources in the country. Malawi has also a Rural Electrification Programme through grid extension, and non-grid micro and mini hydro stations (Figure 1.7).

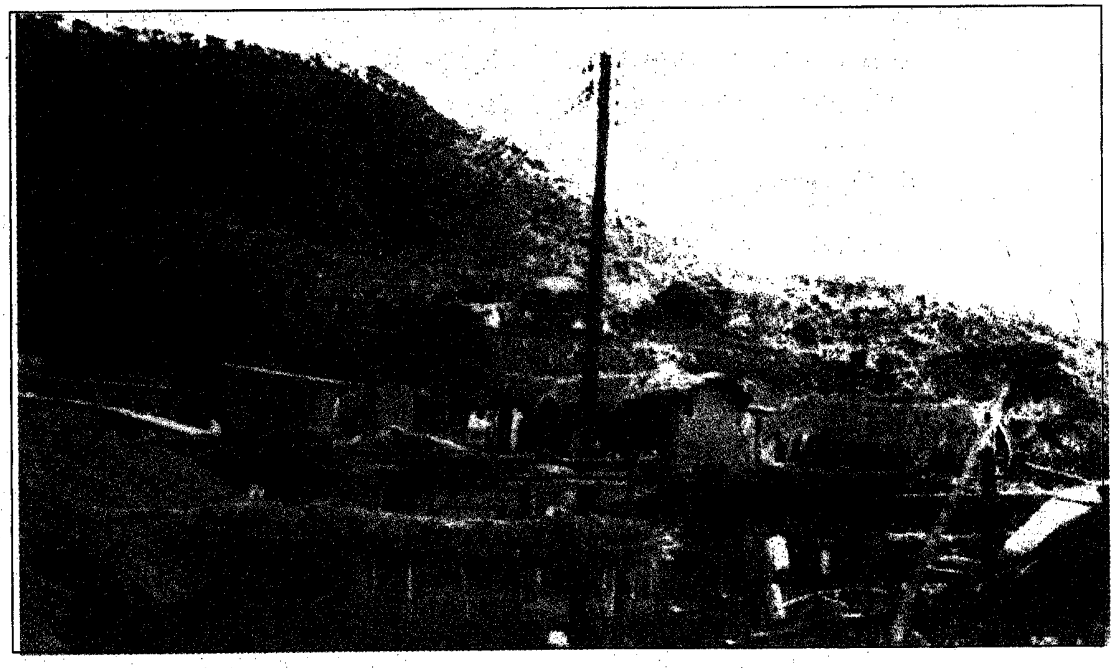


**Figure 1.7: Rural Electrification Programme at Phwezi, Malawi**
Source: Department of Energy

### 1.8.1 Electricity

The distributed electricity on the national grid is generated from hydro-power. This is managed by the Electricity Supply Corporation of Malawi (ESCOM). To abate effects of frequent power distributions private organisations and individuals own and generate their own electricity using diesel/petrol-powered generators and/or solar photovoltaic (PV) which have not been quantified. Table 1.3 shows the electricity generation capacity and consumption from hydro-electric power (HEP) in Malawi.

**Table 1.3: Electricity Generation and Consumption (1990-1996)**

| Year | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|---|
| **GENERATION** | | | | | | | |
| POWER (MW) | 119.4 | 133.4 | 138.7 | 145.3 | 140.2 | 145.4 | 150.2 |
| Energy (GWh) | 707.1 | 772.8 | 779.6 | 841.8 | 831.9 | 858.9 | 873.0 |
| **CONSUMPTION (MW)** | | | | | | | |
| Domestic | 106.1 | 118.0 | 132.1 | 141.1 | 143.9 | 166.8 | 187.3 |
| General | 92.0 | 102.4 | 110.6 | 117.7 | 119.0 | 120.0 | 125.5 |
| Power | 399.7 | 427.6 | 432.5 | 460.4 | 440.7 | 460.7 | 425.7 |
| Export | 0.3 | 0.6 | 0.7 | 0.7 | 0.8 | 1.2 | 2.1 |
| **TOTAL CONSUMPTION** | 598.1 | 648.6 | 675.9 | 719.9 | 704.4 | 749.1 | 729.5 |

Source: Electricity Supply Corporation of Malawi Limited

The total HEP generation has steadily increased from 119 MW in 1990 and 145 MW in 1993, but declined to 140 MW in 1994. Domestic and commercial consumption show consistent increase. Domestic consumers account for 25% while the rest are industrial and other users.

### 1.8.2 Fossil Based Fuels

Except for coal, all the fossil based fuels are imported through the ports of Dar-es-Salaam in Tanzania, Beira in Mozambique and Durban in South Africa The fuels are used for domestic purposes (liquefied petroleum gas [LPG], paraffin), road and marine transport (petrol, Avgas, diesel), air transport (Jet A1, kerosene), industries (diesel, coal, LPG), electricity generation (diesel, petrol) and irrigation (diesel, petrol). The country's HEP generates more electricity than what is actually consumed (Table 1.3).

### 1.8.3 Woodfuel

Woodfuel (firewood and charcoal) remains the main source of energy used for domestic cooking and heating as well as industrial heating. The demand for woodfuel exceeds available sustainable supply and the deficit is ever increasing resulting in high rate of deforestation currently at 2.8% annually. This is negatively impacting on Malawi's environment. The government continues to promote the use of more efficient ceramic stoves and improved mud stoves at household and institutional level in order to conserve woodfuel. Biogas is also promoted as an alternative energy form for domestic cooking and lighting.

## 1.9 Transport

Road and rail transport are the major means for most of the domestic and international freight movement. Table 1.4 gives the statistics of new motor vehicles registered. Of the motor vehicles registered between 1990 and 1999, 39% were passenger vehicles, 41% were goods vehicles, 15% were motorcycles and the balance were others. Details are shown in Table 1.4 and Figure 1.8.

**Table1.4: Annual Motor Vehicle Registration in Malawi (1990 - 1999)**

| Period | Passenger Cars | % Share | Goods Vehicle | % Share | Motor Cycles | % Share | Other | % Share | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1990 | 1560 | 33 | 1853 | 40 | 918 | 20 | 352 | 7 | 4653 |
| 1991 | 2429 | 39 | 2344 | 37 | 1137 | 18 | 357 | 6 | 6267 |
| 1992 | 3279 | 34 | 3046 | 31 | 1386 | 31 | 380 | 4 | 8901 |
| 1993 | 1793 | 42 | 1439 | 34 | 639 | 15 | 374 | 9 | 4245 |
| 1994 | 1912 | 51 | 1202 | 32 | 468 | 13 | 153 | 4 | 3735 |
| 1995 | 844 | 36 | 978 | 42 | 411 | 18 | 113 | 4 | 2346 |
| 1996 | 2003 | 41 | 1856 | 38 | 733 | 15 | 293 | 6 | 4885 |
| 1997 | 3009 | 44 | 2736 | 40 | 752 | 11 | 342 | 5 | 6839 |
| 1998 | 2781 | 38 | 3410 | 47 | 840 | 12 | 227 | 3 | 7258 |
| 1999 | 782 | 21 | 2215 | 60 | 482 | 13 | 212 | 6 | 3691 |

Source: Road Traffic Department.

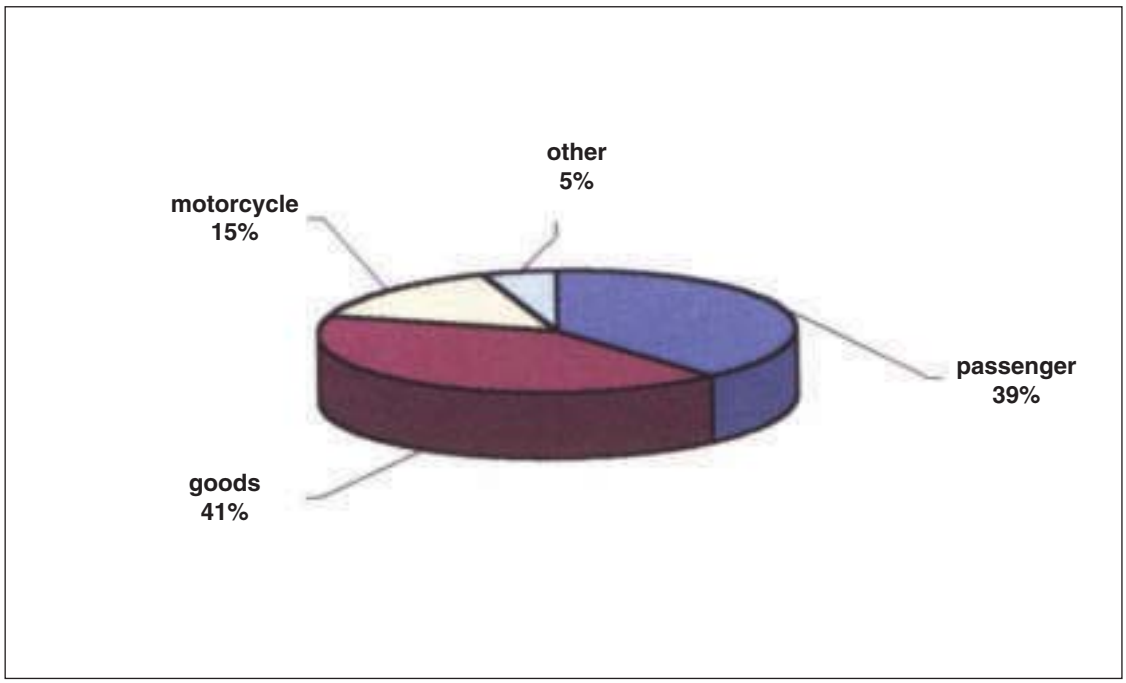



**Figure 1.8: Annual Motor Vehicle Statistics**

Malawi has a total of 15300 km of road infrastructure, of which 2621 km is bituminised, 1469 km is gravelled and the balance is earth, figure 1.9. Climatic factors such as rainfall worsen the poor conditions of roads and bridges thereby limited accessibility

**Figure 1.9 (a): Earth road in Malawi**
Source: EAD Outreach, Lilongwe

**Figure 1.9 (b): Bituminised road.**

The Government has established the National Roads Authority (NRA) to be responsible for the maintenance and rehabilitation of urban and district road infrastructures.

The total railway line within Malawi is 789 km concentrated within Southern and Central Regions. There are also operational lines to Mozambican ports of Nacala and Beira connecting Malawi to the Indian Ocean. The rail transport has recently been privatised and caters mainly for goods apart from carrying passengers.

For the districts along the lake, lake service vessels operate between the northern and southern districts. The services are both for goods and passengers. The lake transport is vulnerable to the low lake levels and stormy weather brought about by strong surface lake winds especially South Easterly winds that generate high waves over the lake. A number of transport vessels as well as human lives are thus lost every year.

Malawi has two international airports for scheduled flights at Lilongwe and Chileka, and a number of aerodromes and airfields in various districts. The flag carrier is Air Malawi which offers regional flights and has working relationships with other international airlines.

## 1.10 Health

The main policy for the health sector is to improve the health status of all Malawians through a sound health delivery system that will promote health, prevent diseases, protect life and foster general well being of all.

Various initiatives have been launched to facilitate the goal of ensuring a healthy nation namely Primary Health Care, Immunisation Programmes, Safe Motherhood Programme and other nutrition and disease control programmes.

The Human Immunodeficiency Virus (HIV) and the Acquired Immune Deficiency Syndrome (AIDS) however, remains the greatest challenge in addition to the other traditional diseases such as malaria and tuberculosis. HIV/AIDs infection rate continued to rise at an annual average rate of 11.7% between 1983 and 1994, resulting in over 35,000 AIDS cases reported by September 1994. By 1994, between 8 and 9.5% of the population were infected with the HIV virus. Its impact on the nation's and productivity due to illnesses and deaths continue to be felt especially in the productive age group, 15-49 years, with prevalence rate at around 16% in 1999.

Malawi has a National HIV/AIDS Strategic Framework and a National HIV/AIDS Control Programme that aim at sensitising the population on the dangers of the disease and offer voluntary testing and/or counselling services. There are several NGOs such as Malawi Aids Counselling and Resource Organisation (MACRO) that are complementing Government's efforts to reduce the infection rates.

## 1.11 Gender

Women form 51% of the population, and are key players and producers in the national economy. Despite the fact that their contribution is often not included in the national statistics, they are involved in a number of sectors such as farming, income generation, trading, and family care-taking (Figure 1.10).

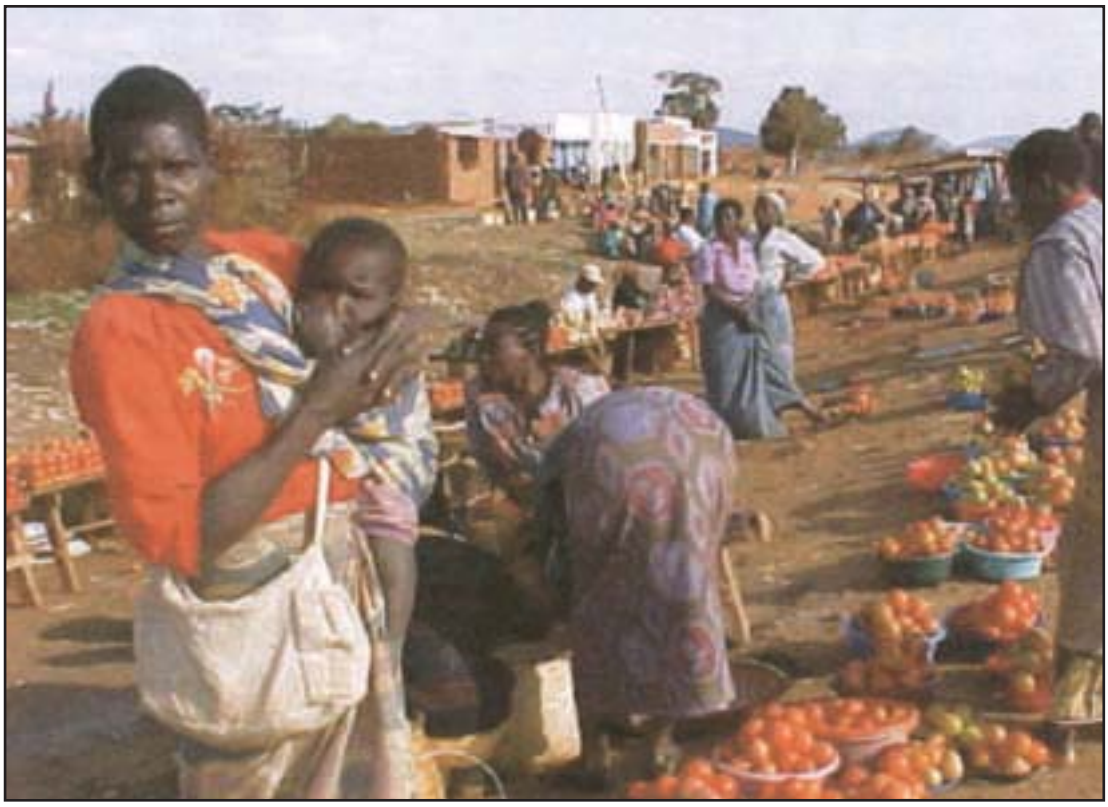


**Figure 1.10: Women Traders at a Produce Market in Malawi.**

Source: EAD Outreach

In fact, women constitute over two-thirds of full time farming population. The main thrust has been to improve the status of the disadvantaged groups, i.e. women and the youth. Integrated approaches have therefore been used to empower the vulnerable groups. Examples include:

- Adult literacy classes;
- Girls' basic education
- Technical skills training for income generating activities;
- Women rights awareness training;
- Population education;
- Youth development and credit scheme; and
- Youth participation in reproductive health project.

There are also a number of local and international NGOs which promote gender related activities.

## 1.12 Poverty

Poverty is still widespread and growing in Malawi, affecting 65% of the population, with women as the most vulnerable group. The government has therefore continued to put poverty reduction as the central theme in its development agenda. In this regard, a number of programmes have been initiated such as Malawi Social Action Fund (MASAF) that uses community-based participatory approaches to deliver development projects such as schools, clinics, roads, and bridges to the communities.

The Safety Nets Programme has been introduced to assist vulnerable groups such as the poor, elderly, disabled and orphans. The Programme has four components which deal with public works, targeted inputs, targeted nutrition inputs and direct welfare transfers.

Currently, the government is developing, through consultative and participatory approaches, the Poverty Reduction Strategy Paper (PRSP) which will be the key instrument for policy direction. In addition, the government is improving its ability to assess and monitor poverty indicators through mini projects such as Qualitative Impact Monitoring, Integrated Household Survey and Complementary Panel Study. The overall aim of all these programmes is to enhance the quality of life of the population and ensure sustainable management of natural resources.

## 1.13 Sustainable Development

Most development projects are often undertaken in isolation, narrow in outlook and with little or no regard to the impact they have on other sectors or the well being of the society in general. Malawi is therefore currently advocating Sustainable Livelihood (SL) approach that is holistic, forward looking and sustainable. The SL approach recognises the fact that developmental issues should consider not only the needs of the current generation, but also the needs and sustenance of the future generation. The approach consists of an integrated package of policy analysis, technology and investment strategies. Appropriate decision making tools applied to and building on adaptive strategies of communities is also involved.

The SL Programme is funded by United Nation Development Programme (UNDP). The programme comprises food security component, enterprise development component, environment and natural resources management component and other components covering special programmes and cross cutting issues.

Malawi undertook studies to develop strategies to improve the productivity of three livelihood systems: enterprise development, smallholder agriculture and fisheries. These studies revealed that most of the natural resources and assets are poorly managed and under utilised. A technology strategy for sustainable livelihood was developed and is currently being piloted in order to develop best transferable models for replication in other parts of the country. The SL programme's overall aim is to alleviate poverty of the rural population in a sustainable manner.

In spite of the low national capacities, Malawi has undertaken measures to implement the UNFCCC. The National Environment Action Plan (NEAP) was developed and finalised in 1994 and outlines measures and priorities to promote sustainable use of the environment. Furthermore, the following strategic aspects are now in place:

- A legal framework for environmental management (Environment Management Act, 1996)
- A National Environmental Policy (1996); and
- Environmental Impact Assessment (EIAs) guidelines and procedures for most development activities.

# CHAPTER 2: GREENHOUSE GAS (GHG) INVENTORY

## 2.1 Introduction

Malawi undertook the Greenhouse Gas (GHG) inventory of emissions by sources and removals by sinks of the GHG as an obligation under Article 4.1(a) of the United Nations Framework Convention on Climate Change (UNFCCC). The GHG inventory was undertaken in the sectors of Energy, Industrial Processes, Agriculture, Land Use Change and Forestry, and Waste Management. The GHG Inventories were based on years 1990 and 1994, and they covered carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), nitrogen oxide (NOX) and carbon monoxide (CO). The Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories were utilised in the studies.

However, the IPCC Good Practice guidelines were not available on time to be fully utilised. The activity data collected in some relevant sectors did not meet the requirements of IPCC Guidelines. The IPCC default emission factors and other default values were used where national factors were unavailable.

Malawi relies on imported fuels and as such is entirely dependent and vulnerable to global markets and fuel price fluctuations. The major sources of activity data were National Statistical Office (NSO), Petroleum Control Commission (PCC), Portland Cement Company of Malawi, Dwangwa Sugar Corporation, Departments of Energy and Forestry, City and Municipal Assemblies of Blantyre, Lilongwe, Mzuzu and Zomba, Ethanol Company of Malawi (ETHCO) and National Economic Council (NEC).

**Figure 2.1: Ethanol Plant at Dwangwa, Malawi**

Source: MIRTDC, Blantyre

## 2.2 GHG Inventory Results

The GHG inventories of emission by sources and removals by sinks for the base year 1994 are shown in Table 2.1. Non-CO2 emissions arose from Biomass Energy and also from Burning of Savannah in Agriculture.

**TABLE 2.1: Summary Report for National Greenhouse Gas (GHG)**

| GREEN GAS SOURCE AND SINK CATEGORIES | $C0_2$ Emissions | $CO_2$ Removals | $CH_4$ | $NO_2$ | $NO_x$ | CO |
|---|---|---|---|---|---|---|
| | | | | | | |
| Total NationalEmissions and Removals | 19247.28 | -1016.00 | 187.90 | 7.77 | 26.31 | 951.80 |
| **1. Energy -Reference Approach** | **660.88** | **0.00** | **135.09** | **0.71** | **24.03** | **879.58** |
| A. Fossil fuels | | | | | | |
| Liquid Fossil Fuels | 529.43 | | | | | |
| Solid Fossil Fuels | 131.01 | | | | | |
| B. Fugitive Emissions | | | | | | |
| Solid fuels | 0.44 | | | | | |
| C. Biomass | | | 135.09 | 0.71 | 24.03 | 879.58 |
| **2. Industrial Processes** | **58.38** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| Cement Production | 56.62 | | | | | |
| Lime Production | 1.76 | | | | | |
| Industrial digesters | 0.00 | | | | | |
| **3. Agriculture** | **0.00** | **0.00** | **48.50** | **7.05** | **2.24** | **72.20** |
| Enteric Fermentation | | | 30.10 | | | |
| Manure Management | | | 1.34 | 0.17 | | |
| Rice Cultivation | | | 14.89 | | | |
| Agricultural Soils | | | | 6.81 | | |
| Prescribed Burning of Savanas | | | 0.42 | 0.01 | 0.19 | 11.06 |
| Field Burning of Agricultural | | | | | | |
| Residues | | | 1.75 | 0.06 | 2.05 | 61.14 |
| **4. Land Use Change and Forestry** | **18528.02** | **-1016.00** | **0.02** | **0.01** | **0.04** | **0.02** |
| Changes in Forestry and | 14003.02 | | | | | |
| Other Woody Biomas Socks | | | | | | |
| Forests and Grassland Conversion | 2183.00 | | 0.02 | 0.01 | 0.04 | 0.02 |
| Abandonment Managed Lands | | -1076.00 | | | | |
| $CO_2$ Emissions and Removals from Soils | 2342.00 | | | | | |
| **5. Waste** | **0.00** | **0.00** | **4.29** | **0.00** | **0.00** | **0.00** |
| Solid Waste Disposal on Land | | | 3.88 | | | |
| Waste Water Handling | | | 0.41 | | | |

The LUCF sector accounts for over 96% of the CO2 emitted in 1994. Changes in Forestry and Woody Biomass Stock is responsible for 75% of the emissions from the LUCF sector. Results are shown in Figure 2.2 (a). The biomass as, a source of energy, accounts for 72% of the $CH_4$ emitted. It should be noted that over 90% of Malawians depend on biomass for their energy requirements. Details are shown in Figure 2.2 (b). Biomass energy is also responsible for the high emissions of CO (92%) and $NO_x$ (91%). See figures 2.2(c) and 2.2 (d).

The agriculture sector accounts for 90.7% of $N_2O$ emission arising from use of chemical fertilisers as shown in Figure 2.2(e).

Poverty and Low access to electricity and other alternative energy sources has greatly contributed to the over dependency on biomass energy and the over-exploitation of the forest resources.

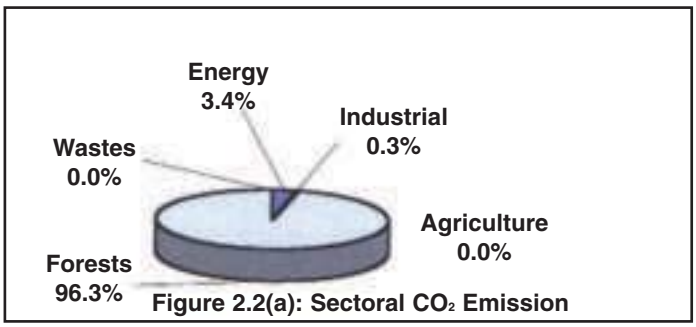


Figure 2.2(a): Sectoral $CO_2$ Emission

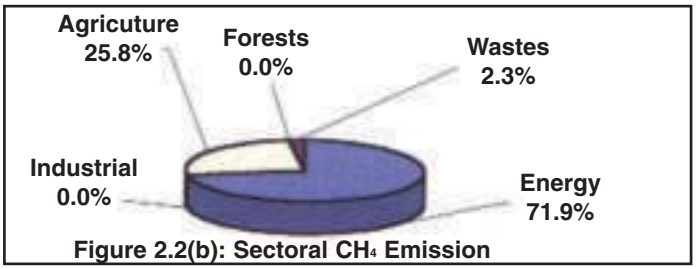


Figure 2.2(b): Sectoral $CH_4$ Emission

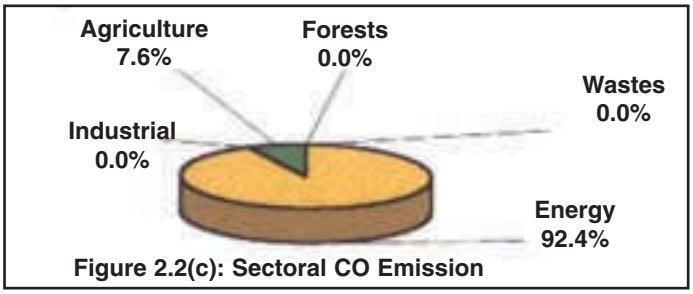


Figure 2.2(c): Sectoral CO Emission

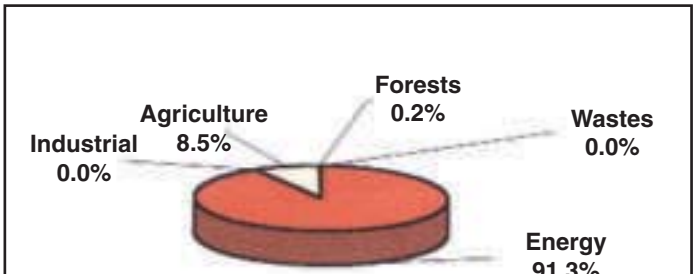


Figure 2.2(d): Sectoral $NO_x$ Emission

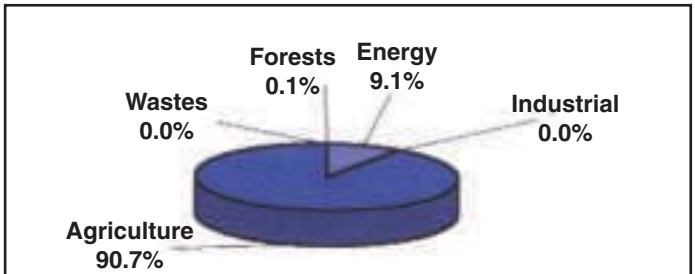


Figure 2.2(e): Sectoral $N_2O$ Emission

**Figure 2.2: Sectoral GHG Emissions 1994**

Table 2.2 shows the 1994 sectoral emissions by gas type converted to their $CO_2$ equivalents. The net $CO_2$ equivalent emitted was 29230 Gg. The LUCF sector contributed 60% of the net $CO_2$-equivalent emitted in 1994 (Figure 2.3).

**TABLE 2.2: Summary Report for National Greenhuse Gas Inventories in $CO_2$-equivalents for 1994 (Gg)**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ Emissions | $CO_2$ Removals | $CH_2$ | $NO_2$ | $NO_x$ | CO | $CO_2$ |
|---|---|---|---|---|---|---|---|
| | 1 | 1 | 24.5 | 320 | 40 | 3 | |
| **Total National Emisssions and Removals** | **19247.28** | **-1016.00** | **4603.55** | **2487.01** | **1052.400** | **2855.40** | **29229.64** |
| 1. Energy - | | | | | | | |
| - Reference Approach | 660.88 | 0.00 | 3309.71 | 227.81 | 961.20 | 2638.74 | 7798.34 |
| A. Fossil fuels | | | | | | | 0.00 |
| Liquid Fossil Fuels | 529.43 | | | | | | 529.43 |
| Solid Fossil Fuels | 131.01 | | | | | | 131.01 |
| B. Fugitive Emissions | | | | | | | 0.00 |
| Solid fuels | 0.44 | | | | | | 0.44 |
| C. Biomas | | | 3309.71 | 227.81 | 961.20 | 2638.74 | 7137.46 |
| 2. Industrial Processes | 58.38 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 58.38 |
| Cement Production | 56.62 | | | | | | 56.62 |
| Lime Production | 1.76 | | | | | | 1.76 |
| Industrial digesters | 0.00 | | | | | | 0.00 |
| 3. Agriculture | 0.00 | 0.00 | 1188.25 | 2256.00 | 89.60 | 216.60 | 3750.45 |
| Enteric Fermentation | | | 737.45 | | | | 737.45 |
| Manure Mangement | | | 32.83 | 54.40 | | | 87.23 |
| Rice Cultivation | | | 364.81 | | | | 364.81 |
| Agricultural Soils | | | | 2179.20 | | | 2179.20 |
| Prescribed Burning of Savannas | | | 10.29 | 3.20 | 7.60 | 33.18 | 54.27 |
| Field Burning of Agricultural Residues | | | 42.88 | 19.20 | 82.00 | 183.42 | 327.50 |
| 4. Land Use Change and forestry | 18526.02 | -1016.00 | 0.49 | 3.20 | 1.60 | 0.06 | 17517.37 |
| Changes in Forestry and Other Woody Biomass Stocks | 14003.02 | | | | | | 14003.02<br>0.00 |
| Forests and Grassland Conversion | 2183.00 | | 0.49 | 3.20 | 1.60 | 0.06 | 2188.35 |
| Abandonment of Managed Lands | | -1016.00 | | | | | -1016.00 |
| $CO_2$ Emissions and Removals from Soils | 2342.00 | | | | | | 2342.00 |
| 5. Waste | 0.00 | 0.00 | 105.11 | 0.00 | 0.00 | 0.00 | 105.11 |
| Solid waste Disposal on Land | | | 95.06 | | | | 95.06 |
| Waste water handling | | | 10.05 | | | | 10.05 |

The 1994 values are similar to the results of the 1990 inventory both in trend and level of magnitude (Table 2.3 and Figure 2.4). However, the total emissions for 1994 were 12% lower than those of 1990, reflecting the significant degree in 1994 of the emission from the Forestry and Grassland Conversion sector.

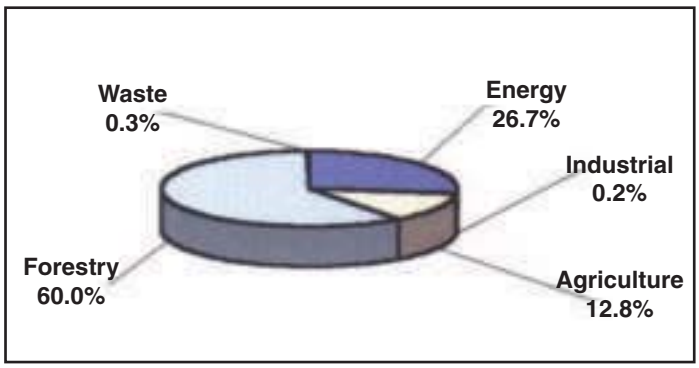


**TABLE 2.3: Summary Report for National Greenhouse Gas (GHG) Inventories and $CO_2$ Equivalents for 1990 (Gg)**

| GREENHOUSE SOURCE AND SINK CATEGORIES | $CO_2$ Emissions | $CO_2$ Removals | $CH_4$ | $NO_2$ | $NO_x$ | CO | $CO_2$ Equivalent |
|---|---|---|---|---|---|---|---|
| Global Warming Potential (GWP) | **1.00** | **1.00** | **24.50** | **320.00** | **40.00** | **3.00** | |
| **Total National Emissions and Removals** | **21869.54** | **-1320.81** | **336.26** | **1.09** | **28.92** | **934.23** | **33093.89** |
| % of Total Emissions /Removals | **66.08** | **-3.99** | **24.89** | **1.05** | **3.50** | **8.47** | **100.00** |
| 1. Energy -Reference Approach | **619.13** | **0.00** | **276.23** | **0.72** | **27.12** | **895.95** | **11391.26** |
| | | **0.00** | **276.23** | **0.72** | **27.12** | 895.95 | **11391.26** |
| A. Fossil fuels | 619.13 | | | | | | 619.13 |
| Liquid Fossil Fuels | | | | | | | 0.00 |
| Solid Fossil fuels | | | | | | | 0.00 |
| B. Fugitive Emmissions | | | | | | | 0.00 |
| Solid Fuels | | | 0.82 | | | | 19.99 |
| C. Biomas | | | 275.41 | 0.72 | 27.12 | 895.95 | 10752.14 |
| 2. Industrial Processes | **50.12** | **0.00** | **4.02** | **0.00** | **0.00** | **0.00** | **148.48** |
| Cement Production | 50.12 | | | | | | 50.12 |
| Lime Production | | | | | | | 0.00 |
| Industrial digesters | | | 4.02 | | | | 98.37 |
| 3. Agriculture | **0.00** | **0.00** | **50.83** | **0.36** | **1.58** | **30.78** | **1514.79** |
| Enteric Fermentation | | | 35.78 | | | | 876.52 |
| Manure Management | | | | | | | 0.00 |
| Rice Cultivation | | | 13.64 | | | | 334.15 |
| Agriculture Soils | | | | 0.31 | | | 99.55 |
| Prescribed Burning of | | | 0.18 | 0.00 | 0.08 | 4.84 | 23.08 |
| Field Burning of Agricultural Savannas Residues | | | 1.24 | 0.04 | 1.50 | 25.94 | 181.48 |
| 4. Land Use Change and Forestry | **21200.30** | **-1320.81** | **0.86** | **0.01** | **0.21** | **7.50** | **19933.39** |
| Changes in Forestry and Other Woody Biomas Stocks | 13883.65 | | | | | | 13883.65 |
| Forests and Grassland Conversion | 7316.65 | | 0.86 | 0.01 | 0.21 | 7.50 | 7370.55 |
| Abandonment of Managed Lands | | -1320.81 | | | | | -1320.81 |
| $CO_2$ Emissions and Removals from soils | | | | | | | 0.00 |
| 5. Waste | 0.00 | **0.00** | **4.33** | **0.00** | **0.00** | **0.00** | **105.97** |
| Solid Waste Disposal on Land | | | 4.04 | | | | 99.04 |
| Waste Water Handling | | | 0.28 | | | | 6.93 |

Although there has been a reduction in the GHG emissions for 1994 compared to 1990 the percentage sectoral contributions in the emissions have remained almost unchanged. The LUCF sector contributed to 60% of the net $CO_2$ equivalent in 1994, the Energy and Agriculture sectors accounted for 27% and 13% respectively.

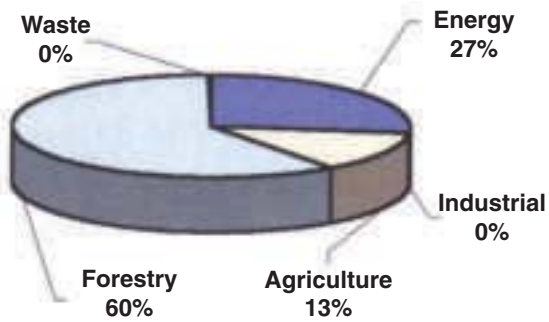



**Figure 2.4: Sectoral GHG Emissions (1990)**

## 2.3 Emissions By Sources

### 2.3.1 Carbon Dioxide ($CO_2$)

The major source of $CO_2$ in 1994 was Land Use Change and Forestry from which 18528.02 Gg $CO_2$ were emitted with changes in Forestry and other woody biomass stocks contributing 14,003.02 Gg of $CO_2$. In 1994 the only removal (sink) is from Abandonment of Managed Lands, that removed 1016 Gg of $CO_2$ from the atmosphere.

The observed decrease in LUCF $CO_2$ removals from the 1990 value of 1321 Gg may be attributed to improved methodology and activity data for the 1994 inventory compared to 1990. Thus the Land Use Change and Forestry sector in 1994 had a net emission of $CO_2$ amounting to 17,512.02 Gg of $CO_2$. In 1990, the Land Use Change and Forestry Sector was also a net emitter of $CO_2$ amounting to 198795 Gg.

### 2.3.2 Methane ($CH_4$)

The 1994 inventory results showed that methane ($CH_4$) was emitted from waste management, burning of biomass for energy, enteric fermentation and rice cultivation in agriculture. Biomass burning is the most significant source producing 135 Gg, followed by Enteric Fermentation and Rice Cultivation which produced 30 Gg and 15 Gg respectively.

The emissions from solid waste management were small due to the fact that most of the landfills are poorly managed, and often not compacted. There is also onsite burning at most landfill sites.

### 2.3.3 Carbon Monoxide (CO)

Biomass burning for energy was the dominant source for carbon monoxide emitting a total of 880 Gg. Field burning of agricultural residues and prescribed burning of savannah emitted 61 Gg and 11 Gg respectively.

### 2.3.4 Nitrous Oxide ($N_2O$)

The dominant source of $N_2O$ is agricultural soils as a result of using chemical fertilisers. The total emission amounted to 7 Gg and the emission from biomass burning was about 1 Gg.

### 2.3.5 Nitrogen Oxides ($NO_X$)

Biomass burning for energy is the dominant source of nitrogen oxide producing 24 Gg of $NO_X$ followed by field burning of agricultural residues which emitted only 2 Gg.

## 2.4 Sectoral Inventories

### 2.4.1 Energy

The Reference Approach methodology was used in computing sources of emissions from the Energy Sector due to non-availability of sectoral energy data such as in transport, agriculture, residential and institutions. The energy balances for Malawi for the year 1994 and earlier were not done. The emissions from the energy sector in 1994 decreased from the 1990 levels in all sub-sectors reflecting improved activity data and methodological utilisation including emission factors. The energy sector emitted a total of 661Gg of $CO_2$. This was from the combustion of liquid fossil fuels such as gasoline, jet kerosene, diesel and paraffin, and solid fossil fuel (coal), which contributed 530 Gg and 131 Gg respectively.

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The non-$CO_2$ emissions from fuel combustions comprised of 135Gg of $CH_4$, 24 Gg of $NO_x$, 880 Gg of CO and 1 Gg of $N_2O$. Emissions from international bunkers were not computed because of lack of activity data. This sector will be included in the next GHG inventory.

### 2.4.2 Industrial Processes

Local production of clinker for cement manufacture is the main source of $CO_2$ emissions giving 57 Gg of $CO_2$ in 1994. Lime production by small-scale producers using firewood for calcinations in traditional kilns emitted only 2 Gg of $CO_2$ in the same period (Figure 2.5).

**Figure 2.5: Firewood logs in a Traditional Lime Kiln (Lirangwe, Blantyre)**
*Source: MIRTDC, Blantyre*

### 2.4.3 Agriculture

Malawi's economy is based on agriculture and has commercial and smallholder sectors which use different levels and types of technology and other inputs. The most important food crops are maize, rice, sorghum and millet, while tobacco, sugar, tea and coffee are grown as cash crops. Livestock production is however not well developed.

The agricultural sector produced significant non-$CO_2$ emissions in 1994, as shown in Table 2.1. The total emissions consisted of 49 Gg of $CH_4$ mainly from enteric Fermentation (30 Gg) and rice cultivation (15 Gg). The other emissions consisted of 7 Gg of $N_2O$ from agricultural soils, 2 Gg of $NO_x$ and 72 Gg of CO from prescribed burning of Savannah and field burning of agricultural residues.

### 2.4.4 Land Use Change and Forestry (LUCF)

Land Use Change and Forestry (LUCF) is the greatest contributor of GHG emissions and removals. The sources of emissions for CO2 in 1994 were Changes in Forestry and Woody Biomass, Forests and Grassland Conversion and Soils that emitted 14003 Gg, 2183 Gg and 2342 Gg respectively.

The only sink for CO2 removals in the LUCF sector was Abandonment of Old Managed Lands that removed 1016 Gg of $CO_2$ from the atmosphere, (Figure 2.6).

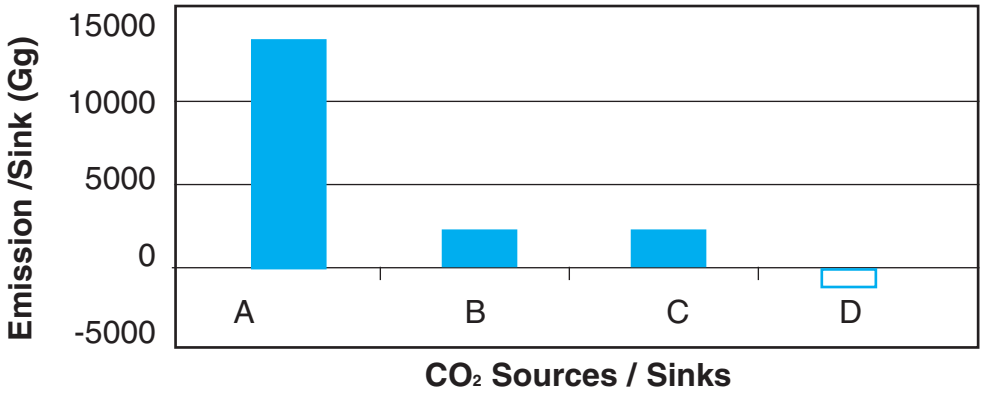


**Figure 2.6: LUCF $CO_2$ Sources and Sinks 1994**

KEY
A- Changes in Forestry and Other Woody Biomass Stocks
B- Forests and Grasslands Conversion
C- Carbon dioxide Emission from Soils
D- Abandonment of Managed Lands

In 1994 the sink capacity decreased by 305 Gg from the 1990 levels. This may be attributed to the inconsistent activity data and emission factors. Other factors also played a role such as increased use of firewood and charcoal, increased seasonal burning and high rate of deforestation due to rapid population growth. Malawi was a net emitter of $CO_2$ in 1994 due to the contribution from LUCF. This will require verification in future GHG inventories.

### 2.4.5 Waste Management

The sector only considered urban and peri-urban areas in the country where only 15% of the population reside. Only about 4 Gg of methane was produced mainly from Solid Waste Disposal on land. Tthe landfills are poorly managed leading to low $CH_4$ emission.

There was an improvement in the quality of activity data for 1994 over 1990. Future GHG inventories should therefore address the quality and quantity activity data, as well as the emission factors, in the waste management sector.

## 2.5 Summary of GHG Inventory Results

### 2.5.1 Total GHG emissions

In 1990, the total $CO_2$ emissions made up 66% of total $CO_2$-equivalent emissions, followed by about 25% from methane. In 1994 the emission percentages were similar to 1990. The sectoral emission percentages also show little differences between 1994 and 1990, and in both years Forestry contributed 60% followed by Energy (27%) and Agriculture (13%).

### 2.5.2 GHG Emissions $CO_2$ - Equivalent

According to the results of the 1990 and 1994 inventories Malawi is a net emitter of carbon dioxide ($CO_2$). This is largely attributed to socio-economic pressures in Land Use Change and Forestry sector such as deforestation and conversion of prime forestry land to agricultural uses. In addition there are few plantations in Malawi and also the forestry per capita in the country is low.

Thus in future GHG inventories acquisition of high quality activity data in land use change and forestry must be a priority. The contribution from Energy sector is also an important GHG source and needs quality activity data.

# CHAPTER 3: IMPACTS, VULNERABILITY AND ADAPTATION

## 3.1 Introduction

The Vulnerability and Adaptation (V&A) assessment of Climate Change is in conformity with Articles 4.1(e), 4.8 and 4.9 of the United Nations Framework Convention on Climate Change (UNFCCC) to which Malawi is a Party. The key socio-economic sectors assessed are Agriculture and Livestock, Water Resources, Forestry, Fisheries and Wildlife. However, Human Health and Settlements, Land Use Change, Land Degradation, Industry and Energy will be assessed in future studies.

Malawi's vulnerability to climate change arises mainly from socio-economic, demographic and climatic factors. These include slim economic base, limited agro-processing facilities, over-dependency on rain-fed agriculture and biomass energy, inadequate health facilities, poverty exacerbated by drought, floods, natural disasters and population pressure.

Malawi experiences a variety of extreme weather events that have recently increased in frequency of occurrence and intensity resulting in loss of life and damage to infrastructures and buildings. El Nino and La Nina global phenomena cause local floods and droughts. Severe droughts occurred in the 1991/1992 and 1994/1995 growing seasons (November-April). There were floods in the 1999/2000 and 2000/2001 rainy seasons. In the 1991/92 drought, rivers in many catchments dried up and the Shire River water levels became precariously low threatening hydro-power generation downstream.

Landslides occur during prolonged torrential rains mainly in the southern parts of the country. In the 1992/1993 rainy season, landslides caused a loss of over 500 lives and severe damage to socio-economic structures in Mulanje - Phalombe areas. Tornado - type wind systems have increased in frequency during the rainy season. This has resulted in loss of life and damage to building structures especially in rural communities where building standards are very low.

Particular weather systems cause outbreaks of pests such as armyworm and diseases like cholera and malaria leading to illness, loss of life and reduced agricultural productivity.

Some measures and strategies exist to deal with the adverse effects of extreme climatic events. A Department of Disaster, Relief and Rehabilitation was established to handle most aspects of the effects of extreme weather events and other natural disasters. Non-Governmental Organisations (NGOs) and Faith Groups also have programmes for such events. Malawi has a Flood Warning System based in the Water Department. In addition the Meteorological Department provides timely weather warnings to the general public. The National Disaster Management Plan for Malawi includes mitigation measures for drought and flood disasters but has no specific adaptation measures.

## 3.2 Climate Change Scenario

The Climate Change model known as Model for the Assessment of Greenhouse Gas Induced Climate Change (MAGICC) and its Scenario Generator (SCENGEN) were used in the V&A assessment for all sectors studied. The national baseline climatic data from the Meteorological Department for the period 1961-1990 were used in the assessments. The model outputs were for climate change scenarios for the periods 2020, 2075, and 2100. The year 2020 is important because Malawi has developed vision 2020 as a guide to its developmental aspirations.

Four Global Circulation Models (GCMs) from MAGICC/SCENGEN namely HadCM2, CSIRO-TR, ECHAM4 and CGCM1-TR were selected and used to project temperature and rainfall to years 2020, 2075 and 2100. The projected results were compared to the 1961-1990 baseline data as shown in Figures 3.1 and 3.2. The comparison shows that all projected temperature and rainfall variations agree with the baseline data trends. However, the HadCM2 and CSIRO models over-predicted and under-predicted the baseline temperatures, respectively. The CSIRO and HadCM2 over-predicted and under-predicted rainfall from baseline data respectively. All the sectors used the same models for scenario generations.

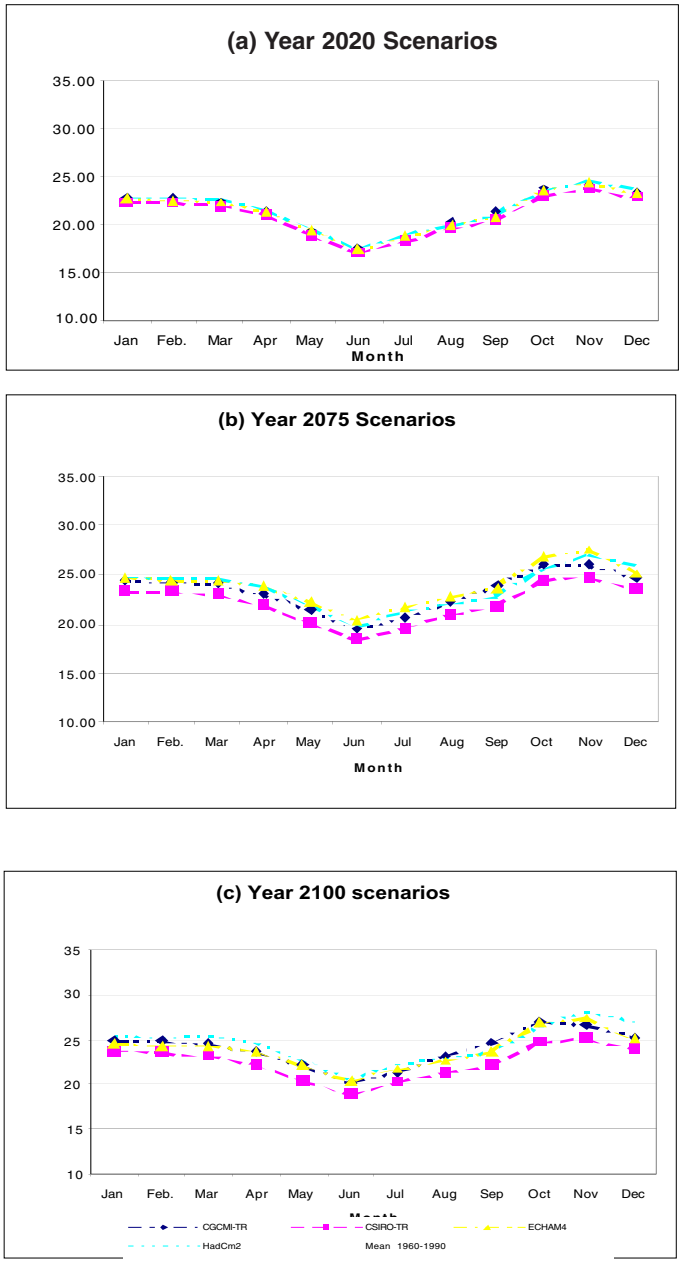


Figure 3.1:Projected Temperature Scenarios for 2020, 2075 and 2100 for Chitedze Agricultural Research Station

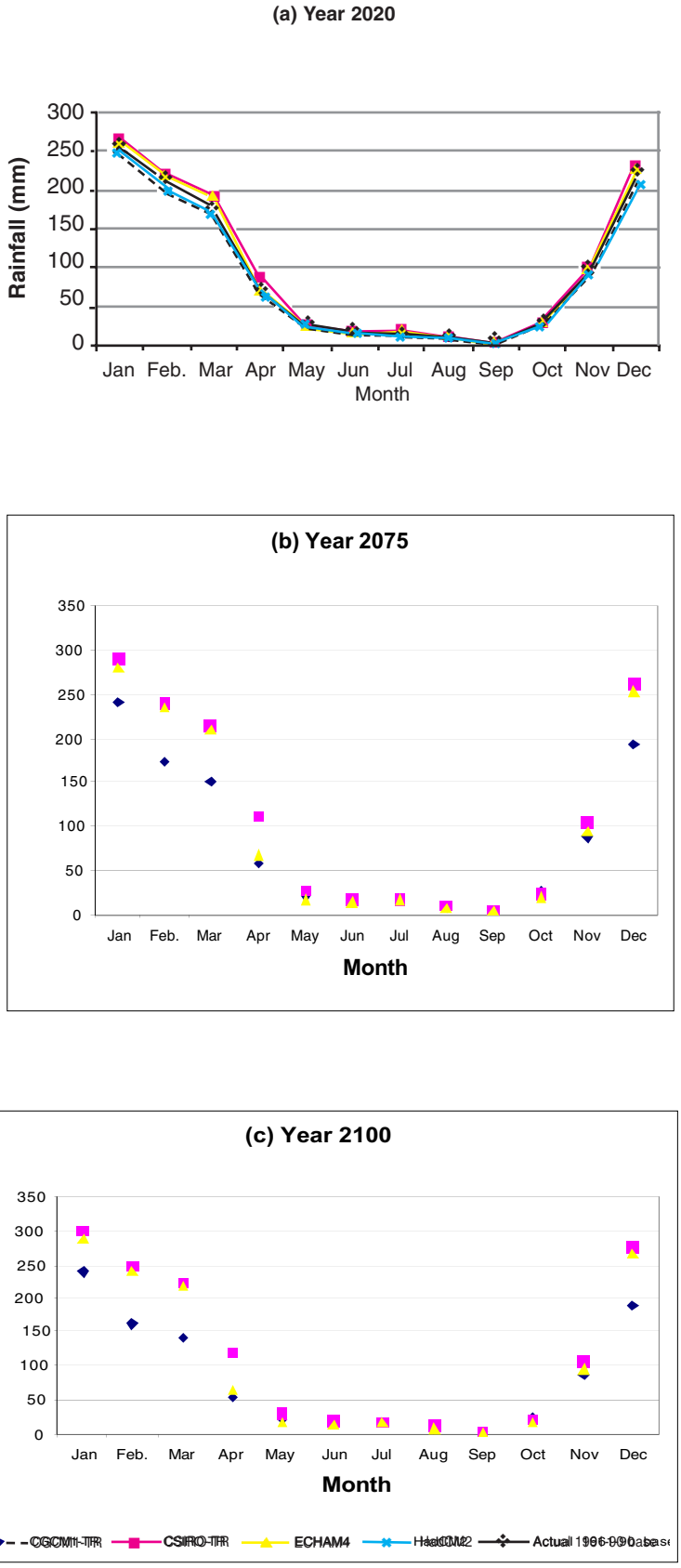


**Figure 3.2 (a-c): Projected Mean Rainfall Scenarios for Bvumbwe Agricultural Research Station**

A major limitation in all the V & A sector studies is that socio-economic scenarios were not developed for the sectors. Future studies will utilise the socio-economic scenarios and models in addition to Climate Change Scenarios.

## 3.3 Water Sector

### 3.3.1. Introduction

Malawi is endowed with surface and ground water resources. The surface water resources consist of the following: -

- A network of river systems, comprising the Shire, Ruo, Bua, South Rukuru, Songwe and other smaller rivers
- Lakes, namely, Lake Malawi, the third largest in Africa, Lake Chilwa, Lake Malombe, and Lake Chiuta.

The drainage system is categorised into three separate units as follows: -

- Lake Malawi system
- Shire River system
- Lake Chilwa system.

Ground water resources are found in two main aquifers, namely: -

- The relatively low yielding Precambrian weathered basement complex 20 percent aquifer, which forms 85% of the country's geology.
- The high yielding quaternary alluvial deposits exclusively covering the shore of Lake Malawi and the Lower Shire Valley.

The quantity of surface water resources, especially in river systems, is highly dependent on runoff from rainfall and thus water resources are usually more abundant during the rainy season than the dry season. The annual groundwater recharge is estimated to be 15-100 mm per year, but in some parts of the country recharge rates greater than 200 mm per annum have been recorded.

### 3.3.2 Study Sites

The study considered only three representative basins for the vulnerability assessments on water resources namely, South Rukuru, Bua and Linthipe river basins (Figure3.3). The basins are within altitudes of 500-1670 metres with mean air temperature between 15-28$^{o}$C and rainfall ranging between 700-1600 mm annually. However, all the basins seem to register higher evaporation rates than rainfall.

However, the Shire River in Southern Region was not included in the assessment because of the artificial hydraulic structures that control its flow. Lake Malawi was also not covered in the assessment because of lack of relevant data from Malawi and the neighbouring countries.

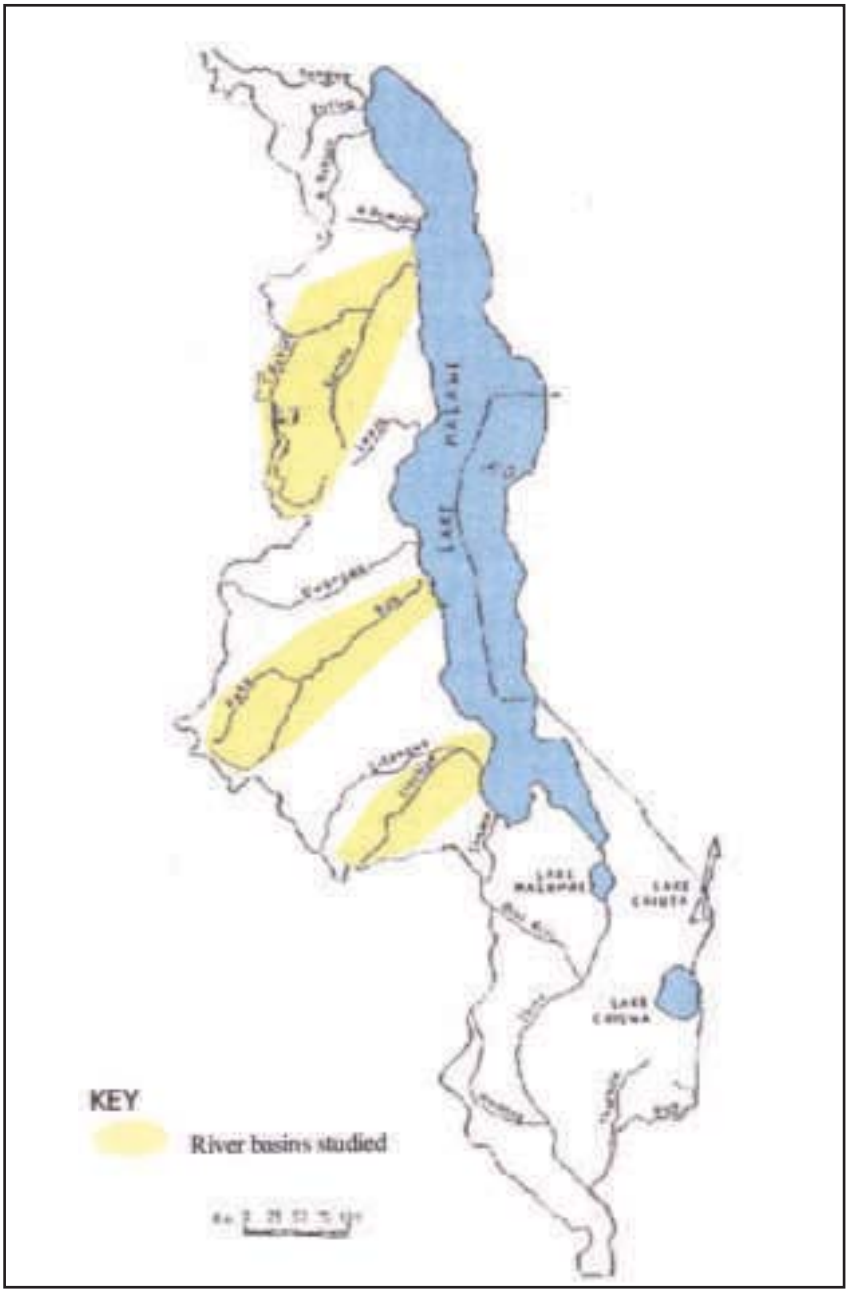


**Figure 3.3: Major River Basins and the Selected Study Sites**

### 3.3.3 Climate Projections from the Models

Two GCM models, the Had CM2 and CSIRO - TR were selected for scenarios generation for the years 2020 -2100. The HadCM2 model under - estimated rainfall, predicting a decline in rainfall by 1 to 18%, thus giving a dry scenario. By contrast CSIRO-TR overestimates rainfall suggesting an increase in the amount of rainfall of 6 to 22% leading to wet scenarios. Run-off projections were estimated using the watball model with inputs from the two scenario generations. The following projected results were obtained for the years 2020, 2075 and 2100.

a) Both models predict that temeperatures of all basins will increase by 0.6$^0$C to 3.8$^0$C.
b) For precipitation CSIRO-TR projects an increase in the amount of rainfall by 6 to 22% where as Had CM2 predicts a decline from -1 to 18%.
c) Watbal predicts that run-off will change by-1 to 44 and -8to 81% using HadCM2 and CSIRO-TR models respectively.
d) Annual availability of water resources in the study basins may not be vulnerable to climate change; and
e) Analysis of the water balance shows that evapotranspiration exceeds annual rainfall. This result implies that the excess water used for evapotranspiration is obtained from the ground water.

### 3.3.4 Water Demand Analysis and Vulnerability

The sectors that are expected to exert high water demand are domestic needs, irrigated agriculture, hydropower generation, and industrial production. In this study it was not possible to undertake direct water demand projections to year 2020 and 2075, in some demand sectors because of lack of activity data and capacity. The current study considered water demand in the basins for domestic and irrigation purposes only, taking into account human population projections, as shown in Table 3.1. A national growth rate of 2% was used in projecting populations to 2020 and only 1% was utilised for the period 2020 to 2075 ( Table 3.2). Per capita water requirements are taken as 40 litres/person/day and 27 litres/person/day in urban and rural areas respectively.

Matching the demand by various sectors to the available water resources shows that in the three basins studied, the amount of water available will be higher than the amount demanded by domestic consumption and irrigated agriculture. There is however a decrease in available water amounts under climate change scenarios, compared to baseline amounts.

**Table 3.1 Available Water Compared With Water Demand Under No Climate Change For The Years 2020 and 2075**

| River Basin | Amount Of Available Water ($10^6m^3$) | Irrigation Demand For the Year 2020 ($10^6$ $m^3$) | Domestic Demand For the Year 2020 ($10^6m^3$) | Total Water Demand For The Year 2020 ($10^6m^3$) | Difference: Supply-Demand ($10^6m^3$) |
|---|---|---|---|---|---|
| South Rukuru | 1388 | 154 | 12 | 166 | +1222 |
| Bua | 1104 | 194 | 19 | 213 | +891 |
| Linthipe | 1293 | 136 | 35 | 171 | +1122 |
| | | | | | |
| River Basin | Amount Of Available Water | Irrigation Demand For The Year 2075 | Domestic Demand For The Year 2075 | Total Water Demand For The Year 2075 | Difference: Supply-Demand |
| South | 13878 | 154 | 24 | 177 | +1210 |
| Bua | 1104 | 194 | 37 | 231 | +873 |
| Linthipe | 1293 | 136 | 69 | 205 | +1088 |

**Table 3:2 Projected Populations**

| Basin /District | Population | | | | | |
|---|---|---|---|---|---|---|
| | Rural | | | Urban | | |
| | 1998 | 2020 | 2075 | 1998 | 2020 | 2075 |
| South Rukuru (Mzimba, Rumphi | 624,563 | 969,650 | 1,892,615 | 114,791 | 178,216 | 347,851 |
| Bua (Mchinji, Ntchisi Kasungu Nkhotakota | 1,138,678 | 1,767,826 | 3,450,539 | 74,108 | 115,055 | 224,570 |
| Lithipe (Deza, Lilongwe, Salima | 1,605,022 | 2,491,838 | 4,863,703 | 476,234 | 739,365 | 1,443,134 |

**Urban Centres**

(1) 29% national growth rate was adopted for population projection to year 2020 and 1% for 2020 to 2075 (National Statistics Office)
(2) South Rukuru: Mzimba, Mzuzu and Rumphi.
(3) Bua: Mchinji, Ntchisi, Mponela, Kasungu and Nkhotakota
(4) Linthipe: Dedza, Lilongwe and Salima

### 3.3.5 Potential Adaptation Strategies

The vulnerability studies carried out in the three river basins of South Rukuru, Bua and Linthipe indicate that water resources may not be stressed by climate change. However, the analysis did not deal wiht extreme weather events and such events are likely to occur more frequently. (IPCC 3rd Assesment Report). Nevertheless Malawi needs to put in place measures to adapt to droughts and floods as detailed below: -

**Adaptation Measures for Droughts**

- Construction of more dams to retain surface runoff during the rainy season, as nearly 24% of annual rainfall is lost as surface run-off;
- Increased sustainable utilisation and monitoring of groundwater resources;
- Conjunctive use of surface and groundwater resources;
- Sustainable agricultural practices including soil and water
- Proper water use to improve water conservation;
- Expansion of rainfall harvesting techniques;
- Leakage monitoring and control in piped networks to avoid water loss;
- Public awareness campaigns for water conservation measures.

**Adaptation Measures for Floods**

- Construction of upstream storage dams for purposes of mitigating flood hazards;
- Construction of dykes, canals or bunds to re-direct or divert flows to minimize flood damages, although this is generally very expensive;
- Increased afforestation in catchment areas to cover areas not yet considered;
- Extension of the installation of telemetry flood forecasting and warning systems to other flood prone areas for timely evacuation of people;
- Delineation of flood prone areas with flood zoning maps and the development of appropriate adaptation strategies and measures;
- More public awareness campaigns;
- Improved wetlands conservation measures ; and
- Effective early warming systems.

### 3.3.6 Prioritizing and Costing of Adaptation Measures

The possible adaptation measures were not fully prioritised and costed because the study lacked the appropriate models to evaluate the technologies used in the proposed adaptation measures. In the next study of V&A assessment this aspect should be given high priority.

### 3.3.7 Study Constraints

The country's vulnerability assessment in the Water Sector encountered a number of constraints as detailed below:

- The largest water body in Malawi, Lake Malawi, and the biggest river, the Shire River (which is the only outlet of Lake Malawi), were not included in the study due to lack of activity data, presence of hydraulic structures and time constraints;
- The activity data as well as meteorological and hydrological data used in generation of climate change scenarios need to be improved;
- Non-availability and limited knowledge of models needed in V&A studies and population projections;
- Lack of representative activity data for each catchments and river basin bearing in mind the disparities in topography and geology;
- Lack of experience and training to effectively run the necessary V&A models that require prior hands-on training; and
- Lack of methodologies/models and necessary skills to use them in evaluating the proposed adaptation measures.

## 3.4 Fisheries Sector

### 3.4.1 Introduction

Malawian water bodies that comprise Lake Malawi, Lake Chilwa, Lake Chiuta and rivers, including the rivers Songwe, Rukuru, Bua, Linthipe and Shire contain a diversity of freshwater fish species. Table 3.3. shows characteristics of some of the major lakes in Malawi. The inland freshwater resources of Malawi have varying and different

ecological zones that determine the various fish distribution in water bodies of the country. There are fish species that adopt more than one ecological zone and most fish in Malawian water bodies adapt to more than one breeding and/or feeding habitats. For example, potamodomus fish family live in open lake waters as adults but migrate into rivers to spawn and most cichlids such as "chambo" live in depths of between 50 – 100 m but migrate to shallow waters less than 50 m to breed. Lake Malawi has an estimated 700-1000 fish species and is regarded as a heritage centre of fresh water fish biodiversity of the world. It has the greatest number of endemic species including chambo (Figure 3.4) in a fresh water body in the world.

Aquaculture has introduced fresh fish availability to many remote areas and hence provides the cheapest form of protein. Fish production from aquaculture has increased as result of increased numbers of farmers and fishponds and better management practices.

**Figure 3.3: Characteristics of Major Lakes in Malawi**

| No. | Name | Features | water Level (m) | Fish Production (%) | Other Parameters | |
|---|---|---|---|---|---|---|
| | | | | | Depth (m) | Area (mk².) |
| 1.0 | Lake Malawi | Bordered by Malawi Mozambique and Tanzania | 473 Highest 476m) | 40-60% (40,000 tonnes) | 292 (Deepest 785 m) | 28,000.00 |
| 2.0 | Lake Malombe | Wholly in Malawi | - | Minimal | 3.8 | 390.0 |
| 3.0 | Lake Chilwa | Bordered by Malawi and Mozambique. Dried completely in 1922/23, 1967/68, and 1993/94 | 630 | 10-30% | 5.0 | 700.0 |
| 4.0 | Lake Chiuta | Bordered by malawi and Mozambique | 620 | 1-3% | 5.0 | 200.0 |

**Figure 3.4: Endemic fish species (Chambo) from Lake Chiuta**

### 3.4.2 Importance of Fish in Malawi.

Fish is very important to the people of Malawi because fish contributes to good nutrition, food security and socio-economic development as follows: -

- Fish provide 60-70% of animal protein consumed and contribute 36- 40% of total available protein to people's diet;
- Fisheries contribute 4% of the GNP;
- Fisheries provide employment directly in fishing and also indirectly in marketing, distribution, input supply and other activities. whereby almost 300,000 people are involved; and
- Aquaculture is integrated with field crops and thereby maximizes use of land.

### 3.4.3 Current Vulnerabilities and Adaptation Experiences

Fisheries in water bodies of Malawi including aquaculture experience a variety of vulnerabilities such as:

a) Pollutants and contaminants in Lake Malawi and other water bodies due to river sedimentation and nutrient loading

b) Metals, pesticides and other persistent contaminants in Lake Malawi.

c) Invading weeds such as Azolla *(Azolla nilotica)* and water hyacinth *(Eichornia crassipes)*, which are a threat to fish production both in lakes and river systems.

d) Vulnerability of fisheries resources to drought whereby water levels vital to fish production are drastically reduced. Shallower lakes such as Lake Chilwa dry out completely as happened in 1914 - 1915, 1966 - 1967 and 1993 – 1994. Drought affects fish production adversely in Malawi both in natural water bodies and aquaculture through non- availability of water and also greatly reduced water levels vital to fish production.

e) The disappearance of some fish species whose habitats are threatened by current declining water level variations and other adverse environmental factors. Such threatened species include the Mbuna which are stenotopic with narrow national distribution

f) There is a general decline in fish production in the country's water bodies (Figure 3.5)

Fish production is of vital socio-economic importance to the development of the country and a number of adaptation measures have been instituted to counter the vulnerabilities as follows:

a) In the lake catchment areas, better cultivation techniques, have been introduced and cutting down of trees and bush burning are discouraged;

b) The use of pesticides in lake catchment areas (through agricultural practices) is being controlled;

c) There is a monitoring system to detect metals in water bodies especially Lake Malawi;

d) The present adaptation measures to the problems of Azolla and water hyacinth

included erection of barriers in rivers, physical removals, biological control and civic education;

e) After severe droughts there has been re-introduction/stocking of fish in Lake Chilwa and fishponds from the National Aquaculture Centre;

f) A water barrage was installed on the Shire River, the only outlet of lake Malawi, to control and regulate waterflow downstream, where there are major irrigation systems and hydropower generation;

g) There are fish resource access restrictions and Community Based Systems to safeguard the fish resources.

h) A project to safeguard the Mbuna fish is being implemented.

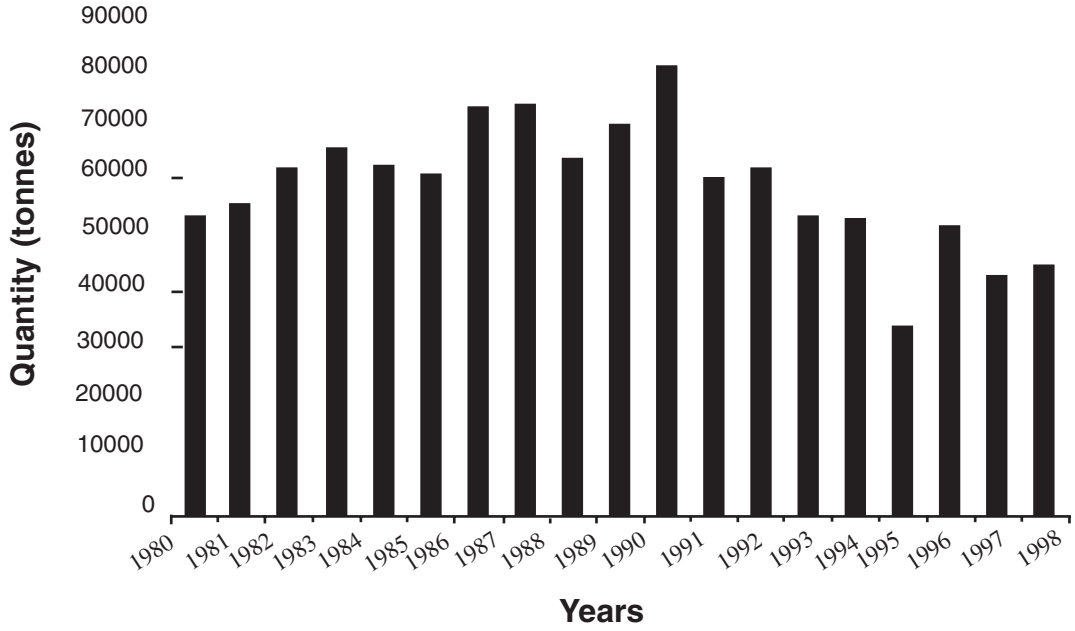


**Figure 3.5: Annual Fish Production in Malawi**

### 3.4.4. Vulnerability of Fisheries Resources to Climate Change

The assessment method focused on evaluating the potential impacts of climate change through actual hydrological conditions.

The model for Assessment of Greenhouse Induced Climate Change (MAGICC) and its Scenario Generator (SCENGEN) was used for Lake Malawi in spite of climatic data limitations. Five GCMs were used namely HadCM2, Uktr, CSIRO-TR, ECHAMA and ECHAM4 to project lake air temperature, rainfall and wind speed to the years 2020, 2025, 2050, 2075 and 2100. The HadCM2 model gave the best -fit temperature, rainfall and wind speed projections.

Table: 3.4 below summaries the projected mean air temperature, wind speed and rainfall over Lake Malawi.

**Table 3.4 Projected Annual Temperature, Wind Speed and Rainfall using MAGICC/ SCENGEN (Had CM2)**

| VARIABLE | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1994 | 2000 | 2020 | 2025 | 2050 | 2075 | 2100 |
| **Temperature ($^0$C)** | 24.1 | 24.1 | 24.8 | 24.9 | 25.9 | 26.1 | 27.8 |
| **Rainfall (mm)** | 1,059 | 1,059 | 1,022 | 1,022 | 1,022 | 986 | 986 |
| **Wind Speed (m/s)** | 2.4 | 2.4 | 2.4 | 2.4 | 2.5 | 2.5 | 2.6 |

The results show that mean temperature and wind speed may increase by the year 2100 while rainfall over the lake shows a declining trend. The relationship between mean air temperature and fish production is not established, hence , the effect of projected temperature increase is not easily translated to fish production. Increase in wind speed, especially the cooler and denser south easterly flow, may increase the upwelling effect on Lake Malawi and other water bodies and adversely affect fish production. The decrease in Lake rainfall may affect the Lake levels which also adversely affect fish production.

### 3.4.5. Study Limitations

The water bodies of Malawi much more data to undertake a meaningful V & A assesment as follows:

- Fish production data-required by location, time periods and species;
- Surface water temperature data is very scantly especially over Lake Malawiand Lake Chilwa. Use of remote sensing techniques could
- Surface water temperature data is very scanty especially over Lake Malawi and Lake chilwa. Use of remote sensing techniques could provide a good data base for the entire Lake Malawi;
- Water temperature measurements at various depths in the water bodies especial ly Lake Malawi are limited and not systematic;
- Standard climatic measurements such as air temperature, wind, rainfall, radiation, humidity and pressure are scanty over the entire Lake Malawi surface;
- The lakeshore weather monitoring stations are more inland to reflect lake conditions and are far apart;
- The extent of upwelling due to cool/cold strong South Easterly trade winds and its effects over Lake Malawi and Lake Chilwa as well as the effects of the Lake land breeze on fish production needs to be investigated.

### 3.4.6 Possible Future Adaptation Options to Address Climate Change

The Fisheries Resources in Malawi face potential adverse impacts from Climate Change which require adaptation options to sustain the fish production as described below:

a) To Develop a policy to determine levels of metal concentrations of contaminants and appropriate standards, more especially for lake Malawi which is an international water body;
b) Adopt sustainable uses of the water weed such as compost, ingredients of animal feed, and biogas production;
c) Strengthen the National Aquaculture Centre to be able to produce tilapia and catfish for restocking programmes in cases of extreme drought;
d) Establish a fish gene bank to maintain the genetic diversity of fish population.
e) Develop a Lake Malawi monitoring system to provide climatic and hydrological data at various points to support fisheries resources production; and
f) Strengthen good agriculture and land use practices around water bodies.

## 3.5 Forestry Sector

### 3.5.1 Introduction

Malawi's vegetation has a wide variety of formations determined by slope, soil type, geology and climatic variables. These have resulted in at least nineteen (19) distinct vegetation communities. The natural forests of Malawi cover about 28% (2.6 million hectares) of land but they are mainly concentrated in upland, hilly areas and along the rift valley escarpments. The Miombo woodland *(Brachystegia, Isobernia, and Julbernadia)* is the dominant natural forest. The country has relatively few commercial forest species such as Pterocarpus angolensis, and Khaya anthontheca. The gazetted forest reserves vary in size from the large Dzalanyama (989.34 $km^2$) and South Viphya (1,144.77 $km^2$) reserves to the extremely small Masenjele (1.01 $km^2$) and Litchenya (0.55 .$km^2$) reserves.

The livelihood of most Malawians is interrelated with the forests, woodlands, and trees because these provide biomass energy, food, fodder, pharmaceuticals, employment, construction materials, income and foreign exchange hence contributing to socio-economic development. Firewood is the major source of energy in Malawi meeting over 90% of energy needs (Figure 3.6).

**Figure 3.6: Firewood, a Major Source of Energy in Malawi**

**Source: EAD Outreach, Lilongwe**

### 3.5.2 Study Site and Methodology

The whole country was assessed for climate change impacts on forest types specifically, its effect on forest ecosystems, sensitivity of forests, identification of possible adaptation and policy options. In addition, Dzalanyama Forest Reserve was selected for a detailed study of the impact of climate change on selected tree species. Dzalanyama was selected because it provides protection for a watershed catchment, it has activity data and it is representative of the country's majority of forests. .In the assessment, the Holdridge Model was utilised to assess climate change impacts on forest types while the GAP Model assessed impacts on individual tree species. To run the Holdridge Model, output from four General Circulation Models namely HadCH2, CSIRO-TR, ECHAMA4 and CGCM1-TR were used. In the GAP Model, four scenarios namely current climate, mild climate change ($1^0$C), moderate climate change ($2.5^0$C) and extreme climate change ($4.5^0$C) were used. Future studies will fully utilise the scenario generations.

### 3.5.3 Results

Climate Change projections show that some forests will change to drier forest types under moderate to extreme climate scenarios. However, some forests such as Vwaza, Nyika, Kasungu and Dzalanyama may not be affected significantly by climate change.

GAP analysis results from Dzalanyama showed that between 2020 and 2100, the magnitude of wood productivity will decline from 0% to 37% per hectare depending on the climate scenario (Figure 3.7).

The GAP analysis results also show that the structure or composition of forests may not change under various climatic scenarios.

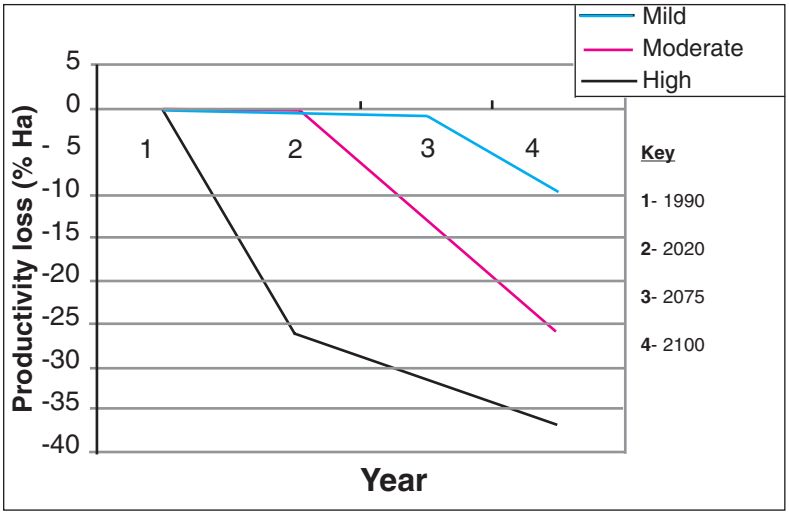


***Figure 3.7: Biomass Productivity Reduction Rates for Mild, Moderate and Extreme Climate Change Scenario.***

### 3.5.4 Current Vulnerabilities and Experiences in Adaptation

The forests in Malawi are vulnerable to a number of factors as detailed below.

***Decline of Forest Quality***

Many people exploit the forests for fuel wood, charcoal, construction poles, and timber through selective cutting that leave external forest boundary unchanged.

***Forest Conversion***

This aspect causes deforestation through land use whereby forests are converted into cropland or rangeland. Deforestation is a major concern presently growing at 2.8% annually translating into an estimated loss of 50000 hectares of forest per year. Other activities such as road, rail, and dam construction in addition to settlements also contribute to deforestation.

***Extreme Climatic Events***

During the rainy season, tornado type wind systems cause a lot of physical damages to forest plantations and other natural forests as happened in 1993/94 rainy season over the Zomba Plateaux. High maximum temperatures and very low relative humidity during the dry season exacerbate bush fires that destroy plantations and natural forests.

Malawi has a Forestry Policy adopted in 1996 to promote sustainable national forests, woodlands and trees in order to improve the quality of life of the people. Other stakeholders involved in forest management who are mandated to protect and manage forest resources include:

- National Parks and Wildlife Department;
- Traditional leaders for woodlands on customary land; and
- Private institutions having plantations.

### 3.5.5 Adaptation Activities

Malawi has undertaken activities to produce and promote the following :-

- New seed varieties;
- Promotion of traditional tree species;
- Co-management; and
- Community based systems.

### 3.5.5 Potential Adaptation Measures

The assessment results indicate that Climate Change will result in Malawi becoming drier except the very high altitude areas. Hence to adapt to future climate change, the following options were identified for the forestry sector.

***Seed bank for drought resistant species***

Seeds of drought resistant tree species already adapted to existing harsh environments in Malawi such as the lakeshore areas and the Lower Shire should be identified, collected and stored for future use in the projected harsh environment.

***Silviculture Research***

The propagation, suitability to various parts of Malawi and management requirements of these drought resistant tree species from most harsh environments of Malawi should be further studied to assist in developing tree planting programs for replacement of less resistant trees.

***Forest Management***

This option aims at increasing the ability of the existing forests to adapt to climate change by adoption of forest management systems that reduce the impact of climate change on trees. Research should be carried out on the development of such management options. It is also necessary to establish a monitoring system to monitor the effects of the Climate Change scenarios on the trees and forests.

### 3.5.6 Study Constraints

1. The global climate models show no data for the lake shore areas of Malawi limiting the use of Holdridge Model.
2. Holdridge Model has also a limited numbers of vegetation forms and variables.
3. The model generated no data for lakeshore areas with great concentration of forests.
4. Very little is known about maximum diameter of most tree species required for the GAP Model.
5. GAP Model is not user friendly due to lack of manuals and technical back up.
6. Lake Malawi poses a constraint in using the Holdridge and GAP Models as a corridor without activity data surrounds Lake Malawi making assessments impossible.

## 3.6 Wild Life Resources

### 3.6.1 Introduction

Malawi has a wide variety of wildlife that is ecologically and socio-economically important. The majority of the wildlife is in protected areas (about 22% of the total land area of over 94000 km2), which also help to conserve catchments. Socio-economically, communities neighbouring protected areas are permitted to harvest resources such as firewood, medicinal plants and thatch grass, within the protected areas as the cases are in Kasungu National Park, and Vwaza Marsh Wildlife Reserve, just to mention two examples.

The values of wildlife and their habitats, however, may be threatened by any changes in climate due to anthropogenically-induced global warming. The temperatures predicted by General Circulation Models (GCMs) under climatic change scenario are higher than those found during the droughts. Severe drought incidents that have so far afflicted wildlife in Southern Africa, including Malawi, have illustrated that impacts of increases in temperatures and deficits in precipitation can be variable, but certainly harmful. For instance during the severe droughts of 1979/80 and 1991/92 rainy seasons, high mortality of Nyala (Tragelaphus angasi G), which is the key species in Lengwe National Park (Figure 3.8) was one of the observed impacts besides overcrowding at water holes, poor regeneration of vegetation and over-browsing. Since the GCMs predict higher temperatures than those observed so far, the implication is that potential impacts might be worse than those observed during the drought incidents thereby necessitating identification of appropriate adaptation measures. This study, therefore, aimed to firstly, assess the likely consequences of global climatic change on wildlife habitats in Malawi. Secondly, the study intended to confirm whether or not the impacts would indeed be worse than those observed during the recent drought episodes.

***Figure 3.8: Nyala (Tragelaphus angasi G) antelope; Lengwe National Park in Malawi marks the most northern limit for distribution of this species.***

### 3.6.2 Study Sites and Methods

The assessment focused on ungulate populations in Lengwe (981.0 km2 in area, and located between 34°22'-34°50'E and 16°00'-16°28'S) and Nyika (3,132.0 km² area; 30°35'-34°05'E and 10°10'-10°55'S) National Parks. Out of the 5 national parks and 4 wildlife reserves, these two areas were chosen because they represent two extreme climatic conditions that characterise areas in which wildlife occurs in Malawi. For instance, the Nyika National Park is located in the northern highlands where temperatures are relatively cool and rainfall is high (Table 3.5), while Lengwe, which lies in the Shire River Valley in southern Malawi, has a semi-arid type of climate.

**Table 3.5: Some Biophysical Characteristics of Nyika and Lengwe Natioanal Parks**

| National Park | Species | Temperature (°C) | | Annnual Rainfall (mm) |
|---|---|---|---|---|
| | | Min | Max | |
| Nyika | Eland *(Taurotragus oryx)*<br>Zebra *(Equis burchell)*<br>Reedbuck *(Redunca arundinum)*<br>Roan antelepoe *(Hippotragus equuinus)*<br>Elephant *(Laxodonta africana)* | 17.0 | 21.0 | 1300.00 |
| Lengwe | Nyala (*Tragelaphus angasi* G)<br>Buffalo *(syncerus caffer)*<br>Kudu *(Tragelophus strepsiceras)*<br>Warthog *(Phachoecorus aethiopicus)*<br>Impala *(Aepycerros melampus)* | 14.3 | 35.8 | 751.0 |

Four General Circulation Models (GCMs) were used to create climate change scenarios. these were the Canadian Climate Center (CCC) model (Boer et al., 1992), the GFDL model from the Geophysical Fluid Dynamics laboratory (Manabe and Wetherrald 1987). the Gorddard Insitute for Meteorological Office UK89 model (Mitchell et al, 1989). As the case was with the baseline data, rainfall and temperatureoutputs from the three grid points close to the study sites were averaged for each model.

The Habitat Suitability Index (HSI) method, which relates the suitability of habitat variables of landscapes to species of interest, was employed to assess whether habitats in the two study areas would change positively or negatively in the event that climate changes. Habitat variables such as annual rainfall, temperature and distance to water, were employed to derive suitability indices that ( completely unsuitable) to ( optimally suitable) precipitation, and soil moisture play important roles in primary production of natural ecosystems.

Because temperature and rainfall might change because of global warming, they were considered to be the principal variables in the HSI approach. For instance in Lengwe, any rainfall up to 700 mm was considered optimally suitable while an amount of less than 500 mm was deemed unsuitable. Minimum and maximum temperatures considered ideal were 14°C and 35°C respectively. Any departure from this range was assumed to be unsuitable. In the Nyika, on the other hand, any rainfall between 700 and 1300mm was deemed suitable, while any amount of less than 700mm was considered unsuitable. Suitable temperatures were considered to be between 17°C and 21°C. The geometric means of the scores of HSI model were used to determine the suitability of wildlife habitats in the two study areas.

To determine whether the likely impacts of global climate change on wildlife habitat will be worse than those observed during the drought of 1979/80, the study compared precipitation and temperature from the drought of 1979/80 and 1991/92 with GCM scenarios using Lengwe National Park as a case study. Herbaceous layer productivity, ground cover, and forage utilisation by browsers during the 1991/92 drought were measured, and inferences were made as to the likely response of these habitat variables to climate change.

### 3.6.3 Results

The study suggests that temperatures will rise in Lengwe by 3.8 °C while rainfall may decrease by about 10% over the period up to 2075. On the other hand, Nyika National Park will experience increased temperature by 3°C and rainfall by 33%. Comparison of precipitation and temperature from recent drought episodes with Global Circulation model outputs indicated that there would be no differences in precipitation distribution and temperature during the drought episodes and climate change scenarios.

The predicted high temperatures will inevitably increase evapotranspiration rates that will not only diminish the effect of increased rainfall, but also reduce soil moisture adversely in areas where predictions indicate that precipitation may decline It can, therefore, be inferred that habitat quality in Lengwe may change negatively; but it may not decline considerably in nyika. In Lengwe, the projected conditions will impact adversely on the Nyala should high populations coincide with low rainfall. Specifically, deterioting habitat conditions such as those observed during the drouhgt incidents might occur under climatic change.

During the 1991 /92 drouhgt incident, there was 2-6 times lower herbaccous layer productivity than in a normal year; low ground cover 22-23%, and a significant increase in the number of intensely browsed plants as the drought progressed. Consequently, it is unlikely that the degraded habitat would support large mammal populations in Lengwe specifically, probabaly in Malawi in general.

### 3.6.4 Adaptation Measures

In the case of extreme changes in climate, compounded by animal populations that are at or near carrying capacity, conventional wildlife management techniques such as translocation, provision of artificial water supplies, and culling could be used. these measures have neither been prioritised nor costed in the present assessment due to lack of financial support.

## 3.7 Agriculture Sector

### 3.7.1 Introduction

Agriculture in Malawi os characterised as being mainly dependent on summer rainfall with little irrigation networks. The majority of farmers are smallholders producing food crops such as cereals, legumes, vegetables, fruits and pices.

However some smallholder farmers produced cash crops such as tobacco, tea, sugar, coffee, cotton, cashew nuts and macadamia nuts. The commercial farming sector is small and grows cash crops for export. Maize is the most important staple cereal crop grown on more than 90% of the cultivated land area it contributes 80% of the daily food calories and has a per capita consumption of 230 kg. During winter (May to August), some cereals like wheat are grown either on residual moisture and winter precipitattion or under irrigation but on limited scale.

The present vulnerability assessment in Agriculture has focussed on the cereal crop, maize which contributes greatly to food security in many households. the assessment was confined to three representative sites of maize growing areas in the country. the study also assessed the vulnerability of cattle productivity an important livestock.

The average maize grain yield per unit area has stagnated around 1.0 tonne per hectare over the last ten years under smallholder system due to constraints such as declining soil fertility use of unimproved crop varieties high costs of artificial fertilisers, poor agronomic practices, frequent and recurring droughts and floods, limited land resources; and crop production undertaken in unsuitable and climatically marginal areas due to population pressures.

### 3.7.2 Study Sites and Methodology

The study was aimed at assessing past climate change impacts on crop yields and management, evaluation and identification of potential alterations in agricultural practices to address climate change issues. Three stations representing dominant agro-climatic zones where maize is grown were selected for the assessments, namely Bvumbwe in the Shire Highlands areas in Southern Malawi, Chitedze in Central Plains of Central Malawi, and Chitala in the Lakeshore areas of Central Malawi.The climatological data for these sites was supplied by the Meteorological Department to compute the 30-year means for the period 1961 to 1990.

The International Benchmark Sites Network for Agro technology Transfer (IBSNAT) which utilise the Decision Support System for Agro Technology Transfer (DSSSAT V3.1) software package was used to assess the impact of climate change on maize yield, then the CERES- Maize Model was used to generate/ simulate maize growth, development and yield as related to weather, soil, crop management and crop genetics.

### 3.7.3 Climate Change Scenarios

The MAGICC/SCENGEN model was used to develop climate change scenarios for Bvumbwe, Chitedze and Chitala. The four GCMs selected for the assessment were CGCM1-TR, CSIRO-TR, ECHAM4 and HadCM2 to project temperature and rainfall of the three sites to the years 2020, 2075 and 2100. However, the maize yields for 1990 are the actual yields. The outputs obtained were then used in the CERES-Maize model to predict future maize yields.

### 3.7.4 Results of the Assessment

Assessment results show that areas represented by Bvumbwe will experience positive increases in maize yields under impacts of climate change in response to better temperature and rainfall regimes. Those areas represented by Chitedze and Chitala may experience slightly decreased yields under climate change scenario due to increased temperatures and reduced rainfall (Figure 3.9).

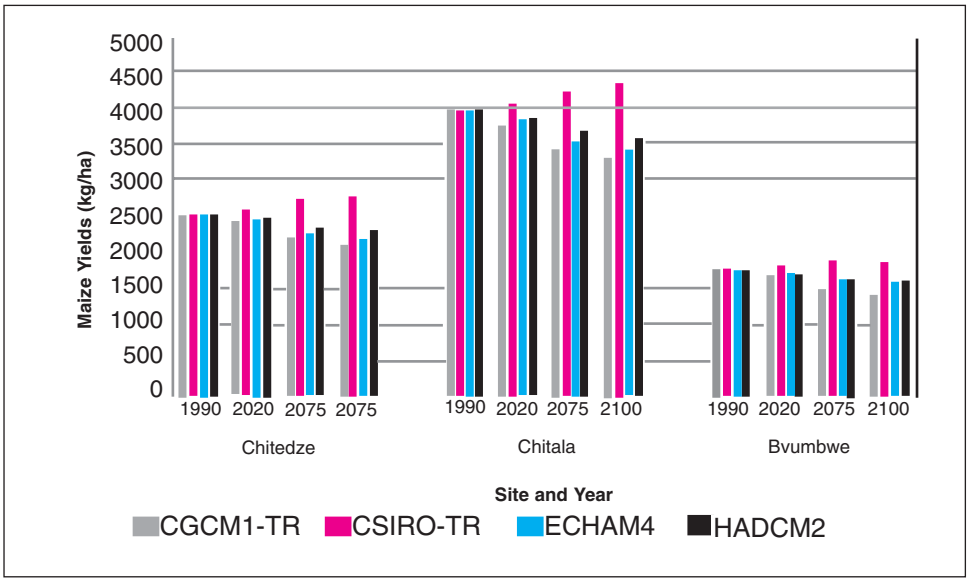


**Figure 3.9: Projected Yields of maize based on rainfall and temperature changes for 2020, 2075 and 2100**

Specific results from model projections show the following:

- All models point to increased temperature above the 1961-1990 baseline;
- Model CSIRO-TR was the closest to the base year. It is the cool model for the assessment;
- Model ECHAM4 and HadCm2 over predicted the baseline temperature, and was considered the warmer models for the assessment;
- All models are close to the base year for the year 2020; and
- Temperature changes range from $2^0$C to $3^0$C;

The projected rainfall changes show that at the three sites:

- CGCM1 and HadCm2 were dry models;
- CSIRO-TR and ECHAM$_4$ were wet models;
- All models predict decrease winter rainfall (April to August);
- Rainfall Decreases in, ranged from 2 to 40% on monthly basis; and
- Rainfall Increases in range from 3% to 50% on monthly basis.

### 3.7.5 Adaptation Measures Prioritisation and Costing

***Adaptation in Agriculture Sector***

Adaptation measures are considered against changing social and technological innovations, population pressures, environmental degradation, soil erosion, rampant deforestation, and increasing poverty among the rural households. National initiatives should prepare agricultural systems for climate change and to recognise climate as a natural resource to be incorporated in agricultural planning. At farm level, the options include changes in the land use, crop and livestock management strategies.

Adaptation measures and options need to be consistent with government policy on Poverty Alleviation and Food Security that are currently integrated in a proposed Agricultural and Livestock Development Strategy Plan (ALDSP).

### 3.7.6 Adaptation Options in Crops Sub-Sector

The climate change scenarios developed show that the new adaptation options need to be considered and incorporated in the crops sub-sector such as:

(a) Changes in land use

- Changes in cultivated land area in line with projected climate change;
- Changes in crop types;
- Changes in crop location;

(b) Changes in Crop Management Strategies

- Use of irrigation water and fertilisers;
- Control of pests, weeds, parasites, and diseases;
- Soil drainage and erosion control;
- Farm infrastructure; and
- Crop husbandry practices.

The prioritisation and costing have not been done in the present assessment due to capacity constraints.

### 3.7.7 Adaptation Options in Livestock Sub-sector

The projected climate change scenarios also require adaptation options/measures to be taken such as:

(a) Introduction of native pastures/grasses tolerant to drought such as local Ntchisi panicum;
(b) Better breeding and feeding practices;
(c) Switch from cattle to small stock adapted to marginal conditioned such as goats, sheep etc; and
(d) Improved animal husbandry practices.

### 3.7.8 Study Constraints

In the assessment undertaken, some constraints were experienced which could affect the results such as:

(a) Lack of fundamental training and experience in running the models such as IBSNAT-ICASA, CERES and MAGICC/SCENGEN;
(b) Inadequate activity data on crops and soils;
(c) Lack of meteorological activity data, availability, quality and quantity for the period 1961 to 1990; and
(d) Time constraints to comprehensively cover the agricultural and livestock sectors.

# 4.1 Forestry Sector

## 4.1.1 Introduction

The GHG Inventories of 1990 and 1994 show that Forests and Other Woody Biomass component is a net emitter of $CO_2$ from burning (Figure 4.1) and decaying of woody biomass on and off-site.

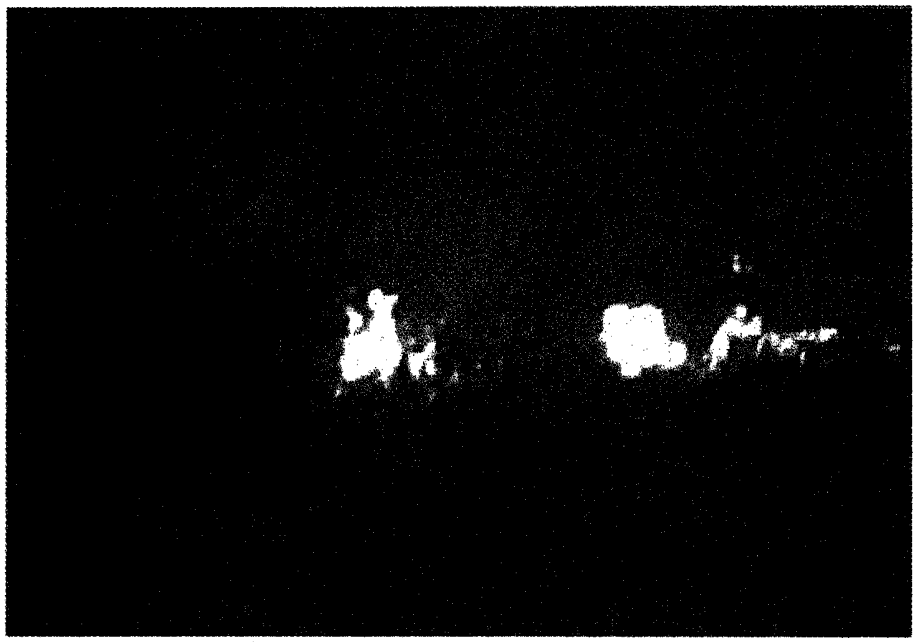

**Figure 4.1: Savannah Bush Fires**
*Source: EAD Outreach, Lilongwe*

## 4.1.2 Methodology

The Comprehensive Mitigation Analysis Process (COMAP) model was used to assess Forestry and Land Use mitigation options for Malawi. For each mitigation option, potential carbon sequestration, and costs and benefits per hectare were computed using the COMAP. The carbon and cost benefit information assisted in the assessment of the cost effectiveness of each option.

## 4.1.3 Mitigation Options

***Forestation***

- Expand carbon sinks by encouraging projects and policies that promote re-vegetation; and
- Land unsuitable for crop rotation and under smallholder farmland could be used for potential tree growing areas using agroforestry systems.

***Forest Protection***

- Malawi has about 1.8 million hectares of land under protected forests and reducing deforestation would improve the duration of carbon storage; and

- Substitution of fossil fuels, with biomass derived from renewable sources to delay the release of carbon.

***Forestry Policy and Legislation***

The 1996 Forestry Policy emphasises forest protection. The Forestry legislation protects the rights of people who plant trees and also promotes organised participatory initiatives in tree/forest management at grassroot level. The Decentralisation Policy (1998) and Local Government Act (1998) empower local communities and District Assemblies, thereby promoting local governance.

### 4.1.4 Mitigation Analysis Results

COMAP was used in the three main approaches, namely: use of natural regeneration, forestry protection and short rotation forest to reduce carbon emissions and enhance carbon sequestration. The results were projected to years 2010, 2020 and 2030. The results are outlined below:

***Biomass Supply and Demand***

The baseline biomass pool of 288 million tonnes in 1990 decreased to 191 million tonnes by 2030. Mitigation biomass pool of 288 tonnes in 1990 increased to 301 million tonnes by 2030. Thus, mitigation measures bring benefit of 110 tonnes of biomass pool. Figure 4.2 illustrates the overall biomass supply and demand projections.

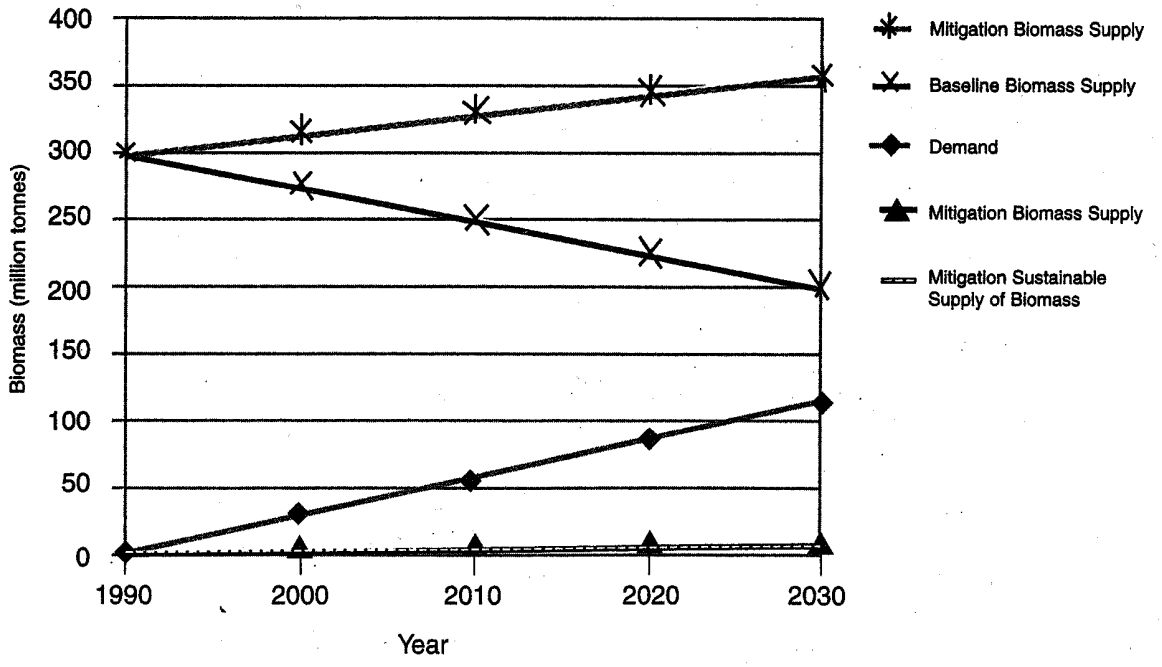


**Figure 4.2: Overall Biomass Supply and Demand Projection**

In 1990 timber supply exceeded demand. COMAP Model projections up to 2030 indicate that supply will continue to exceed demand. However, the Model predicts that, for the same period, fuelwood demand will be greater than sustainable fuelwood supply.

**Carbon Sequestration Using Forest Protection**

Mitigation Scenario shows benefit where carbon pool increases over the baseline by 2030, (Figure 4.3).

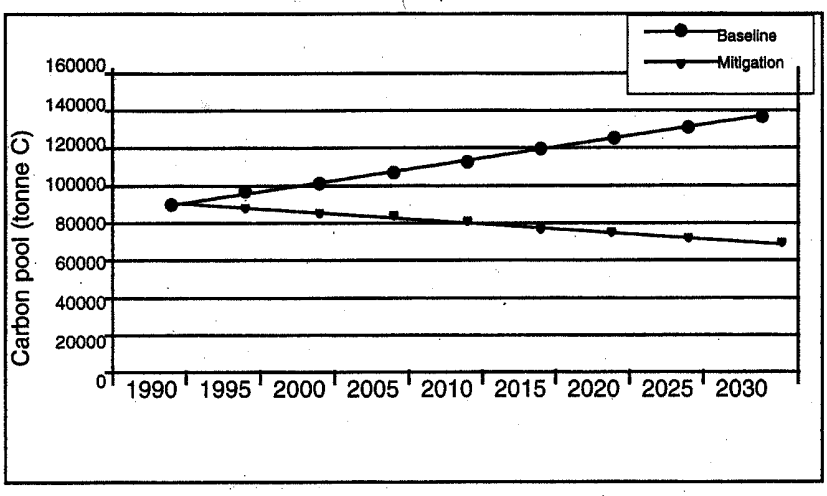


**Figure 4.3: Vegetation Carbon Pool Under Forestry Protection Option**

COMAP projections up to the year 2030 for the forest protection mitigation option shows that the carbon pool increases over the baseline.

### 4.1.5 Implementation Strategies

Strategies proposed for the enhancement of sinks and reduction in $CO_2$ emissions include:

- increasing photosynthesis potential of forests through introduction of selective cutting of trees and woody biomass;
- enhancing and promoting re-afforestation and growing of improved tree and agro-forestry species;
- co-management of protected forest areas and expansion of agroforestry tree planting;
- development of climate change policy and legal framework; and
- education, training and public awareness.

## 4.2 Energy Sector

### 4.2.1 Introduction

Malawi is endowed with several forms of energy resources, which include biomass, coal, many perennial rivers for hydropower generation, high solar irradiation, wind energy, hot springs and uranium deposits. Liquid fuels (petroleum products) are mostly imported. The use of these energy resources result in the emission of GHGs which contribute significantly to global warming.

The use of these energy resources is companied by the emission of GHGs which contribute significantly to global warming.

### 4.2.2 Methodology

The following criteria was used to identify technology-based (hardware) and market-based (software) mitigation options:

- Potential for large impact on GHG;
- Consistency with national environment goals;
- Ease of implementation;
- Long-term sustainability; and
- Consistency with national development goals.

Among the technology-based mitigation options, only the biomass-based mitigation options were analysed in detail due to activity data limitations. Nevertheless, the biomass-based mitigation options offer the greatest potential for GHG emission reduction. Using GACMO, firewood savings and the resultant GHG emission reductions, and their carbon dioxide ($CO_2$) equivalent were projected for 2000, 2010, 2020 and 2030, using 1994 as the base year.

### 4.2.3 Mitigation Options

Table 4.1 gives technology-based options with high potential in Malawi.

**Table 4.1: Technology-based Mitigation Options**

| Technology | Baseline Case | Alternative Option |
|---|---|---|
| Woodfuel Stoves | ● 3-stone stove<br>● Metal (charcoal stove) | ● Improved mudstove<br>● Ceramic stove |
| Biogas | ● Paraffin for lightining<br>● Firewood for cooking | ● Use biowastes to produce biogas for lighting and cooking. |
| Lighting | ● Paraffin<br>● Incandescent lamps | ● electricity (rural electrification)<br>● Compact flourescent lamps |
| Renewable energy (solar) | ● Firewood for cooking and water for heating<br>● Parraffin for lighting<br>● Conventional electricity for lighting and powering of electronic equipment | ● Solar cookers<br>● Solar water heaters<br>● Solar PV |

Detailed analyses were conducted on biomass-based mitigation options as they offer the greatest potential for GHG emission reduction. These are;

- Improved firewood mudstove for cooking and heating water;
- Improved ceramic stove for cooking and heating water; and
- Biogas technology for cooking, heating water and lighting.

The potential market-based mitigation options considered include energy pricing, regulation and standardisation, and demand side management (DSM).

### 4.2.4 Mitigation Analysis Results

#### Impact of the Biomass-Based Mitigation Options

Mitigation efforts in the biomass energy subsector can take either the form of energy savings through improved end-use device efficiency or provision of alternative sources. Use of the improved firewood mudstove instead of the 3-stone stove, and use of the charcoal ceramic stove instead of the traditional metal stove result in energy savings. Use of the biogas technology provides an alternative energy source.

Use of the biomass-based mitigation options would result in substantial annual wood savings, which show an increasing trend with time. Aggregate annual savings are projected to increase from around 41,000 tonnes in year 2000 to about 800,000 tonnes in year 2030 (Table 4.2). The overall impact of the biomass-based mitigation options is illustrated in Figure 4.4.

**Table 4.2: Annual Wood Savings by Biomass Based Mitigation Option.**

| | Annual Wood Savings (tonnes) | | | | |
|---|---|---|---|---|---|
| | 1994 | 2000 | 2010 | 2020 | 2030 |
| Mudstove | 0 | 18,615 | 162,936 | 374,490 | 638,111 |
| Ceramic Stove | 0 | 21,900 | 43,450 | 83,220 | 145,854 |
| Biogas | 0 | 37 | 2,482 | 4,964 | 7,446 |
| Total Savings | **0** | **40,552** | **208,868** | **462,674** | **791,411** |

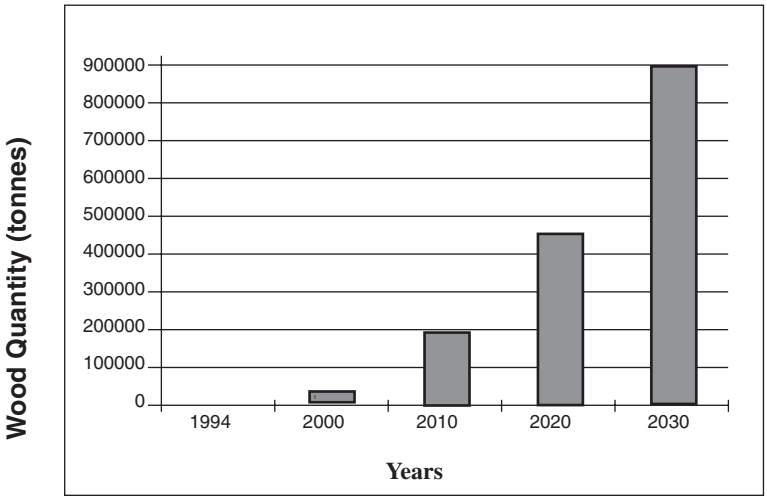


**Figure 4.4: Total Firewood Savings**

***Reduction of Green House Gas (GHG) Emissions***

From the above wood savings, GHG emission reductions were estimated using the GACMO and IPCC revised emission factors. Table 4.3 shows the projected annual GHG emission reductions as a result of introducing the biomass-based mitigation options.

The GHG emission reductions show an increasing trend between the base year, 1994, and 2030. By the year 2030 the combined mitigation options would result annual emission reductions of 48197 Gg CO, 5508 Gg $CH_4$, 1369 Gg $NO_x$ and 38 Gg $N_2O$. The annual GHG reductions from the biomass-based mitigation options are illustrated in Figure 4.5.

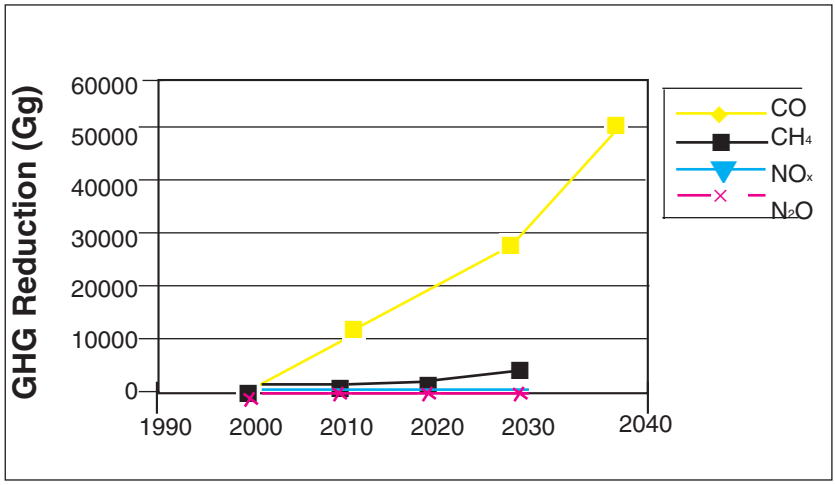


**Figure 4.5 Annual GHG Emission Reductions**

Figure 4.6 shows the annual emission reductions in $CO_2$-equivalent arising from the biomass based mitigation measures. The annual emission reductions in $CO_2$ equivalent show an upward trend. It is estimated that by 2030, the annual reductions in $CO_2$ equivalents will be about 279 308 Gg. These reductions would contribute to the reductions in $CO_2$ emissions from Land Use and Forestry change.

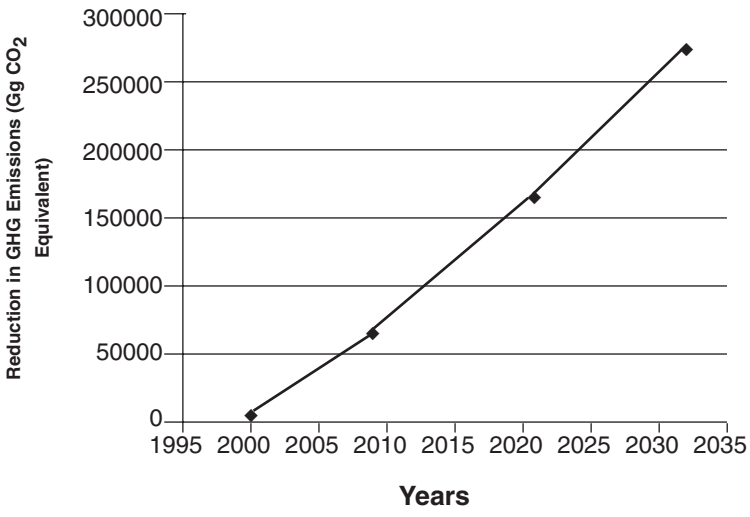


**Figure 4.6 Annual GHG Emission Reductions in CO2-Equivalents**

**Other Technology-Based Mitigation Measures**

Apart from the biomass-based mitigation options analyzed above, there is potential for further GHG reduction through:

- Use of briquettes instead of firewood;
- Rural electrification through grid extension, mini/micro hydropower and solar PVs which would reduce use of biomass energy. Introduction of back-metering of solar PV and grid electricity would increase the number of customers for solar PVs;
- Increased use of public transport and catalytic converters which would reduce GHG emissions from liquid fuels; and
- Wind water pumping instead of diesel and petrol engines.
  Detailed analyses of these options could not be conducted because of limited data.

**Assessment of Market-Based Mitigation Options**

The market-based mitigation options are likely to create an enabling environment for the proliferation of technologies that would significantly reduce GHG emissions. Removal of duty and surtax on Renewable Energy Technology RETs (energy pricing) and certification of RETs installers and inspection of installation (regulation and standardization) would result in the wider use and acceptance of the RETs, which are cleaner technologies.

The potential for emission reduction through Demand Side Management (DSM) is very high. At present, most of the industries in Malawi do not practice DSM because of cost implications. Studies have shown that by practicing DSM, the average growth in power demand is likely to be reduced to 4.8% from 7.8% on the high peak demand, and from 5.5% on the base case. The country is likely to reduce demand up to 25 MW by implementing DSM.

### 4.2.5 Implementation Strategies

The National Sustainable and Renewable Energy Programme (NSREP) has ensured a coordinated approach to the financing and implementation of RETs in Malawi. The NSREP is being supported by GEF, UNDP, DANIDA, JICA and the World Bank. NSREP supports projects in solar home systems, biogas, biomass energy conservation, biomass briquettes, mini/micro hydro and wind energy. The current delivery modes ensures that the RET supplier offer backup support and services to the users. Public media is also used to promote the awareness of the RETs.

All project activities under NSREP are GHG mitigation measures. However, there is currently no arrangement to quantify the GHG emission reductions which would arise from implementing the measures.

Consequently, there is need to finance activities that would quantify the GHG emission reductions resulting from promoting RETs such as solar PVs, solar thermal, wind for water pumping and mini and micro hydropower.

# 4.3 Agriculture

## 4.3.1 Introduction

The 1994 GHG Inventory from Agricultural sector indicate that the predominant emissions were Carbon Monoxide and methane. Livestock and manure management accounted for 65% of the total methane emissions followed by rice cultivation at 30%. The use of synthetic fertilizers was responsible for 37% of $N_2O$ emissions. The $N_2O$ emissions in 1994 were higher than in 1990. Proposed strategies to reduce impacts of climate change include:

- Proper utilisation of crop residues rather than open burning to increase soil fertility;
- Effective and efficient use of fertilisers to reduce volatilisation and leaching;
- Enhanced reductions in savanna burning during the dry season; and
- Increased use of organic manure and hence agroforestry technologies for soil fertility improvement.

## 4.3.2 Methodology

The Comprehensive Mitigation Analysis Process (COMAP) is not ideal for the Agriculture sector since largely annual crops are involved where as the COMAP deals with perennial crops.

## 4.3.3. Mitigation Options for Agriculture Sector

To reduce GHG in the agriculture sector such as methane ($CH_4$) Carbon monoxide (CO), etc. the following measures could be taken:

- Enhanced in nutrient and water management practices in rice fields;
- Balancing fertiliser applications;
- Efficient water use;
- Nutrient improvement in livestock, particularly daily farming by providing additional animal protein feed; and
- Improve mammal management system facilities to influence methane emission.
- No detailed analysis was undertaken.

## 4.3.4 Implementation Strategies

The major sources in the Agriculture sector were burning of agriculture residues, livestock and manure management and rice cultivation. Improvement in agricultural practices would result in reduction of GHG emissions. Crop residue could also be use as raw materials for compost manure and biomass briquettes.

# CHAPTER 5: RESEARCH AND SYSTEMATIC OBSERVATION

## 5.1 Introduction

Research and systematic observations are encouraged under the UNFCCC through Article 4.1(g) and Article 5 as related to the climate system atmosphere, hydrosphere, biosphere and geosphere and their interactions. Malawi has observational data in these fields but their period vary greatly. The earliest rainfall data is from 1890 while that of air temperature goes back to 1901. However, systematic observations started only after the Second World War. In the other sectors, such as hydrology and agriculture, systematic observations have been recently introduced and maintained. The UNFCCC Reporting Guidelines on National Observing System as adopted by the CoP has been used to report on the national systematic observation.

Although Malawi is a Least Developing Country, research in the field of Agriculture started quite early because of the agro-based economy. However, research in other sectors, is relatively new and hampered by limited financial and human resources

The National Research Council of Malawi (NRCM) was set up in 1974 with the mandate to provide national direction on Science and Technology (S&T) and promote and coordinate the development and application of S&T for maximum economic and social benefit of the Malawi population.

The NRCM has the following programmes and activities:

- Development of a national science and technology policy for Malawi;
- Development of a national research strategy and master plan;
- Management of contract research programmes;
- Development of linkages in research matters
- Development of databases and inventories;
- Provision of S&T Awards; and
- Coordination of Sustainable Development Network Programme (SDNP).

Some scientists in Malawi are participating in national and international activities in fulfilment of the country's commitments in the implementation of the Climate Change Convention and other programmes. Malawi participates in the activities of the following bodies:

a) The United Nations Framework Convention on Climate Change;
b) The World Climate Programme of the World Meteorological Organisation;
c) The Inter-Governmental Panel on Climate Change (IPCC); and
d) The United Nations Environmental Programme (UNEP).

In Malawi there are also some well established research institutions whose mandates cover environmental sciences. However Climate Change research is not yet specifically a mandate of any of the established institutions due to lack of capacity, resources and infrastructure.

## 5.2 Research Institutions

As stated earlier, the National Research Council of Malawi (NRCM) has the mandate to co-ordinate and direct research development in the country. However, only limited research is being carried out in some institutions on the new science of Climate Change due to inadequate funding. The following institutions are mandated to conduct research, training, consultancy and outreach programmes on environmental issues.

1. Department of Agricultural Research and Technical Services (DARTS)
2. Department of Animal Health and Industry (DAHI)
3. Department of Fisheries
4. Forestry Research Institute of Malawi (FRIM)
5. Department of National Parks and Wildlife
6. University of Malawi
    - Bunda College of Agriculture
    - Agricultural Research and Policy Unit
    - Chancellor College
    - Centre for Social Research (CSR)
    - Centre for Educational Research and Training (CERT)
    - Natural Resources and Environmental Centre (NAREC)
    - College of Medicine
    - Molecular Biology and Ecology Research Unit (MBERU)
    - Malawi Polytechnic
7. Mzuzu University
8. National Herbarium and Botanic Gardens of Malawi (NHBG)
9. Tea Research Foundation
10. The Malawi Sugar Industry
11 Malawi Industrial Research and Technology Research Centre (MIRTDC)
12 Agricultural Research Extension Trust (ARET)

## 5.3 Research Funding and Organisation

The Malawi recurrent budget allocation to research in agricultural and natural resources is only 0.78% of the Agricultural Gross Domestic Product (AGDP). However, a 2%of AGDP is recommended internationally. The research system is presently fragmented, but efforts are underway to strengthen the research system through restructuring of research institutions in government ministries, universities, private sector, and NGOs. Currently, several international organisations support national institutions in agriculture and natural resources research.

## 5.4 Archives and Databanks

The socio-economic, environmental and cultural data and information collected in Malawi are stored in many different forms of media mostly by the data collecting institutions. Centralised storage of data and information need to be strengthened in order to allow easy access to information. The National Research Council of Malawi is the national documentation centre for science and technology. Some of the institutions concerned with data and information management include the following.

### 5.4.1 National Archives of Malawi

The National Archives of Malawi is the lead institution in the country which is legally mandated to identify, collect, organise and store the country's documentary heritage, irrespective of the media, and make it available to the people for their research and information needs. However the capacity in the National Archives of Malawi needs to be strengthened so as to allow for easy access to and retrieval of information. The present capacity is not able to fully meet this challenge because most of the work is being done manually. There is need to automate the archival functions as an immediate solution to improve access to climatic change information which is available both in published format and unpublished i.e. primary sources.

The National Archives holdings include a large collection of semi-current Government records, public archives and historical manuscripts, which are open for research under agreed conditions. It also maintains a comprehensive collection of Malawiana literature in its Library. Access to Library materials is open to every person of mature age. Other materials in the Archives include audio-visual materials, maps, charts, microfilms and others.

### 5.4.2 Meteorological Department

The Department has a data bank for all meteorological parameters such as rainfall, temperature, wind, atmospheric pressure, relative humidity, thunder and lighting, radiation, sunshine hours, cloud cover, etc, both for surface and upper air. The data are quality controlled according the World Meteorological Organisation (WMO) standards and procedures. This is a centralised data bank and is computerised.

The Meteorological Department has its own archive holding original hard copies of all data including some microfiche.

### 5.4.3 National Statistical Office (NSO)

The NSO is mandated to provide timely, appropriate and accurate statistical information for decision-making and policy formulation for the well being of all Malawians. The NSO is therefore an authority on statistical information whose capacity needs to be strengthened in order to develop its databank so that it should be able to provide accurate and up-to-date activity data.

## 5.5 Systematic Observations

The UNFCCC Reporting Guidelines on Global Observing System as adopted by the CoP were used. Systematic observations in time and space are limited in scope in all sectors in the country. The main constraints are financial, capacity and capability of various institutions to undertake and maintain the observations according to international procedures and standards. Below are some institutions that maintain systematic observations in the country.

### 5.5.1 Meteorological Department

Malawi is a member of the World Meteorological Organisation (WMO) and follows the WMO standards and procedures for observations for its twenty-six stations for both surface and upper air. However, upper air observations have stopped because of breakdown of infrastructures, lack of materials and limited financial resources. Hence upper air observations have not been continuous and hence unsystematic. Surface observational structures are still in place to maintain systematic observations but lack of financial resources will affect the future ability to maintain systematic observations.

The Meteorological Department in the Ministry of Transport and Public Works is mandated to make, collect, process, store and disseminate meteorological data, information and products to all users. It provides efficient weather and climate services to all socio-economic sectors nationally and regionally.

### 5.5.2 Ministry of Agriculture and Irrigation

The Ministry of Agriculture and Irrigation carry out seasonal systematic observations such as phenological observations, crop statistics, agricultural inputs, labour and agricultural costs. The Ministry also maintains a large number of rain gauges to provide rainfall data in many areas. These rainfall data are quality controlled by the Meteorological Department and kept in its data bank and archives.

### 5.5.3 Water Department

The Water Department has two sections namely the Hydro-geology Water and Hydrology. The department maintains systematic observations of stream flows, rainfall, evaporation, water quality, water quantity, Lake Malawi levels, and other parameters. Only the rainfall and evaporation data are quality controlled and data banked by the Meteorological Department.

### 5.5.4 University of Malawi

The University of Malawi also collects and stores topographical and meteorological data in some of its constituent colleges such as Bunda College of Agriculture and Chancellor College.

## 5.6 Data Exchange and Barriers to Exchange

Data exchange in the Meteorological Department is carried out nationally, regionally and globally through the Global Telecommunication System (GTS) via two Regional Telecommunication Hubs (RTHs) in Lusaka, Zambia and Pretoria, South Africa. The barriers to data exchange nationally, regionally and globally under the WMO Guidelines are mainly due to inconsistent availability of systematic data, ageing telecommunication systems, financial resources and lack of capacity.

## 5.7 Meteorological and Atmospheric Observations

Malawi participates in the Global Climate Observing System (GCOS), through the provision of meteorological observations from two main stations at Chileka and Lilongwe through the GTS as part of international data exchange (Table 5.2). Malawi also participates in provision of Meteorological data to World Data Centres, and also archiving efforts with other institutions. The Meteorological Department is mandated to quality control all atmospheric observations in the country according to WMO standards and procedures and archive them.

**Table 5.1 Participation in the Global Atmospheric Observing Systems.**

| | GSN | GUAN | GAW | Other |
|---|---|---|---|---|
| How many stations are the responsibility of the....? | 3 | 1 | 1 | 21 |
| How many stations are operating now? | 3 | Nil | Nil | 21 |
| How many of those are operating to GCOS standards now? | 2 | Nil | Nil | Nil |
| How many are expected to be operating in 2005? | 3 | 1 | 1 | 24 |
| How many are providing data to international data centre now? | 2 | Nil | Nil | Nil |

KEY: GAW: Global Atmosphere Watch
GSN: Global Surface Network
GUAN: Global Upper Air Network

## 5.8 Oceanographic Observations

Malawi is an inland country as such has no oceanographic observations. However, Malawi has the third largest lake in Africa, Lake Malawi, which lacks meteorological and some hydrological data such as surface water temperature, winds, lake rainfall and radiation.

## 5.9 Terrestrial Observations

Malawi has no Global Terrestrial Network but other institutions have networks that monitor land-use, land cover, land-use change and forestry, and fire distribution but the data are not exchanged. Participation in international quality control and archiving programmes is limited by inadequate technical capacity and financial resources.

## 5.10 Space-based Observing Programmes

Malawi has no national space based observing programmes. However, the country has ground-based systems to receive data and information from METEOSAT series of satellites.

# CHAPTER 6: EDUCATION, TRAINING AND PUBLIC AWARENESS

## 6.1 Introduction

Articles 4.1 (i) and of the UNFCCC urges Parties to promote and encourage the development and implementation of educational and public awareness programmes on Climate Change and its impacts. The 1994 National Environmental Action Plan of Malawi identified provision of environmental education and public information as necessary actions to address environmental issues such as Climate Change and Air Pollution. However the low literacy and high poverty levels are major constraints to education and training in Malawi.

Some Malawians have been exposed to Climate Change issues during conferences, workshops, meetings and study tours through the efforts of the UNDP, WMO, UNEP, UNFCCC Secretariat, USCSP, and other bilateral institutions. It is alsonecessary to impart the skills, and knowledge and attitudes to rural communities through training and advocacy linkages between stakeholders.

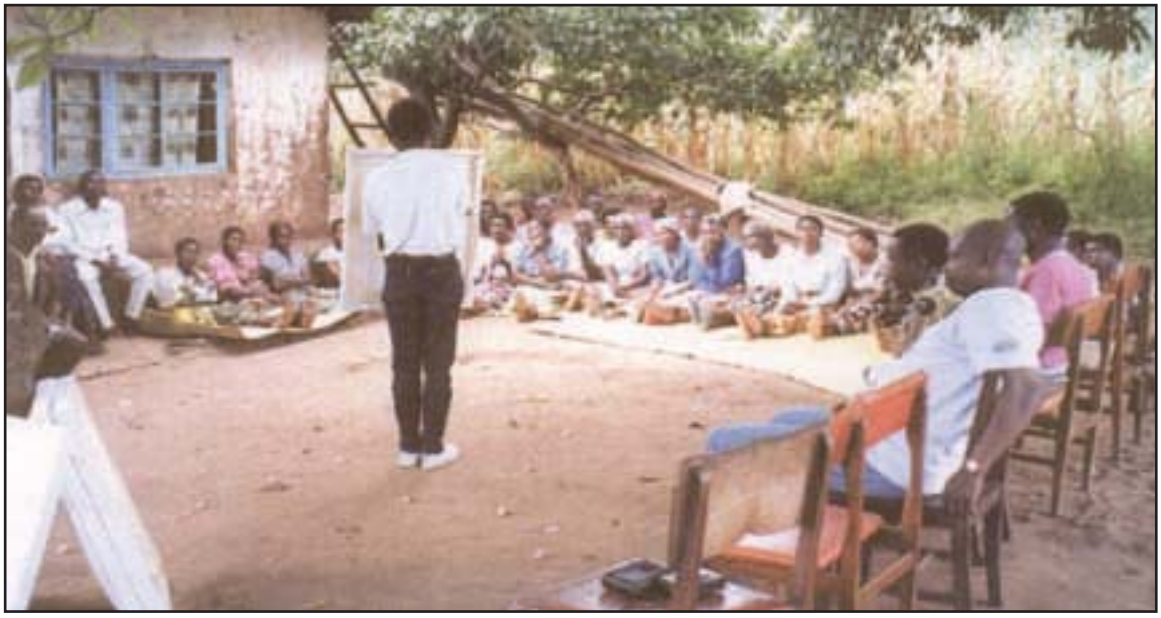

**Figure 6.1: Community-based environment training session in progress**
*Source: EAD Outreach, Lilongwe*

## 6.2 Education and Outreach Unit of the Environmental Affairs Department

The Environmental Affairs Department (EAD) has an Education and Outreach Unit whose aim is "*to ensure that all Malawians are environmentally aware and propelled to take appropriate action to ensure sustainable use of the environment"*. The formal and non-formal education establishments, and the mass media are encouraged and supported to take responsibility in communicating environmental education as apart of their tasks. Recent EAD outreach activities include:

- Encouraging grassroot participation in environmental decision-making and management.
- Facilitating the development of training materials.
- Enhancing access to information on environmental issues.
- Increasing environmental awareness on climate change issues.

## 6.3 Tertiary Education

Malawi has two institutions of higher learning, namely: the University of Malawi and the newly established Mzuzu University. The University of Malawi has five constituent colleges, namely, Chancellor College, Malawi Polytechnic, College of Medicine, Bunda College of Agriculture and Kamuzu College of Nursing. Currently Mzuzu University has not yet opened up constituent colleges. These institutions offer various environmental science courses at under-graduate and post-graduate levels. However only the Malawi Polytechnic offers Bachelor of Science (BSc) in Environmental Health, and BSc in Environmental Science and Technology. At the post-graduate level, only the Faculty of Science at Chancellor College offers Masters of Science (MSc) in Environmental Sciences. The Environmental Affairs Department, with financial assistance from DANIDA, has introduced an in-service MSc degree in Environmental Science at Chancellor College based on the existing full time programme.

In all the environmental courses offered at the various local institutions, Climate Change is not adequately covered due to lack of basic equipment, reference materials, infrastructure and human resources. Thus it is necessary to build capacity and infrastructure at all levels.

## 6.4 Primary and Secondary Education

At the primary and secondary levels, elements of national weather and climate are included in the curriculum. However, as at the tertiary level, most schools lack basic equipment and materials for effective environmental studies including Climate Change. There is also need to build capacity both for teachers and teacher training institutions to adequately promote environmental education including Climate Change.

## 6.5 Decentralisation Process

The Malawi Local Government Act (1998) has put in place a decentralisation process whereby District, Town and City Assemblies were created and mandated to take care of local development initiatives in all socio-economic sectors. The Environmental Affairs Department (EAD) also decentralised its functions and with assistance from DANIDA and UNDP established environmental offices in all District Assemblies to promote environmental education and Climate Change issues at all levels. District Environmental Action Plans (DEAPs) have been established to address local environmental problems.

## 6.6 First National Communication of Malawi

The UNFCCC obligates Malawi under Article 4.a (1) and 12 to communicate to the Conference of Parties (CoP) its National Inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases, information and steps taken or envisaged to implement the Convention.

With financial assistance from the Global Environmental Facility (GEF) through UNDP, Malawi undertook the preparation of the First National Communication in September 1999. This initiative enabled Malawi to arrange for overseas training on Climate Change

issues of some public and private sector personnel involved in the preparation of the communication. However, this training did not include the rural communities. As such future programmes should also target such communities.

In the same connection, Malawi also benefited from the US Country Studies Programme to undertake GHG Inventory and also Vulnerability and Adaptation Assessments to Climate Change. National scientists underwent training in USA to undertake the Climate Change studies in Malawi.

## 6.7 Mass Media and Public Awareness

Malawi has a high illiteracy level of 44% and a large rural population of 85% most of whom depend on subsistence farming as their main livelihood. In general, people are aware of the socio-economic impacts of environmental degradation due to climate variations. However, limited efforts have been made to relate these environmental problems to Climate Change issues especially in the rural areas. The mass media, which carry environmental messages, is not readily accessible by many rural communities because of lack of funds, poor infrastructure and a high illiteracy level. Despite the above constraints Climate Change issues have been promoted through the print media, radio, television and roundtable conferences. Furthermore the EAD is supporting both public and private radio stations to produce and broadcast environmental programmes, which include some Climate Change issues.

Malawi's newly established sole local television services covers some environmental events including national and international conferences and workshops on Climate Change. The decentralisation process in Malawi will also enhance public awareness in environmental issues including Climate Change.

A number of non-governmental organisation (NGOs) and Faith Groups in Malawi have not only played a key role in disseminating information on environmental issues but also undertaken adaptive and mitigative measures to address environmental problems which indirectly address climate change concerns. These NGOs and Faith Groups' roles need to be fully developed in order to address climate change issues explicitly.

# CHAPTER 7: SUSTAINABLE DEVELOPMENT AND CLIMATE CHANGE

## 7.1 Introduction

Economic growth is the sustained increase in income levels. While this is a necessary condition for sustainable development, it is not a sufficient condition. Development also necessitates provision of social services, empowerment of communities and inter-generational equity and sustenance of natural resources. Poverty leads to high dependence on natural resources and environment resulting in their over-exploitation. Because of prevalence of poverty, there is high dependence on biomass energy in Malawi, which contributes to GHG emissions and deforestation. Deforestation is also caused by a large number of individuals who depend on the production and sale of firewood and charcoal as sources of income.

Management of the environment affects availability of natural resources for future generations. It is important that activities of the present generation should not reduce availability of natural resources for future generations. The current over-exploitation of the natural resources in Malawi negatively affects availability of these resources for future Malawians. There is need to promote equity and sustenance in availability of natural resources between the present and future generations.

Equity and sustenance of these natural resources require proper management. Involvement of local communities in planning the use and management of the natural resources (community-based management) is essential. This empowers communities to take charge of their destiny, thereby instilling self-esteem among communities.

Empowerment of communities requires provision of social services such as education/training, health and infrastructure development for example road and communication networks as well as good governance, transparency and accountability.

## 7.2 Development Agenda

The Development agenda for Malawi is provided by two documents namely, Vision 2020 and Poverty Reduction Strategy Paper (PRSP).

### 7.2 .1. Vision 2020

Vision 2020 is the national long-term development perspective for Malawi, which provides a framework for national development goals, policies and strategies. It emphasizes on sustainable development and recognizes the importance of monitoring GHG emissions, adoption of ozone-friendly technology and promotion of public awareness on climate change issues.

### 7.2.2 Poverty Reduction Strategy Paper

Because of the high prevalence of poverty, Government is in the process of designing a PRSP that will be used for poverty reduction programming by government, donors and other stakeholders. The PRSP will draw on existing work on policy formulation including the Vision 2020.

The Government initiatives on poverty reduction are critical to sustainable utilization of natural resources and the environment because poverty is one of root causes of environmental degradation. The PRSP, once finalized, will therefore significantly improve the current state of the environment and hence contribute to sustainable development of the country.

## 7.3 Environmental Policy, Legal Framework and Management

### 7.3.1 National Environmental Policy

The National Environmental Policy (NEP) 1996 provides an overall framework through which sectoral policies are reviewed to assess their consistency with the principles of sound environmental management. The Policy also emphasizes on empowering local communities in the management of their natural resources to promote social equity. Inter alia, the policy also aims at minimizing the adverse impact of climate change and reducing air pollution and GHG emissions. The Policy provides guiding principles and strategies for achieving this objective.

### 7.3.2 Legal Framework

The government has put in place the Environmental Management Act 1996 so as to enforce compliance with the various regulatory measures, to protect and preserve the environment. There is also a Cabinet Committee on Environment and Health in addition to a Parliamentary Committee on the Environment. The Environmental Affairs Department (EAD) also has the National Council on the Environment (NCE), which is assisted by the Technical Committee for the Environment (TCE) to deal with all environmental issues. Malawi also has a National Climate Change Committee (NCCC) with the responsibility to review policies and programmes in climate change and is chaired by the Meteorological Department while the EAD acts as the Secretariat.

The Environment Management Act is the legal instrument for implementing and enforcing the National Environmental Policy. The Act also provides for protection of the ozone layer by regulating substances, activities and practices that deplete or are likely to deplete the stratospheric ozone layer or other components of the stratosphere. This legal framework implicitly supports activities of UNFCCC.

### 7.3.3. Promotion of Compliance

Environmental Impact Assessments (EIAs) have been instituted and promoted as an environmental management tool to ensure that developmental activities are implemented in a sustainable and environmentally-friendly manner. Many institutions both public and private are now undertaking EIAs before project implementation. However, there is need to ensure that climate change components are incorporated in all EIAs.

### 7.3.4. National Environmental Action Plan

Malawi developed the National Environmental action Plan (NEAP) in 1994 whereby key national issues relating ti tge environment were identified including air pollution and climate change. The NEAP is used as a framework for all development plans to ensure an environmentally sustainable development in line with the strategic objectives of the Vision 2020.

To operationalise NEAP, Government is implementing the Environmental Support Project (ESP) whose overall objective is to integrate environmental concerns into socio-economic development of the country and to provide for high priority intervention.

## 7.4 Sectoral Programmes/Projects on Climate Change

As part of efforts to achieve sustainable development, Government has initiated mechanisms and programmes/projects in poverty reduction and climate change.
These integrate environmental and climate change issues into socio-economic development of the country.

### 7.4.1 Related Environmental Programmes/Projects

***Renewable Energy Program***

Malawi has in place the National Sustainable and Renewable Energy Programme (NSREP) supported by GEF, DANIDA, and SADC/FINNESE which aims at promoting the use and development of Renewable Energy Technologies (RETs). The Department of Energy is the co-ordinating and implementing agency of the programme.

***Biomass Energy Projects***

Biomass energy is the major source of energy for Malawians, and is also one of the major causes of deforestation and emission of GHGs. There are a number of national programmes, which are being implemented to promote efficient use of biomass energy as well as looking at alternatives to firewood and charcoal (Figure 7.1).


**Figure 7.1 ProBEC Workshop, Mzuzu, Malawi**
*Source: Department of Energy, Lilongwe*

**Some of the programmes/projects are:**

1. SADC Regional Programme on Biomass Energy Conservation (ProBEC) funded by GTZ/EU. The programme is currently disseminating improved firewood stove in the rural areas.
2. Briquetting project using sawdust under the NSREP programme;
3. Biogas dissemination project under NSREP; and
4. Dissemination of improved ceramic firewood and charcoal stoves by various NGO's.

### 7.4.2 Poverty Reduction Related Programmes/Projects

***The Poverty Alleviation Programme***

The Poverty Alleviation Programme (PAP) was launched in 1994 to address chronic poverty in the country. Programmes/Projects undertaken under PAP include the Safety Net Programmes and the Malawi Social Action Fund.

***(i) Safety Net Programme***

Safety Net Programmes, coordinated by the National Economic Council, are part of poverty reduction initiatives. Poverty results in chronic food shortages and food insecurity. The Safety Net Programmes aim at alleviating these problems and targets vulnerable groups such as the poor, elderly, infirm, disabled, poor female headed households. Safety Net Programmes include Public Works Programme, Targeted Inputs Programme, Targeted Nutrition Programme and Direct Voucher Transfers to the disadvantaged groups.

***(ii) Malawi Social Action Fund (MASAF)***

MASAF jointly funded by the Government and World Bank, is a key program under PAP. MASAF provides inter alia, infrastructure for provision of social services such as school blocks, clinics, water supply, roads and bridges and other social infrastructures.

### 7.4.3 Activities Promoting Good Governance, Transparency and Accountability

***Decentralization***

The Decentralization Policy 1998 and the Local Government Act 1998 devolves administrative and political authority to the district and local levels. This helps promote good governance, transparency and accountability. In line with the Policy and Act, preparation of the Environmental Action Plans and Micro-Projects is decentralized. The decentralization process also fosters empowerment of communities.

***Other Institutions***

There are other institutions that also promote good governance, transparency and accountability such as Parliamentary Finance and Audit Committee, the Anti-corruption Bureau and NGOs such as . The National Initiative for Civic Education (NICE).

# CHAPTER 8: PROPOSED CLIMATE CHANGE PROJECTS

## 8.1 Introduction

The Climate Change Studies carried out under the Enabling Activities Project through GEF/UNDP and US Country Studies Programme funding, have identified limitations which need to be addressed to improve future National Communications on Climate Change to the Conference of Parties of the UNFCCC.

To address these limitations, project proposals have been developed in Energy Agriculture, water monitoring and capacity building with the aim of:

- Improving quality and quantity of activity data for future climate change studies (Green House Gas (GHG) Inventory, Vulnerability & Adaptation (V & A), and Mitigation Analysis);
- Developing Energy Balance sheets for Malawi to improve GHG Inventory;
- Building local capacity in scenario development and model operation; and
- Abating $CO_2$ emissions in the energy and forestry sectors
- Improve capacity for adaptation to climate change

## 8.2 Energy Projects

### 8.2.1 Project Title: Renovation and extension of Matandani Mini-Hydropower Station in Mwanza District

**Project Linkages to National Priorities:** Malawi has the lowest electrification rate in the Southern African Development Community (SADC) where the average rate of electrification in the region is about 20%. The country has only 4% of its population having access to electricity. In rural areas, less than 1% of the population has access to electricity.

In view of this situation, Malawi has put rural electrification as one of its priorities. This is because it is understood that Poverty Reduction can be achieved faster through energizing rural areas for rural transformation. Apart from extending the national grid, it is felt that mini- and micro-hydropower generation will play a greater part in supplying electricity in rural areas. This has generated the need to rehabilitate the Matandani Mini-Hydropower Station in Mwanza District.

**Project Rationale**

Matandani Rural Growth Centre and Neno Trading Centre are 36Km away from the existing power transmission line, and power supply to these centres is difficult because of the numerous hills in the area. The centres have Primary Schools, health centres, secondary schools and other public facilities as well as many private homes and villages. It is envisaged that once renovated the existing Matandani Mini-hydro Power Station will provide electricity to the surrounding areas. In terms of promotion of local electrification in Malawi, this project is expected to be a model project of hydropower development using small rivers and supplying that power to the community at minimal cost and run independently of the national grid. The mini-hydropower station would reduce the GHG emissions arising from the use of paraffin and wood fuel.

**Project Objectives**

The objective of the Matandani Mini-hydropower Project is to supply power to Neno Trading Centre and Matandani Rural Growth and Surrounding rural areas in Mwanza District, and enhance reduction in greenhouse gas emissions.

**Brief Description of the Project**

Originally, the Seventh Day Adventist Mission built the Mini Hydropower at Matandani for power supply to the mission. However, over the years the mission could not generate enough resources to maintain the power station. A recent Feasibility Study done by the Department of Energy has established that it is possible to renovate the existing plant and extend the power station so that more power could be generated and supply not only Matandani Mission, but also Neno Trading Centre and surrounding areas.

The Feasibility Study has established that the maximum power demand in the Matandani area is expected to be 26Kw, while that in Neno Trading Centre it is expected to be 89Kw giving a total of 115Kw. The output of the power station is therefore set at 120Kw taking into consideration the distribution loss of 5% in the operation.

**Stakeholders**

The stakeholders in the Matandani Mini Hydro power plant will include the following:
- Matandani Seventh Day Adventist Mission;
- Mwanza District Assembly;
- Department of Energy;
- Electricity Supply Corporation of Malawi (ESCOM);
- The Local Community; and
- Donors of the Project.
- Environmental Affairs Department (EAD)
- Malawi Industrial Research and Technology Development Centre (MIRTDC)

**Project Output**

Expected outputs of the project are:
- A renovated Old Matandani Mini- hydropower station;
- An extended Matandani Mini- hydropower station;
- Local expertise built in running a mini-hydropower plant; and
- Electricity supply to Matandani Mission and Neno Rural Growth Centre.
- Reduction in GHG emissions.

**Planned Activities**

The major work in the proposed project is the actual construction of the mini-hydropower plant because of feasibility study has already been done. The remaining

activities are:

- Renovation of Matandani Mini-hydropower plant;
- Construction of an extension of Matandani Mini-hydropower station; and
- Construction of distribution lines to Matandani Mission and Neno Rural Growth Centre.
- Quantification of current energy consumption
- Quantification of GHG emission reduction

**Project Budget**

The cost of the renovation and extension work will be as follows:

| | | |
|---|---|---|
| • Civil works | = | US$ 31,200 |
| • Cost of electrical works | = | US$232,100 |
| • Cost of Transmission and Distribution line | = | US$251,300 |
| • Quantifications | | US$85,400 |
| **Total** | **=** | **US$600,000** |

**Project Duration :** 2 years

### 8.2.2 Project Title

Establishment of Energy Data Management System and Preparation of Energy Balance for Malawi.

**Project Linkages to National Priorities**

Development in the energy sector has an important bearing on the success of development initiatives of other sectors in any country. This is because energy is a crucial input into the different demand sectors of the economy, be it households, agriculture, transport, industry, mining and construction. Economic development is positively associated with per capita energy consumption.

Again prevalence of intensive manufacturing industries is associated with use of modern sources of energy such as electricity, liquid fuels and coal. In view of these issues, it is always important to collect and update an energy database, which can be used for preparing energy balance. In energy planning, energy balances are very important making projections about the energy sector and how it would impact on other sectors of the national economy.

**Project Rationale**

Malawi has had no energy balances since 1994. The main problem has been the lack of relevant data to be used in preparing the energy balances. Again lack of local expertise on the preparation of the energy balance is another problem. At regional level, this has created a problem for Malawi in that the Southern Africa Development

Community (SADC) Energy Protocol, requires each member state to report to the Energy Ministers on its energy balances every year to enable SADC to compile energy balances for the SADC region. At national level, the absence of energy balance has made planning in the energy sector and compilation of GHG Inventory to be very difficult. As one is not clear in terms of the overall picture of the energy sector and hence it is difficult to make any meaningful projections.

**Project Objectives**

The objectives of the project are as follows:

1. To gather relevant energy data and prepare an energy data base for Malawi;
2. To prepare energy balances and establish a framework for a sustainable arrangement of preparing energy balances; and
3. Provide technical expertise in preparation of energy balances.

**Brief Description of the Project**

A number of energy surveys have been conducted recently mainly in the urban household and biomass sub sector. However, data on the transport sector, the industrial sector, small-scale industries, rural household and the agriculture sector is not available. Even the data that is available, it is not packaged in a way that one can use to prepare energy balances easily.
In view of this, the proposed project will assist in gathering and packaging the energy database in all the economic and social sectors of the Malawian economy.

The last credible energy balance for Malawi was prepared in 1994 and the experts who were involved at that time have since left the Department of Energy. This had left a big vacuum in the Department. Under the proposed project, it is expected that an expert will be identified under technical assistance arrangements for a period of at least one year. During this time two local officers would be attached to this expert for on the job training on preparing energy balances. Under this arrangement, it is felt that the expertise to prepare energy balances would be internalised and be sustainable

**Lead Institutions**

- Department of Energy Affairs
- Environmental Affairs Department (EAD)
- NSO

**Stakeholders**

Energy issues cut across many sectors of the economy. This being the case, stakeholders to this proposed project will include energy industries, agriculture, consumer associations, mining, transport, service and social sectors such as health, education etc.

**Project Outputs**

Expected outputs of the project are:
- Survey Reports (various economic & social sectors);
- Computerized Energy Data Base;
- Energy Balances (1995 – 2001); and
- Framework for sustainable preparation of Energy Balances.

**Planned Activities**

***Energy Surveys***

In order to gather all the relevant energy data, there is need to conduct energy surveys in various economic and social sectors in order to establish the type of energy used in such sectors as well as establish the demand patterns. Energy surveys will therefore be conducted in the following sectors:
- Rural Household Energy Survey;
- Urban Household Energy Survey;
- Energy Demand Survey in Industries;
- Energy Use in Agricultural Sector;
- Energy Demand in Social Sectors (health, education and other services); and
- Energy Demand in Small scale Industries (e.g. brick burning, fish smoking baking, beer brewing etc).
- Energy use in Transport sector

***Establishment of an Energy Database***

In order to have a sustainable energy database, a computerized energy database is proposed. This will entail acquiring computers that would store a large amount of data and acquiring computer software package that would be used for processing the data i.e. statistical software packages. Two computer experts will be trained in the computerisation of the energy database.

***Preparation of Energy Balance***

It is expected that under the proposed project, Technical Assistance will be obtained with expertise in the preparation of Energy Balance. This expert will have two local officers attached to him for on the job training. However, these local experts will also be sent for specialized training on preparation, maintaining and updating energy balance.

**Project Budget**

***Energy Surveys***

| | | |
|---|---|---|
| • Rural Household Energy Survey | = | US$250,000 |
| • Urban Household Energy Survey | = | US$150,000 |
| • Energy Demand Survey in Industries | = | US$100,000 |
| • Energy use in Agriculture sector | = | US$100,000 |
| • Energy demand in social sectors | = | US$150,000 |
| • Energy demand in small scale industry | = | US$150,000 |
| **Sub Total** | = | **US$900,000** |

***Establishment of Energy Database***

| | | |
|---|---|---|
| • Computer and Printers | = | US$ 50,000 |
| • Training computer experts | = | US$ 60,000 |
| • Stastical packages | = | US$ 15,000 |
| • Other office equipment | = | US$ 20,000 |
| • Computer servicing | = | US$ 10,000 |
| **Sub Total** | = | **US$155,000** |

***Preparation of Energy Balance***

| | | |
|---|---|---|
| • International Expert Technical Assistant for 2 years at US$50,000/year | = | US$150,000 |
| • Training Energy Balance specialist | = | US$100,000 |
| • Preparing Energy Balance | = | US$ 50,000 |
| • Maintaining and updating energy balances | = | US$ 50,000 |
| **Sub Total** | = | **US$ 350,000** |
| • Energy Surveys | = | US$ 900,000 |
| • Energy Database | = | US$ 95,000 |
| • Preparation of Energy Balances | = | US$ 250,000 |
| Training of national Experts | = | US$ 160,000 |
| **Sub Total** | = | **US$1,405,000** |

**Project Duration:** 3 years

## 8.3 Capacity Building Projects

### 8.3.1 Project Title:

Global Climate Observing System (GCOS) Surface Station on Mount Mulanje.

**Objectives**

To measure a range of atmospheric observations such as air temperature, rainfall, solar radiation, wind speed and direction in accordance with GCOS Standard, utilising Automatic Weather Stations (AWS)

**Planned Activities**

The main activities will involve:

- Procurement and installation of equipment;
- Training of staff in all aspects of manning the station.

**Project Description**

Mulanje Mountain is one of 200 global eco-regions in the world for Conservation of Biodiversity and is designated as an Afro-montane Regional Centre of Endemism since it has a large number of endemic flora and fauna

since it has a large number of endemic flora and fauna.
Currently there is a Mulanje Mountain Conservation Trust Project, supported by Global Environment Facility (GEF) under the Biodiversity Convention that is addressing sustainability of the Mount Mulanje ecosystem. Activities of the GCOS station would, therefore, augment this project such that data and information from the site will not only be confined to the studies of the atmosphere, but also to other sectors such as forestry, wildlife, fisheries, agriculture, water, energy and many more. Furthermore, Mulanje Mountain site would be categorised as a fragile area and disaster prone as well. The Phalombe Disaster that occurred in 1992/93 seasons was within the neighbourhood of Mulanje Mountain. Data and information from the top of the mountain, which is about 3000 metres above sea level, would form a good comparison with ground level activity, which is about 600 metres above sea level

**Stakeholders/Beneficiaries**

This project will take on board various stakeholders including those from agriculture, water, energy, mining, wildlife, forestry, fisheries, tourism and the local community.

**Expected Outputs**

It is expected that the data collected from the top of the mountain and that on the ground, will be a major input to climate change studies, which cuts cross many sectors as indicated above. There will be a database on Mulanje Mountain to be used in GCOS-Network.

**Estimated Cost**

US$ 300,000 which will include equipment, installation, freight, training, vehicle, operational costs, computers and insurance.

**Duration:** 2 Years

Future Potential Sites: Likoma and Chizumulu Islands on Lake Malawi, Zomba Mountain and Nyika Plateau.

### 8.3.2 Project Title:
### Establishment of a Unit for Climate Change Studies at the Natural Resources and Environmental Centre (NAREC) University of Malawi.

**Project Linkages to National Priorities**

The issues of climate change need to be incorporated in national development policies and programmes to adaptation to climate change.

**Project Rationale**

The project aims to enable Malawi have a Climate Change Unit within the Natural Resources Centre (NAREC) of the University of Malawi to spearhead climate change issues in the Country.

**Project Objectives**

The goal objectives of the project is to establish a Unit for Research, Training and Advocacy in Climate Change issues
The specific objectives are to:

- Undertake climate change research into Climate Change
- Develop training materials and curriculum for undergraduate and postgraduate levels
- Contribute to advocacy on Climate Change issues at local regionally and internationally levels
- Facilitate networking among key players within Malawi and partners beyond
- Formulate climate change policies in line with UNFCCC and Kyoto Protocol and other relevant conventions.

**Lead Institution**

Meteorological Department, University of Malawi, Chancellor College (NAREC)

**Stakeholders**

Environmental Affairs Department, National Economic Council, Natural Resources and Environment Centre, University of Malawi, Ministry of Education.

**Project Outputs:**

- A Laboratory for Research and Development on Climate Change
- A directory of Research Scientists, Technologists, Social Scientists and Outreach Organizations (NGOs)
- National /country emission factors
- Curriculum and teaching materials and modules at University including sandwich distant education and distance education models.
- A regular newsletter on Climate Change to target various stakeholders including policy and decision makers.
- Training courses developed for community leaders and NGOs and media staff Involved in climate change issues for enhanced awareness
- Development of predictive models related to drought
- Socio-economic indicators associated with Climate Change
- 5-year mitigation analysis of effect of climate change
- Methodologies identified for measuring CO2 uptake by Malawi
- Nature and extent of air pollution
- A systematic and dedicated programme for monitoring GHG emission and enhancing sinks

**Project Budget**

| | | |
|---|---|---|
| Unit | US$ | 71, 000 |
| A Vehicle | US$ | 30, 000 |
| Research Equipment | US$ | 100, 000 |
| Research costs (publications/network/field costs/overheads) | US$ | 500, 000 |
| **Total** | **US$** | **701, 000** |

**Project Duration:** 3-5 Years

## 8.4 Vulnerability and Adaptation Projects

### 8.4.1 Project Title

Siltation Reduction along Shire River for Hydropower Enhancement and GHG Emission Reduction

**Project linkage to national priorities, action plans and programs:**

The Middle Shire is faced with several problems associated with serious environmental degradation due to population pressure, land cover degradation, soil erosion, deforestation, fish stock reduction, loss of wildlife, food and timber genetic diversity as identified by the National Environmental Action Plan (NEAP). Soil erosion is one of the major types of land degradation, which threatens agriculture production and water contamination. About 11-50 tones of soil are lost per hectare annually hence declining soil fertility, reduction in crop yields, siltation and sedimentation. Siltation in the river causes reduced capacity and consequently flooding and bank overflows as well as water treatment costs. At Nkula hydro power station, siltation hampers national electricity generation and results in frequent electricity black out. This has resulted in private production of electricity using diesel/petrol generators resulting in increased GHG emission. Standby power generation capacity averages 25MW. Furthermore, electricity blackout have increased the production and use of charcoal which is also GHG emitter.

**Project Rationale and Objectives**

Soil erosion, deforestation, population pressure on land, poverty and inappropriate agriculture practices along the river catchment lead to serious siltation, which affect electricity generation, bio-diversity, water quality and quantity. The decreased water quality leads to prevalence of water hyacinth and increases the cost of power generation and water purification. Deforestation resulting from charcoal production increases GHG emissions and reduces the carbon sink

**Project objectives**

The objective of the Project is to develop an integrated approach, which contributes to and promote sustainable use of natural resources in Shire basin by reduction of CO2 emission and enhancement of sink.

**Lead Institutions**

The Natural Resources and Environment Centre (NAREC), University of Malawi, Chancellor College (Faculty of Science) ESCOM

**Stakeholders**

Blantyre Water Board, ESCOM, University of Malawi- (Chancellor College, Bunda College of Agriculture and The Polytechnic), Environmental Affairs Department, Fisheries Department, Department of Water, Blantyre City Assembly, Department of Energy affairs, Department of Forestry, Co-ordination Committee for the Rehabilitation of the Environment (CURE), Malawi Environmental Endowment Trust (MEET), World Universities of Canada (WUSC) and Malawi Enterprise Development Institute (MEDI).

**Expected outcomes**

The main outcome is an integrated participatory strategy and action plan for the sustainable utilization and conservation of natural resources in the Shire River Basin and hence greater reduced siltation. This will contribute to poverty reduction, increased reafforestation, decreased siltation and greater conservation of the natural resources. Consequently, increased carbon sink, leading to decreased green house gas emissions, alternative and more efficient use of energy, less flooding in the lower Shire; enhanced and more efficient electricity generation with fewer blackouts and water abstraction, better monitoring of the natural resources and water management, reduced bio-diversity loss and increased agricultural production.

**Planned Activities**

A stakeholder survey and analysis will be undertaken to determine the level of partner com mitment/involvement in the project and also the relevance of the study to the communities.

**Project Budget**

US$ 1,000,000

**Project Duration:** 3 –5 years

### 8.4.2 Project Title

Upgrading Of The Flood Forecasting And Warning System For The Shire Valley

**Sponsoring Agency**

Nil

## 1. Origin And Background

Floods in Lower Shire Valley occur almost every year causing damage to property and loss of life. The worst of these floods occurred in 1942, 1952, 1957 and 1989 and resulted in damages to infrastructure such as roads, railway lines, bridges, buildings and to a large extent, washing away of villages. Homes in flood prone areas were destroyed with loss of lives of people and livestock. Recurrent flooding is therefore a serious obstacle to development projects in the area.

The frequency of floods in the Lower Shire Valley prompted the government to initiate a manual flood warning system in 1956, intended to provide advance warning on the likelihood of flooding in order to safeguard against loss of life and reduce flood damages to property. However, this system proved to be unsuccessful. The transmission of data in most cases took several hours and the data collected was inadequate for flood forecasting. As a result flood warnings were issued after the floods had already occurred and caused damages to property and loss of lives. Recognizing this shortfall, and taking into account in-creased develop-ment in the Lower Shire Valley, the govern-ment requested assistance from UNDP to establish a real-time/near real time modern flood forecasting and warning system. This system was expected to give adequate lead time to allow evaluation and suspen-sion of transport routes in the flood prone areas before the occurrence of floods.

The Shire Valley is a densely populated area particularly along the river valley. The population density for this area ranges from 72 persons /$Km^2$ to as high as 267 persons /$Km^2$ in the densely populated areas. A large proportion of this population depends on food produced on land using residual moisture from the receding river water levels after floods. Also situated within the flood prone areas are commercial farming activities which include sugar cane fields and rice schemes. The sugar and rice estates cover a large area of over 40,000 hectares and are based on rain fed water as well as irrigation from river water. The proposed Shire Valley smallholder irrigation scheme of 20 to 60,000 hectares has half of its area lying in the flood prone areas. Therefore, the threat of floods to the development of the Shire Valley cannot be overemphasized. All these agricultural developments and future rural development plans need protection against such floods in order to ensure the socio-economic development which will benefit not only the people of the Lower Shire valley but the nation as whole.

Malawi is on the upstream of Mozambique and the floods of 2000 and 2001 have shown that the region needs to be adequately prepared in its disaster management. The upgrading or restoration of the modern flood forecasting and warning system for the lower Shire valley will definitely help in providing adequate warning with enough

lead time for protection of population and property in the downstream reaches of the valley up to Mozambique.

The project is a follow-up to the UNDP/WMO project MLW/-88/011 "Flood Forecasting and Warning System for the Lower Shire Val-ley".

The project will improve the forecasting and issuing of warnings of impending floods in good time to allow timely evacuation of the inhabitants and the imple-mentation of other precautionary measures and relief activities. It will consolidate the capacity in the Ministry of Water Development to develop national expertise to effi-cient-ly operate and maintain the system. It will also provide improvements to the existing telemetry system installed in the early 1990's.

**Existing Situation And Major Constraints**

Problems of floods in the Lower Shire Valley are having regional and national importance because of high population densities and demand for food and the frequent use of transportation routes in the valley. At present, the flood forecasting models and the flood warning procedures have been developed, and the development of these models is dependant on availability of adequate and good quality rainfall, water level and river flow data, which also depends on the telemetry system. However, at present, the available data is insufficient and there is need to collect more data from the upper Shire catchment as well. It is also expected that some essential rainfall and river flow data for some ungauged part of the basin will be collected through the expansion of the existing telemetry system. The preparation of a flood warning system also requires detailed flood prone area-maps which at the moment are not available due to lack of funds and expertise in surveying and mapping. There is also presently no sound alarm system in the Lower Shire Valley for alerting the people on impending floods.

There is therefore need for full time personnel to co-ordinate and deal with the day-to-day activities of the project. Also, there is need to improve, operate and main-tain the telemetry system in light of experience gained so far, and the reliability of the existing telemetry system through the addition of a back-up satellite based data transmission.

There is need for the development and calibration of flood forecast models for the lower Shire Valley.

**Other Related Activities**

The UNDP/WMO Project MLW/88/011 "Flood Forecasting and Warning System for the Lower Shire" came to an end in December 1991. It has prepared necessary groundwork for establish-ing a real-time flood forecasting and warning system for the Lower Shire Valley. It has provided a telemetry system that collects rainfall and water level data in real-time. It has also provided necessary training to Water Resources Divi-sion personnel in the operation of the telemetry system and in the collection and analysis of hydrological data.

There was also a Norwegian Trust Fund/WMO Contribution to the project which

supports some activities in the building of a real-time flood forecasting and warning system. It has provided consultancy services on the building of micro-computer based flood forecasting models. The Norwegian Trust Fund provided two micro-computers and training to Water Resources Divi-sion hydrologists in the installation, calibration and testing of the models. However, this work was not finalised and presently there are no flood forecast models that may be used for the area.

A French Development Assistance Programme has also provided financial and technical support for studies and designs for irrigation under the Lower Shire Valley Development Pro-ject. It is expected that 20,000 hectares will be devel-oped for irrigation in the first phase.

The government has commissioned 6 satellite based stations under a Southern Africa Development Community -Hydrological Cycle Observation System Project (SADC-HYCOS). One of these stations is located within the Lower Shire valley project area. The SADC-HYCOS aims at improving collection of real time data via a EUMETESAT satellite channel transmitted through a Regional Centre in South Africa.

**Project Goals And Objectives**

The project goal is to improve the social and economic welfare of the people, by providing security against floods and creating a favorable atmosphere and working conditions for the social, agricultural and transport activities in the Shire Valley. The agricultural (irrigation schemes) and transport activities have national and regional dimensions in their contribution to the social and economic growth of the country.

The project objective is to develop an integr-ated flood forecasting and warning system for the Shire Valley. This will be achieved by improving and expanding under the UNDP/WMO Project MLW/88/011 and by establishing an opera-tional flood forecasting and warning system. The activi-ties initiated under the Norwegian component will be integrated with those of the project.

**Project Description**

There are three main expected outputs from this project and these are: to have a fully operational and upgraded system of data collection and processing; to have an integrated flood forecast-ing and warning system for the Lower Shire Valley and to have suitable trained personnel in flood forecasting, water resources engineering and hydrological data processing.

To achieve the above outputs, a number of activities will be carried out as detailed below.

- Upgrade and improve the telemetry system through the installation of a satellite based data transmission system; develop and implement procedures for quality control for data collected from remote telemetry stations; develop discharge mea-surement techniques and activities for the streamflow telemetry stations which do not have discharge measurement data; update stage discharge relation-ships for all water level/discharge stations; prepare hydrometeorological

and streamflow data for flood fore-casting modelling inputs; upgrade the data pro-cessing procedures and the flood forecasting database.

- Develop relationships between various flood plain zones to corresponding flood magnitudes; develop procedures for integrating weather forecasts prepared by the Meteorological Departent with river flow (flood) forecasts; integrate telemetry (data collection and processing system), flood forecasting model and flood warning software; develop emergency procedures for the flood forecasting centre (data polling, processing, flood warnings); develop an integrated manual for the flood forecasting and warning system; prepare and issue on a regular basis flood forecasts and warnings to the users.

- Select and provide training to nationals in the areas indicated; organize on-the-job training in the operation and maintenance of the flood forecasting and warnings to the users.

**Summary of Inputs and Costs**

| DONOR CONTRIBUTION | AMOUNT (USD) |
|---|---|
| Data Collection Platform Equipment | 300,000 |
| Spares | 35,000 |
| Technical Assistance | 300,000 |
| Installation & Training costs | 65,000 |
| **Sub-total** | **700,000** |
| **LOCAL COMPONENT** | 140,000 |
| **Total Cost of Project** | **840,000** |

**Arrangement For Implementation**

The Water Resources Department of Ministry of Water Development will be the implementing agency.

Co-ordination at national level will continue to be facilitated by co-operation already existing between the Malawi Broadca-sting Services, the Police and the Disaster Preparedness and Relief Organizations. This co-operation will also facilitate the speedy dissemination of flood forecasts and warnings and education of the general opportunities with the commercial enterprises benefiting from the flood forecasting and warning system.

**Proposed Approach To Monitoring**

The Project will be subject to a tripartite review betw-een the Government, executing age-ncy and Sponsor/Donor) at least once every 12 months, the first such meeting to be held within the first 12 months of the start of full implementation.

National Project Co-ordinator shall prepare and submit at each tripartite review meeting a Project Performance Evaluation Report.

A Project terminal report will be prepared for consider-ation at the terminal tripartite review meeting. It shall be prepared in draft, sufficiently in advance to allow review and technical clearance by the executing agency at least two months prior to the terminal tripartite review.

During the later stages of the project, and eventually in the project terminal report, consideration will be given to the possibility of an extension to the existing project at the implementation of a new but complementing of the proposed project. In addition, or alternatively, it might consider the implementa-tion of similar flood fore-casting systems in other areas based on the expertise gained in the Lower Shire Valley. The following types of revisions may be made to this project document provided all parties which are signatories of the project document agree:

(a) Revision in or addition of, any of the Annexes of the project document.

(b) Revisions which do not involve significant changes in the objectives, outputs, or activities of the project, but are caused by the re-arrangement of inputs already agreed to or by cost increases due to inflation.

(c) Mandatory annual revisions which reschedule the delivery of agreed project inputs, increased expert or other costs due to inflation or take into account agency expenditure flexibility.

**Expected Benefits, Impacts And Risks**

It is expected that at the end of this project, the country will have a fully operational and enhanced flood forecasting and warning system capable of predicting flooding with an adequate lead time.

By providing early warnings of the likelihood of flood, the project will greatly reduce damages and loss of life, thereby creating a favourable atmosphere for increasing agriculture productivity by the rural population and the commercial sector. This will, in turn, assist in alleviat-ing poverty of the rural people through increased agriculture production. It will also improve and safeguard their employment opportunities with the commercial enterprises gaining benefits from the flood forecasting and warning system.

The direct beneficiaries will be the rural people living in the flood prone area. The Malawi Railways, the users of public roads in flood prone areas and the commercial farmers will also benefit from the project as they would have advance warnings of flooding in the area.

The project will help to provide adequate warning to the people living in the flood prone areas located in the Shire valley area in Malawi as well as those living in the Zambezia region in neighbouring Mozambique.

There are no real risks involved, which would have the effect of preventing the achievement of the project's objectives.
However, the following may be considered as possible risks:

(a) Delays in the appointment of project co-ordinator and consultants;

(b) Delays in the delivery of equipment and materials;

(c) Inadequate data due to lack of floods during the project period.

## 8.5 Agriculture Projects

**Project Title**

Developing appropriate agriculture technologies to mitigate Climate Change

**Project Linkages to national priorities**

**Project Rationale**

As a nation that is dependent on agriculture, and is undergoing the democratisation and decentralisation process, Malawi faces a multitude of social, economic and environmental problems that are threatening a deepening dependency on foreign assistance. The heart of the problem is the nation's high population that is estimated 10 million hectare against a background of increasing deforestation, land degradation and incidences of frequent and recurrent droughts.

Simulation models in spite of limitations represent plausible and important tools for forecasting agricultural productivity and environmental degradation. Research is urgently required on integrated nutrient management systems that reduce environmental pollution and optimise crop, pastures and livestock productivity under low and variable climatic conditions.

The strategy would be to use as much as possible of the organic fertilizers in combination with as little as possible of the inorganic fertiliser materials to optimise crop yield, reduce GHG emissions and environmental degradation and the pollution of ground water aquifers."

**Project Objectives**

The Overall objective is to develop appropriate environmentally friendly agricultural technologies. The specific objectives include:

- To determine organic and inorganic fertiliser mixtures that optimise crop yields while reducing GHG emissions and environmental degradation and pollution
- To develop appropriate cereal and legume varieties, which would improve, soil fertility through biological nitrogen fixation (BNF)
- To calibrate and validate appropriate mod~~el to predict s~~oil, weather, crop, pastures and livestock productivity and environmental degradation under changing climatic conditions; cropping patterns and for technology transfer.

**Project Description**

The project will facilitate in institutionalising production – increasing technologies in face of biotic, a biotic constraints, and water stress

**Lead Institutions**

Bunda College of Agriculture, Ministry of Agriculture,
Chitedze Research Station, Department of Agriculture Research and Technical Services (DARTS)
Meteorological Department

**Stakeholders/Beneficiaries**

Smallholder farmers; University of Malawi, Meteorological Department

**Expected Outcomes**

- GHG emission reduction.
- Increased crop yields
- Reduced Soil erosion and surface run-off and environmental degradation
- Improved fertiliser use efficiency
- Conservation of soil water
- Crop varieties suitable for intercropping identified
- Agricultural crop husbandry practices recommended
- Pest and disease control measures identified and recommended
- Increased crop yield production unit area
- Increased soil fertility

- Reduce environmental degradation.

**Planned Activities**

- Conduct in farm and on station trials throughout the country using participatory methodologies and farmer yield schools;
- Conduct on station and on farmer verification trials and demonstrations using participatory approaches with farmers, elaterium, NGOs and the grass root communities farmers;
- Conduct on station and on farm trial to determine soil, weather and crop livestock management database;
- Calibrate and validate simulations models; and
- Experiment with models as tools for alternative production possibilities.

**Project Budget (US $)**

| | | | |
|---|---|---|---|
| Integrated Nutrient Management | | = | 270,000.00 |
| Intercropping Cereals with legumes | | = | 250,000.00 |
| Use of Simulations Model | | = | 500,000.00 |
| | **Total** | **=** | **1020,000.00** |

**Project Duration**

| | | |
|---|---|---|
| Integrated Nutrient Management | : | 3 Years |
| Integrated Nutrient Management | : | 3 Years |
| Use of Simulations Model | : | 3 Years |

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